European Commission

Digital Contact Tracing Study

Study on lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic

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Executive summary

This report presents the results of the study on "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic". The study was commissioned by the European Commission (EC), DG CONNECT, and carried out by empirica Communication and Technology Research from January to September 2022.

The study provides a comprehensive overview of the approach and lessons learned from EU-level actions on cross-border interoperability and the epidemiological impact of digital contact tracing by Member States, EEA countries, Switzerland, and the United Kingdom.

Contact tracing is an important public health intervention in the context of the COVID-19 pandemic that has seen high infectiousness and rapid spread of the virus throughout the world. Conventional contact tracing is used to detect and isolate possible infected individuals by tracing previous contacts as fast as possible. Digital contact tracing was explored early in the pandemic as a promising complementary solution to conventional contact tracing methods. Digital tools can capture anonymised interactions between individuals, identify contacts at risk of getting infected and subsequently issue alerts, all through a mobile interface. The technology is based on measuring signal strength between devices to trace proximity between users. There are several advantages of using digital contact tracing: it can capture interactions between individuals that otherwise cannot be identified via conventional contact tracing, including asymptomatic cases; it is a promising scalable approach when conventional contact tracing staff is overburdened by a high number of cases; it can support public health processes.

The study examined 27 national digital contact tracing apps developed by European countries and deployed within a narrow timeline following the official declaration of the pandemic on 13 March 2020.

Austria	Stopp Corona App
Belgium	Coronalert
Croatia	Stop COVID-19
Republic of Cyprus	CovTracer-EN
Czech Republic	eRouska
Denmark	Smittestop
Estonia	HOIA
Finland	Koronavilkku
France	TousAntiCovid
Germany	Corona-Warn-App
Hungary	VirusRadar
Iceland	Rakning C-19
Ireland	COVID Tracker
Italy	Immuni
Latvia	Apturi Covid
Lithuania	Korona Stop LT
Malta	COVIDAlert
Netherlands	CoronaMelder
Norway	Smittestopp
Poland	STOP COVID
Portugal	StayAway COVID
Slovenia	#OstaniZdrav
Spain	Radar Covid
Switzerland	SwissCovid
UK – England & Wales	NHS COVID-19
UK – Northern Ireland	StopCOVID NI
UK – Scotland	Protect Scotland

As tracing contacts across borders and across apps of Member States is essential for ensuring the EU's freedom of movement principle, the EC has worked together with Member States to ensure a common approach to digital contact tracing, focusing on technical, legal, organisational, and epidemiological aspects.

To enable a quick informed response to the pandemic, supported by digital solutions, the eHealth Network (eHN) formed in April 2020 dedicated working groups of Member State experts covering technical, public health, organisational and legal matters. Wherever necessary, the groups have been supported by additional external experts. This approach was a rather new working paradigm in terms of flexibility and intensity. The coordinated pan-European approach led to several guidelines and a Common EU Toolbox for Member States to guide the development and deployment of the national digital contact tracing apps.

Member States benefited from the close exchange on technical issues related to the apps, peer support, and learning from the insights, practices, and experiences of others. Furthermore, there was a strong agreement that the exchange of best practices and outcomes at EU level has reduced the implementation and operation costs of several national aps. 25 apps are open-source and some countries reused codes or parts of the codes of other European contact tracing apps. Member States broadly agreed that the approach of technical working groups as used within the eHealth Network should be applied to other health and care topics beyond the pandemic, incorporating the lessons learnt and practices of other areas where the groups have contributed to.

The apps were developed mostly through public-private partnerships involving a wide range of stakeholders.

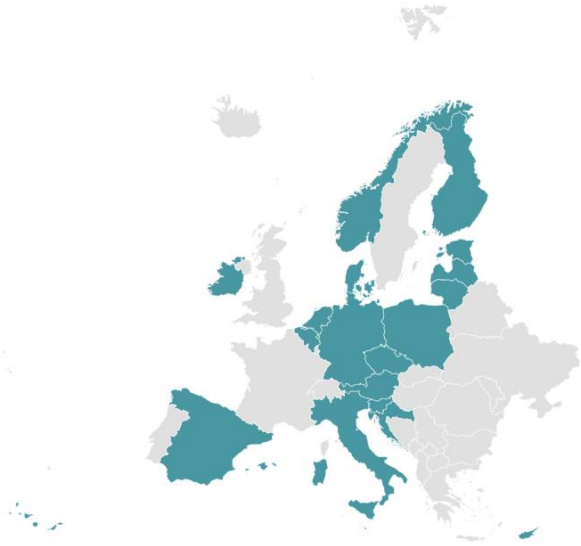
In most countries, the government or a national institute or ministry acted as commissioner, sponsor, regulator, and controller of the app, while private entities were responsible for the technical lead, design, continued development and support of operations. The development of the apps was often facilitated through dedicated strategies or programmes. To enable digital contact tracing, countries either introduced new legal instruments or adapted existing legislation. All apps were made available on a voluntary basis. Despite the narrow timeline, some governments managed to involve key stakeholders in the contact tracing development process, including citizens, academic experts, and civil society organisations. This involved organising public consultations to gather feedback on important issues such as privacy, security, and public trust. To promote app uptake and usage, countries have created specific webpages and promotional materials, organised awareness campaigns, and coordinated advocacy actions on the use of contact tracing apps. All countries carried out Data Protection Impact Assessments and governments in many Member States actively consulted Data Protection Authorities during the contact tracing app development and implementation process.

Early in the pandemic, one of the main discussions revolved around the app architectural set-up – centralised or decentralised - and its impact on citizens' privacy and security. Most countries opted for a decentralised approach based on the Google and Apple Exposure Notification Framework. Exceptions are France and Hungary, which implemented a centralised architectural approach. All countries studied opted for Bluetooth Low Energy technology to enable digital proximity tracing.

During the pandemic, it was important to safeguard the right to free movement of EU citizens. As conventional contact tracing cannot account for cross-border infections, the EC set up the European Federation Gateway Service (EFGS) to allow different national apps to "talk" to each other, supporting Member States to have their own apps and features integrated within national processes.

If two citizens from different Member States using their national apps connected to the EFGS, come into contact while abroad, their app will warn them about a possible infection and encourage them to take appropriate actions when one of them tests positive.

A total of 19 countries[1] were connected to this EFGS (marked in teal in the figure to the right), and until August 2022 a total of 67,553,125 keys have been uploaded to the EFGS by the participating countries. While the privacy-preserving nature of the apps poses limits to detailed analyses of the EFGS performance, the study has approximated that as many as 8.6 million citizens that tested positive to COVID-19 in one of the 19 participating countries, may have contributed to potentially breaking infection chains while being abroad.



As the pandemic situation improved, several countries decided to suspend their apps and consequently to offboard from the EFGS. The EFGS is expected to continue to be operated until no Member State is connected to it. As of 31 August 2022, a total of eight apps were still connected to the EFGS. The European Commission and the European Centre for Disease Prevention and Control (ECDC), responsible for the EFGS daily operations since April 2022, are assessing the future of the digital contact tracing ecosystem at the European level. This also includes the potential complementarity of the EFGS and mobile contact tracing applications with other tools such as the Early Warning and Response System or the EU Digital Passenger Locator Form platform.

While digital contact tracing apps had been originally designed as "silent applications" that run in the background and alert users in case they had been in contact with someone diagnosed positive, additional functionalities have been included in several apps.

Additional functionalities supported users with tracking symptoms, vaccination statistics, displaying additional information related to the epidemiological situation and related travel restrictions, vaccine or test certificates, check-in functions, self-isolation countdowns and the issuance of self-isolation certificates.

France, Italy, Slovenia, and Germany opted to integrate the EU Digital COVID Certificates with their contact tracing apps. In a few countries, the additional functionalities supported conventional contact tracing processes, including booking tests, receiving test results, or contacting relevant authorities via the app. The German app for example has been continuously updated to connect to around 270 laboratories and up to 20,000 test sites, making it possible to directly upload test results into the app. Users could directly access their results and, in case of a positive test result, issue a warning. Throughout the pandemic, over 228 million German tests results were accessed in the Corona Warn-App.

To evaluate the impact of contact tracing apps, a few countries reported to have carried out dedicated evaluations. The information provided showed a high degree of heterogeneity in the evaluation objectives and methodologies used, as well as a limited set of evaluation indicators. Lack of underlying data for a more detailed assessment of the app's effectiveness was a recurring theme in the study, dictated by certain choices in technical architectures and privacy and ethics considerations. The urgent need for the apps to be deployed in support of the pandemic management meant that discussions around a common methodology for assessing the app's impact were limited. First attempts to achieve greater harmonisation through the development of an overarching monitoring and analysis framework were undertaken by the World Health Organization (WHO) and ECDC through the development of an

[1] Countries connected to the EFGS: Germany, Denmark, Ireland, Italy, Latvia, Spain, Croatia, Poland, Netherlands, Cyprus, Belgium, Finland, Austria, Norway, Slovenia, Czech Republic, Malta, Lithuania, Estonia

indicator framework for the public health effectiveness of digital proximity tracing. The study used the framework as a foundation, proposing a few updates based on richer knowledge of how the apps were used later in the pandemic. The resulting framework therefore represents a comprehensive set of forward-looking indicators. Retrospectively, only some of the indicators can be used, based on the country-level data availability. To calculate those indicators, data was gathered via the study survey, eHealth Network or publicly available sources, including dashboards, official evaluations, and published reports.

Data analysis across the investigated countries revealed that, since their launch in 2020 and until July 2022, the apps surpassed 206 million unique voluntary downloads.

In six of the studied countries where the apps have been most intensely used (Finland, Ireland, Germany, Iceland, France, Switzerland), the percentage of active users per total population ranged between 26 and 45%, adding up to 56 million active users. Up to 70% of app users who were diagnosed positive with COVID-19 entered their test results in the app to warn others. Across the studied apps, over 13.4 million positive tests were entered into the apps to warn other people at risk of infection, with best practices showing that the number of positive tests entered into the app can reach up to 20% of the total number of positive cases in the respective country. Countries reported that between 0.8 and up to 19 exposure notifications per positive entered test into the app were sent to notify contacts at possible risk of infection. Data reported from seven countries revealed that over 177 million warning notifications have been generated. Surveys carried out across the investigated countries found that between 2.3% and up to 41% of app users that got tested due to a notification were found to be positive, showing that the apps have the capacity to detect contacts at risk of infection.

The analysis[2] from Netherlands found that approximately 1.5% of total COVID-19 tests requests within the period of September 2020 to April 2021 were performed as a result of the CoronaMelder notification. Of the test requests that actually led to a test following a message in CoronaMelder, only 17% of the test requests were also triggered by a warning by conventional tracing (83% of tests performed due to digital contact tracing were not triggered by the conventional testing), emphasising the capacity of digital contact tracing to complement conventional tracing efforts. The data from the same period shows that spontaneously performed tests (having symptoms or being warned in a face-to-face setting / informally) had a 10% positivity rate, conventional tracing had a 18.1% positivity rate, whereas CoronaMelder recorded 10.4% positivity rate.

More than half of the persons who scheduled a test after receiving a notification from the Dutch app were not approached yet by the public health authorities at the time of booking a test. Out of those that got tested due to the notification and were declared positive for COVID-19, about 3 to 5% did not have any symptoms. At the same time, the detection rate of random screening over the same period is estimated to be lower, i.e., approximately 1%[3]. Until April 2022, the percentage of identified positive contacts that did not present any symptoms out of those that got tested after receiving a notification via the digital contact tracing app reached 11%.

Digital contact tracing was part of health systems' resilience response to a new situation, developed at a very fast pace related to other innovations, and adopted at a considerable scale in a voluntary manner by a higher than expected amount of the population. This effect is particularly striking, in the sense that not everyone immediately accepts a disruptive idea. In the context of contact tracing apps, an unprecedented large adoption of a new digital public health technology was observed in several countries. Ultimately, the effectiveness of contact tracing apps is dependent on the cascade of actions users need to undertake and adhere to; from downloading the app, to using the app, to testing after

2 GGD GHOR NEDERLAND. (2021). Tabellenrapport CoronaMelder GGD GHOR Nederland. 6.05.2021.

3 Dutch evaluation on 23 May 2021 in: Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

being notified, self-quarantining until test results, and if so, reporting in the application after being tested positive and isolating themselves.

The present findings indicate that the behaviour of citizens towards digital contact tracing was heterogenous and varied across the studied countries, yet best practice examples show that the apps can be a powerful tool to complement conventional contact tracing and support public health processes, by consistently identifying contacts that tested positive which would otherwise be missed by conventional contact tracing (contacts that remain asymptomatic). Furthermore, getting test results directly through the app may help persons to quarantine faster and to relieve the workload on traditional processes and services.

To support the future use of contact tracing apps, recommendations have been derived based on the literature review performed in the study, the interviews and the survey, as well as the analysis of available data from the apps. These are aimed at ensuring that the European Commission, Member States and other countries exploit the experiences and lessons learned through the use of digital contact tracing in the COVID-19 pandemic:

- Complement early on conventional with digital contact tracing: Countries should consider deploying digital contact tracing solutions if they want to address situations which cannot be timely captured by conventional contact tracing or situations in which conventional tracing is overwhelmed and can benefit from digital tracing.
- Develop further and keep up to date the common EU Toolbox: The EU Toolbox on mobile applications in the EU's fight against COVID-19 is valued by Member States and should be kept up to date and extended, if necessary, for pandemic preparedness.
- Maintain the dynamic and agile EU collaboration: The flexible and dynamic collaboration of Member States supported by the European Commission should be maintained as a good model and refined based on the lessons learnt, including collaborating on digital contact tracing with interested countries outside the EU.
- Sustain the common EU infrastructure and services such as the EFGS: The European Federation Gateway Service is a unique example of a cross-border infrastructure that connects apps developed at MS level.
- Enhance integration and alignment with overall public health processes: Countries should, within the boundaries of privacy regulations, consider integrating or aligning their digital contact tracing solutions with the services, processes and informational flows of conventional contact tracing and the wider public health ecosystem to achieve a user-friendly experience and increase the attractiveness of the apps.
- Boost promotion early on and invest in further functionalities: Putting more effort into promoting the apps, their features and benefits of and possible incentives for using them will increase their uptake and lead to more effective warning of users about potential infections.
- Evaluate and monitor from the onset using common indicators: Planning the evaluation of the apps' use and effectiveness and related metrics should be an integral part in the early app planning and development phase. Common indicators can be agreed upon using privacy-preserving analytics and the necessary data can be planned to be collected from the onset.

The efforts related specifically to digital contact tracing demonstrated the ability of Europe to agree on and deliver an innovative tracing and warning technology to millions of users in a privacy-preserving timely manner, enabled by effective coordination and sharing of experiences between countries, resulting in a system ready to be used in new health and care scenarios.

Abbreviations

Acronym	Meaning
ADP	Belgian Data Protection Authority
AEM	Associated Encrypted Metadata
AEPD	Agencia Española de Protección de Datos
AISBL	Association internationale sans but lucratif (International Non-Profit Organisation)
AKOS	Agencija za komunikacijska omrežja in storitve Republike Slovenije
ANORC	the National Association of Operators and Responsible for the Custody of Digital Content
ANSSI	Agence Nationale de la Securité des Systèmes d'Information (French: National Security Agency of Information Systems)
APD	Autorité de protection des données (The Belgian Data Protection Authority)
API	Application Programming Interface
APIS	Agencija za podršku informacijskim sustavima (Croatian IT company)
ARC	Remembrance Call Centre and Active Response Centre (Czech Republic)
ASA	ASA Quality Solutions, Estonian consultants
ASL	Azienda Sanitaria Locale (Italian local health service)
AZOP	Agencija za zaštitu osobnih podataka (Croatian Agency for the Protection of Personal Data)
BAME	Black, Asian, Minority, Ethnic
BLE	Bluetooth Low Energy
BMSGPK	Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz (the Austrian Federal Ministry of Social Affairs, Health, Care and Consumer Protection)
BRU	Behavioral Research Unit
BSL	British Sign Language
CCAA	Comunidad autónoma (the autonomous regions of Spain)
CCC	The Chaos Computer Club (Europe's largest association of hackers)
CERTH	Centre for Research and Technology
CIPHIS	Cyprus Innovative Public Health ICT System
CLEA	Cluster Exposure Verification protocol
CNCS	Centro Nacional de Cibersegurança (The Portuguese National Cybersecurity Centre)
CNIL	Commission national de l'informatique et des libertés (the French Data Protection Agency)
CNPD	Comissão Nacional de Proteção de Dados (Portuguese Data Protection Authority)
CSV	Comma-Separated Values (a file format)
CTA	Contact Tracing Application(s)
CTU	Faculty of Information Technology, Czech Technical University in Prague
CWA	Corona Warn App (Germany)
CYENS	Centre of Excellence (Research and Innovation Centre in Cyprus)
DCT	Digital Contact Tracing
DCTA	Digital Contact Tracing Application
DCTQ	Digital Contact Tracing and Quarantine
DEP	System d'Informations de DEPistage (France's national COVID-19 screening platform)
DGS	Directorate-General of Health (Portugal)
DHSC	Department of Health and Social Care (UK)
DMRID	Deputy Ministry of Research, Innovation and Digital Policy (Cyprus)
DOI	Digital Object Identifier
DPA	Data Protection Authority

Acronym	Meaning
DPER	Department of Expenditure and Reform (Ireland)
DPIA	Data Protection Impact Assessment
dPLF	Digital Passenger Locator Form
DPO	Data Protection Officer
DPS	Diagnosed Positive Subject
DPT	Digital Proximity Tracing
DRI	Digital Rights Ireland
DSI	Data State Inspectorate (Latvian Data Protection Authority)
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
EDPB	European Data Protection Board
EDUS	Event-Driven User Survey
EEA	European Economic Area
EFGS	European Federation Gateway Server / Service
EHDS	European Health Data Space
EHR	Electronic Health Record
ENF	Exposure Notification Framework
ENS	Exposure Notifications System
EPFL	École Polytechnique Federale de Lausanne (Public research university, Lausanne)
ESRI BRU	Economic and Social Research Institute Behavioural Research Unit (Ireland)
ETH	Public research university in Zürich, Switzerland
EU	European Union
EUR	Euro (European Monetary Unit)
EWRS	European Early Warning and Response System
FAQ	Frequently Asked Questions
FCT	Foundation for Science and Technology (Portugal)
FDPIC	Swiss Federal Data Protection and Information Commissioner
FHI	Folkehelseinstituttet (Norwegian Institute of Public Health)
FIT CTU	Faculty of Information Technology, Czech Technical University
FIZ	Frankfurt Innovationszentrum Biotechnologie (Frankfurt Innovation Center for Biotechnology)
FOB Solutions	Software Development company
FOI	Features of Interest
FOITT	Federal Office for Information Technology, Systems and Telecommunication (Switzerland)
FOPH	The Federal Office of Public Health (Switzerland)
FRA	European Union Agency for Fundamental Rights
GAEN	Google-Apple Exposure Notification
GDPR	General Data Protection Regulation
GFF	Gesellschaft für Freiheitsrechte
GGD	Gemeentelijke Gezondheids Dienst (The Dutch Municipal Health Service)
GPS	Global Positioning System
GSM	GSM Association (commonly referred to as 'the GSMA' or Global System for Mobile Communications)
HOIA	Estonian Contact Tracing App
HSE	Health Service Executive (Ireland)
ICCL	Irish Council for Civil Liberties

Acronym	Meaning
ICO	Information Commissioner's Office
ICT	Information Communication Technology
ICU	Intensive Care Unit
IDEA	The Institute for Democracy and Economic Analysis
IDPC	Information and Data Protection Commission
IGEES	Irish Government Economic and Evaluation Services
IMEI	International Mobile Equipment Identity
INESC TEC	The Institute for Systems and Computer Engineering, Technology and Science
INRIA	National Institute for Research in Computer Science and Automation (France)
IOS	Mobile operating system
IQR 163	Interquartile Range
ISBN	International Standard Book Number
ISPUP	Institute of Public Health of the University of
ITM	Innovációs és Technológiai Minisztérium (Hungarian Ministry of Innovation and Technology)
JSON	File format
KIFÜ	Kormányzati Informatikai Fejlesztési Ügynökség (Hungarian Government Agency for Development of Informatics)
KIOS CoE	Research and Innovation Center of Excellence, University of Cyprus
LFPH	Linux Foundation Public Health
LMT	Mobile GSM/UMTS/LTE operator in Latvia
LWCV	Living, Working and COVID-19
MAK IT	A Latvian company that provides full cycle services for software development
MCT	Manual Contact Tracing
MITA	Malta Information Technology Agency
MIT-PACT	Massachusetts Institute of Technology - Private Automated Contact Tracing
MS	Member State(s)
MSIS	Meldingssystem for Smittsomme Sykdommer (the Norwegian Surveillance System for Communicable Diseases)
NAIH	National Authority for Data Protection and Freedom of Information
NAKIT	Národní agentura pro komunikační a informační technologie (the National Agency for Communication and Information Technologies)
NCSC	National Cyber Security Centre
NES	NHS Education for Scotland
NHS	National Health Service
NIJZ	Nacionalni institut za javno zdravje
NIPH	Norwegian Institute of Public Health
NNK	National Centre for Public Health
NOK	Norwegian Krone (currency of Norway)
NOS	Network Operating System
NOYB	None Of Your Business (European Centre for Digital Rights and SBA Research)
NSS	National Services Scotland
NVSC	Nacionalinis visuomenės sveikatos centras (Lithuanian National Centre for Public Health)
NYOB	European Center for Digital Rights (styled as noyb, from "none of your business")
OECD	Organisation for Economic Co-operation and Development
OGCIO	Office of the Government Chief Information Officer (Ireland)
OTP	One-Time Passwords

Acronym	Meaning
PCR	Polymerase chain reaction
PEPP-PT	Pan-European Privacy-Preserving Proximity Tracing
PHA	Public Health Authority
PHS	Public Health Scotland
PPA	Privacy-Preserving Analytics
PRC	Potentially Risky Contacts
RGPD	Règlement Général pour La Protection des Données (General Data Protection Regulation)
RIVM	Rijksinstituut voor Volksgezondheid en Milieu (Dutch: National Institute for Health and Environment)
RKI	Robert Koch Institute
ROBERT	Robust and Privacy-preserving proximity tracing protocol (France)
ROI	Return on investment
RPS	Really Positive Subjects
RRC	Relatively Risky Contacts
RSTEAM	Slovenian local software development firm
SAM	Sveikatos Apsaugos Ministerija (Ministry of Health of Republic of Lithuania)
SAP	Systems, Applications and Products in Data Processing (a German multinational software corporation)
SAR	Secondary Attack Rate
SBA Research GmbH	Research center for Information Security, Austria
SEDIA	State for Digitalisation and Artificial Intelligence of the Ministry of Economic Affairs and Digital Transformation
SEQRED SA	A polish company that specializes in running security tests and audits
SFI	Science Foundation Ireland
SGAD	Secretariat-General for administration (Spain)
SPMS	Serviços Partilhados do Ministério da Saúde, E.P.E.
SSII	French digital services company
TAN	Transaction Authentication Number
TCN	Temporary Contact Numbers
TEHIK	Health and Welfare Information Systems Center (Estonia)
TEK	Temporary Exposure Key(s)
THL	Terveyden ja hyvinvoinnin laitos (Finnish Institute for Health and Welfare)
TSI	T-Systems International GmbH
TWG	Technical working group
UEQ	User Experience Questionnaire
UNIQA	Austrian Insurance foundation
UODO	Urzad Ochrony Danych Osobowych (Polish Data Protection Authority)
VEO	Versatile emerging infectious disease observatory
VWS	Ministerie van Volksgezondheid, Welzijn en Sport (Ministry of Health, Welfare and Sports)
WHO	World Health Organization
WMC/GREY	Marketing agency in Prague

1 Introduction

Contact tracing has been a cornerstone of countries' response to the COVID-19 pandemic, and it remains a key strategy for interrupting chains of transmission of COVID-19 virus and reducing COVID-19-associated morbidity and mortality.

At a recent meeting[4] organised by the World Health Organization (WHO/Europe) and the European Centre for Disease Prevention and Control (ECDC), gathered experts from 39 countries and territories from the WHO European Region, including 24 European Union (EU)/European Economic Area (EEA) countries, reflected on their experiences with contact tracing. Despite the diversity in tracing strategies, similar challenges were observed among countries, including difficulties around workforce recruitment and training, sustainable financing, timeliness in reaching cases or contacts, adjusting contact tracing operations according to the epidemiological situation, and issues around digitalisation, risk communication and community engagement.

Reflections on the future use of contact tracing included concerns about the challenge in maintaining human and financial resources for the manual tracing process and the need to explore alternative solutions, such as promotion and education campaigns, self-testing, and digital systems.

Digital solutions and the use of technology were explored early in the pandemic and identified as promising tools in support of public health measures for contact tracing. Digital proximity tracing or digital contact tracing (DCT) typically uses smartphones or purpose-built devices to capture anonymised interactions between individuals and subsequently issue alerts, all through a mobile interface (app)[5]. A digital contact tracing app is defined as "a technique to identify individuals who have possibly come in close contact with an infected person while that person was the carrier of the viral pathogen"[6]. The underlying main function is proximity tracing, i.e., measuring signal strength between devices to determine the proximity between users, in order to establish whether the virus could be spread based on this proximity[7].

Around 152 countries/territories from 6 continents produced 180 contact tracing apps (CTA) that use various technologies and approaches[8]. This variety was fuelled by extensive discourse among the scientific community, industry and the wider public and was linked to the way and extent to which public health authorities collect and manage data from the apps in a secure and privacy-preserving way. Debates related to the type of tracing (Global Positioning System (GPS) vs. Bluetooth) and protocols used (centralised vs. decentralised architectures) shaped countries' developments (for details about those technical approaches, see section 3).

Digital contact tracing is complementary to conventional tracing

It should be stressed that digital contact tracing is not meant to replace manual contact tracing (MCT). It should be seen as a complementary measure to conventional tracing efforts which are performed primarily by the health authorities, and which can quickly reach maximum capacity during pandemics.

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4 COVID-19 Contact Tracing: country experiences and way forward. Meeting report. Copenhagen: WHO Regional Office for Europe and Stockholm: European Centre for Disease Prevention and Control; 2022. Licence: CC BY 3.0 IGO

5 World Health Organization, & European Centre for Disease Prevention and Control. (2021). Indicator framework for the evaluation of the public health effectiveness of digital proximity tracing solutions. Geneva: World Health Organization and European Centre for Disease Prevention and Control. [pdf] Available at: https://www.who.int/publications/i/item/9789240028357

6 Shahroz, M., Ahmad, F., Younis, M. S., Ahmad, N., Boulos, M. N. K., Vinuesa, R., & Qadir, J. (2021). COVID-19 digital contact tracing applications and techniques: A review post initial deployments. Transportation Engineering, 5, 100072.

7 World Health Organization. Ethical considerations to guide the use of digital proximity tracking technologies for COVID-19 contact tracing. Interim guidance 28 May 2020. https://apps.who.int/iris/rest/bitstreams/1278803/retrieve

8 Bardus, M., Al Daccache, M., Maalouf, N., Al Sarih, R., & Elhajj, I. H. (2022). Data management and privacy policy of COVID-19 contact-tracing apps: systematic review and content analysis. JMIR mHealth and uHealth, 10(7), e35195.

The automatic capturing of a user's encounters and subsequent analysis of associated risks address areas of use in which manual contact tracing is not suitable, e.g., to capture encounters with unfamiliar persons (such as nearby passengers in public transportation or visitors in a theatre). In addition, in case of many encounters on a given day, the users' mental ability to recall and record them is backed up by the app running in the background[9].

A unique pan-European approach to contact tracing and warning apps was pursued by the European Union. Both the EU Member States, responsible for developing their own national apps, and the European Commission, supporting Member States in cross-border health scenarios, consider the interoperability of the apps to be essential for the effective tracing of cross-border infection chains in the EU[10]. Interoperability is to be understood as the capacity of the apps to "talk" to each other. Depending on technical choices at the national level, the majority of EU countries developed an interoperable app, enabling their citizens to use one single app when travelling in the EU and at the same time to be informed of an epidemiologically relevant exposure to another user that might use a different app and who has COVID-19.

This report presents the results of the study on "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic". The study was commissioned by the European Commission's DG CONNECT and carried out by empirica Communication and Technology Research in the period January-September 2022.

The study aimed to provide an up-to-date and comprehensive overview of the digital contact tracing approach and epidemiological impact of digital contact tracing by Member States, EEA countries, Switzerland, and the United Kingdom (UK). Specifically, the study's objectives were to:

1. Provide an up-to-date and comprehensive overview of the approach and lessons learned regarding EU-level actions on cross-border interoperability, coordination, implementation, and epidemiological impact of digital contact tracing by Member States, EEA countries, Switzerland and the UK
2. Propose a monitoring framework and methodology to gather and evaluate evidence on the use and comparative performance of digital proximity tracing solutions in the EU.
3. Provide an up-to-date and comprehensive assessment of the impact of digital contact tracing across the EU Member States based on the monitoring framework and methodology set out in Objective 2.

To address these objectives, research questions were formulated and detailed in the methodological approach. Within the study scope, 27 countries and territories have been identified, which developed and deployed national contact tracing apps in a period of nine months since the state of pandemic was declared. The investigation and data collection took place between January 2022 – August 2022.

The report is structured as follows:

- Section 2 describes the study's methodological approach and the associated limitations
- Section 3 details countries' activities related to the development, deployment and roll-out of contact tracing apps
- Section 4 reports on the cross-border contact tracing coordination and collaboration activities
- Section 5 presents the results of the monitoring and evaluation of contact tracing apps based on available data provided by the countries or obtained by the study team
- Section 6 presents an outlook for digital contact tracing in Europe as well as key recommendations in light of future use and uptake.

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9 Elmokashfi, A., Sundnes, J., Kvalbein, A., Naumova, V., Reinemo, S., Florvaag, P., Stensland, H. and Lysne, O., 2021. Nationwide rollout reveals efficacy of epidemic control through digital contact tracing. Nature Communications, 12(1).

10 National COVID-19 contact tracing apps - IPOL | Policy Department for Economic, Scientific and Quality of Life Policies, May 2020; ISBN 978-92-846-6755-0; doi:10.2861/ 808426

2 Methodological approach

To capture lessons learned, best practices and available impact-related data, the study applied the following methods: strategic exploratory interviews, desk research, evaluation framework review and refinement, survey, consultations and validation workshops, and data analysis.

Strategic exploratory interviews

As part of the initial phase of the study, exploratory interviews were carried out in order to validate the study scope and collect insights that could be further explored in the subsequent wider stakeholder consultation phase. To capture focus areas and relevant priorities, the interview format included questions concerning EU-level coordination actions and national-level actions. Questions were aimed at an initial stock-taking of barriers, enablers, success factors and decisional aspects in the development, deployment, use and monitoring of contact tracing apps across European countries. Several countries were approached for the interviews, representing different app architectures and different geographic representation. Interviews were conducted with representatives from following countries: Republic of Cyprus, France, and Ireland. The interviewees have been closely involved in the development and deployment processes of their national apps.

Desk research and data collection

The desk research concerned existing practices regarding the development, adoption, roll-out and monitoring of digital contact tracing applications. Furthermore, the study team screened for indicators, metrics, and publicly available (country-level) data regarding the use and uptake of contact tracing apps (e.g., number of downloads, active apps). The desk research and data collection were guided by the following research questions:

Focus of the desk research and data collection

- When where the apps launched, what was the timeline and pace of implementation?
- Who were the main institutions involved in the development of the apps?
- What where national policies or strategies associated with DCT?
- Did the app development include a participatory process, which stakeholders were engaged?
- How was DCT seen in relation with traditional public health process, manual contact tracing? Was there any integration into access to testing?
- How were the apps developed, type of architecture and protocols? Are they open-source? Were the apps based on existing models, has the EU toolbox been used?
- How was data protection and security ensured: Was there a Data Protection Impact Assessment (DPIA) of the app performed, who is the data protection authority, who is responsible for data collection and processing; besides DPIAs, what other types of security and privacy checks were performed? How are citizens informed of their privacy? Was there a privacy notice published on the websites?
- What functionalities do these apps have in addition to proximity detection and warning?
- Were there any significant updates for some of the apps? (e.g., centralised to decentralised, the addition of COVID certificates)
- Were there any specific actions for implementation taken (e.g., post-design activities to promote or maintain the app uptake, targeted communication campaigns)?
- What studies on perceptions of contact tracing, reasons for use and non-use of digital contact tracing have been carried out?
- What types of evaluations on health impact and performance of digital contact tracing have been carried out, what metrics, indicators, methodologies, frameworks have been published?
- What data sources, datasets, and variables are available?

To address the research questions in the analytical framework, the study team performed a literature

search in Google Scholar and PubMed databases and screened the websites of relevant institutions and governments for relevant reports and publications. Multiple sources have been consulted and included peer-reviewed articles, EU reports, studies and surveys, Member State governmental publications, reports by international organisations, academically published sources and datasets, European Centre for Disease Prevention and Control (ECDC), World Health Organization (WHO), eHealth Network, Organisation for Economic Co-operation and Development (OECD), Eurostat databases. Sources with a publication date prior to 01.01.2020 were excluded. The following key terms were used:

EU-level analysis: EU-monitoring, eHealth Network, COVID-19, coordination, approach, support action, epidemiological impact, lessons learned, implementation, Member States, EEA countries, EU Toolbox, guidelines, cross-border interoperability, data management, European Federation Gateway Service, technical, legal, coordination
Qualitative data on app development, deployment and roll-out dimensions: Contact tracing, digital proximity tracing, app development, interoperability, implementation, accessibility, security, privacy, functionalities, data protection, tracing method, frontend, backend, feature, tracing algorithm, design architecture, centralised, decentralised, app audit, app controller, national policy, strategy, legal frameworks, architecture, public health integration, manual contact tracing, promotion, uptake
Refined indicator framework: Evaluation, effectiveness, monitoring, framework, adoption, adoption rate, uptake, data sets, digital, contact tracing, proximity tracing, interoperability, cross-border, privacy
Quantitative data on uptake, actual use, effectiveness, process efficiency: app roll-out, population data, app controller data, survey data, public health authorities, app users, active users, app use, non-use, non-users, newly diagnosed cases, test certificates, notification, exposure notification, contacts, notification speed, tests, positive tests, demographics, socio-demographic characteristics, downloads, active use, usability, privacy, information accuracy, usability, adherence, barriers, enablers, conventional tracing, traditional tracing, manual tracing, reproduction number, activation codes, entered codes

Review and refinement of the WHO/ECDC evaluation framework to measure the use and performance of contact tracing apps

Previous studies that evaluated the use and effectiveness of contact tracing applications relied on different methodologies. Empirical evidence identified by the study team in the beginning of the study was limited and largely based on model-based research, suggesting a need for evaluation studies based on real-world data. Given the differences in the development, implementation, and integration of contact tracing applications across countries, a clear methodological approach to monitoring and evaluation was highlighted as a priority. The study proposal identified a suitable framework on which to base the study work: the "Indicator framework for the evaluation of the public health effectiveness of digital proximity tracing solutions"[11] developed by experts from the WHO and the ECDC and published in June 2021 (henceforth referred to as the WHO/ECDC framework). The WHO/ECDC framework was elaborated by leading digital health experts from WHO and ECDC, and was validated with experts from 10 European countries, representing at the time a significant advancement in the topic. It covers important dimensions: adoption and use of digital contact tracing in the population, the capacity of digital contact tracing to detect contacts at risk, the speed of notifying contacts compared to conventional contact tracing, and barriers and enablers of digital contact tracing approaches.

Of note, the WHO/ECDC framework was developed relatively early in the pandemic (with consultations taking place in late 2020), when limited evidence of and experiences with digital contact tracing app implementation and effectiveness were available. While the framework broadly covers the use and performance of digital contact tracing, not all of the required data to feed the indicators is publicly

[11] Who.int. 2022. Indicator framework for the evaluation of the public health effectiveness of digital proximity tracing solutions. [online] Available at: <https://www.who.int/publications/i/item/9789240028357> [Accessed 6 September 2022].

available. Additionally, for some indicators, the level of detail and transparency vary due to the lack of data and different available formats across different countries (early desk research showed that only the number of downloads was publicly available for most of the countries). Considering these aspects, the study team proposed several modifications to the framework to reflect data availability.

In the review process, the study team analysed the coverage of indicators based on the points at which the user and their smartphone interact with the health system environment (touchpoints). This can be visualised through a notification cascade presented in the figure below.

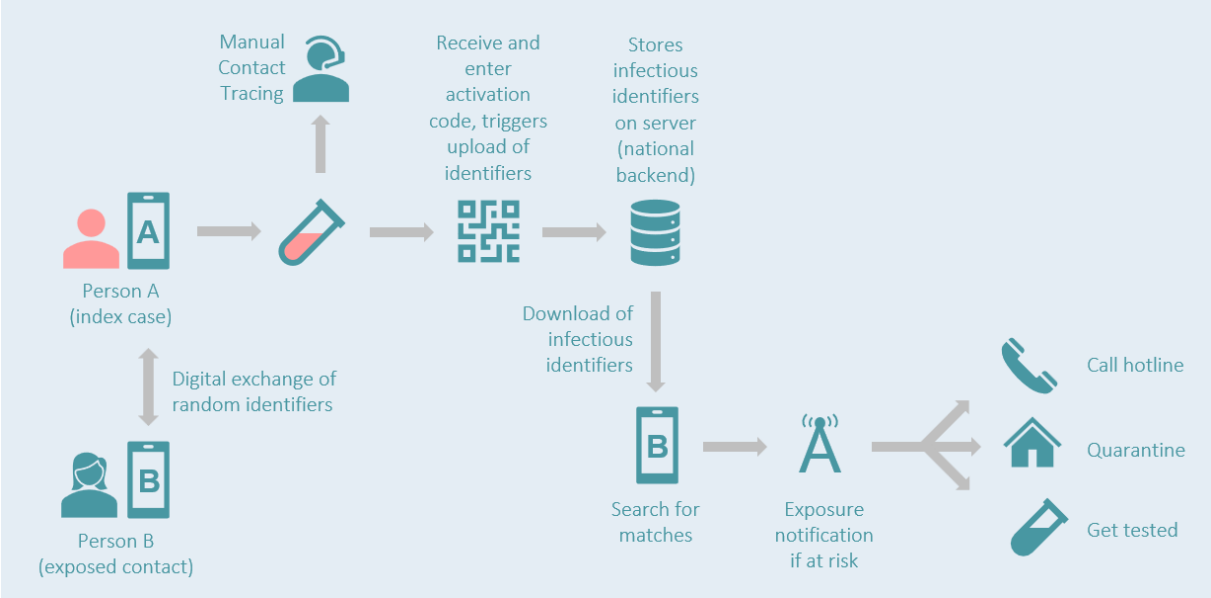


Figure 1. Notification cascade of decentralised proximity tracing systems
Possibilities of reacting after receiving the notifications differ between countries. Adapted from doi.org/10.3389/fdgth.2021.677929

Person A (Index Case) represents an infected app user who gets tested, receives a positive test result and enters an activation code. After consenting, the app uploads the random identifiers to a (national back-end) server. Person B (Exposed Contact) represents a proximity contact, whose device regularly downloads infected keys. Because of the exposure, person B receives the app notification of having been in contact with an infected person. After receiving the notification, person B can either call a hotline, gets tested or enters voluntary quarantine (the options depend on the country's approach).

At some touchpoints data is available for all countries that use decentralised systems. At other touchpoints, the availability of data depends on further design and development choices made in the countries, as well as the level of integration of DCT with MCT and the wider public national health systems.

The main update of the WHO/ECDC indicator framework consisted of refining several of the existing indicators and proposing the inclusion of three additional ones that are complementary. A detailed description of the analysis and update of the framework is presented in Annex III.

Subsequently, the study framework was validated by a group of experts through a consultation process with the eHealth Network technical working group on DCT apps (eHN TWG on apps), the primary body created early in the pandemic to foster collaboration among EU Member States on digital contact tracing and facilitated by the European Commission. Members of the group, representing their Member States, received individual consultation papers and were asked to provide written feedback from the viewpoint of the country they represent. They were encouraged to involve further experts at national level as they see fit but provide consolidated national-level feedback. In the consultation, feedback was asked regarding the degree of helpfulness of the adapted WHO/ECDC framework in enabling Member States to understand and analyse the use and performance of their apps, collection of specific comments for the indicators, and general feedback on the framework as a whole.

Representatives and experts involved in the study activities (consultation and validation workshops, survey)

The study team has been supported by the European Commission and through the eHealth Network in reaching out to the EU Member States' experts who have been closely involved in national digital contact tracing app's development, roll-out, and uptake. Typically, those experts comprise governmental employees, technical experts (e.g., on interoperability, on app development), researchers, epidemiologists as well as further experts designated by the Member States and participating in the eHealth Network's working groups related to digital contact tracing.

Similarly, for the non-EU countries, the study team has reached out to the official contacts responsible for the apps (typically the data controllers) which have been identified as part of the study's literature review.

Apart from being involved in a workshop, for the study survey those experts, having a clear mandate to represent the country regarding digital contact tracing, were requested to provide consolidated survey responses at national level, representing the country's position on the topics explored in the survey.

Subsequently, the survey results are presented as the countries' views. For improved readability, the report uses the style "Country A reported/shared/reflected/etc."

Comments were received from experts in Belgium, Estonia, Malta, Finland, and Republic of Cyprus. There was general agreement with the framework and belief that the indicators are useful and will provide value to the extent that they are available within the digital contact tracing system, especially for the long-term maintenance of contact tracing apps.

The consultation was complemented by a validation workshop targeting the members of the eHN TWG on apps. In addition to the Member States which provided feedback in the first round, seven other Member States joined the workshop: Italy, Ireland, Slovenia, Croatia, Germany, Norway, and the Netherlands.

Across the two consultation activities, feedback was collected from 12 Member States, or 60% of all Member States with apps. Some Member States did not provide a response but did not object to the framework in several subsequent study status updates provided to Member States upon invitation by the European Commission. Based on that feedback, the adapted WHO/ECDC framework was finalised and used in subsequent study activities to collect and analyse data to evaluate the use and performance of CTAs.

Survey to capture countries' experiences and collect country-level data to feed the indicator framework

A survey was prepared and launched among participating countries to collect information that could be used to understand countries' experiences during the COVID-19 pandemic with regards to the development and use of digital contact tracing apps, as well as the overall coordination and cooperation facilitated by the European Commission. The survey aimed to capture i) countries' experiences (lessons learnt, insights) both related to the EU-level activities as well as national ones (for EU Member States), ii) available data to feed an indicator framework used to analyse the apps' performance and use, and iii) to review available data collected by the study team about the national app.

The survey was in the form of an online collaborative document – one document per country – that could be edited by multiple national-level experts and completed only once per country, reflecting the overall situation in the country regarding the survey topics.

The survey consisted of four sections:

1. EU-level actions on digital contact tracing (applicable only to EU Member States): countries were asked in this section to reflect on their experience with regards to the EU-level actions and coordination activities that facilitated the foundation for and supported the rapid development of the national contact tracing apps.
2. National-level actions on digital contact tracing: countries were asked to report on their

experiences with the development and operations of the apps.

3. Data required for populating the indicator framework: countries were asked to provide available data, datasets and links to sources that could feed into the indicators of the framework
4. Country-level data: countries were asked in this section to validate data collected by the study team via public sources regarding key facts about the DCT app.

Countries were asked to rate their level of agreement or disagreement with defined statements, provide reflections and suggestions via open questions, review facts about the DCT app that have been collected by the study, and provide data (datasets) in support of analysing the apps' effectiveness and uptake according to the indicator framework.

Analysis of collected data and deriving study findings and recommendations

The desk research, interviews, survey results, and quantitative data were used to analyse:

- EU-level coordination actions on cross-border interoperability, coordination, and implementation of contact tracing apps by Member States, EEA countries, Switzerland, and the UK
- Factors involved in development, deployment, and roll-out of the contact tracing apps and their current state-of-the-art
- Uptake, process efficiency, and effectiveness monitoring by using the indicator framework.

The multi-level analysis has been used to derive best practices, lessons learned, and recommendations for future use of digital contact tracing.

While the focus of the study was on the digital contact tracing experiences of the EU Member States, EEA countries, Switzerland, and the UK, not all EU Member States developed national digital contact tracing solutions. Bulgaria, Greece, Luxembourg, Romania, Slovakia, and Sweden did not develop a national solution to be deployed by their governments in the pandemic, leaving 21 Member States with a digital contact tracing app. At the same time, in the UK more than one app was developed for different countries and territories, so the study distinguishes between three UK apps – one developed for England and Wales, one for Scotland and one for Northern Ireland.

The final list of 27 countries and territories that the study included in the analysis are presented below, together with the respective data availability. Blank cells indicate that no response was given following several requests for contact. In addition, several countries have abstained from responding to the survey. The reasons reported relate to changes in the teams of experts responsible for digital contact tracing, as well as shifts in national priorities during the pandemic, all of which reportedly resulted in insufficient resources that could be allocated to responding to the survey.

Table 1. Availability of relevant data at country level collected via desk research and a survey

Country / Territory	Desk research	Survey response	Input to indicators and source
Austria	✓	✗	
Belgium	✓	✓	
Croatia	✓	✗	
Republic of Cyprus	✓	✓	
Czech Republic	✓	✗	
Denmark	✓	✗	

Country / Territory	Desk research	Survey response	Input to indicators and source
Estonia	✓	✓	📋
Finland	✓	✓	📋 💻
France	✓	✓	📋 💻
Germany	✓	✓	📋 💻
Hungary	✓	✗	✗
Ireland	✓	✓	📋
Italy	✓	✓	💻
Latvia	✓	✓	📋
Lithuania	✓	✓	📋
Malta	✓	✓	📋
Netherlands	✓	✓	📋 💻
Norway	✓	✓	📋
Poland	✓	✗	💻
Portugal	✓	✓	📋
Slovenia	✓	✓	📋 💻
Spain	✓	✗	💻
Iceland	✓	✓	📋
Switzerland	✓	✓	📋 💻
UK – England and Wales	✓	✗	💻
UK – Northern Ireland	✓	✗	✗
UK – Scotland	✓	✗	💻

✗ abstained from providing a response / providing data 📋 data provided via study survey

💻 data obtained by study team via public sources, or through the eHealth Network

Study limitations

Privacy and security are key concerns of digital contact tracing and warning apps, therefore the solutions were developed to allow users a very high degree of privacy in the way their data is handled to increase acceptance of this technology among the population. This was reinforced by decisions made by major tech companies, i.e., Google and Apple, who provided a user interface and associated protocols which did not allow personally identifiable information about the user or their device to be obtained. Although this approach was considered more likely to increase adoption, it posed a challenge in obtaining data to evaluate the use and performance of the apps. Consequently, the data collected by the countries and provided to the study team were limited.

The availability of data is a key factor in applying a monitoring framework across countries. The updated WHO/ECDC framework which was used to analyse the available country data from the apps is a forward-looking framework, to assess the apps' use and performance. Based on the collected country data, only a small subset of the framework's indicators could be analysed. Several countries have reported that they plan to use the WHO/ECDC framework or are working to align with it, which is a positive development towards a more uniform view of the apps' performance. Further limitations include fewer responses and delayed survey response times due to summer holidays, shifting national priorities, and a limited timeframe for response elicitation.

The study focuses on collection and analysis of data and information from the beginning of the pandemic, 15 March 2020 up to August 2022. The recommendations provided in this report are forward-looking and based on the knowledge available up to August 2022. Where possible, an outlook has been provided based on consultations with relevant experts. However, the COVID-19 pandemic and its dynamic nature necessitates adjustment of procedures, adaptation of solutions and re-thinking of approaches, as the situation evolves.

3 Development, deployment, and roll-out of contact tracing apps in Europe

3.1 Development and deployment timeline

The first COVID-19 infection in Europe was confirmed in Bordeaux, France, on 24 January 2020[12], and by 13 March 2020 a state of pandemic was declared by the World Health Organization[13]. The digital contact tracing and warning apps were developed within a narrow timeline, with Austria releasing the first version of its national app already on 25 March 2020. Within the study scope, 27 countries and territories have been identified, which developed and deployed national contact tracing apps in a period of nine months since the state of pandemic was declared.

Table 2. European countries with contact tracing apps

Country / Territory	App	Launch
Austria	Stopp Corona App	25.03.2020
Belgium	Coronalert	30.09.2020
Croatia	Stop COVID-19	27.07.2020
Republic of Cyprus	CovTracer-EN[14]	05.04.2020
Czech Republic	eRouska	20.04.2020
Denmark	Smittestop	18.06.2020
Estonia	HOIA	20.08.2020
Finland	Koronavilkku	31.08.2020
France	TousAntiCovid[15]	22.10.2020
Germany	Corona-Warn-App	16.06.2020
Hungary	VirusRadar	13.05.2020
Iceland	Rakning C-19	02.04.2020
Ireland	COVID Tracker	07.07.2020
Italy	Immuni	15.06.2020
Latvia	Apturi Covid	29.05.2020

12 Euro.who.int. 2022. 2019-nCoV outbreak: first cases confirmed in Europe. [online] Available at: <https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/news/news/2020/01/2019-ncov-outbreak-first-cases-confirmed-in-europe> [Accessed 6 September 2022].

13 Who.int. 2022. WHO Director-General's opening remarks at the media briefing on COVID-19 - 13 March 2020. [online] Available at: <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-mission-briefing-on-covid-19---13-march-2020> [Accessed 6 September 2022].

14 The CovTracer-Exposure Notification (CovTracer-EN) app was presented on 11.03.2021 as the replacement for the previous CovTracer app launched on 05.04.2020. In comparison to the previous app which employed the GPS technology, the new version used the Bluetooth technology and other data such as the length of the encounters set up by the Google/Apple Exposure Notifications Application Interface (GAEN). The information is based on the countries' analysis. See Annex for more details.

15 The first version of the French contact tracing app was called StopCovid and was launched on 02.06.2020. TousAntiCovid is an updated, rebranded and renamed version of the CTA in France launched on 22.10.2020 in an effort to boost downloads and users' engagement.

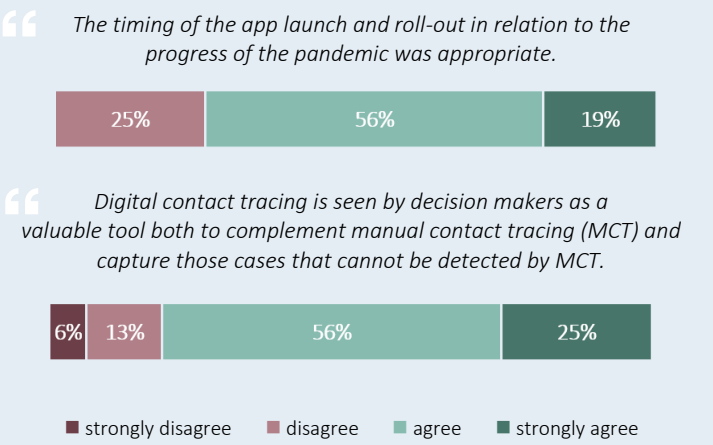
Country / Territory	App	Launch
Lithuania	Korona Stop LT	06.11.2020
Malta	COVIDAlert	18.09.2020
Netherlands	CoronaMelder	10.10.2020
Norway	Smittestopp 2[16]	21.12.2020
Poland	STOP COVID[17]	09.06.2020
Portugal	StayAway COVID	01.09.2020
Slovenia	#OstaniZdrav	17.08.2020
Spain	Radar Covid	21.08.2020
Switzerland	SwissCovid	25.06.2020
UK – England and Wales	NHS COVID-19	24.09.2020
UK – Northern Ireland	StopCOVID NI	30.07.2020
UK – Scotland	Protect Scotland	10.09.2020

The countries were asked through the study survey to reflect on the role of digital contact tracing and the timing of the launch of the national apps.

Survey insights: importance of DCT and timing of the app launch

Most countries confirmed that the launch of their app was timely in supporting their efforts to curb the pandemic.

Digital contact tracing is mostly considered to be a valuable tool that complements manual contact tracing efforts.



Based on responses by 16 countries.

Timelines for launching the app were dependent on required legislative changes as well as on the pace of technical developments, such as the Google and Apple Exposure Notification.

16 The first version of the Norwegian app (Smittestop 1) was launched on 16.04.2020 and suspended in September 2020 as the number of infected individuals declined dramatically and the privacy issues were debated. The second version of the contact tracing app, Smittestopp 2, released on 21.12.2020 is based on the Google Apple Exposure Notification technology and was developed by Netcompany.

17 On 20.04.2020 the Ministry of Digital Affairs released the first version of the ProteGo Safe app, which originally only provided information and health monitoring functions. On 29.04.2020 it produced a newer version that made use of Bluetooth technology and allowed for contact tracing. On 09.06.2020 after a series of controversies surrounding the previous versions, the Ministry produced yet another version – this time using the Google Apple Exposure Notification technology (previously it had used the BlueTrace approach). In September 2020, the government rebranded the app from ProteGo Safe to STOP COVID.

3.2 Main stakeholders involved

The main stakeholders involved in the development and deployment of contact tracing apps were identified via their respective websites (see Annex I and II) and through the survey. For 24 of the 27 countries investigated in the study, the development of the national app was the result of a public-private collaboration (i.e., a collaboration between governmental institutions on one side and private software developers, technology, IT and research organisations on the other side). Exceptions to the case include Republic of Cyprus, Malta, and the Netherlands. In Cyprus the development of the app was a collaboration between two research centres of the public University of Cyprus. The Maltese app was developed by the Malta Information Technology Agency (MITA) in collaboration with the Ministry of Health and the Malta Digital Innovation Authority. In the Netherlands, the Ministry of Health, Welfare, and Sports (VWS) is both app developer and app controller.

Nine countries reported that national research institutes and innovation centres were involved in the application development process (the KU Leuven in Belgium, the KIOS Center of Excellence from University of Cyprus and the CYENS Centre of Excellence, Statens Serum Institut in Denmark, the National Institute for Research in Digital Science and Technology in France, the Robert Koch Institute in Germany, the Economic and Social Research Institute in Ireland, the University of Latvia, the Institute of Public Health of the University of Porto, Oxford University in the UK). Furthermore, in some of the countries, international non-profit organisations participated in the development of apps: the Red Cross in Austria,the PathCheck Foundation in the Republic of Cyprus, and the "CERTH/ITI Research Center, Greece" that provided for free their 12-digit OTP generator subsequently used in the Verification Server of the CovTracer-EN app in Cyprus.

In most countries, the government or a national institute or ministry acted as commissioner, sponsor, regulator, and controller of the app, while private entities were responsible for the technical lead, design and documentation, which included the creation and design of back-end systems, subsequent testing of app processes, as well as continued development and support of operations after launch. Data controllers were further responsible for the secure collection, transmission, and processing of data including the development of related guidelines. An overview of all data controllers in each country is available in the table below.

Table 3. Data controllers of the 27 European contact tracing apps[18]

Country		Data controller
	Austria	Austrian Red Cross
	Belgium	Sciensano
	Croatia	Ministry of Health of the Republic of Croatia
	Republic of Cyprus	Ministry of Health of the Republic of Cyprus
	Czech Republic	Ministry of Health of the Czech Republic
	Denmark	Danish Patient Safety Agency
	Estonia	Estonian Health Board
	Finland	Finnish Institute for Health and Welfare
	France	National Institute for Research in Digital Science and

[18] The information is based on the countries' analysis. See Annex II for more details.

Country		Data controller
		Technology, French Ministry of Health
	Germany	Robert Koch Institute
	Hungary	National Centre for Public Health
	Iceland	Ministry of Justice
	Ireland	Health Service Executive
	Italy	Presidency of the Council of Ministers
	Latvia	Centre for Disease Prevention and Control
	Lithuania	Ministry of Health of the Republic of Lithuania
	Malta	Department for Health Regulation, Office of the Superintendent of Public Health
	Netherlands	Municipal Health Service
	Poland	Chief Sanitary Inspector
	Portugal	Directorate-General of Health
	Slovenia	Ministry of Public Administration
	Spain	Ministry of Health and the Autonomous Communities
	Norway	Norwegian Institute of Public Health
	Switzerland	Federal Office of Public Health
	UK – England and Wales	Department of Health and Social Care
	UK – Northern Ireland	Health and Social Care Department of Health
	UK – Scotland	Scottish Government

3.3 Participatory processes and public engagement

The COVID-19 pandemic put many governments in the position of making high-stake decisions quickly and often with little involvement of stakeholders[19]. During a pandemic, the challenges of participatory involvement are based on the time-consuming nature of methods which require dedicated meetings and focus groups. Despite these obstacles, few countries have decided to carry out stakeholder consultations and involve citizens in the development of contact tracing apps, as deliberative decision-making, that is inclusive and transparent, can lead to more trust and acceptance of decisions on ethically difficult issues, such as the acceptance of digital contact tracing.[20] Participatory processes in this context are understood as those involving various stakeholders, where approaches can include informing interested parties about new laws, public services and technologies as well as listening to their concerns

[19] Norheim, O., Abi-Rached, J., Bright, L., Bærøe, K., Ferraz, O., Gloppen, S. and Voorhoeve, A., 2020. Difficult Trade-Offs in Response to COVID-19: The Case for Open and Inclusive Decision-Making. SSRN Electronic Journal

[20] Norheim, O.F. et al. (2021). Difficult trade-offs in response to COVID-19: the case for open and inclusive decision making. *Nat Med* 27, 10–13. https://doi.org/10.1038/s41591-020-01204-6

while involving them in decision-making or policy-shaping.[21] These processes can strengthen democracy, generate public trust, and increase the effectiveness of solutions, improving the efficiency of expenditures and public accountability.[22]

Various approaches to the development of digital contact tracing can be observed among the different countries. Austria launched a website that explains the functions of the app and invited public feedback to generate trust and promote the app's acceptance.[23] In Belgium, several public consultations were carried out for a similar purpose: in August 2020, Devside and the inter-federal working group held a public consultation via an online form created by KU Leuven for input on the development of the Coronalert app. A second public consultation was held from September to October 2020 which involved academic and non-academic experts in law, social sciences, public health, cybersecurity, and app development and further included civil society organisations, municipalities, and citizens. Feedback was gathered on various factors such as app usage by minors, inclusivity of the app, public trust and understanding, the privacy statement, user-friendliness, as well on the role of medical professionals in app usage, among others. Based on this consultation, the minimum user age was lowered to 13 years, the privacy statement was updated, and an interdisciplinary, independent oversight committee for assessing the app's effectiveness was formed. Furthermore, the working group engaged with healthcare providers to garner feedback and distribute brochures about the Coronalert app among them[24]. In Belgium[25], the Netherlands[26], Finland[27], Northern Ireland[28], and Spain[29] the contact tracing apps were pre-tested with volunteers. In Northern Ireland, a Steering Committee was created, and app prototypes were tested with members of the public, senior level stakeholders, and human rights organisations to ensure a human-centred approach to app development[30]. In Slovenia[31], Finland[32] and the Netherlands[33], a public tender was formulated to which individual companies could apply with their project ideas. Ireland engaged in a series of research activities both via Department of Health focus groups and additional research assessing acceptance trust which drove the communication strategy for COVID Tracker. Ongoing focus groups were used to inform the Contact tracing and isolation roadmap. The oversight group included patient representative organisations along with academic involvement, who

21 Buchanan, W. et al. (2020). Use of participatory apps in contact tracing – options and implications for public health, privacy and trust. Digital Health and Care Institute, University of Strathclyde, Glasgow. https://doi.org/10.17868/73197

22 Falanga, R. (2020). Citizen participation during the COVID-19 pandemic. Insights from local practices in European cities. [pdf] Available at https://library.fes.de/pdf-files/bueros/lissabon/17148.pdf

23 Austria invites suggestions to improve coronavirus track and trace app. (2020). Retrieved 6 September 2022, from https://www.reuters.com/article/healthcoronavirus-austria-apps-idUSL8N2EF1BB

24 Conclusions public consultation Coronalert 5-31 August 2020. Version 1.0 – 25 September 2020. [pdf] Available at https://www.esat.kuleuven.be/cosic/sites/corona-app/wp-content/uploads/sites/8/2020/09/Public_consultation_v1_0_sep25_2020-1.pdf

25 Luxen, M. (2020). Probleme beim Testen der Coronalert-App: Nicht jeder kann sie downloaden. Retrieved 7 September 2022, from https://www.vrt.be/vrtnws/de/2020/09/18/probleme-beim-testen-der-coronalert-app-nicht-jeder-kann-sie-do/

26 NPO1 COVERS TESTING CORONAMELDER IN TWENTE.(2020). Retrieved 6 September 2022, from https://www.utwente.nl/en/designlab/news/2020/7/695757/npo1-covers-testing-coronamelder-in-twente#watch-the-item

27 Trial of coronavirus app Koronavilkku continues. (2020). Retrieved 6 September 2022, from https://www.dailyfinland.fi/health/17280/Trial-of-coronavirus-app-Koronavilkku-continues

28 Data Protection Impact Assessment COVID-19 Proximity App 'StopCOVID NI'. [pdf] Available at https://covid-19.hscni.net/wp-content/uploads/2020/08/DPIA-for-StopCOVID-NI-Proximity-App-31.07.2020.pdf

29 Vega, G. (2020). Spain launches first phase of coronavirus-tracking app. Retrieved 6 September 2022, from https://english.elpais.com/society/2020-06-29/spain-launches-first-phase-of-coronavirus-tracking-app.html

30 Data Protection Impact Assessment COVID-19 Proximity App 'StopCOVID NI'. [pdf] Available at https://covid-19.hscni.net/wp-content/uploads/2020/08/DPIA-for-StopCOVID-NI-Proximity-App-31.07.2020.pdf

31 Ministrstvo za javno upravo objavlja poziv za oddajo ponudbe po evidenčnem postopku javnega naročanja za prilagoditev mobilne aplikacije za obveščanje o stikih z okuženimi s covid-19. (2020). Retrieved 6 September 2022, from https://www.gov.si/novice/2020-07-12-ministrstvo-za-javno-upravo-objavlja-poziv-za-oddajo-ponudbe-po-evidencnem-postopku-jn-za-prilagoditev-mobilne-aplikacije-za-obvescanje-o-stikih-z-okuzenimi-s-covid-19/

32 Kilpailutus koronaviruksen tartuntaketjujen jäljityssovelluksesta on käynnissä - Uutinen - THL. (2022). Retrieved 4 October 2022, from https://thl.fi/fi/-/kilpailutus-koronaviruksen-tartuntaketjujen-jaljityssovelluksesta-on-kaynnissa

33 Uitnodiging slimme digitale oplossingen Corona. (2020). Retrieved 6 September 2022, from https://www.tenderned.nl/aankondigingen/overzicht/192421/details

provided insights and considerations from different viewpoints - technology, privacy, ethics[34].

3.4 National policies, strategies, and legal frameworks

Following the rapid developments and uptake of digital contact tracing tools mainly in 2020, the World Health Organization published in July 2021 considerations for the review, development and monitoring of legal frameworks for digital contact tracing tools. Three steps are defined for forming, strengthening, and evaluating countries' legal frameworks in this regard, as depicted in the figure below.

Figure 2. Considerations for strengthening legal frameworks for digital contact tracing and quarantine tools for COVID-19 (adapted from WHO)[35]

The guideline states it is particularly important that legal frameworks are in place to govern the use of personal data to ensure privacy and prevent loss, unnecessary intrusion, and commercial exploitation. The legal frameworks should be regularly monitored and evaluated based on a set of criteria that guide the assessment of new laws governing the use of contact tracing apps. These criteria include proportionality, time limits for data retention, data minimisation, transparency, consent, use restrictions, security, privacy of people notified, defined governance and regulating bodies, and finally human rights and equity. The evaluation of the legal basis can be done within the government or by an external civil society group that can assess the legal frameworks and complete an independent third-party review.[36]

To enable digital contact tracing, countries introduced new legal instruments and binding orders, such as decrees (e.g., Italy, Belgium), resolutions (e.g., Czech Republic), executive orders (e.g., Denmark), ordinances (e.g., Switzerland), governmental decisions (e.g., Italy) and regulations (e.g., Northern Ireland).

Existing legislation required adaptation in several countries, such as in Croatia where the Law on Electronic Communication was amended to allow more comprehensive monitoring of citizens' mobile devices for pandemic control. In Estonia, amendment to a regulation on the statute of the health information system was added in order to secure the protection of app user data and ensure the involved responsible parties in the process uphold the standards of safety and transparency. Similarly in Malta, subsidiary legislation entitled "Contact Tracing and Alerting Mobile Application Order", 2020 was enacted on the 1st of October 2020, as amended by Legal Notice 128 of 30 March 2021.[37]

Countries developed dedicated strategies and programmes employing digital contact tracing to control the pandemic and minimise infections. For example, the Czech app eRouska was integrated into the

[34] Research-Report-App-user-experience-and-perspectives-May-2020 (igees.gov.ie) Available at: https://igees.gov.ie/wp-content/uploads/2020/07/Research-Report-App-user-experience-and-perspectives-May-2020.pdf

[35] Who.int. 2022. Considerations for strengthening legal frameworks for digital contact tracing and quarantine tools for COVID-19. [online] Available at: <https://www.who.int/publications/i/item/considerations-for-strengthening-legal-frameworks-for-digital-contact-tracing-and-quarantine-tools-for-covid-19> [Accessed 6 September 2022].

[36] Who.int. 2022. Considerations for strengthening legal frameworks for digital contact tracing and quarantine tools for COVID-19. [online] Available at: <https://www.who.int/publications/i/item/considerations-for-strengthening-legal-frameworks-for-digital-contact-tracing-and-quarantine-tools-for-covid-19> [Accessed 6 September 2022].

[37] Legislation.mt. 2022. LEĠIŻLAZZJONI MALTA. [online] Available at: <https://legislation.mt/eli/ln/2021/128/> [Accessed 6 September 2022].

Smart Quarantine Strategy[38] of the Czech Republic. The French TousAntiCovid app was embedded in the national "Test-Alert-Protect" health strategy, corresponding to the alert component.[39] The England and Wales NHS COVID-19 app was presented as the part of a large-scale, combined testing, contact tracing and outbreak management programme across England, called NHS Test and Trace large-scale contact tracing and outbreak management programme.[40]

In terms of scope and specificity, some instruments target concrete measures and specifically address digital contact tracing through provisions (e.g. the Italian decree, which was later converted into law), others specify an environment that enables digital contact tracing to be applied but are branded as a broader set of measurements related to the management of the pandemic (e.g., the Croatian decision of the government on "digital platform and interoperability implementation for the purpose of monitoring and repressing infectious diseases"). In other cases, decrees are set in place to provide exemptions from existing provisions governing data processing in relation to COVID-19 (e.g., in Hungary).

All apps are available on a voluntary basis. As part of political discussions in Slovenia, the idea of making the use of a mandatory app for those who have tested positive for the virus or those in quarantine was raised[41]. The plan was met with opposition[42] and was ultimately not accepted[43]. This initial idea was not connected to the subsequently developed Slovenian app #OstaniZdrav, which is made available in a voluntary manner and has a legal basis (see the table further below).[44].

In general, most legal provisions and decisions have a temporal component, i.e., they are applicable during the pandemic and expire based on defined criteria, or are extended continuously until no extensions are granted (e.g. extending temporary acts in the Netherlands). As some countries are beginning to shift towards classifying the disease as endemic, like Spain[45], the use of contact tracing apps is also expected to drop. Some apps have been suspended and their websites have been decommissioned (see section 6.1).

A quick summary of pertinent legal acts (valid as of 25 August 2022) identified in the study is given below[46]. The table contains the legislation that first introduced a legal basis for (digital) contact tracing in the respective countries. Later modifications or revocations are not explicitly mentioned.

38 Covid19cz.cz. 2022. Chytrá karanténa - Covid19CZ. [online] Available at: <https://covid19cz.cz/covid19-cz/manifest/chytra-karantena> [Accessed 6 September 2022].

39 Gouvernement.fr. 2022. Info Coronavirus Covid-19 - Tester - Alerter - Protéger. [online] Available at: <https://www.gouvernement.fr/info-coronavirus/tests-et-depistage> [Accessed 6 September 2022].

40 Faq.covid19.nhs.uk. 2022. COVID-19 app support. [online] Available at: <https://faq.covid19.nhs.uk/article/KA-01107/en-us?parentid=CAT-01040&rootid=CAT-01021> [Accessed 6 September 2022].

41 Dq4n3btxmr8c9.cloudfront.net. 2022. [online] Available at: <https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf> [Accessed 6 September 2022].

42 Themayor.eu. 2022. Slovenia paves the way forward for the creation of COVID contact tracing app | TheMayor.EU. [online] Available at: <https://www.themayor.eu/en/a/view/slovenia-paves-the-way-forward-for-the-creation-of-covid-contact-tracing-app-5340?trans=en-US> [Accessed 6 September 2022].

43 2022. [online] Available at: <https://www.state.gov/report/custom/616ca6013f-2/> [Accessed 6 September 2022].

44 https://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO8190

45 English.news.cn. 2022. Spain moves toward "endemic" approach to COVID-19. [online] Available at: <https://english.news.cn/20220329/5ac405afff504ad2a99378b28d5b75b0/c.html> [Accessed 6 September 2022].

46 Countries without a dedicated legal act are not included

Table 4. Summary of legal acts introduced to provide a legal basis for (digital) contact tracing[47]

Country	Legal Act	Significance: new legal provisions for contact tracing
Belgium	Cooperation Agreement of 25 August 2020[48]	Introduces digital contact tracing via an app and defines cases of data processing collected via the app.
Czech Republic	Gov. Resolution No.576 of 25 May 2020[49]	Stipulates the Smart Quarantine 2.0 Strategy, allowing further development and operation of DCT and cooperation between communication and health authorities
Denmark	Executive Order 1539 of 29 October 2020[50]	Regulates the digital processing of contact data in the Danish "Smittestop" app to contain COVID's spread
Estonia	Amendment to Regulation No. 138 – Statutory Regulation of the Health Information System – of 16 July 2020[51]	Authorises and sets out rules for data exchange in the national app for the purpose of preventing the spread of an infectious disease
Finland	Temporary Amendment of the Infectious Diseases Act 1227/2016 of 9 July 2020[52]	Establishes an information system (mobile app and backend) to break up COVID transmission chains and rules for data processing within it
France	Decree No. 2020-650 of 29 May on Data Processing [in] "TousAntiCovid"[53]	Establishes the TousAntiCovid app for COVID contact tracing, setting out rules for data processing
Hungary	Government Decree 181/2020 of 21 May 2020[54]	Stipulates electronic control of the official home quarantine through the app, including facial image transmission and involvement of police to check compliance
Italy	Decree-Law 28 of April 30 2020[55]	Establishes a COVID warning app to alert contacts of potentially infected persons and regulates the processing of data
Latvia	Law 2022/110A on the Management of the Spread of COVID-19 of 5 June 2020[56]	Stipulates the use of a contact tracing warning IT system and the data exchange details, including in the European Federation Gateway
Malta	Subsidiary legislation entitled	This legislation provided the basic framework that guided

47 The table reflects the most recent valid legal act, as of August 25th 2022. Previous acts are not included.

48 Corona-tracking.info. 2022. [online] Available at: <https://www.corona-tracking.info/wp-content/uploads/2020/10/Samenwerkingsakkoord.pdf> [Accessed 6 September 2022].

49 Apps.odok.cz. 2022. Požadavek byl zablokován. [online] Available at: <https://apps.odok.cz/attachment/-/down/IHOABPYAU3IL> [Accessed 6 September 2022].

50 Retsinformation. 2022. BEK nr 1539 af 29/10/2020, Sundhedsministeriet. [online] Available at: <https://www.retsinformation.dk/eli/lta/2020/1539> [Accessed 6 September 2022].

51 Riigiteataja.ee. 2022. Vabariigi Valitsuse 1. detsembri 2016. a määruse nr 138 „Tervise infosüsteemi põhimäärus" muutmine–Riigi Teataja. [online] Available at: <https://www.riigiteataja.ee/akt/118072020004> [Accessed 6 September 2022].

52 Finlex.fi. 2022. Laki tartuntatautilain väliaikaisesta... 582/2020 - Säädökset alkuperäisinä - FINLEX ®. [online] Available at: <https://www.finlex.fi/fi/laki/alkup/2020/20200582> [Accessed 6 September 2022].

53 Legifrance.gouv.fr. 2022. [online] Available at: <https://www.legifrance.gouv.fr/loda/id/JORFTEXT000041936881/2022-08-26/> [Accessed 6 September 2022].

54 Njt.hu. 2022. 181/2020. (V.4.) Korm. rendelet - Nemzeti Jogszabálytár. [online] Available at: <https://njt.hu/jogszabaly/2020-181-20-22> [Accessed 6 September 2022].

55 2022. [online] Available at: <https://www.gazzettaufficiale.it/eli/id/2020/04/30/20G00046/sg> [Accessed 6 September 2022]. Transformed into law, with amendments, by Law 70 of 25 June 2020.

56 LIKUMI.LV. 2022. Covid-19 infekcijas izplatības pārvaldības likums. [online] Available at: <https://likumi.lv/ta/en/en/id/315278> [Accessed 6 September 2022]. Later amendments, extending the law, followed.

Country	Legal Act	Significance: new legal provisions for contact tracing
	Contact Tracing and Alerting Mobile, as amended by Legal Notice 128 of 30 March 2021	both the deployment and the eventual decommissioning of the app together with the relevant steps.
Netherlands	Temporary Act on notification application COVID-19 of 6 October 2020, amending Public Health Act[57]	Introduces a notification app to combat COVID-19 for the purpose of contact tracing and sets out rules for data processing.
Norway	Royal Resolution - Regulations on digital infection tracking and epidemic control in the event of an outbreak of Covid-19 of 27 March 2020[58]	Authorises the Norwegian Institute of Public Health to establish mobile app as a system for digital contact tracing for COVID-19 and sets out rules for data processing.
Portugal	Decree-Law no. 52/2020 of 11 August 2020[59]	Establishes the responsible for data processing and regulates the intervention doctors in the STAYAWAY COVID system
Slovenia	Act Determining the Intervention Measures to Contain the COVID-19 Epidemic and Mitigate its Consequences for Citizens and the Economy of 23 October 2020"	Establishes legal basis for operating of a voluntary contact trancing app #OstaniZdrav, with the purpose of help in managing the COVID-19 crisis.
Spain	Order SND/297/2020 of 28 March 2020[60]	Entrusts State Secretary of Digitalisation with development of an application to manage the COVID-19 crisis
Switzerland	Amendment to the Epidemic Act 818.101 of 19 June 2020[61]	Establishes a proximity tracing system for Coronavirus, operated by Federal Office of Public Health, and sets out rules for data processing
UK – England	The Health Protection (Coronavirus, Restrictions) (Self-Isolation) (England) Regulations 2020 of 27th September 2020[62]	Provides legal basis for COVID-19 data processing, additionally to the Data Protection Act 2018
UK – Wales	The Health Protection (Coronavirus Restrictions) (No. 5) (Wales) Regulations 2020 of 18 December 2020[63]	Provides legal basis for COVID-19 data processing, additionally to the Data Protection Act 2018

57 Eerstekamer.nl. 2022. [online] Available at: <https://www.eerstekamer.nl/behandeling/20201009/publicatie_wet/document3/f=/vlcqcoql0wxg.pdf Duration extended by Decree of 11 December 2020> [Accessed 6 September 2022].

58 Regjeringen.no. 2022. [online] Available at: <https://www.regjeringen.no/contentassets/116076d9a39b473a97d97474048e1fb0/kgl.-res.-27.-mars-digital-smittesporing.pdf> [Accessed 6 September 2022].

59 Dre.pt. 2022. [online] Available at: <https://dre.pt/dre/detalhe/decreto-lei/52-2020-140013521> [Accessed 6 September 2022].

60 Boe.es. 2022. BOE.es - BOE-A-2020-4162 Orden SND/297/2020, de 27 de marzo, por la que se encomienda a la Secretaría de Estado de Digitalización e Inteligencia Artificial, del Ministerio de Asuntos Económicos y Transformación Digital, el desarrollo de diversas actuaciones para la gestión de la crisis sanitaria ocasionada por el COVID-19. [online] Available at: <https://www.boe.es/buscar/act.php?id=BOE-A-2020-4162#:~:text=Orden%20SND%2F297%2F2020%2C,ocasionada%20por%20el%20COVID%2D19.> [Accessed 6 September 2022].

61 Fedlex.admin.ch. 2022. Fedlex. [online] Available at: <https://www.fedlex.admin.ch/eli/cc/2015/297/de> [Accessed 6 September 2022]. Article 60a, effective until 30 June 2022 and extended to 31 December 2022.

62 2022. [online] Available at: <https://www.legislation.gov.uk/uksi/2020/1045/made> [Accessed 6 September 2022].

63 2022. [online] Available at: <https://www.legislation.gov.uk/wsi/2020/1609/made> [Accessed 6 September 2022].

3.5 App data protection, privacy, and security

Guidance on contact tracing apps in relation to data protection

Supplementing the Commission's Recommendation and the EU Toolbox of the eHealth Network, on 17 April 2020 the Commission issued a guidance[64] on apps supporting the fight against the COVID-19 pandemic in relation to data protection which builds upon input from the European Data Protection Board (EDPB) and the eHealth Network. The guidance states that the least intrusive solutions should be found, fully compliant with EU data protection and privacy requirements including state-of-the-art information security protections. It elaborates ten elements for the trustful and accountable use of apps in order to achieve those aims.

Privacy and data protection have a pivotal role and are essential in building and sustaining trust in digital solutions. The guidelines given by the European Commission on CTA development in relation to data protection are:

- clear identification of national health authorities (or entities carrying out tasks in the public interest in the field of health) as data controller to ensure transparency in the responsible parties for compliance with EU personal data protection rules
- ensuring that users are always in control (consent for specific functionality given separately and use of the app should be voluntary).
- a legally guaranteed purpose limitation (the purpose of any processing must be precisely defined and based on a specific legal basis).
- data minimisation, including carrying out an assessment of the necessity to process the personal data and its relevance
- the need for a time limit (applied to the retention period of all collected personal data) and legal sunset clauses (termination of the apps).
- proportionality of the measures taken (with the possibility to withdraw the measure where there is no concrete evidence of its benefits).
- involving Data Protection Authorities
- transparency of the data processing operations, (this notably includes the publication of the source code of the software, of impact assessments and security audits).
- accountability of data controllers, integration of privacy by design, realisation of data protection impact assessments of the processing and relevant security measures.[65]

Using these guidelines as framework, the contact tracing apps from different EU and EEA states have been cross examined and key findings are presented in the following sections.

Source Code

According to the EU Toolbox recommendations, the publication and sharing of an app's source code, including peer review, is encouraged and highly recommended for apps supported by national authorities.

Besides ensuring transparency, publication of open-source code gives the broader public and the developer community the opportunity to actively contribute to the app's success, through reporting of errors, discussions, code reviews and contributions via pull requests.[66] For example, in Austria the source code of the contact tracing app was reviewed by independent research organisations who identified

64 Ec.europa.eu. 2022. [online] Available at: <https://ec.europa.eu/info/sites/default/files/5_en_act_part1_v3.pdf> [Accessed 6 September 2022].

65 Digital Solutions to Fight COVID-19 2020 Data Protection Report, Council of Europe

66 Coronawarn.app. 2022. Open-Source Project Corona-Warn-App – FAQ. [online] Available at: <https://www.coronawarn.app/en/faq/#why_oss> [Accessed 6 September 2022].

weaknesses and inspired the developers to adapt features.[67]

Almost all investigated countries (25/27) have an open-source code for the contact tracing app. Some critics argue that the apps are not really open-source because the operating system codes of Android and iOS are not public, that is, the apps are only open-source to the level of OS API calls[68].

Countries like Belgium, Slovenia, and Hungary reused the code of other European contact tracing apps. Specifically, Belgium, Cyprus, and Slovenia used some or all the source code of Germany's Corona-Warn-App (CWA) while Hungary's app was built on an IT solution which was previously used in North Macedonia.[69]

Different practices can be observed with regards to the quality and the extent to which the source code is shared. The initial source code published by Spain seemed to be incomplete and confusing[70]. In Denmark, the code of the Smittestop app was published on GitHub "solely for reference", thus discouraging additional contributions to the code.[71]

Table 5. Countries with Open-source codes

Country	App	Open Source-Code	GitHub/Documentation Page
Austria	Stopp Corona App	✓	github.com/austrianredcross
Belgium	Coronalert	✓	github.com/covid-be-app/cwa-app-android
Croatia	Stop COVID-19	✓	github.com/covid-be-app/cwa-app-android
Republic of Cyprus	CovTracer-EN	✓	github.com/CovTracer-EN/covtracer-en-app
Czech Republic	eRouska	✓	github.com/covid19cz/erouska-ios
Denmark	Smittestop	✓*	github.com/Sundhedsdatastyrelsen
Estonia	HOIA	✓	koodivaramu.eesti.ee/tehik/hoia/documentation
Finland	Koronavilkku	✓	github.com/THLfi/koronavilkku-android
France	TousAntiCovid	✓	gitlab.inria.fr/stopcovid19/accueil
Germany	Corona-Warn-App	✓	github.com/corona-warn-app
Hungary	VirusRadar	✗	-
Iceland	Rakning C-19	✓	github.com/aranja/rakning-c19-app
Ireland	COVID Tracker	✓	github.com/HSEIreland/covid-tracker-app
Italy	Immuni	✓	github.com/immuni-app/immuni-documentation
Latvia	Apturi Covid	✓	github.com/ApturiCOVID/apturicovid-android

67 Digital Solutions to Fight COVID-19 2020 Data Protection Report, Council of Europe

68 Vaudenay, S., & Vuagnoux, M. (2022). SwissCovid in the Perspective of its Goals. Digital Threats: Research and Practice.

69 Joinup. 2022. Reusable code in COVID-19 apps. [online] Available at: <https://joinup.ec.europa.eu/collection/open-source-observatory-osor/news/reusable-code-covid-19-apps> [Accessed 6 September 2022].

70 2022. [online] Available at: <https://elpais.com/tecnologia/2020-09-09/el-gobierno-publica-hoy-el-codigo-de-radar-covid-casi-medio-ano-despues-de-lanzar-el-proyecto.html> [Accessed 6 September 2022].

71 GitHub. 2022. GitHub - Sundhedsdatastyrelsen/Coronapas.Mobile: The Coronapas app's source code. [online] Available at: <https://github.com/Sundhedsdatastyrelsen/Coronapas.Mobile> [Accessed 6 September 2022].

Country	App	Open Source-Code	GitHub/Documentation Page
Lithuania	Korona Stop LT	✗	-
Malta	COVIDAlert	✓	github.com/GOVMT-MITA
Netherlands	CoronaMelder	✓	github.com/minvws
Norway	Smittestopp	✓	github.com/folkehelseinstituttet/Fhi.Smittestopp.App
Poland	ProteGO Safe	✓	github.com/ProteGO-safe
Portugal	StayAway COVID	✓	github.com/stayawayinesctec/stayaway-app
Slovenia	#OstaniZdrav	✓	github.com/si-covid-19
Spain	Radar Covid	✓	github.com/radarcovid
Switzerland	SwissCovid	✓	github.com/SwissCovid
UK – England and Wales	NHS COVID-19	✓	github.com/nihp-public/covid19-app-system-public
UK – Northern Ireland	StopCOVID NI	✓	covid-19.hscni.net/stopcovid-ni-open-source/
UK - Scotland	Protect Scotland	✓	github.com/NES-Digital-Service/protect-scotland

* Source code published for transparency but does not allow contributions.

Data Protection Impact Assessments

The Data Protection Impact Assessment (DPIA) is a GDPR instrument designed to protect personal data in processing activities.[72] It is essentially a risk analysis which examines possible risks that come with the processing of personal data. This risk analysis aims to foresee the impact of possible risks and mitigate their effects through appropriate precautionary measures.

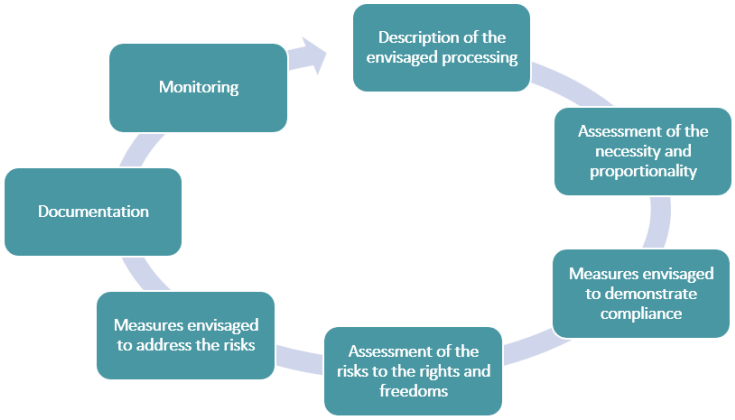


Figure 3. Generic iterative process for carrying out a DPIA

A DPIA is supposed to be carried out by the data controller with the DPO (Data Protection Officer) and

[72] Schwabe, C., 2022. data protection impact assessment. [online] Robin Data GmbH. Available at: <https://www.robin-data.io/en/data-protection-academy/wiki/data-protection-impact-assessment> [Accessed 6 September 2022].

the data processor(s) prior to the processing of any data. A DPIA is required to be published in full or in part and must be communicated to the supervisory authority in case of prior consultation.

There are different methodologies to carry out a DPIA, but the Working Party on the protection of individuals with regard to the processing of personal data, which was set up under Article 29 of the Directive 95/46/EC, proposes a set of criteria that the data controllers could use to assess the adequacy of the assessment[73]:

- a systematic description of the processing is provided
- necessity and proportionality are assessed
- risks to the rights and freedoms of data subjects are managed
- interested parties are involved

The countries that published the DPIAs are Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Poland, Portugal, Norway, Switzerland, and UK (England and Wales, Northern Ireland, Scotland). Italy, Latvia, Malta, Lithuania, Slovenia, Croatia, and Iceland are countries where the assessment either was not made publicly available or was published only as a summary. The table below provides a list of countries who carried out a DPIA, with the respective authorities that conducted it.

Table 6. Summary of Data Protection Impact Assessments by different countries

Country	App	DPIA	Conducted by
Austria	Stopp Corona App	✓	Data controller Austrian Red Cross (the team at the Research Institute - Digital Human Rights Centre)
Belgium	Coronalert	✓	The Belgian Data Protection Authority
Croatia	Stop COVID-19	✓*	The Croatian Agency for the Protection of Personal Data (AZOP)
Republic of Cyprus	CovTracer-EN	✓**	The KIOS Center of Excellence and the CYENS Centre of Excellence in their capacity as data processors with consultation from the Office of the Commissioner for Personal Data Protection. Available upon request
Czech Republic	eRouska	✓**	Available upon request
Denmark	Smittestop	✓	The Danish Agency for Patient Safety
Estonia	HOIA	✓	Ministry of Social Affairs
Finland	Koronavilkku	✓**	Privaon Oy[74]
France	TousAntiCovid	✓*	CNIL
Germany	Corona-Warn-App	✓	TSI[75] and SAP[76]
Hungary	VirusRadar	✓**	Governmental IT Development Agency
Ireland	COVID Tracker	✓	Health Service Executive (HSE Ireland)
Italy	Immuni	✓	Ministry of Health

[73] Datenschutz-grundverordnung.eu. 2022. [online] Available at: <https://www.datenschutz-grundverordnung.eu/wp-content/uploads/2017/07/wp248_enpdf.pdf> [Accessed 6 September 2022].

[74] the leading Finnish company operating in the fields of Privacy and Data Protection

[75] T-Systems International GmbH

[76] Systems, Applications and Products in Data Processing

Country	App	DPIA	Conducted by
Latvia	Apturi Covid	✓	Available upon request
Lithuania	Korona Stop LT	✓ **	The National Cyber Security Centre
Malta	COVIDAlert	✓	Maltese Information and Data Protection Commissioner (IDPC)
Netherlands	CoronaMelder	✓	Ministry of Health, Welfare and Sports (VWS)
Poland	ProteGO Safe	✓	-
Portugal	StayAway COVID	✓	Portuguese Data Protection Authority (CNPD)
Slovenia	#OstaniZdrav	✓ **	National Institute of Public Health (NIJZ)
Spain	Radar Covid	✓ **	Department of Health and Social Care (DHSC)
Norway	Smittestopp	✓	National Institute of Public health (FHI)
Iceland	Rakning C-19	✓	Available upon request
Switzerland	SwissCovid	✓	Swiss Federal Data Protection and Information Commissioner (FDPIC)
UK - England and Wales	NHS COVID-19	✓	UK DHSC (Department of Health and Social Care)
UK - Northern Ireland	StopCOVID NI	✓	Department of Health-NI
UK - Scotland	Protect Scotland	✓	DHCD (Digital Health and Care Directorate)

*Only summaries were published

** Not publicly disclosed (saved in Archives)

Involvement of Data Protection Authorities

Involvement of Data Protection Authorities (DPAs) in the development and assessment of contact tracing apps is important to ensure compliance with data protection laws. DPAs provided extensive guidance on how to employ contact tracing apps in line with data protection standards with most referring to the EDPB guidelines, helping to ensure a harmonised approach to the use of contact-tracing apps across the EU. They underlined issues such as the need for a legal basis and adequate safeguards, the importance of the pseudonymisation of data, the necessity of conducting prior impact assessments, and the deletion of data once they are no longer required. They further supported integrating requirements for data protection during the development process by default and called for a ban on using data for other purposes. [77]

Governments in many countries actively consulted DPAs as part of the discussion on the use of contact-tracing apps. The Belgian government consulted the national DPA on two draft royal decrees aimed at regulating tracing activities. The Authority suggested revising the drafts to include further information on the means of collecting tracing data, the individuals who may access the data, and on the purposes justifying data processing. The Authority once again iterated that data collected for the purpose of

[77] 2022. [online] Available at: <https://www.cnil.fr/sites/default/files/atoms/files/deliberation_du_24_avril_2020_portant_avis_sur_un_projet_dapplication_mobile_stopcovid.pdf > [Accessed 6 September 2022].

contact-tracing cannot be processed for other purposes.[78]

Similarly, the French DPA was consulted on the StopCovid app (the first version of the French app) and issued recommendations that apply mutatis mutandis to all apps to ensure their safe and legal use. It emphasised that the app should be voluntary, safe, grounded in law, preceded by a data protection impact assessment, and it should be aligned with good data processing practices.[79]

In the Netherlands, the government requested the Dutch DPA to assess selected apps following a call for tender.[80]

The Italian DPA initially presented its position on contact-tracing technologies at a parliamentary hearing. It stated that consent to use such apps must be voluntary and raised concerns about the storage of personal data in telecom operators' databases, stressing that preference should be given to measures minimising the collection and storage of identifying information. In addition, the Authority suggested introducing specific statutory offences to punish the use of such data for other purposes than those initially prescribed by law. Subsequently, the Italian DPA was also consulted by the government on the proposed bill.

Other DPAs published guidance on their own initiative. In Finland, the Data Protection Ombuds institution assessed the government's plans to develop contact tracing apps, insisting on the requirements of legality, voluntariness, and data anonymisation.[81]

The Croatian DPA issued a statement on CTAs based on the EDPB's guidance, while the Spanish DPA published an assessment of the costs and benefits of using new technologies in the fight against the pandemic. In addition, information provided to the European Union Agency for Fundamental Rights show that DPAs in Denmark, Italy, Latvia, and the Netherlands were actively involved in the development and/or assessment of contact-tracing apps.[82] In Cyprus, for the CovTracer-EN app a consultation with the national DPA took place (i.e., Office of the Commissioner for Personal Data Protection), who finally approved the app DPIA. The DPIA was submitted to the eHealth Network as part of the EFGS onboarding process[83].

78 Belgium, Data Protection Authority (2020), Tracking applications and COVID-19 database: for the APD, the draft Royal Decrees need to be reviewed, 30 April 2020; see also relevant parliamentary discussions.

79 France, CNIL (2020), Deliberation n° 2020-046 giving an opinion on a mobile application project called 'StopCovid', 24 April 2020.

80 The Netherlands, Dutch Data Protection Authority (2020), Onderzoeksrapportage bron- en contactopsporingsapp, 20 April 2020.

81 Finland, Data Protection Ombuds institution (2020), MyData ja tietosuoja lähtökohtana terveyssovellusten suunnittelussa, 7 April 2020.

82 Fra.europa.eu. 2022. [online] Available at: <https://fra.europa.eu/sites/default/files/fra_uploads/fra-2020-coronavirus-pandemic-eu-bulletin-may_en.pdf> [Accessed 22 September 2022].

83 Via study survey and feedback consultations

3.6 Architectural choices, protocols, and technologies

Centralised and decentralised architectures

Early in the pandemic, one of the main discussions around introducing digital contact tracing apps focused on the communication protocols used – centralised and decentralised – and their impact on citizens' privacy and security. While both the EC and the EDPB consider the decentralised approach to be "more in line with the [data] minimisation principle"[84], Member States were responsible for choosing the approach for their apps, as both approaches have their merits and in general offer good privacy[85],[86].

Centralised and decentralised architectures - overview

With **decentralised apps**, the arbitrary ephemeral identifiers of all phones in contact with another user are generated, stored and processed on the user's device (i.e., mobile phone), which calculates the risk scores for all users and stores all identifiers at risk of infection. When a person receives a positive COVID-19 test result from a public health authority, they upload their exposed contact data to a back-end server[87]. Examples of such systems include the DP-3T[88] and TCN[89] protocols and the Google-Apple Exposure Notification (GAEN) application programming interface (API)[90]. GAEN is necessary in order to have contact tracing apps perform Bluetooth Low Energy (BLE) operations smoothly in the background on a smartphone.

With **centralised apps**, the arbitrary ephemeral identifiers of all phones in proximity to the user are generated, stored and processed on a central server operated by the public health authorities, which calculates updated risk scores for all relevant users and decides which affected users to inform. When a person receives a positive COVID-19 test result from a public health authority, they upload their exposed contact data to a back-end server. Examples of such systems include ROBERT[91], PEPP-PT[92], and OpenTrace/BlueTrace/TraceTogether[93].

Source: National COVID-19 contact tracing apps - IPOL | Policy Department for Economic, Scientific and Quality of Life Policies, May 2020; ISBN 978-92-846-6755-0; doi:10.2861/ 808426

84 European Data Protection Board: Guidelines 04/2020 on the use of location data and contact tracing tools in the context of the COVID-19 outbreak. Adopted on 21 April 2020

85 Rossello, S. and Dewitte, P., 2022. Anonymization by decentralization? The case of COVID-19 contact tracing apps. [online] European Law Blog. Available at: <https://europeanlawblog.eu/2020/05/25/anonymization-by-decentralization-the-case-of-covid-19-contact-tracing-apps/> [Accessed 6 September 2022].

86 Techcrunch.com. 2022. [online] Available at: <https://techcrunch.com/2020/04/06/eu-privacy-experts-push-a-decentralized-approach-to-covid-19-contacts-tracing/> [Accessed 6 September 2022].

87 National COVID-19 contact tracing apps - IPOL | Policy Department for Economic, Scientific and Quality of Life Policies, May 2020; ISBN 978-92-846-6755-0; doi:10.2861/ 808426

88 En.wikipedia.org. 2022. Decentralized Privacy-Preserving Proximity Tracing - Wikipedia. [online] Available at: <https://en.wikipedia.org/wiki/Decentralized_Privacy-Preserving_Proximity_Tracing> [Accessed 6 September 2022].

89 GitHub. 2022. GitHub - TCNCoalition/TCN: Specification and reference implementation of the TCN Protocol for decentralized, privacy-preserving contact tracing. [online] Available at: <https://github.com/TCNCoalition/TCN> [Accessed 6 September 2022]

90 Covid19-static.cdn-apple.com. 2022. [online] Available at: <https://covid19-static.cdn-apple.com/applications/covid19/current/static/contact-tracing/pdf/ExposureNotification-CryptographySpecificationv1.2.pdf> [Accessed 6 September 2022].

91 GitHub. 2022. GitHub - ROBERT-proximity-tracing/documents: Protocol specification, white paper, high level documents, etc. [online] Available at: <https://github.com/ROBERT-proximity-tracing/documents> [Accessed 6 September 2022].

92 En.wikipedia.org. 2022. Pan-European Privacy-Preserving Proximity Tracing - Wikipedia. [online] Available at: <https://en.wikipedia.org/wiki/Pan-European_Privacy-Preserving_Proximity_Tracing> [Accessed 6 September 2022].

93 Bluetrace.io. 2022. [online] Available at: <https://bluetrace.io/static/bluetrace_whitepaper-938063656596c104632def383eb33b3c.pdf> [Accessed 6 September 2022].

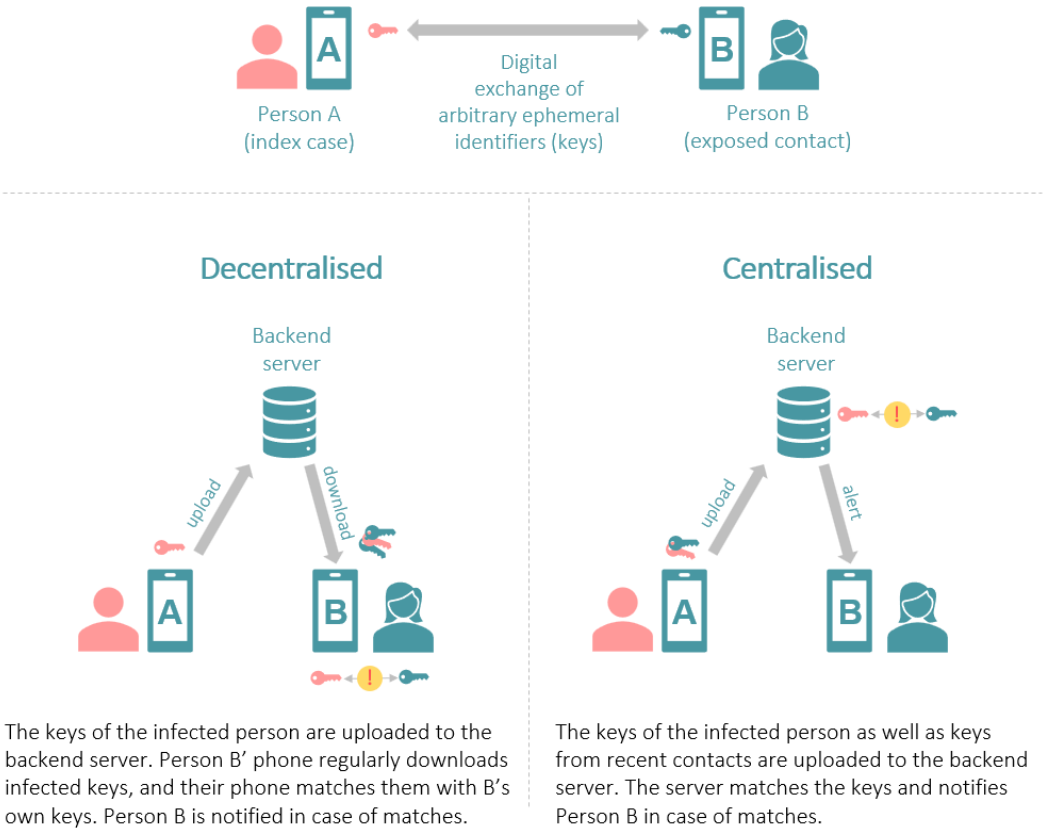


Figure 4. Visualisation of the centralised and decentralised communication protocols

Proponents of the centralised approach are, for example, France and Hungary. The French government favoured the adoption of a centralised approach for its StopCovid (later version renamed to TousAntiCovid) app for several reasons; these can be categorised as efficiency-related reasons (enabling real-time knowledge of the epidemiological situation, monitoring of the number of warnings sent, full control of warning criteria), sovereignty-related reasons (keeping control of citizens' health data and of the technology) and privacy-related considerations (seeking the opinion of the DPA as soon as possible[94])[95].

Opponents of the centralised approach point to risks in enabling a form of government or private sector surveillance that would hamper trust in and acceptance of such an application by society at large. This was, for example, communicated in an open letter[96] from 19 April 2020, signed by 300 leading academics from 27 countries.

Some countries initially opted for a centralised approach in planning their app development, but subsequently adopted a decentralised approach, mainly citing technical reasons, privacy concerns and desire for interoperability with other apps in an EU context:

- Germany: Despite German researchers leading the establishment of a centralised approach with the European Privacy-Preserving Proximity Tracing (PEPP-PT) protocol, the country changed its plan and adopted a decentralised approach, after Apple Inc. in particular refused to change settings to

94 However, similar considerations can also be applied to the decentralised approach.

95 Vincent Roca. From ROBERT to DESIRE exposure notification: situation and lessons learned. Workshop on Security and Privacy in Contact Tracing, Sep 2020, Vienna, Austria. hal-02936838

96 Google Docs. 2022. Joint Statement.pdf. [online] Available at: <https://drive.google.com/file/d/1OQg2dxPu-x-RZzETlpV3lFa259Nrpk1J/view> [Accessed 6 September 2022].

its platform requested by the PEPP-PT consortium[97].

- Italy: Following criticism in the IT community in Italy, as well as desire for greater interoperability, the Italian government adopted a decentralised approach to its Immuni app[98].
- Norway: In June 2020, the Norwegian Smittestopp v1 was shut down by the Norwegian Data Protection Authority (Datatilsynet) due to privacy concerns, specifically regarding the centralised storage of positional data and Bluetooth contacts. Subsequently, Norway developed a new app (Smittestopp v2) based on the GAEN API, which uses a decentralised architecture, and was launched in December 2020.[99,100]

Technologies enabling digital tracing

There are two modern technologies enabling tracing:

- the location determination of an individual device using the GPS signal of the user's device, giving the longitude and latitude coordinates of the device over time
- a measurement of the distance (proximity) to other devices using Bluetooth Low Energy (BLE).

Hybrid apps using both approaches are possible, e.g., the early version of the Care19 app used in North Dakota, USA[101].

Both approaches have technical limitations. Measuring GPS signals with high spatial resolution is difficult indoors so that the app fails in exactly those situations where transmission of the virus is more likely[102].

From a privacy perspective, as GPS enables the disclosure of an individual device location over time, this has potential for the re-identification of that individual. Knowing a short history of someone's whereabouts provides more insight into their private lives than the mere disclosure of anonymous codes that can facilitate a message to users that have been near the infected user[103].

This was a prime reason as to why all EU Member States and ultimately most European countries opted for the BLE-enabled approach. Early versions of the Smittestopp app in Norway included plans for using GPS in addition to BLE, but the final version of the app does not use GPS.

3.7 Integration with public health processes

During a pandemic, several public health processes need to function flawlessly to minimise the spread of the virus, including processes related to prevention, contact tracing, testing, isolation, and the issuing of certificates. Digital contact tracing integration with public health processes allows the digital contact tracing apps to work in coordination with and complement conventional contact tracing processes.

Countries like Germany and Belgium demonstrated excellent examples of such integration. The German app had been continuously updated to connect to around 270 laboratories and up to 20,000 test sites,

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97 2022. [online] Available at: <https://www.reuters.com/article/us-health-coronavirus-europe-tech/germany-flips-on-smartphone-contact-tracing-backs-apple-and-google-idUSKCN22807J> [Accessed 6 September 2022].

98 2022. [online] Available at: <https://bylinetimes.com/2020/05/01/is-it-safe-the-immuni-app-digital-surveillance-during-the-coronavirus-pandemic/> [Accessed 6 September 2022].

99 Meijerink, H., 2021. The First GAEN-Based COVID-19 Contact Tracing App in Norway Identifies 80% of Close Contacts in "Real Life" Scenarios. Frontiers in Digital Health, 3.

100 Digital Health. 2022. Norway forced to backtrack on mass surveillance track and trace app. [online] Available at: <https://www.digitalhealth.net/2020/06/norway-track-and-trace-app/> [Accessed 6 September 2022].

101 Department of Health. 2022. North Dakota announces launch of Care19 Alert app to help reduce spread of COVID-19 as students return. [online] Available at: <https://www.health.nd.gov/news/north-dakota-announces-launch-care19-alert-app-help-reduce-spread-covid-19-students-return> [Accessed 6 September 2022].

102 Hundhammer, K., 2022. Contact tracing apps in the Corona pandemic | bidt. [online] bidt english. Available at: <https://www.bidt.digital/en/blog-contact-tracing-apps/> [Accessed 6 September 2022].

103 Gsma.com. 2022. [online] Available at: <https://www.gsma.com/newsroom/wp-content/uploads/GSMA-Briefing-Paper-Contact-Tracing-Apps.pdf> [Accessed 6 September 2022].

making it possible to directly upload test results into the app. Users could directly access their results and, in case of a positive test result, issue a warning.

Similarly, in the Belgian app, test results could be received in the app with pseudonyms, thus being privacy friendly. In addition, in case of a high-risk contact, it was very easy to get, starting from the app, a code to get a PCR test. Furthermore, a toolbox was later added to the Belgian app that contained links to sites for finding a nearby test centre, accessing vaccination information, a link to reserve a test, a link to , obtain a quarantine certificate, and a link to accessing a passenger locator form for travel. Ireland, France, Italy, Slovenia, and Germany all opted to integrate the EU Digital COVID Certificates with their contact tracing apps.

Another example of a highly integrated contact tracing app is represented by the NHS COVID-19 app, which allowed users to book tests and directly receive test results. Further features to support public health included symptom tracking and reporting, storing digital covid certificates in the app, and issuing self-isolation certificates, etc. An overview of additional functionalities is provided in section 3.8.

Estonia has a national e-Health platform that collected all PCR results for COVID-19 which included results from both private and public clinics. The process was automated and created a database of all infections. However, for ethical, data protection related and security reasons, no automatic notification mechanism was implemented. Instead, the Estonian app HOIA had a mechanism that allowed users to prove their identity to the backend using their national electronic identity. This made the infection confirmation available to all users with no extra effort, and everyone who was tested was eligible for confirming their infection. Later, this mechanism was also extended to allow for confirmation of infections for people who have caretakers, e.g., children. Several countries reported in the study survey to have no integration or poor alignment between manual and digital contact tracing processes, although they strongly agreed that the integration of digital contact tracing with manual contact tracing is of importance. Some countries reported that the automation of issuing COVID codes to warn high risk contacts within the app from the start would have decreased the workload for contact tracers and health care professionals within their municipalities.

3.8 Additional app functionalities

Most contact tracing apps were originally designed as “silent apps” that run in the background and alert users in case they have been in contact with persons who have tested positive for the coronavirus or alert others in case they themselves test positive. Later in the process some governments started considering adding extended functionalities, due to different reasons e.g., to increase user interaction, promote usage, support public health processes, etc. The additional functionalities included symptoms tracking, vaccination statistics, displaying additional information related to the epidemiological situation and related travel restrictions, integration with vaccine or test certificates, as well as check-in functions with QR codes, self-isolation countdowns and the issuance of self-isolation certificates. An overview of the different functionalities of contact tracing apps in the countries examined in the study is provided further below.

The Stopp Corona App (Austria), TousAnticovid (France), Corona-Warn-App (Germany), COVID Tracker (Ireland), COVIDAlert (Malta), STOP COVID (Croatia) and NHS COVID-19 (UK – England and Wales) have an integrated symptom tracking. The Finnish Koronavilkku had integration to a service for digital symptom assessment called Omaolo. The Irish “COVID Tracker” app allows citizens to record their daily state of health and check their symptoms with the help of the “Corona Check-In” function. Users are given two options (“I’m good, no symptoms” or “I’m not feeling well today”), and, in case of illness, they receive further information about the most common symptoms of the COVID-19 infection and health

advice. These daily check-ins are stored anonymously for 28 days[104]. Germany uses the additional information collected on symptoms to improve the app's risk calculation[105]. The Austrian app offers further the possibility to report the suspicion of COVID-19 symptoms through a "symptom check"[106]. In this process, the user needs to answer four decision questions on possible symptoms. Depending on the answer given, the user's contacts (determined by the app algorithm) are warned in case of suspicion of infection. If the test is subsequently negative, an all-clear can also be sent out. In addition, several apps (Cyprus, France, Lithuania, Malta, the Netherlands, and Switzerland) give citizens direct access to a call centre via a call button.

Most apps display additional statistical information, such as vaccination statistics, epidemiological figures, and statistics on users of the app. However, while epidemiological and vaccination statistics are provided by several apps, only a few countries (Germany, Ireland, Spain, and Switzerland) offer the possibility to retrieve app statistics from users through the app (e.g., the number of infected users reported through the app or the number of active users). Additionally, Poland's app offers information on travel restrictions.

A few apps offer the possibility to check in via QR-code (France, Germany, Switzerland, and the UK) or to create a QR-code for an event (Germany, Switzerland, and the UK). In Germany, the check-in data is stored locally on the smartphone for 14 days[107]. If the test result is positive, the check-in data and anonymous IDs are sent to the central server of the Corona-Warn-App and are transmitted to smartphones with an activated Corona-Warn-App. In case of matching, the persons concerned are warned.

The apps from England, Wales, Scotland, and Northern Ireland include a self-isolation countdown. Furthermore, the apps of the latter two offer the possibility to issue a self-isolation certificate that can be submitted to employers and local authorities.

The German and Belgian apps offer the possibility of retrieving test results in the app. The England and Wales app include the unique feature of both booking a test and receiving test results in the app.

On 1 July 2021, the digital COVID certificate (digital document proving that citizens have either been vaccinated against COVID-19, recovered from COVID-19, or tested negative via an official antigen or PCR test) was introduced in the EU[108]. France, Germany, Ireland, Slovenia, and Italy chose to support the digital COVID certificate in their respective apps. The certificate is loaded into the app via a QR code (Germany, France, Ireland) or an 8-digit code (Italy). Users can add their digital vaccination certificate in the app, which allows them to show their vaccination status digitally via QR code[109]. Most countries have opted for a separate app to display the digital COVID certificate, motivated under the fact that for the certificate personal data is being processed by the DCC[110].

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104 Www2.hse.ie. 2022. Tracking your symptoms. [online] Available at: <https://www2.hse.ie/services/covid-tracker-app/tracking-your-symptoms.html> [Accessed 6 September 2022].

105 Deutscher Ärzteverlag GmbH, R., 2022. Corona-Warn-App wird um Symptometagebuch erweitert. [online] Deutsches Ärzteblatt. Available at: <https://www.aerzteblatt.de/nachrichten/117492/Corona-Warn-App-wird-um-Symptometagebuch-erweitert> [Accessed 6 September 2022].

106 DER STANDARD. 2022. Welche Neugerungen die "Stopp Corona"-App ab Donnerstag erhält. [online] Available at: <https://www.derstandard.de/story/2000116605458/stopp-corona-welche-neugerungen-die-app-ab-donnerstag-erhaelt> [Accessed 6 September 2022].

107 Verbraucherzentrale.de. 2022. Corona-Warn-App: Fragen und Antworten zur deutschen Tracing-App | Verbraucherzentrale.de. [online] Available at: <https://www.verbraucherzentrale.de/wissen/digitale-welt/apps-und-software/coronawarnapp-fragen-und-antworten-zur-deutschen-tracingapp-47466> [Accessed 6 September 2022].

108 European Commission - European Commission. 2022. EU Digital COVID Certificate. [online] Available at: <https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/safe-covid-19-vaccines-europeans/eu-digital-covid-certificate_en> [Accessed 6 September 2022].

109 2022. [online] Available at: <https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/WarnApp/Uebersicht-Versionen.html;jsessionid=BC5112B56A7C0D1513069D37416723D6.internet112?nn=13490888#doc16718622bodyText16> [Accessed 6 September 2022].

110 Covidsafe. 2022. Frequently Asked Questions. [online] Available at: <https://covidsafe.be/en/frequently-asked-questions#why-have-you-created-another-app-in-addition-to-the-coronalert-app> [Accessed 6 September 2022].

Table 7. Overview of app functionalities

App name and country / Functionality	Stopp Corona App	Coronalert	Stop COVID-19	CovTracer	eRouska	Smittestop	HOIA	Koronavilkku	TousAntiCovid	Corona-Warn-App	VirusRadar	COVID Tracker	Immuni	Apturi Covid	Korona Stop LT*	COVIDAlert	CoronaMelder	Smittestopp	ProteGO Safe	StayAway COVID	#OstaniZdrav	Radar Covid	Rakning C-19	SwissCovid	NHS COVID-19	StopCOVID-NI	Protect Scotland
Symptom tracker	✓			✓					✓	✓		✓				✓			✓						✓		
Report suspicion of symptoms																									✓		
Notify contacts when positive	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diary/Journal	✓									✓									✓		✓	✓					
Share app to social media platforms	✓	✓							✓	✓			✓	✓			✓			✓		✓		✓			
In-app COVID-19 related statistics		✓		✓		✓		✓	✓	✓		✓		✓		✓		✓	✓					✓			
Vaccination statistics		✓				✓			✓	✓		✓						✓	✓								
Statistics on app use										✓		✓										✓		✓			
Information on travel restrictions																			✓								
Manage vaccine/test certificates									✓	✓		✓	✓								✓						
Navigate to external resources		✓					✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓		
Call button to a call centre				✓					✓						✓	✓	✓							✓			
Check-in with QR codes									✓	✓											✓			✓	✓		
Venues/check-in history									✓	✓											✓			✓	✓		
Create QR codes for events										✓											✓			✓	✓		
Receive test results in the app		✓								✓															✓		
Book tests in the app																									✓		
Self-isolation countdown												✓													✓	✓	
Self-isolation certificate																										✓	✓

An interesting development in some countries was the possibility of registering a positive self-test via the CTA. In Norway, citizens can register positive self-test results on the webpages of the municipalities. However, the self-tests cannot be used as recovery certificate, nor are self-tests reported to MSIS (the Norwegian Surveillance System for Communicable Diseases)[111].

3.9 Promotional activities

To enhance the uptake of the digital contact tracing apps, many countries publicised their benefits by using standard promotional tools. In addition to advertising the app, this promotion was also used as an opportunity to raise public awareness about privacy, data protection and digital healthcare. In some cases, reduced uptake of digital contact tracing apps was improved by launching renewed promotional campaigns and incorporating new advertising strategies. Examples of promotional activities derived from the desk research and the survey results are given below.

Early promotional activities

Finland started the promotion of the contact tracing app while the app was still in the development phase by organising webinars and publishing reports on the topic.

Initial launch advertisement

For most countries including Germany, France, Belgium, Netherlands, Malta, Lithuania, Republic of Cyprus, Estonia, Ireland, Slovenia, and Portugal, the largest promotional effort regarding the app happened around the initial launch, with advertising campaigns incorporating social media, TV, radio, newspaper coverage and press conferences for medical professionals.

Countries like Finland, Ireland, and Estonia approached advertising the app as a part of a bigger strategy to fight the pandemic. For example, the Finnish app Koronavilkku was one of the five elements in a massive multi-lingual campaign (Finnish, Swedish and English) for educating people about the key means to prevent infections. During the first 24 hours Koronavilkku was downloaded by a million phones[112]. Likewise, the Estonian app was reportedly included in the "standard COVID-19 package" by the national communication organisation and promoted in several languages.

Examples of key topics and messages used in the promotional campaigns

The promotional messages in the Netherlands focused on the fact that by downloading the app, citizens protect those around them.

Malta focused on calls to action to download the application, to learn about the app features and to understand the policies that govern the use of the app.

France secured the involvement of high-level political persons to serve as a positive example (using the app publicly).

A few countries utilised social media in a different way. For example, Belgium involved influencers to advertise the positive aspects of using the app. In other countries, key national figures like Mika Salminen, Director of Health Security at the Finnish Institute for Health and Welfare and politicians at presidential and ministerial level from Germany and France were active in the news and media sharing

111 Helsenorge.no. 2022. Self-test for the coronavirus. [online] Available at: <https://www.helsenorge.no/en/coronavirus/testing-for-koronavirus/selvtest/> [Accessed 6 September 2022].

112 News. 2022. Coronavirus app downloads quickly reach 1 million. [online] Available at: <https://yle.fi/news/3-11521081> [Accessed 6 September 2022].

information of digital contact tracing apps at the time of the launch.

Involving a wide range of organisations and channels

Additional promotional approaches reported by countries via the survey involved branching out to organisations through diverse channels. For example, in the Republic of Cyprus informational banners were used in airports and hospitals. In Malta, the Republic of Cyprus, France and the Czech Republic the government worked with mobile phone operators to mass broadcast SMS messages to citizens with a link to download the app. In Finland specifically, the mobile phone operators cooperated pro-bono.

In general, countries aimed at the widest promotion possible. In Belgium, the football league, the railway company, public bus companies and the tech sector were all engaged in promoting the app.

Homepage and websites

Almost all countries set up an official website for the app which included detailed information about the app and a Frequently Asked Questions (FAQ) section for the app's users. These websites communicated the importance of digital contact tracing with clear calls to action to download and use the app. In many cases, a dedicated section aimed at informing the public about the privacy and data protection measures was also available.

Renewed and Intermediate promotional campaign

It was observed that the intensity of promotional efforts diminished over time. The survey respondent in Belgium reported that, because of a limited budget, there was no sustained advertising support after the launch. In addition to budgetary restrictions, they also reported over time the media become very critical and focused mostly on reporting the few technical glitches that are typical for such projects. This was counterproductive to the government's promotional efforts.

A similar trend was reported in the Netherlands due to a lack of clear, consistent, continued promotional efforts which were integrated with the overall COVID-19 national strategy. In some countries, the promotion of the contact tracing app was significantly reduced or even discontinued when the promotion campaigns for vaccinations started.

Proactively addressing concerns related to privacy and security – An example by Finland

As one way of reducing citizens' concerns related to the privacy and security of the Koronavilkku app, the Finnish government applied for and was awarded the Cybersecurity Label by the Finnish Transport and Communications Agency Traficom[113]. The Cybersecurity Label lets consumers know that the labelled devices and applications meet basic information security standards. Traficom awards the label to applications and connected smart devices that meet the certification criteria.

Incentives for using the apps

To increase the uptake of contact tracing apps, several countries added new functionalities to the apps. Such as integrating statistics, the EU Digital COVID Certificate and many others (see previous section). Establishing a link between the app's risk warnings and eligibility for free tests was another way of increasing interest in the app. Germany and France reported such practices at specific times during the pandemic.

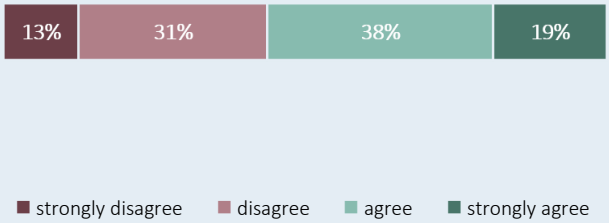
[113] Traficom. 2022. Finnish Transport and Communications Agency Traficom Awards Cybersecurity Label to Contact Tracing App Koronavilkku | Traficom. [online] Available at: <https://www.traficom.fi/en/news/finnish-transport-and-communications-agency-traficom-awards-cybersecurity-label-contact> [Accessed 6 September 2022].

Despite all the promotional efforts, almost every second country that responded to the study survey pointed out that national level efforts were sometimes insufficient to ensure the app is taken up by the population.

Survey insights: promotional activities' effectiveness at national level

Among the "missed opportunities" countries reported dedicated budget for national promotional activity, continuous and complementary communication messages alongside other measures like vaccinations, including mentioning the app when communicating with citizens via manual contact tracing.

Sufficient promotional activities were carried out to ensure the app is taken up by the population.



Based on responses by 16 countries.

4 Cross-border coordination and collaboration on digital contact tracing

The pace at which the apps across Europe were developed and deployed was facilitated by focused pan-European collaboration and large-scale networking which enabled the swift development of digital contact tracing. The European Commission worked together with Member States to ensure a common approach to contact tracing, delineating technical, legal, organisational, and epidemiological aspects.

4.1 Collaboration set-up and mode of work

To enable Member States and the European Commission to develop rapidly new solutions in the pandemic, new coordination and collaboration mechanisms were set up under the eHealth Network. Established under the cross-border healthcare Directive 2011/24/EU (Art. 14) to connect national eHealth authorities, the voluntary eHealth Network (eHN) supports Member States in developing common guidelines and measures for health data and their use, enabling cross-border transferability of information[114]. To enable a quick and informed response to the pandemic, supported by digital solutions, the eHealth Network formed dedicated in April 2020 COVID-19 working groups of Member State level experts covering technical, public health, organisational and legal matters. Wherever necessary, the groups have been supported by additional external experts.

The urgency of the pandemic necessitated that these groups convened much more intensively than other eHealth Network subgroups in the past and that solutions and approaches were quickly agreed to under significant time pressure. In the beginning, the different groups were convened weekly and in certain circumstances also ad-hoc with additional meetings several times per week to coordinate and agree on the different aspects linked to the development of warning apps.

Two permanent working groups of the eHealth Network monitor operations on the EU level of the digital contact tracing infrastructure:

- A technical working group dedicated to contact tracing apps and the European Federation Gateway Service (EFGS)
- A working group of the joint controllers of the EFGS (see section 4.3)

With time, the frequency of the official meetings of the two groups was gradually reduced. Since March 2022, the two groups are convened monthly as a joint group. They focus mainly on the monitoring and reporting of operations of the EFGS, as well as the state of play of mobile contact tracing applications in the participating countries.

This was a rather new way of working in terms of flexibility and intensity. As a result, Member State participation in the eHN and their interaction with its technical working groups has influenced subsequent national-level app developments, as described in the dedicated sections that follow.

Member States' feedback and lessons learnt

As part of the study survey Member States were invited to reflect on this mode of collaboration.

All Member States agree that the development of recommendations and guidance by EC for Member States, and exchange of experience and expertise have been greatly facilitated by the eHealth Network and dedicated technical working group meetings. The reported benefits include the close exchange on

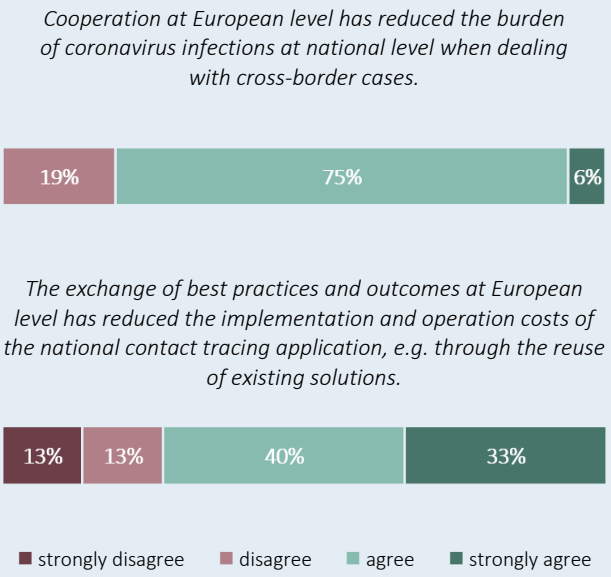
[114] European Parliament. (2011). Directive 2011/24/EU of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare. Official Journal of the European Union, L 88/45. [pdf] Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:088:0045:0065:en:PDF

technical issues related to the apps, peer support, and learning from the insights, practices and experiences of others; In some countries, such as in Cyprus, it has influenced national decisions and communication strategies. Specific examples of exchange of information included Member State experiences with different Bluetooth signal strength, as well as calibration settings of the GAEN framework.

Survey insights: reflection on the EU cooperation and exchange of practices

There is strong agreement among Member States that the EU cooperation through the different working groups on contact tracing has helped reducing the burden of cross-border infection detection.

In addition, for more than 70% of Member States the app implementation and operation costs have been reduced, through the exchange of practices and sharing of insights. Finland, for example, reported decreased costs, speed-up development and eased problem solving as positive effects.



Based on responses by 16 Member States.

- Difficulties in discerning the responsibilities of the different groups
- Inefficiencies, e.g., topics being discussed and being repeatedly present in the agenda of meetings for extended periods of time
- Participation limited to EU and EEA countries. In the case of Switzerland, for example, Swiss experts were invited as technical experts representing a Member State.

In addition, it was pointed out that a vital part of cooperation at European level is the use of communication platforms, such as the Early Warning Response System of the European Union (EWRS), which is a tool with restricted access (for the ECDC, the EU Member States and the Directorate General Health and Food Safety – SANTE) for monitoring public health threats in the EU[115, 116].

Modularity and configurability were mentioned by several Member States when reflecting on the areas that the working groups could explore further (- digital contact tracing has to be flexible and modular to adapt to developing insights). Examples for flexibility are a possible extension to presence detection or a shift to open access proximity tracing, i.e., moving away from the GAEN framework and relying on open access frameworks and protocols that are highly configurable, such as the Open Tracing[117] protocol and the Herald API[118] for proximity tracing.

The position of the EU and approach in relation to the rest of the world was also discussed by several Member States. Reflections included discussions on the possibility of an EU-level solution, which, had it been implemented, would have raised the EU's technical profile and negotiation capacity with Google and Apple; allowing for better interoperability, shared consensus on parameters, stronger integration

115 DECISION No 1082/2013/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 October 2013 on serious cross-border threats to health and repealing Decision No 2119/98/EC. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013D1082

116 Explanatory Memorandum to COM (2015) 617 - Report on the implementation of Decision 1082/2013/EU on serious cross-border threats to health. Available at: https://www.eumonitor.eu/9353000/1/j4nvhdfdk3hydzq_j9vvik7m1c3gyxp/vk0j5z2vhfvf

117 The OpenTracing project. (2022). Retrieved 6 September 2022, from https://opentracing.io/

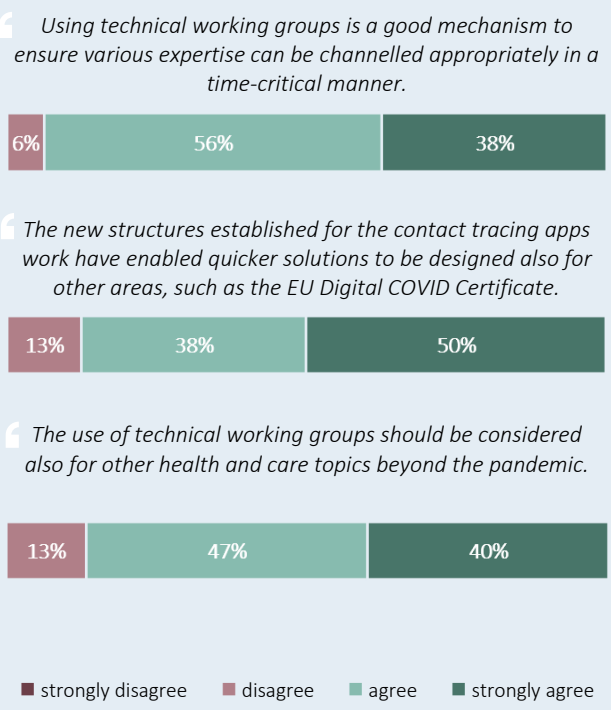
118 Herald and Contact Tracing. (2022). Retrieved 6 September 2022, from https://heraldprox.io/applications/ct

with a shared code base, and modular interfaces to health infrastructures. Such an approach, however, would require for some well-known digital health challenges to be solved first, including language issues across Member States and enabling connectivity with public health systems and services. The path taken in the EU with national apps, the majority of which are connected for cross-border detection of infections, is nevertheless a fascinating case worldwide. Member State experts active in the field reported that other countries such as Canada, Japan, the US, and South Korea showed a high interest in learning about the EU approach.

Looking forward, respondents to the survey agree that the set-up used for digital contact tracing is effective and should be considered in other scenarios.

Survey insights: Using technical working groups

Member States broadly agree that technical working groups as used within the eHealth Network should be used for other health issues that require interoperability, incorporating the lessons learnt and practices of other areas such groups have been used for, including the European Federation Gateway Service and the EU Digital COVID Certificates. However, it should be noted that such groups require a compromise by Member States in ensuring that their national bodies have the capacity to participate in various groups. Creation of groups should therefore be carefully considered so as to avoid a national team's burden over wider European agenda topics vis-à-vis national responsibilities.



Based on responses by 16 Member States.

4.2 Adopting a common EU Toolbox for mobile applications to combat the pandemic

In order to harness the full potential of privacy-enhancing digital contact tracing systems across borders, the European Commission Recommendation C(2020)2296, adopted on 8 April 2020, called for a common coordinated pan-European approach that supported national public health authorities in combating the COVID-19 pandemic[119]. Following the Commission Recommendation, EU Member States participating in the eHealth Network adopted a common EU Toolbox[120] to use mobile applications for contact tracing and warning in response to the pandemic on 15 April 2020. The requirements and functionalities for a common pan-European approach as set out in the Toolbox were grouped into four components, based on information and best practices shared by countries within the eHealth

[119] European Commission. (2020). Commission Recommendation of 8.4.2020 on a common Union toolbox for the use of technology and data to combat and exit from the COVID-19 crisis, in particular concerning mobile applications and the use of anonymised mobility data. C(2020)2296 final. [pdf] Available at: https://ec.europa.eu/info/sites/default/files/recommendation_on_apps_for_contact_tracing_4.pdf

[120] eHealth Network. (2020). Mobile applications to support contact tracing in the EU's fight against COVID-19. Common EU Toolbox for Member States. Version 1.0. [pdf] Available at: https://ec.europa.eu/health/sites/health/files/ehealth/docs/covid-19_apps_en.pdf

Network[121]:

- Essential requirements for national apps and cross-border interoperability (epidemiologic framework, technical functionalities, cross-border interoperability requirements, cybersecurity, safeguards)
- Accessibility and inclusiveness
- Governance and approval of tracing apps
- Supporting actions (sharing of epidemiological information, monitoring effectiveness, preventing proliferation of harmful apps).

The Toolbox focused on establishing a coherent coordination approach for the Member States and the Commission in relation to the development and use of COVID-19 related mobile apps.

Member States' feedback and lessons learnt

All Member States which responded to the study survey reported that in their view, the EU toolbox provided valuable guidance for them to ensure that key common principles for contact tracing apps were followed. Likewise, all responding Member States confirmed that the EU toolbox and the work around developing it with experts was key in ensuring a harmonised approach, especially at a time when multiple technological implementations were being considered (e.g., communication protocols) which needed to be appraised and agreed upon.

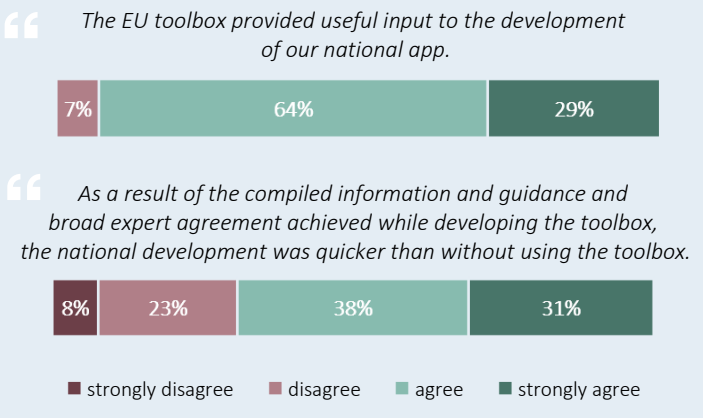
Member States reported various benefits from the EU Toolbox, including a simplified process of developing national apps (incl. technical support), a clear common understanding of the context and key terms, and consensus building around some technologies (e.g., decision on not using GPS-based solutions due to privacy issues). The guidance on cross-border interoperability, cybersecurity, and other safeguards addressed in the toolbox was especially welcomed by Member States. Overall, the toolbox proved to be a valuable reference document that made it possible to build a strong use case for contact tracing apps.

Member States were specifically asked to reflect on whether the EU toolbox provided useful input for the development of their national app, as well as whether the development at a national level had been influenced by the toolbox.

Survey insights: impact of the EU toolbox on Member States' digital contact tracing app development

Most Member States confirmed the importance of the toolbox in providing useful input to the development of their national apps.

At least 7 Member States reported that the use of the toolbox resulted in quicker development of the app.



Based on responses by 14 Member States.

In some cases, such as for the Republic of Cyprus' app, the development was largely based on the open-source solutions by the German app's back-end; similarly, the Slovenian and the Lithuanian apps were

[121] eHealth Network. (2020). Mobile applications to support contact tracing in the EU's fight against COVID-19. Common EU Toolbox for Member States. Version 1.0. [pdf] Available at: https://ec.europa.eu/health/sites/health/files/ehealth/docs/covid-19_apps_en.pdf

also based on the German one as was the mobile app solution of the PathCheck Foundation, a volunteer-led non-profit organisation that developed COVID-19 apps for digital contact tracing, founded in February 2020 at MIT. Nevertheless, the Cypriot app benefitted from the toolbox guidance especially in the areas of cybersecurity and cross-border interoperability. Several other Member States also based their app development on existing open-source projects and adapted them to their own public health procedures, allowing for quicker development.

Most Member States reported that the toolbox covers all currently relevant aspects of contact tracing apps which should be taken into consideration. Several Member States also reported areas for improvement, which include:

- Clearer discussions on the implications of using different communication protocols: while two main approaches emerged early on in the pandemic (decentralised vs. centralised architectures, see section 3.6), the approaches were presented in the toolbox as compatible. However, only through deeper analysis later in the pandemic could it be ascertained that the approaches are in fact not compatible, e.g. for connecting to the EFGS.
- Keeping the toolbox up to date to reflect the evolving situation during the pandemic. Member States pointed to several areas that could be updated or to new aspects that could be added to enrich the toolbox, including:
    - an update following the issuing of the Google/Apple API
    - addition of new app features, e.g., for harmonised event registration and presence tracing based on QR-codes
    - guidance about integration with the national public health and tracing ecosystem (e.g., guidelines for interacting with the various health system touchpoints, such as lab tests, hospitals, call centres, conventional tracing teams)
    - addition of risk estimation covering also the latest and most widely spread virus variants
    - reflection on and possibly guidance on the addition of results from self-tests natively to the apps, enabling a common approach for how and if to register positive results diagnosed in another Member State
    - a discussion on which metrics were useful in collecting EU wide data and helping Member States to collect that data early on in a uniform way, as well as guidance on privacy-preserving analytics
    - A possible extension going beyond proximity tracing: one Member State pointed out that as soon as it was discovered that aerosols play a crucial role in transmission of the virus, the role of “presence tracing” should have been discussed and possibly added to the digital contact tracing and warning solutions provided in a privacy-friendly way. This mode of contact tracing was analysed by the technical working group as a possible extension to the national apps. However, while originally interest was high, very few development teams ended up working on such feature.

4.3 Deploying an EU cross-border infrastructure for contact tracing apps communication

An important principle of the common EU approach is that citizens should be able to rely on a single contact tracing and warning app when travelling within the EU. Based on the interoperability between the different apps and between the Member States, as manual contact tracing cannot account for cross-border infections. To ensure cross-border interoperability between national app back-ends and to facilitate continuous contact tracing, Member States supported by the European Commission have set up a new EU-wide interface, the European Federation Gateway Service (EFGS), in October 2020. It was set up in response to Commission Implementing Decision (EU) 2020/1023 of 15 July 2020 amending Implementing Decision (EU) 2019/1765 which refers to the cross-border exchange of data between national contact tracing and warning mobile applications as regards the COVID-19 pandemic.

The EFGS builds on the guidance of the Toolbox wherein eight interoperability guidelines were defined, interoperability needs and main challenges were explained, and a table of illustrative user stories was included[122],[123]. Both the European Commission and the eHealth Network guidelines are not legally binding but serve as important recommendations.

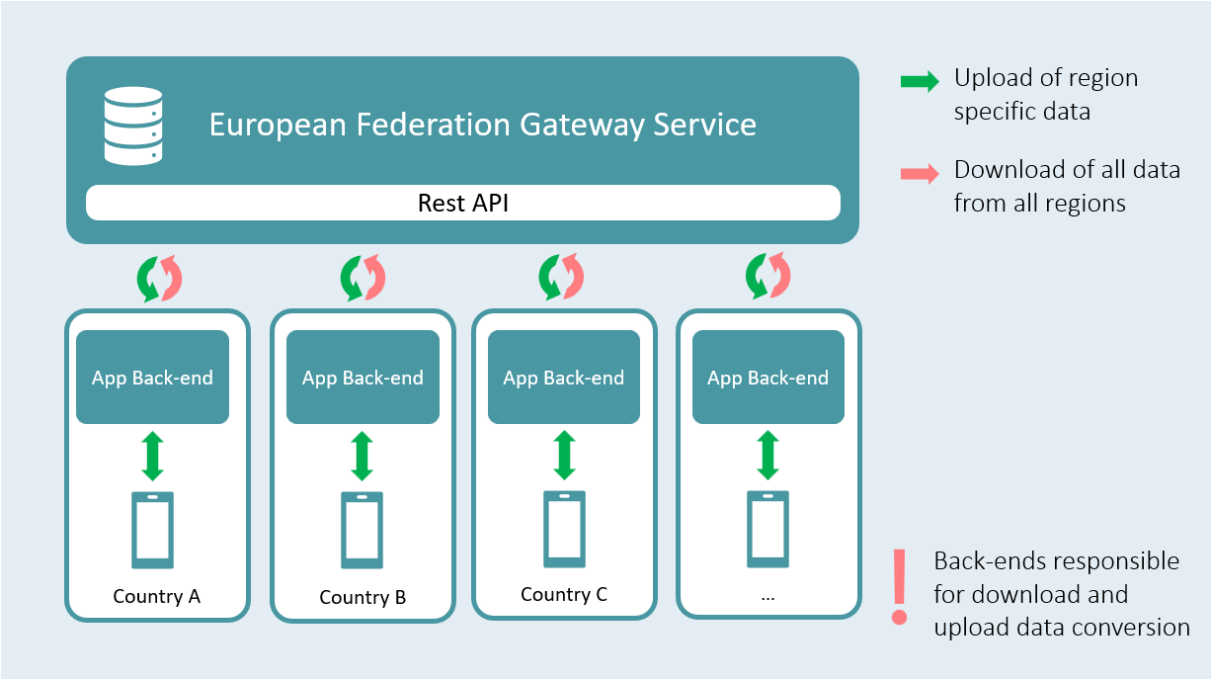


Figure 5. Federation Gateway Service Overview. Adapted from: eHealth Network (2020)[124]

The EFGS facilitates the exchange of information from national decentralised contact tracing applications, keeping data volumes to the necessary minimum. Competent authorities of countries who have linked their national back-ends to the EFGS jointly control the processing of encrypted personal data on the diagnosis key and the visited country, which is temporarily stored in the Gateway for a maximum of 3 days. If two citizens from different countries are using such apps connected to the EFGS, the framework detects proximity and duration of the contact in a non-traceable manner on both devices.

Use cases

Two scenarios detailed in the DPIA report of the EFGS illustrate the typical use cases that are addressed through the EFGS and are presented in the box below.

[122] eHealth Network. Towards a common approach for the use of anonymised and aggregated mobility data for modelling the diffusion of COVID-19, and optimising the effectiveness of response measures. Version 4.3 Available at: https://health.ec.europa.eu/system/files/2020-07/modelling_mobilitydata_en_0.pdf

[123] eHealth Network. Interoperability guidelines for approved contact tracing mobile applications in the EU. Available at: https://health.ec.europa.eu/system/files/2020-05/contacttracing_mobileapps_guidelines_en_2.pdf

[124] eHealth Network. (2020). eHealth Network Guidelines to the EU Member States and the European Commission on Interoperability specifications for cross-border transmission chains between approved apps – Basic interoperability elements between COVID+ Keys driven solutions. Version 1.0. [pdf] Available at: https://ec.europa.eu/health/sites/default/files/ehealth/docs/mobileapps_interoperabilityspecs_en.pdf

EFGS use cases

1. A citizen travels from MS A to MS B. Several days later, the citizen tests positive and wants to warn the citizens of MS B. Through the app the citizen can upload the related Temporary Exposure Keys (TEK, henceforth referred to as diagnosis keys) and can voluntarily add as "country of interest" the MS B. The information about the "countries of interest" is attached to the diagnosis keys and sent to the national back-end. The back-end also adds the information "country of origin" to the keys and forwards it to the EFGS. The EFGS provides the keys of the last 14 days of all participating countries for download to the connected national back-ends. By the information "country of interest" the back-end of MS B knows that these diagnosis keys must be made available to all users of its country. They are therefore made available for download together with the national diagnosis codes. All other MSs recognise by means of the "country of origin" from which country the keys come and make them available for download to their users in their national back-end, sorted by origin.

2. A citizen living in MS A is interested to receive notifications from other countries, e.g., because the citizen lives in a large city with many tourists and is concerned that they may have had contact with a person who was tested positive but who is a foreigner and uses their own national app (MS B). The citizen from MS A can indicate in the app which countries are of interest for the diagnosis keys by choosing the "countries of interest". The national back-end creates a folder for the keys of each participating MS by the information "country of origin" and makes the keys available. The national app makes a request to the back-end and downloads the keys the user is interested in. The ENF (Exposure Notification Framework) that runs on the mobile device then compares whether the user had a contact at risk with the owner of one of the downloaded keys.

Source: EFGS DPIA report[125]

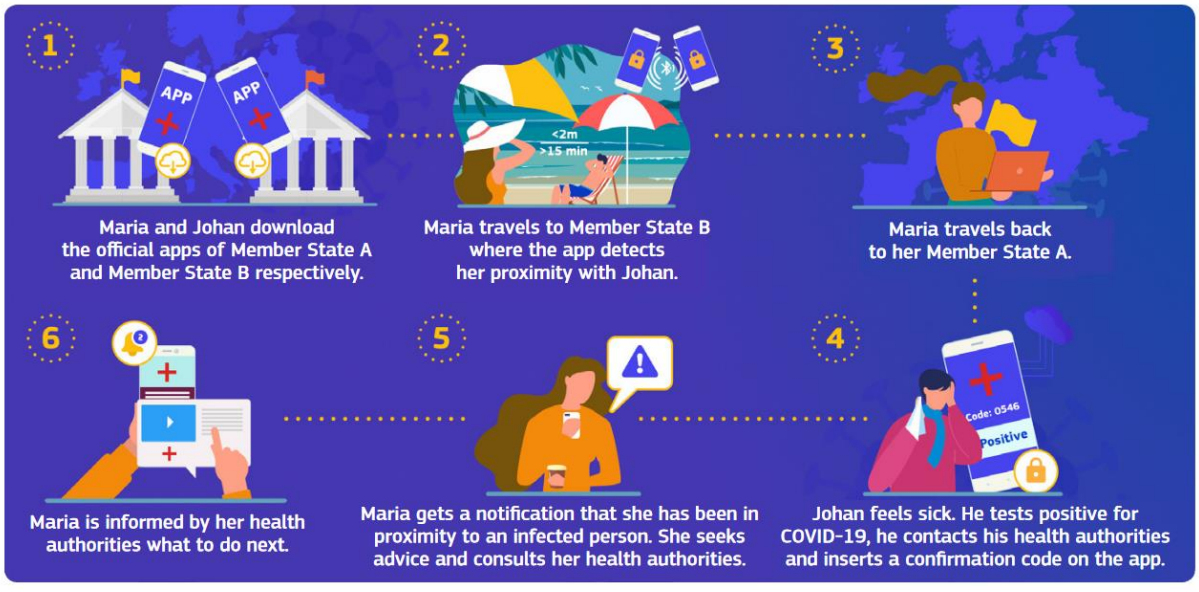


Figure 6. Visual explaining the functioning of the EFGS from a user perspective[126]

Set-up and operation

Due to the architecture of the EFGS, the user cannot restrict sharing to certain MS. All connected MS

[125] "Information from the processor to the joint controllers regarding the European Federation Gateway Service for the purpose of their Data Protection Impact Assessments – DPIA draft" created by SAP SE and T-Systems International GmbH for the European Commission, with the latest public version 1.4 made available on 7 October 2020. [online] Available at: https://ec.europa.eu/health/system/files/2020-12/efgs_dpia_en_0.pdf

[126] European Commission. (2020). EU interoperability gateway for tracing and warning apps. Retrieved 6 September 2022, from https://ec.europa.eu/commission/presscorner/detail/en/fs_20_1943

upload their new diagnosis keys (upload keys) daily to the EFGS which stores the keys and provides them for download (download keys) to the national back-ends, which in turn download, on a daily basis, all available diagnosis keys from all MS which are connected to the EFGS.

The EFGS was developed by SAP SE and T-Systems International GmbH and has been operational since October 2020. It provides four interfaces: downloading diagnosis keys, uploading diagnosis keys, call-back if new keys are available, as well as an auditing interface[127].

The DPIA report for the EFGS provides details about the processing of personal information through the EFGS as well as the privacy, security and ethical safeguards implemented.

Participating countries

Countries interested to connect to the EFGS go through an on-boarding procedure, consisting of a formal application providing details such as the responsible joint controllers, privacy notice and legal bases for processing personal data in the EFGS, technical adherence to the API of the EFGS. An EFGS Service Desk is available to support countries in the connection process.

At its peak use, a total of 19 countries were connected to the EFGS. Despite the aim of connecting as many countries as possible, the EFGS was ultimately limited to EU countries with decentralised national apps. The 19 countries thus represent 95% of all countries that are eligible for connecting (i.e., they are a Member State with a national CTA that uses a decentralised architecture). Portugal cited technical and societal aspects (i.e., the lack of societal confidence in the app's efficiency and effectiveness) as the main reasons for not connecting to the EFGS.

The agreement of the 19 Member States to participate in the EFGS as an EU cross-border infrastructure was achieved in a timely manner due to the pressure on Member States put forth by the pandemic, building on the existing set-up with the eHN working groups. It was also achieved without the need for a specific regulation, as opposed to subsequent developments such as the common EU Digital COVID Certificate, which was enacted via a dedicated regulation.

The modalities for processing the data in the EFGS were defined through an amendment of the Cross-Border Healthcare Directive (2011/EU/24). However, despite great interest from countries like Switzerland, the scope of application of the EFGS was limited to the EU and EEA countries.

An overview of EFGS connected countries is provided in the figure below:

[127] eHealth Network. (2020). eHealth Network Guidelines to the EU Member States and the European Commission on Interoperability specifications for cross-border transmission chains between approved apps – Detailed interoperability elements between COVID+ Keys driven solutions. Version 1.0. [pdf] Available at: mobileapps_interoperabilitydetailedelements_en.pdf (europa.eu)

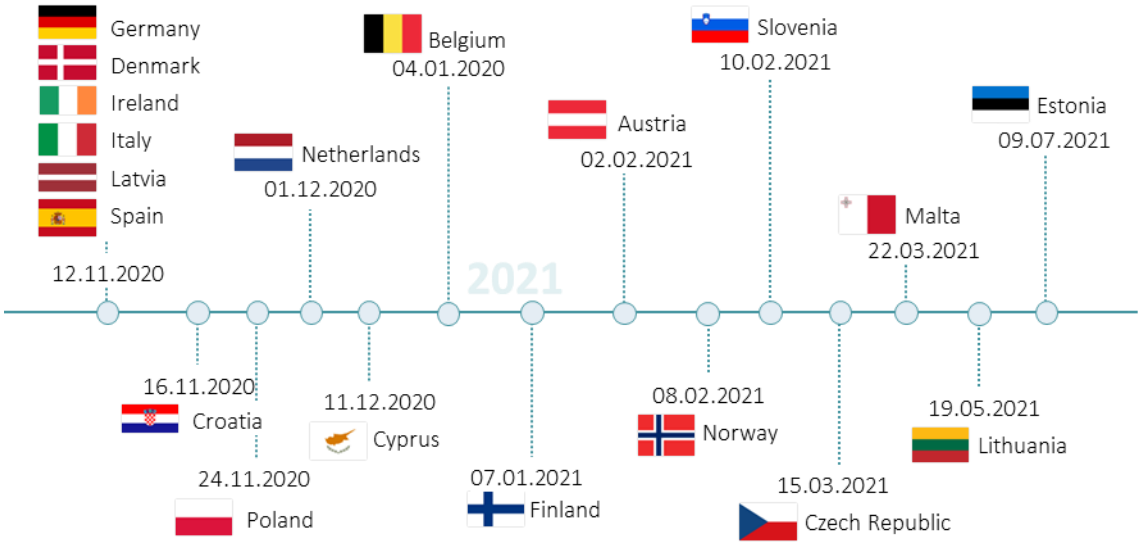


Figure 7. Timeline of countries' participation in the EFGS

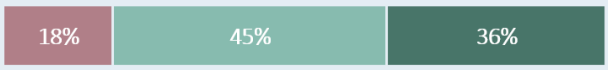
As part of the study's survey, Member States were asked to reflect on the EFGS role as well as the related processes.

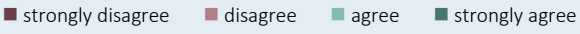
Survey insights: role of the EFGS and onboarding experience

Most Member States agree that the EFGS is a valuable tool in support of cross-border contact tracing. Member States with reservations point to the inability to determine its exact effect on braking infection chains, which is linked to the privacy-preserving choices made in the apps' development. Regarding the onboarding, two Member States reported lack of documentation[128] and a delay in the connection due to negative onboarding experiences.

The EFGS is a valuable tool for tracing contacts across borders to support the freedom of movement of people.

The onboarding process was well organised and there was adequate continuous technical support.





Based on responses by 11 Member States.

Connection status

As the pandemic evolved, some countries have decided to suspend their participation and either have or are in the process of offboarding. As of 10 August 2022, the status of countries' participation in the EFGS is as follows:

[128] The Member States in question did report that this is understandable, as they were among the first Member States to join the EFGS.

Table 8. EFGS connection status (as of 10 August 2022)

Country	EFGS status
Austria	Disconnected (since 28 February 2022)
Belgium	Connected
Croatia	Connected
Republic of Cyprus	Disconnected (since 17 March 2022)
Czech Republic	Disconnected (since 28 October 2021)
Denmark	Disconnected (since 30 March 2022)
Estonia	Disconnected (since 2 May 2022)
Finland	Disconnected (since 1 June 2022)
Germany	Connected
Ireland	Connected
Italy	Connected
Latvia	Connected
Lithuania	Disconnected (since 9 April 2022)
Malta	Disconnected (since 7 July 2022)
Netherlands	On hold (since 22 April 2022)
Norway	Disconnected (since 12 August 2022)
Poland	Disconnected (since 25 March 2022)
Slovenia	Connected
Spain	Connected

The main reported reason for disconnecting is related to national-level decisions to decommission or suspend the apps as the COVID-19 situation has improved (reported by the Netherlands, Malta, Finland and Norway). The Republic of Cyprus decided to pause the app and consequently disconnect from the EFGS due to low usage by the public.

As part of the exploratory interviews in the study it was suggested by a Member State that more could be done to convince Member States to remain in the EFGS; for example, by exploring the possibility of gathering data through privacy-preserving analytics to calculate the share of notifications that have been triggered in the Member State due to EU citizens from other countries. Another suggestion included communicating the benefits of the EFGS more prominently amongst Member States.

Exchanged EFGS keys

As of 22 August 2022, a total of 67,553,125 keys have been uploaded to the EFGS by the participating countries. It should be noted that one key does not correspond to one infected person. An app user who has tested positive and allows the uploading of its keys to the EFGS may have up to 14 keys, depending on how long they were travelling and/or how long their app has been detecting proximity to

apps from another country. An approximation using the average stay when travelling in the EU to another country could be used (7.8 nights) to illustrate the significance of the EFGS uploads relative to its users. For example, in Germany, as of 22 August 2022, a total of 57,915,041 uploads are registered in the EFGS, which could be approximated to around 7,425,005 citizens who have contributed to potentially breaking transmissions while being abroad.

However, Germany is rather an exception, because the upload keys for all other countries are significantly lower. This may be due to the very high uptake of the German app among the population, as well as due to cultural and behavioural aspects.

Applied to all participating countries using the same assumptions for average nights and average keys per user, it can be estimated that approx. 8.6 million users may have contributed to potentially breaking infection chains while being abroad.

Table 9. EFGS download and upload keys (period: app connection to EFGS – 22.08.2022)

Country	Upload keys	Download keys
Austria	16,633	91,560,323
Belgium	467,479	134,512,448
Croatia	296	857,060,392
Cyprus	436	157,037,057
Czech Republic	65,859	6,345,566
Denmark	4,892,320	56,299,705
Estonia	16,715	246,105,509
Finland	582,643	53,133,773
Germany	57,915,041	34,759,097
Ireland	85,494	79,360,281
Italy	307,370	66,924,798
Latvia	42,809	115,716,324
Lithuania	83,085	39,937,701
Malta	102	633,534,768
Netherlands	1,792,300	94,253,843
Norway	280,191	78,662,322
Poland	446,387	34,568,778
Slovenia	270,935	656,467,401
Spain	287,032	69,815,925
Total	67,553,125	3,505,908,962

When it comes to download keys, as most national back-ends are downloading all keys from all countries in bulk, the figures cannot lend themselves to useful interpretation about how efficiently users are informed about a possible infection originating from a user in a different country.

EFGS participants' feedback and lessons learnt

Reflecting on their experience in the survey, many Member States confirmed that they perceive the EFGS as a valuable tool. For example, Malta reported that the update of its national app to support the interoperability framework of the EFGS has improved trust and confidence in the process. Despite the fact that, due to the highly privacy-friendly approach, no clear link could be shown between the role of the EFGS and citizens' satisfaction, the processes of connecting to the EFGS enhanced Malta's ability to communicate to its citizens about the value of the app, especially with respect to safer travel.

Some Member States reported in the survey that they perceived the EFGS model and learnings as the foundation for other activities and future developments, including elements being applied in the EU Digital COVID Certificate development in 2021, thus contributing to the Certificate's speedy development, or using similar models for validating electronic documents via public keys. Several Member States pointed out that the EFGS offers a clear future for rapid agile EU integration based on open standards and agreed protocols, and that the EFGS can be valuable in other health contexts requiring the federated and secure exchange of data among Member States (however, additional example contexts were not provided).

A major critique made by several participants in the survey was related to the limited participation of countries. Switzerland, England, Scotland, and Wales could not connect to the EFGS, as the EFGS does not have the legal base to connect countries outside the EU. In addition, the importance of neighbouring countries' participation was underlined as key to raising the importance of the EFGS among other hesitant Member States. For example, Finland reported that the importance of the EFGS would have been significantly greater if Sweden and Estonia had also joined (Sweden did not develop a national app and Estonia joined the EFGS approx. 6.5 months after Finland joined).

Several areas for improvement have been proposed via the survey:

- The lack of concrete EFGS-related success stories may be due to the lack of a technical solution for enabling the counting of cross-border infections (due to the current limitations of the GAEN framework). The number of cross-border infections should also be reported by all Member States in order to be able to demonstrate the benefit of the EFGS.
- More top-down effort in promoting the EFGS across Member States (e.g., making sure all airports/ports/borders used promotional materials) alongside the promotion of the national apps would have resulted in better adoption of the apps and more visibility to the EFGS and the justified investment at EU level for having this important cross-border exchange function.
- It was decided that there would be no obligation for Member States to add a switch to the connected apps for users to indicate that they had been abroad. Such a function could have resulted in a substantial reduction of the traffic through the EFGS. In particular, in late 2021 and early 2022, when the number of infections peaked in many countries, a large number of keys were shared via the EFGS even if most of them had been from persons who never left their country. This huge volume posed problems with exposure calculation updates on some older phones. The EFGS' countries of interest functionality was developed for use in such situations, however it was not actively used/implemented by MS.

Regarding the difficulty of determining the contribution of the EFGS to preventing infections and to measure its effectiveness against the costs and efforts involved by the EC and Member States, EFGS participants pointed to several contributing factors:

- Member States with different policies regarding their apps and the sharing of infected keys with the EFGS
- No technical solution being available to enable the onboarding of Member States with centralised apps (i.e., France and Hungary). During the exploratory interviews an expert commented that France had an especially high app uptake of more than 50%, which would have increased the attractiveness of the EFGS if it could have connected to the EFGS.
- Several Member States with high (seasonal) cross-border mobility of EU citizens (e.g., Greece

as a popular holiday destination during summer) never released a national contact tracing solution

Current state and future use of EFGS

The application of the EFGS in processing personal data has a temporal limitation. Once the incidence of infections with the COVID-19 virus is low and remains foreseeably low, the processing of the personal data in the EFGS is no longer effective and is no longer required to help break infection chains. Article 7a(7) of Implementing Decision 2020/1023 stipulates a termination clause for the gateway, imposing that the gateway "be deactivated at the latest 14 days after all the connected national contact tracing and warning mobile applications cease to transmit keys through the federation gateway." This is in line with most national provisions regarding the apps' applicability, as described in section 3.

Since April 2022, the daily operations of the EFGS are managed by the ECDC. Since then, the ECDC team have been attending the regular eHealth Network meetings of the two groups and providing updates on the EFGS connection status and workload. The European Commission and the ECDC are assessing the future of the digital contact tracing ecosystem at European level and the potential integration of the EFGS and mobile contact tracing applications with other tools such as the Early Warning and Response System or the EU Digital Passenger Locator Form (dPLF) platforms.

5 Monitoring and evaluation of contact tracing apps

During the COVID-19 pandemic, governments implemented a series of interventions to reduce the spread of the virus. By considering the effects these interventions had on viral transmission, governments could make more-informed decisions about how to control the pandemic. Yet the biggest challenge to understanding what impact these interventions had on the COVID-19 pandemic is that the number of broken chains of infections or prevented cases cannot be measured, only simulated. This also directly concerns the evaluation of the impact of digital contact tracing. Initially there was no consensus about what effectiveness means in the context of contact tracing apps, and most of the conceptual work on how to analyse an app's effectiveness was only achieved after the apps had already been deployed and data collection procedures had already been firmly defined. Contact tracing is usually considered effective when positive individuals are identified and quarantined as fast as possible to prevent the subsequent spread of the virus.

How many citizens should use the app? – early simulation studies

What was evident since the beginning of the pandemic was that the effectiveness of contact tracing apps is highly dependent on the level of uptake and continuous use by citizens. Various simulation studies tried to understand the extent to which contact tracing apps should be adopted and used for the number of cases to be significantly reduced. An early study found that 90-95% of the population must use a contact tracing app to stop the spread of COVID-19 without physical distancing[129]. However, based on data from the UK, a study revealed that the pandemic could be supressed if 56% of the population used a contact tracing app[130]. While some studies showed that a large proportion of the population would need to use contact tracing apps to completely stop the pandemic, available data indicates that any uptake level will help lower the transmission of the virus. For example, based on data acquired from the Netherlands, the authors of a study found that even with an adoption rate of 20%, contact tracing apps would be more effective than manual tracing, and approximately 40% of the population would need to use the app to control the pandemic[131]. Similarly, two other studies[132,133] report on the effectiveness of contact tracing apps even at low uptake levels. A combined simulation and observation study published earlier in 2021 found out that every 1% increase in app adoption might lead to a decrease of 0.8% up to 2.3% in the number of COVID-19 infections[134].

However, further research is needed on what proportion of individuals should be identified by manual or digital contact tracing in the context of a pandemic (assuming these individuals would follow quarantine rules) to reduce the spread of the virus. This section details the evaluation challenges faced by digital contact tracing and reports on related evaluation studies conducted in European countries. It further reports on the uptake, use, and effectiveness of contact tracing apps through the lens of the adapted WHO/ECDC framework.

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129 Xia, Ye & Lee, Gwendolyn. (2020). How to Return to Normalcy: Fast and Comprehensive Contact Tracing of COVID-19 through Proximity Sensing Using Mobile Devices. https://doi.org/10.48550/arXiv.2004.12576

130 Hinch, R. et al. (2020). Effective configurations of a digital contact tracing app: a report to NHSX. [pdf] Available at: https://cdn.theconversation.com/static_files/files/1009/Report_-_Effective_App_Configurations.pdf?1587531217

131 Kretzschmar, M. et al. (2020). Impact of delays on effectiveness of contact tracing strategies for COVID-19: a modelling study. *The Lancet Public Health*, *5*(8), e452-e459. doi: 10.1016/s2468-2667(20)30157-2

132 Yasaka, T., Lehrich, B., & Sahyouni, R. (2020). Peer-to-Peer Contact Tracing: Development of a Privacy-Preserving Smartphone App. *JMIR Mhealth And Uhealth*, 8(4), e18936. doi: 10.2196/18936

133 Moreno López, J. et al. (2021). Anatomy of digital contact tracing: Role of age, transmission setting, adoption, and case detection. *Science Advances*, *7*(15). doi: 10.1126/sciadv.abd8750

134 Wymant, C. et al. (2021). The epidemiological impact of the NHS COVID-19 app. *Nature*, *594*(7863), 408-412. doi: 10.1038/s41586-021-03606-z

5.1 Evaluation challenges of digital contact tracing

Different methodologies have been proposed to assess the impact of digital contact tracing. Efficacy evaluations are often used in clinical trial testing under controlled and laboratory conditions environments, but do not consider practical, dynamic factors in real-life environments. On the other hand, effectiveness evaluations consider real-life factors of implemented interventions and related real-life datasets but are limited due to the (often) observational nature of the data gathered. These general problems are compounded by additional challenges (discussed in greater detail in von Wyl et al., 2020[135]) that are specific for contact tracing applications which include the following:

- The effectiveness of the apps is dependent on the actions that notified app users undertake to prevent potential onward transmission. These actions are voluntary and not monitored.
- The apps were designed to collect only minimal, non-identifiable information for monitoring purposes but have limited value for effectiveness analyses.
- Preventive actions following exposure notifications include (self-)quarantine and regular testing and are often part of the general health system response to COVID-19. Any data generated by such actions are located in different systems or health services. These data can often not be linked to app usage or receipt of exposure notification.
- At any given time-point, the individual-level probability for being tested positive for COVID-19 or for the receipt of exposure notification is small (cumulative probabilities are higher). Therefore, survey-driven investigations may require very large sample sizes and longitudinal assessments to have good statistical power for observing outcomes of interest related to the app use.
- Compliance with recommended preventive actions upon exposure notification are key for effectiveness. However, reasons for app use and compliance are multifaceted and require a highly interdisciplinary research approach and expertise from many research fields (including epidemiology, psychology, social sciences).

Effectiveness studies highlighting the advantages of CTA over MCT, may need to focus on more proximal outcomes such as improvements in speed (shortening the delay between exposure, testing, and measures such as quarantine and self-isolation), greater network reach by informing contacts (including asymptomatic people) that may not be personally know, and better scalability. These three aspects are also reported as the main advantages of CTA[136].

5.2 Evaluation studies in European countries on the apps' impact on public health

Published European evaluations seeking to assess the digital contact tracing apps' positive impact and role in the COVID-19 pandemic are rather few and lack standardised assessment methods, as evidenced by the assessment and measurement schemes reported by different organisations and research institutes across European countries. Countries reported high heterogeneity in the aims of the evaluations carried out and the methodologies used, due also to the fact that no uniformly accepted framework existed when the evaluations were carried out. Furthermore, data availability varies significantly across countries due to different ways of collecting, measuring, analysing, and presenting the data, as well as being limited by privacy-preserving architecture.

As part of the survey, every third country reported that measuring the effectiveness of the app was not an aspect that was taken into consideration from the start of the development process. While many countries did report some indicators had been defined in advance, most countries considered only 1 or

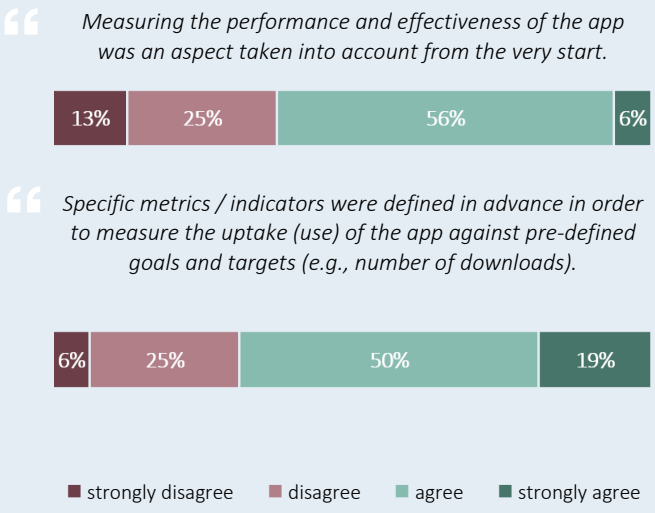
[135] von Wyl, V. et al. (2020). A research agenda for digital proximity tracing apps. *Swiss Medical Weekly*. doi: 10.4414/smw.2020.20324

[136] Troncoso, C. et al. (2022). Deploying decentralized, privacy-preserving proximity tracing. *Communications of the ACM*, 65(9), 48-57.

2 indicators, such as app downloads or active users, where available. None of the countries reported having a comprehensive assessment framework in place.

Survey insights: countries' preparedness in measuring the performance use of the apps

The metrics reported by most countries were very limited and include the number of downloads and, where available, the number of active users (with some difficulties in measuring the metric accurately) and the number of activation codes. Additionally, some countries report that due to implemented privacy preserving principles, data can be kept and used for evaluation purposes only for a limited time, e.g., 3 months.

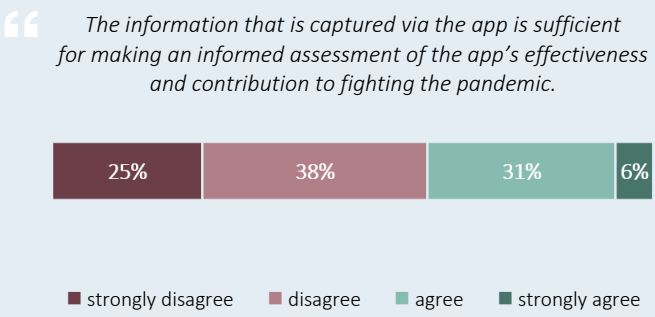


Based on responses by 16 countries.

Many evaluations also relied on data that were collected by other health system actors such as contact tracers or test centres. These data were not uniformly available in all countries due to differences in organisation of the health systems or in legal bases for data collection and reuse of administrative data.

Survey insights: Availability of data for evaluation purposes

Two thirds of the surveyed countries reported that the information that is available through the app is insufficient for carrying out an effectiveness analysis and determining the app's contribution to fighting the pandemic.



Based on responses by 16 countries.

A summary of identified publications and reports on the impact of digital contact tracing is given below.

Norway

To evaluate the CTA efficacy, Norwegian researchers used a Bluetooth contacts dataset (Norwegian Institute of Public Health) of the first CTA released in the Spring of 2020. The sample size for study was approximately 12.5% of adult population over 16 years old and the data collection period lasted from May 18th to June 4th, 2020. The evaluation had the main objective of assessing both the technological efficacy and the impact of minimising the spread of the virus through random tracing. The primary methodology used to evaluate technological efficacy was modelling, taking into consideration the probability of how different operating systems (IOS and Android) detected positive contacts. Within the scope of detecting potential risks, the risk levels were divided into three levels based on proximity and duration of contacts including Proximity Contacts (PC), Relatively Risky Contacts (RRC), Potentially Risky Contacts (PRC). The correlated probabilities between how IOS and Android phones detected potential

exposures based on the three mentioned risks level are the main indicators of technology efficacy evaluation scheme. Another set of indicators which were used were represented by the app uptake. This was employed to project the threshold percentage of app uptakes in the population which could effectively reduce the number of infection cases in conjunction with other measures. However, the latter approach was shown to be out of scope due to data limitations. The technological tracing efficacy was approximated to be 80%, and at least 11% of the discovered close contacts were estimated as being not possible to be identified by manual contact tracing[137].

Spain

The epidemiological impact of the Spanish Radar Covid app was assessed using a 4-week population-based experiment between June and July 2020 in the Canary Islands. To assess the usefulness of the app, KPIs assessing user behaviour (adoption, adherence, compliance, turnaround time, follow-up) and effectiveness (overall detection, hidden detection) were defined. Data was collected from surveys run through the app, online surveys and data retrieved from the APIs. The researchers estimated that at least 33% of the population adopted the technology and that the app detected 6.3 close-contacts per primary simulated infection, where a significant percentage was represented by contacts with strangers. Furthermore, there was indirect evidence of a potentially high adherence from survey data: from 735 within-app surveys, 82% concluded that the app was a useful tool, and the question "I will recommend friends and family members to download and use Radar COVID" was given 7.8/10 marks[138].

England and Wales

An investigation[139] of the NHS COVID-19 app used in England and Wales was conducted based on a data set gathered from 24 September 2020 until the end of December 2020. Modelling and statistical analysis estimated that the app was used by 16.5 million users (28% of the population) and that 1.7 million exposure notification were sent. The secondary attack rate (SAR) was approximated around 6%, similar to manual contact tracing. The researchers estimated that for every percentage point increase in app uptake, the number of cases could be reduced by 0.8% (using modelling) or 2.3% (using statistical analysis). The study used survey data, data from health authorities and data collected through the app. There were multiple indicators and outputs from statistical analysis, including app uptake focused on the number of app users and their behaviours, or the SAR of notified users.

Germany

The first evaluation of the German app was conducted in March 2021 and it aimed to examine the app's effectiveness and associated benefits. The following data was used in the analysis: data from user surveys (Event-Driven User Surveys - EDUS and Privacy Preserving Analytics - PPA), data from back-end components (test registration, sharing and retrieval of daily keys), and data from additional sources (case numbers, test capacities, model calculations and simulations, Apple App Store and Google Play Store). Since there are different types of results, the app differentiates between different sources of shared test results; whether they are from QR codes (users agree to have their results received from app through a QR code provided by the test laboratory/facility) or from TAN – Transaction authentication number (where users opted out of app result syncing and receive the TAN code from PHA hotline to enter into the app to warn others). The number of keys shared per day is the main indicator. The number of keys shared is also categorised into different transmission risk levels from 1 (least risky) to 8 (most risky). The results showed that a large proportion (88%) of users who were tested and received their test results via the CWA reported that their test results were available either within

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137 Elmokashfi, A. et al. (2021). Nationwide rollout reveals efficacy of epidemic control through digital contact tracing. *Nature Communications*, *12*(1). doi: 10.1038/s41467-021-26144-8

138 Rodríguez, P. et al. (2021). A population-based controlled experiment assessing the epidemiological impact of digital contact tracing. *Nature Communications*, *12*(1). doi: 10.1038/s41467-020-20817-6

139 Wymant, C., Ferretti, L., Tsallis, D., Charalambides, M., Abeler-Dörner, L., Bonsall, D., ... & Fraser, C. (2021). The epidemiological impact of the NHS COVID-19 app. *Nature*, *594*(7863), 408-412.

24 hours or 2 days. A relatively high proportion of users (61%) who registered a positive test result via the CWA and who received their result via the app (771,957) shared their result, and therefore used the app to warn other people (473,974). Several users were surprised to receive a notification that they were exposed to 'increased risk'. The majority of users who received a red warning (data from the EDUS: 87% (13,515 of 15,540) also subsequently underwent testing. Survey data showed that around 6% (792 of 13,493) of the tests carried out because of a (red) warning were positive for COVID-19. The data gathered via donation, the app stores and the CWA back end roughly indicated that users who share positive test results via their daily key warn around six other users, i.e., six other users receive a red warning showing them to be at 'increased risk'[140].

A subsequent evaluation from March 2022 used the same data sources. It estimated the number of active users of the warning function at 27 million[141]. It revealed that, on average, test results were transmitted to the app within 20 hours after testing (median: 13 hours). Warning contacts with a known infected person took on average 4.2 days. While nearly 2.9 million users have shared a positive test result, an average of 19 people received a high risk (red) alert for every warning person. Of those persons testing after a red alert, every fifth person tested positive. At the beginning of 2022, 17% of all positive corona test results were shared in the app. This illustrates that the potential of warning contacts of a positive test results is underused. 53.9%-65.9% of downloaded apps are used for active warning. The data, however, lacks consistency, since the number of warned individuals relies on data donations and the number of persons testing after receiving a red alert only captures official tests (and not self-tests). As an additional caveat, the definition of active users is also not unequivocally defined.

Switzerland

In Switzerland, several analyses were carried out. An analysis from the Zurich SARS-CoV-2 Cohort study of 328 cases and 261 close contacts observed that contacts notified via the app about their risk exposure entered quarantine approximately 1 day earlier than contacts who did not receive an app notification[142]. A study using data from the COVID-19 Social Monitor from 2403 respondents showed that 29 (1.2%) participants received a SwissCovid exposure notification. Among these, 22 (76%, 95% confidence interval [CI] 60–92%) took at least one mitigative action after receiving the exposure notification. Twenty respondents who received an exposure notification sought testing, among whom 6 (30%, 95% CI 12–54%) were tested positive for COVID-19 afterwards[143]. A simulation study was conducted using aggregated, publicly available data and research data to quantify the effect of the CTA on pandemic mitigation in the Canton of Zurich for the 537 app users who received a positive COVID-19 test result in the month of September 2020. The study estimated that using the app could have led to an equivalent of 5% of all persons in manual contact tracing-mandated quarantine in Zurich to enter voluntary self-quarantine as a result of receiving a voluntary quarantine recommendation after an exposure notification. Furthermore, 30 persons tested positive following an exposure notification[144]. One study that reported on population-level effectiveness for Switzerland found out that by 10 September 2020, the SwissCovid app has been downloaded 2.36 million times, the number of active apps per day has been estimated at 1.62 million, and the number of active users to 18.9% of the Swiss population. During the study period, 2447 activation codes were released, and 67.2% of activation codes were entered into the app. The authors approximated that the entered activation codes triggered 1695 phone calls to the

[140] About the Effectiveness and Benefits of the Corona-Warn-App. (2021). Retrieved 6 September 2022, from https://www.coronawarn.app/en/science/2021-06-15-science-blog-1/

[141] How many active users does the Corona-Warn-App have?. (2022). Retrieved 6 September 2022, from https://www.coronawarn.app/en/science/2022-03-03-science-blog-5/

[142] Ballouz, T. et al. (2021). Adherence and Association of Digital Proximity Tracing App Notifications With Earlier Time to Quarantine: Results From the Zurich SARS-CoV-2 Cohort Study. *International Journal Of Public Health*, *66*. doi: 10.3389/ijph.2021.1603992

[143] Daniore, P. et al. (2021). Using Venn Diagrams to Evaluate Digital Contact Tracing: Panel Survey Analysis. *JMIR Public Health And Surveillance*, *7*(12), e30004. doi: 10.2196/30004

[144] Menges, D. et al. (2021). A Data-Driven Simulation of the Exposure Notification Cascade for Digital Contact Tracing of SARS-CoV-2 in Zurich, Switzerland. *JAMA Network Open*, 4(4), e218184. doi: 10.1001/jamanetworkopen.2021.8184

Swiss-Covid hotline[145].

Netherlands

The Netherlands published a comprehensive report on 21 May 2021 evaluating the adoption, usage and effects of implementing the CoronaMelder app. The data sources used were data gathered by PHA (GGD), the back-end data from operating system provider and user data obtained through surveys. Data from PHA indicated that up to 77% who booked a test after exposure notifications from the app had not been approached by regular manual contact tracing at the time of testing. Through initial analysis of sample data from 26 September 2020 to 18 April 2021, 152,245 people (1.5% of the 9,853,035 test requests, σ=0.66%) answered that they had arranged a test after receiving a notification from CoronaMelder. Of those, 74,735 had symptoms when requested the test (49% of the 152,245), compared to 7,563,191 (78% of the 9,700,790 test requests) with symptoms among those not requesting a test following a notification from CoronaMelder[146].

France

An evaluation of the app was carried by the MoH for TousAntiCovid for the period of June 2021 to November 2021[147]. The French application registered 39.4 million app registrations, as recorded on 1 January 2022, and there were approximately 49 million single device downloads. On 1 January 2022, the number of users who declared themselves positive in TousAntiCovid to notify other users represented 25 % of the total number of positive cases reported in France in SI-DEP. Since the launch of TousAntiCovid, that average varied between 5 and 25 %, and stood at 20 % on average throughout December 2021. On 28 November 2021, 35 % of the total number of cases reported in France declared in the application (n = 2309), planned to notify 10 316 users as high-risk contacts via the Robert protocol (contact tracing via Bluetooth). On average, around 21,049 of notifications were sent per day. The ratio of the number of contacts notified via the Robert Protocol to the number of cases reported is 1,9 on average for November 2021, which is the same ratio as reported by the sickness insurance scheme over the week from 24 to 30 November 2021. A study carried out by Kantar Public in October 2021 (also described in the Activity Report) showed that the application as a whole is widely appreciated. Access to the EU DCC was the main reason for downloading TousAntiCovid for respondents, and the contact tracing functionality (Bluetooth) ranked fourth after the functionality of figures and news and that of the attestations.

Finland

An effectiveness analysis of the Koronavilkku app was conducted in the Pirkanmaa region of Finland (540,000 residents, under 10% of Finland's population), on a sample of 2368 people[148]. According to the study, in the period from 1 October 2020 to 31 May 2021, 41% of the individuals interviewed during a contact tracing interview stated that they were using the app, and 2.2% of these users had received a high-risk alert in the app before being contacted by a healthcare professional through the traditional contact tracing protocol.

According to a 2021 survey by Statistics Finland, 52% of the population used the Koronavilkku app[149].

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145 Puhan, M. et al. (2020). Zurich Coronavirus Cohort: an observational study to determine long-term clinical outcomes and immune responses after Coronavirus infection (COVID-19), assess the influence of virus genetics, and examine the spread of the Coronavirus in the population of the Canton of Zurich, Switzerland. *Http://Isrctn.Com/*. doi: 10.1186/isrctn14990068

146 Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

147 Ministry of Solidarity & Health Directorate General of Health. (2021). Activity Report. TousAntiCovid from 2 June 2020 to 30 November 2021.

148 Rannikko, J., Tamminen, P., Hellsten, R., Nuorti, J. P., & Syrjänen, J. (2022). Effectiveness of COVID-19 digital proximity tracing app in Finland. Clinical Microbiology and Infection.

149 Official Statistics of Finland (SVT): The population's use of information and communication technology [online publication]. ISSN=2341-8699. 2021, Appendix table 19. Downloading and keeping the Koronavilkku application in use 2021, % share of the population. Helsinki: Statistics Finland [cited: 5 October 2022]. Access: http://www.stat.fi/til/sutivi/2021/sutivi_2021_2021-11-30_tau_019_fi.html

Italy

The evaluation of the Italian CTA Immuni, in an article from June 2022, used app data from the Ministry of Health on the number of downloads, number of daily notifications sent and the number of users uploading their positive test results[150]. These data were compared to the official positive case numbers within the same time span. The authors state a download rate of 36.7% (n=5,886,411) of eligible population between June 2020 and December 2021. Despite this interest, the app had identified only less than 1% (n=44,880) of the official COVID cases in the same period. A later increase in download numbers is attributed to individuals using only the mandatory EU DCC, and not the warning function.

A few country representatives have reported via the study survey that they are working on publications that will follow after this study.

5.3 The need for a standardised monitoring and analysis framework

As outlined in the previous section, existing effectiveness analyses exhibit large heterogeneity with respect to analysis methods, study populations, or databases used. This heterogeneity is detrimental to the cross-national comparability of findings. This potential problem has been recognized very early on, and attempts have been undertaken to achieve greater harmonization through the development of an overarching monitoring and analysis framework.

The WHO/ECDC framework

In order to guide national health authorities in monitoring and evaluating their digital contact tracing and warning solutions, digital health and contact tracing experts from the World Health Organization (WHO) and the European Centre for Disease Prevention and Control (ECDC) developed an indicator framework for the public health effectiveness of digital proximity tracing (DPT)[151]. This framework is intended to serve as a basis for a standardised evaluation of DPT. The indicators were selected in terms of their feasibility for data collection across different settings as well as their public health relevance based on expert consultations and literature reviews. The list of proposed indicators is grouped into four sets of information that should be collected. The framework highlights that the data collection capacity for each indicator can vary across Member States given differences in the design of DPT solutions, their integration in the national COVID-19 response strategies, as well as national regulatory and governance contexts. Therefore, various approaches to data collection and sources of data were suggested for each indicator component.

When evaluating the public health effectiveness of DPT, the WHO and ECDC pointed out that special considerations should be given to indicators' limitations, the proportion of active users, geographic differences in adoption and utilisation rates, the reliability of DPT (likelihood of false-positive and false-negative exposure), as well as population groups who are unable or unwilling to use the solution. In addition, any cross-country comparison should take the level of implementation and integration of DPT with COVID-19 testing and traditional contact tracing services into account.

Revision and update of the WHO/ECDC framework

The WHO/ECDC framework was developed and released in the summer of 2021 when there was only a

[150] Ussai, S. et al. (2022). "Immuni" and the National Health System: Lessons Learnt from the COVID-19 Digital Contact Tracing in Italy. *Int J Environ Res Public Health*, 19(12):7529. doi: 10.3390/ijerph19127529.

[151] World Health Organization & European Centre for Disease Prevention and Control. (2021). Indicator framework for the evaluation of the public health effectiveness of digital proximity tracing solutions. Geneva: World Health Organization and European Centre for Disease Prevention and Control. [pdf] Available at: https://www.who.int/publications/i/item/9789240028357

very limited experience base and a lack of reports on best practices for analysing CTAs available at the time. As more countries performed CTA analyses, limitations of the framework and challenges associated with data availability for CTA investigations became apparent. Therefore, an important first step for our effectiveness analyses was a critical examination and adaptation of the original WHO/ECDC framework. This revision process was jointly conducted with the domain experts as previously described in section 2.

Additionally, for some indicators, the level of details and transparency varied due to the lack of data and differences in available formats across countries. Therefore, taking into consideration the current challenges, the study team proposed modifications aimed at better reflecting the availability of data.

Table 10. Proposed changes to existing WHO/ECDC indicators

Indicator	Change
A1 Proportion of population who have downloaded the app	Instead of using the variable "total country population" to calculate this indicator, the study team proposed adjusting the variable to take into account that a portion of the population cannot possibly use the app, since in most countries there is a lower age limit. 16 years of age was recommended.
A2 Proportion of population who actively uses the app	Similarly, to A1, the variable "total country population" was adjusted to only include the population above 16 years.
A3 Proportion of all positive tests that occur among app users	Given that in some EU countries activation codes are issued to all persons, not just app users, the study team proposed to use the number of activation codes entered into the app instead of the number of activation codes issued, with the disclaimer that it will represent only a subset of all app users.
A5 Rate of positive tests among app users relative to the rate of positive tests reported in the general population.	The numerator variable in A5 is the number of activation codes issued which covers all the test results (i.e., not only for positive tests). Additionally, in some EU countries, activation codes are issued to all persons, including non-app users. Therefore, the study team proposed to change 'issued tests' into 'entered tests'.
C2 Evolution of average time between symptom onset and upload of app keys	Modified to focus on distributional changes over time, which may be indicative of emerging bottlenecks in the app notification cascade (e.g., access to testing, receipt of upload authentication code).

Table 11. Proposed new indicators to complement the existing WHO/ECDC framework

Indicator	Description
D5 Adherence to testing guidelines	A new indicator to describe adherence to testing guidelines, which is a key factor for successful break of infection chains.
D6 Adherence to quarantine guidelines	A new indicator to describe adherence to quarantine guidelines, which is a key factor for successful break of infection chains.
E1 Proportion of cross-border notifications to national infections	A new indicator to depict the contribution of cross-border notification sharing through the EFGS that enables potential infections to be identified across borders.

Of note, the framework represents a "wish list" or blueprint, on which monitoring procedures should ideally be modelled. Forward-looking, decisions regarding CTA data collection and monitoring procedures ought to be made prior to country-specific CTA releases, as admissible data collections in

certain situations need to be made explicit in laws and ordinances). The framework therefore should be seen as a guiding document for future CTA implementations. Our attempts to collect CTA data and to perform harmonised analyses of CTA indicators should be considered as a status quo assessment of data availability and quality, wherein the interpretability of actual indicators needs further standardisation for cross country comparison, due to country-specific differences in data collection methods and contexts.

5.4 Results of applying the WHO/ECDC framework

To calculate the indicators, data was gathered via the study survey or publicly available sources, such as dashboards, official evaluations, or publicly available reports (data availability reflected in the methodology section). Since the operation of the apps was suspended at different time points according to the evolution of the pandemic and numbers have been reported according to available data, the tables below contain figures from different time periods.

5.4.1 Adoption and use of contact tracing apps in the population

Proportion of total population who have downloaded the app

Since their launch in 2020 until July 2022, the apps examined in the study have reached an impressive number of 206 million downloads (number representing unique downloads, and not unique number of users). Ireland had the highest download proportion with 4.5 million downloads, accounting for 89.1% of the total population. This was followed by France, with 59 million downloads, accounting for 87.3% of the population. Germany, Finland, and UK reached between 50 and 60% download rate (Germany with 46.4 million downloads, representing 55.8% of the population; Finland: 3 million downloads, 55.7% of the population, UK: England and Wales 31 million downloads, representing 52.2% of the population).

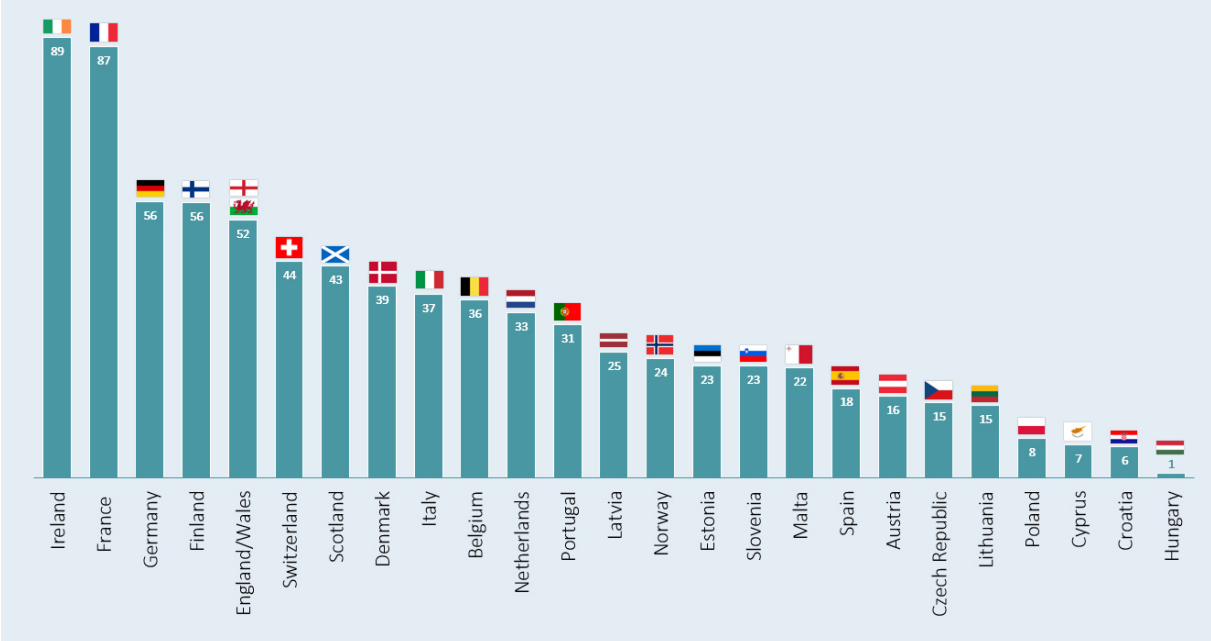

Figure 8. App downloads as a share (%) of the population

Table 12. Total number of app downloads in the investigated countries

Country	Latest total number of downloads reported	App intended to users older than
France	59.2 million	no mention of age limit in official resources
Germany	46.4 million	16
UK – England and Wales	31 million	16
Italy	21.9 million	14
Spain	8.5 million	18
Netherlands	5.8 million	no mention of age limit in the official resources
Ireland	4.5 million	16
Belgium	4.2 million	13
Switzerland	3.8 million	15
Portugal	3.2 million	no mention of age limit in the official resources
Finland	3.1 million	whole population
Poland	2.9 million	17
UK – Scotland	2.3 million	12
Denmark	2.3 million	15
Czech Republic	1.6 million	no mention of age limit in official resources
Austria	1.47 million	no mention of age limit in the official resources
Norway	1.3 million	16
Iceland	547,937	no mention of age limit in official resources
Latvia	476,512	whole population
Slovenia	475,687	16
Lithuania	410,300	16
Estonia	301,585	13
Croatia	243,426	12
Malta	115,695	13
Hungary	95,000	no mention of age limit in official resources
Cyprus	60,958	18

To compare across countries, the current calculation used the Eurostat whole population statistics, although the contact tracing apps were intended for different age groups in different countries (e.g., in Italy, citizens older than 14 can install the app, whereas the Protect Scotland app is intended to users older than 12). To reflect a more accurate uptake of the eligible population, the number of smartphone users belonging to a certain age category would have to be taken into account, but this information is unavailable in most countries.

While this indicator was meaningful in the beginning of the pandemic when the CTAs were launched, it became less interesting as the pandemic evolved due to several reasons, namely app installs and deinstalls, different app updates etc. For example, Iceland had 145% downloaded apps compared to their whole population (not included in the graph). Yet this number represents accumulated number of

downloads of the app from 2 April 2020 onwards. The number most likely does not represent only Icelandic users and includes downloads from foreign users like tourists that travelled to Iceland in the summer. Furthermore, the GPS enabled version of the app is also reflected in these numbers[152]. Iceland reported that the number of uninstalls and downloads closely followed the development of the spread of the virus in Iceland, hinting to the possibility that users uninstalled the app if the spread was low and then installed again when the spread went up. This is the case for all countries, where the number of downloads includes repeated downloads and downloads across multiple devices.

One of the factors that may have influenced the uptake of the apps was represented by the on-going promotional campaigns, as well as population-perceived and/or study-backed effectiveness of CTA apps. Furthermore, the inclusion of the digital COVID certificate may have increased the proportion of citizens who downloaded the app. For example, it was reported that in France the main reason for downloading TousAntiCovid was the covid certificate, and the contact tracing functionality (Bluetooth) ranked fourth after the functionality of figures and news and that of the attestations, according to a survey carried out (see French evaluation).

Proportion of total population who actively used the app

While the number of downloads reflects citizens' intention to use the app, the number of active users is a more accurate reflection of active use. The highest proportion of peak active users has been registered in Finland, where 45% (approximately 2.5 million users) were recorded to have been actively using the app. In Ireland, the CTA reached a peak of 40% of active users of the population (over 2 million users), and in Germany a peak 37.3% of the total population (31 million users). Iceland, France, and Switzerland had similar shares of active users per population, rounding to 26-27%, (Iceland reaching 100.000 peak active users, France 18 million active users, and Switzerland 2,3 million active users).

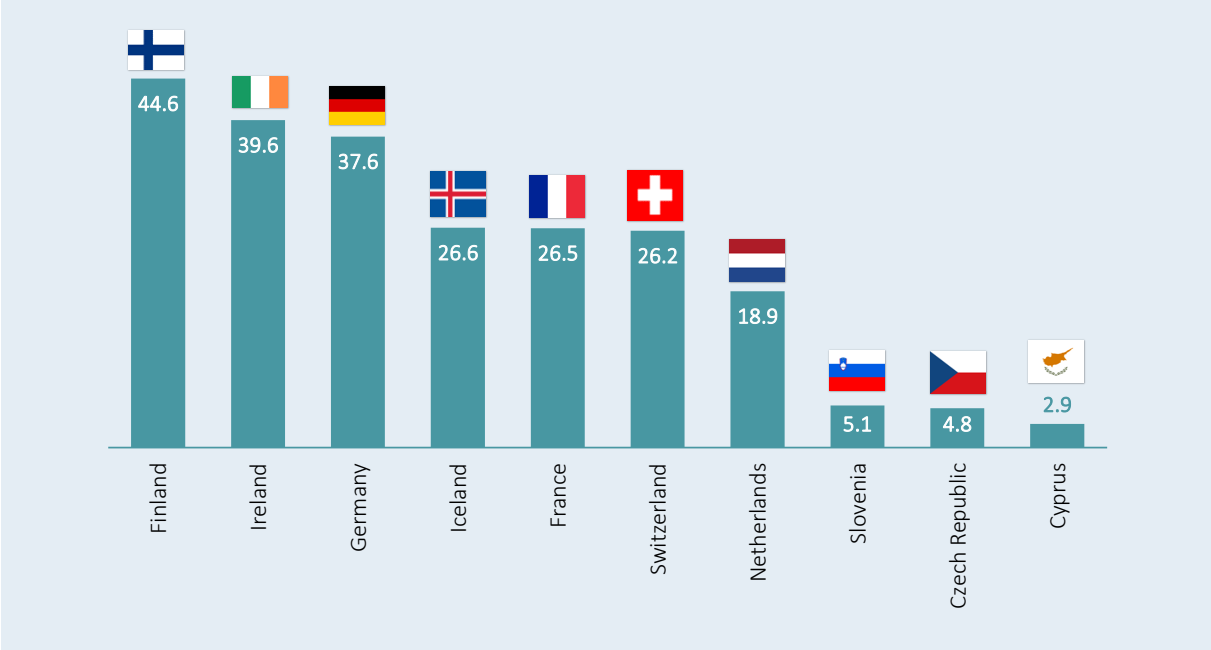

Figure 9. Peak active users as a share (%) of the population

While the figure only displays the peak percentage of active users, this fluctuated across the pandemic. Due to the privacy-preserving design of the apps, it is not possible to compute this accurately unless an analytics engine has been integrated into the system where each device featuring the CTA periodically transmits an empty-request "pulse" signal to the backend. Therefore, countries used different ways to

[152] The initial version of the Icelandic app used GPS. The app was updated to use Bluetooth on May 11, 2021

estimate this parameter. Most countries had empty requests, and the time-print differs from country to country. In Netherlands for example, signals were on average sent once every 14 days, and in Switzerland, once every five days. In Cyprus this was based on the number of active installs reported on the Google Play Store, i.e., the number of Android phones that have currently installed the app and these numbers were projected to iPhone users to estimate the total active users. In Germany, estimates of active use were between 25 million based on app store data and an analysis of data in the CWA back-end) and 31 million (based on estimates from the number of warnings and the voluntary data donation), accounting at its peak for approximately 37.2% of the total population[153]. To be able to have a meaningful cross-country comparison, there is a need for technical standardisation of the way data is collected and how the associated systems work.

Proportion of all positive tests that occur among app users

In principle, the respective authority or healthcare professionals should issue an activation code to positive tested app users, which enables the release of infectious TEKs and enables the notification of exposed proximity contacts. However, due to practical considerations, several EU countries started to issue activation codes to all persons who were tested positive for the coronavirus, not just to the ones who have the app (app users representing only a subset of all who received an activation code). In Estonia for example no codes are issued, but citizens can confirm their infection in the app by linking it to the national registry. Furthermore, even if activation codes are only issued upon positive tests, it has been described that not all activation codes are entered (see next subsection). Therefore, there are differences in what 'activation codes issued' represent. For example, for Scotland, the number of unique test codes generated for the Protect Scotland app include resent codes (replacements for a lost code, the code has expired or did not work)[154].

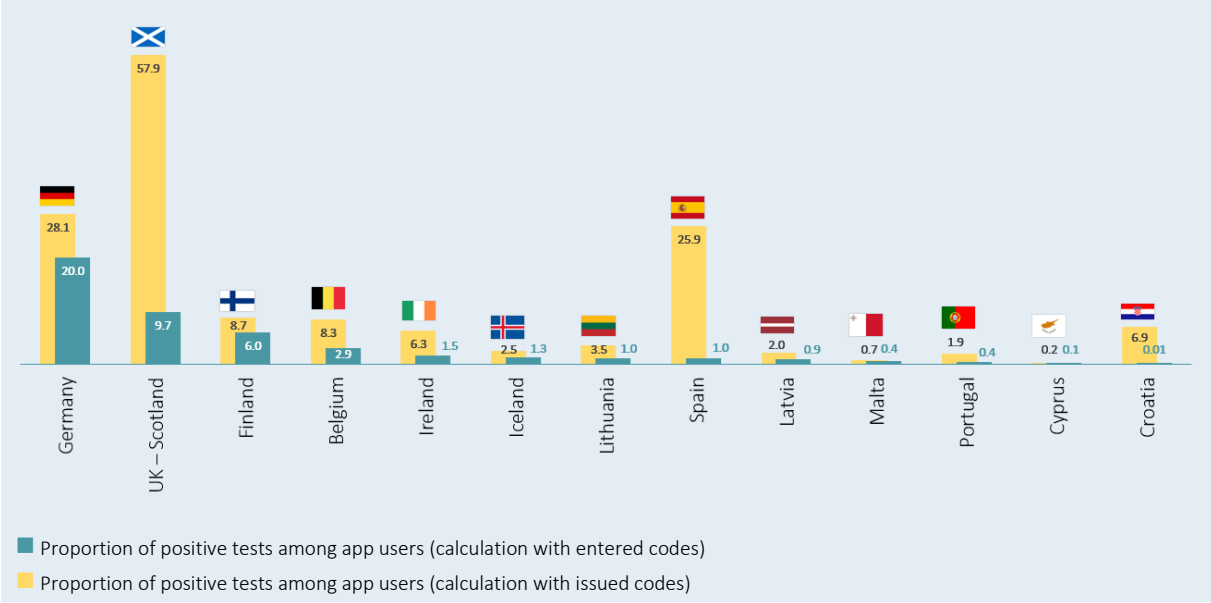

Figure 10. Cumulative proportion of all positive tests that occur among app users
Calculation using activation codes issued and activation codes entered for the countries with available data

Most countries reported the number of entered activation codes that led to the sharing of positive test results. Although the number of entered activation codes represents only a subset of the total number

[153] See evaluation of Corona-Warn-App

[154] The Scottish Government. (2022). Analysis of Protect Scotland app: FOI release. Information request and response under the Freedom of Information (Scotland) Act 2002. Retrieved 6 September 2022, from https://www.gov.scot/publications/foi-202100257923/#:~:text=As%20at%2024%2F11%2F2021,App%20and%20the%20Federated%20Server

of positively tested app users, it can hint at the proportion of positive tests among app users as a fraction of all positive tests registered at a given time-point. Overall, a total of 13.4 million activation codes (positive tests) were entered across EU countries, accounting for 0.01 to 20% of all positive tests reported in the specific countries. Those fractions are a function of app adoption (number of active app users), receipt of an activation code (reflecting a health system's capacity to issue codes in a timely manner, which was impaired in some settings), as well as probability for entering the activation code in a timely manner (reflecting voluntary user decisions to utilise the delivered code and to actually share the positive test result with exposed contacts).

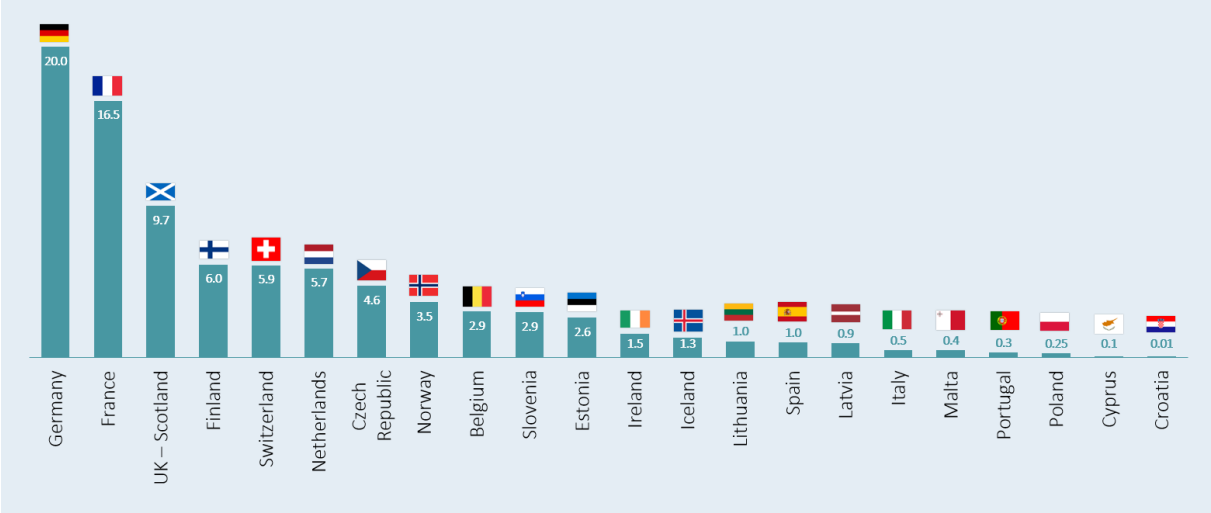

Figure 11. Proportion of positive tests among app users (using entered codes as a nominator)

A total of 13.4 million positive tests reported in the apps across studied countries, accounting between 0.001 and 20% of all positive tests reported in the countries.

Table 13. Number of issued and entered activation codes and positive tests

Country	Entered codes	Issued codes	Positive tests [155]	Timeframe
Germany	6,656,979	9,387,164	30,411,546	16.06.2020 – 26.07.2022
France	5,500,000	34,000,000	33,362,655	22.10.2020 – 12.08.2022
Netherlands	455,083	-	7,951,227	10.10.2020 – 22.04.2022
Switzerland	204,862	-	3,466,071	25.06.2020 – 31.03.2022
Spain	123,996	3,324,839	12,840,525	21.08.2020 – 29.07.2022
Belgium	118,564	336,916	4,040,302	30.09.2020 – 05.06.2022
Italy	88,363	-	18,285,821	15.06.2020 – 30.06.2022
UK – Scotland[156]	68,355	407,081	703,325	10.09.2020 – 25.11.2021
Czech Republic	67,802	-	1,479,610	20.04.2020 – 24.03.2021

[155] Source of number of positive tests: Johns Hopkins Coronavirus Resource Center. Retrieved 6 September 2022, from https://coronavirus.jhu.edu Scotland: GOV.UK Coronavirus (COVID-19) in the UK. Cases in Scotland. (2022). Retrieved 6 September 2022, from https://coronavirus.data.gov.uk/details/cases?areaType=nation&areaName=Scotland

[156] The Scottish Government. (2022). Analysis of Protect Scotland app: FOI release. Information request and response under the Freedom of Information (Scotland) Act 2002. Retrieved 6 September 2022, from https://www.gov.scot/publications/foi-202100257923/#:~:text=As%20at%2024%2F11%2F2021,App%20and%20the%20Federated%20Server.

Country	Entered codes	Issued codes	Positive tests [155]	Timeframe
Finland	64,742	94,461	1,083,991	31.08.2020 – 31.05.2022
Norway	48,351	-	1,368,663	21.12.2020 – 06.04.2022
Slovenia	24,906	759,025	860,602	07.04.2021 – 30.07.2022
Ireland	24,857	102,000	1,629,800	07.07.2020 – 23.08.2022
Lithuania	11,900	40,800	1,161,577	06.11.2020 – 31.07.2022
Estonia	8,556	-	335,316	20.08.2020 – 31.01.2022
Latvia	7,787	17,016	831,820	29.05.2020 – 26.06.2022
Poland	6933	-	2,784,391	09.06.2020 – 05.05.2021
Portugal	3,137	14,741	788,763	01.09.2020 - 27.05.2021
Iceland	2,590	5,018	202,949	02.04.2020 – 23.08.2022
Malta	458	737	104,048	18.09.2020 – 06.07.2022
Croatia	87	81,931	1,188,417	27.07.2020 – 08.08.2022
Cyprus	79	197	123,591	05.04.2020 – 29.10.2021

Proportion of positive tests among app users that are entered into the app (positive tests uploaded)

The proportion of positive tests among app users that are uploaded varies to a great extent; up to 70% of users entered their positive results in the app, with a few countries reporting proportions lower than 5%. The highest reported proportions are in Germany, where around 70% of the users uploaded their positive test result in the app, accounting for 6.65 million positive tests uploaded (almost half of all activation codes entered across Europe), according to the latest figures gathered in July 2022.

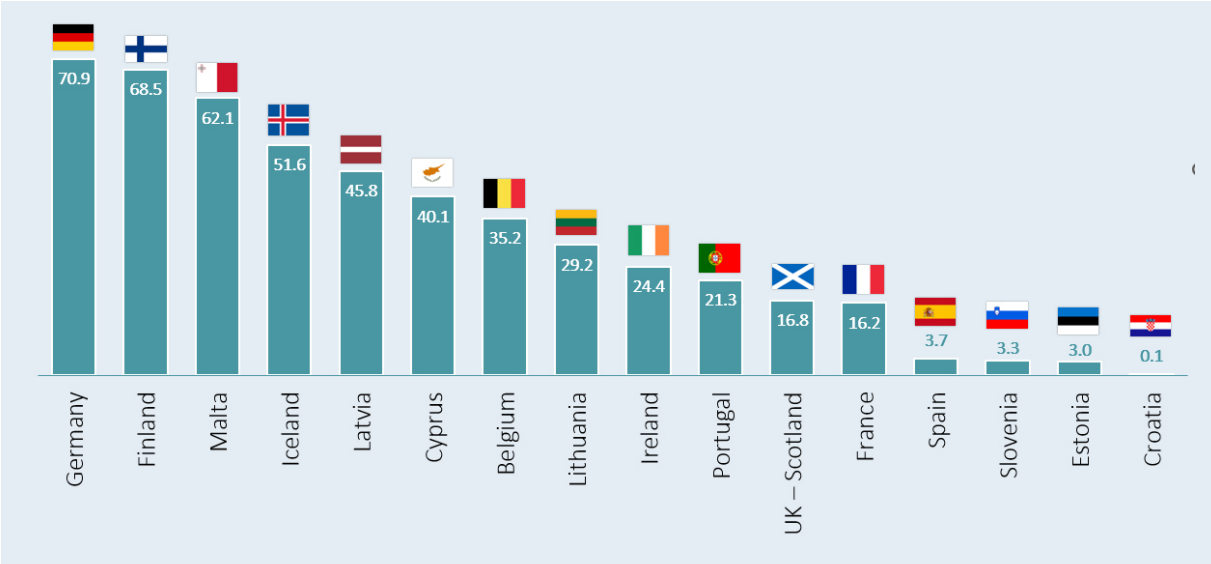

Figure 12. Proportion (%) of positive tests among app users that are entered into the app

This figure seems to be consistent with earlier German evaluation from 2021, where it was reported that 61% of the users have shared their result in the app[157]. For France, Slovenia and Estonia this is not

[157] About the Effectiveness and Benefits of the Corona-Warn-App. (2021). Retrieved 6 September 2022, from https://www.coronawarn.app/en/science/2021-06-15-science-blog-1

an accurate reflection, as the number of activation codes issued totals the number of positive tests, therefore the parameter reflects the proportion of positive tests entered into the app among all citizens tested positive. A further consideration is that when antigen tests became more widely available, only positive PCR-tests may have been admissible for the issuance of an authentication code in some settings (or only with delays), whereas the denominator reflecting all positive tests often included both PCR- and antigen-based tests. Yet, the relevance of such setting-specific differences with respect to acceptance of different forms of COVID-19 testing is difficult to assess.

Some studies also looked into reasons for not entering codes. For example, late code delivery may lead to expiration of the code validity date, which was reported for some settings during high-incidence phases (e.g., in Switzerland). A Swiss study also provided anecdotal evidence that index cases chose not to use the activation code because they had already informed the exposed contacts by other means or only had proximity contacts with same-household members[158].

Another indicator from the WHO/ECDC framework involves comparing the rate of positive tests among app users relative to the rate of positive tests reported in the general population. The data needed to calculate this indicator is only available from a few countries that have published research studies on the topic and at unspecific timepoints, therefore it is difficult to calculate the general population test positivity for the appropriate timeframe to have a meaningful comparison. While the indicator is potentially valuable, the data collection, indicator calculation and interpretation must be planned in advance, in the next implementation of CTA.

5.4.2 Apps' capacity to detect contacts at risk of infection

Manual contact tracing involves carrying out an interview with the confirmed cases to identify close contacts with whom the confirmed person interacted 1-3 days before showing symptoms or being confirmed positive. However, it relies on accurately identifying all possible close contacts and on providing reliable contact data. This process lacks privacy and is also highly dependent on the capacity of manual contact tracing systems. Furthermore, there is always the possibility that the positively confirmed person infected others he or she might not be aware of. Therefore, one of the core questions concerning CTA effectiveness is whether the contact tracing apps can accurately notify persons at risk (including asymptomatic cases that otherwise would probably not get tested), and whether these persons could not have been identified by manual contact tracing. The WHO/ECDC framework proposes indicators to assess the capacities of digital contact tracing to detect contacts at risk. However, several of these parameters require data that is not readily available in most countries because they require extensive surveys and statistics on manual contact tracing that are either not systematically collected or not available at a centralised level due to the regional decentralized organisation of manual contact tracing in most jurisdictions. Therefore, this section presents results from a few selected countries.

Ratio of exposure notifications received to positive test results entered

Across European countries, between 0.8 and 16.5 contacts were notified by the app per index case entering their positive test result into the app. These data stem from heterogenous sources (standard monitoring, surveys, simulations). Most countries reported between 0.8 and 4 notifications sent per positive result confirmed in the app (France[159], Netherlands[160], Switzerland[161,162], Belgium, Italy, Czech

158 Ballouz, T. et al. (2022). Individual-Level Evaluation of the Exposure Notification Cascade in the SwissCovid Digital Proximity Tracing App: Observational Study. *JMIR Public Health and Surveillance*, 8(5), e35653.

159 Ministry of Solidarity & Health Directorate General of Health. (2021). Activity Report. TousAntiCovid from 2 June 2020 to 30 November 2021.

160 Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

161 Daniore, P. et al. (2021). Using Venn Diagrams to Evaluate Digital Contact Tracing: Panel Survey Analysis. *JMIR Public Health Surveill*, 7(12):e30004. doi: 10.2196/30004

162 Ballouz, T. et al. (2022). Individual-Level Evaluation of the Exposure Notification Cascade in the SwissCovid Digital Proximity Tracing App: Observational Study. *JMIR Public Health and Surveillance*, 8(5), e35653.

Republic, Ireland, Latvia – according to the collected data). For France, since 13.09.2021, the ratio between the number of contacts notified at least once as a risk contact and the number of positive cases reported in the application is greater than one. The French evaluation reports that the ratio between the number of contacts notified at least once and the number of cases reported was 2.5 in November 2021. In comparison, in the week between 24 and 30 November 2021, the Sickness Insurance reported an average ratio of 1.9 contact at risk for one case[163]. Finland reported as preliminary results based on a recent survey that approximately 15% of the population has received an exposure notification. Significantly higher figures have been reported for Germany. The early evaluation from 2021 of the German app estimated that approximately 6 contacts were notified per uploaded test (using data donation, app stores data and CWA back-end data)[164]. More recent figures however show that since 5 March, 2021 (compared to the data from the CWA data donation) 2,572,787 individuals have warned others via the app that accounts for 19 (red) warned individuals per individual uploading one code (as of February 28, 2022)[165].

Table 14. Ratio of exposure notifications received to positive test results confirmed in the app

Country	Activation codes entered	Notifications generated	Ratio of exposure notifications received to positive test results	Time frame
Germany	6,656,979	172,474,208	Between 6 and 19	Until 26 July 2022
France	5,500,000	4,200,000	On average 1.9, max 3.4	Until August 2022
Netherlands	455,083	-	Between 0.8 and 1.4	Until 31 May 2021
Switzerland	204,862	-	Between 2.5 and 4	Until 31 March 2022
Belgium	118,564	425,931	On average 3.6	Until 5 June 2022
Italy	88,363	195,045	On average 2.2	Until 30 June 2022
Czech Republic	67,802	257,086	On average 3.8	Until 24 March 2021
Ireland	24,857	50,974	On average 2.1	Until August 2022
Latvia	7,787	12,004	On average 1.5	Until 26 June 2022

This parameter varies due to several factors, including the way exposure notifications are calculated, whether people upload the activation code in the app, and by population density, social distancing or lockdowns. For example, based on data from The Netherlands, it was observed that the correlation between the activation code request and average travel movements is significant, as it pointed to an increase in the number of test requests in response to shared activation codes, suggesting that the contact tracing app effectiveness might increase as the travel movements increase[166]. However, the availability of data for this parameter is limited, as in decentralised settings the number of received exposure notifications is not always available. This is due to the fact that standard GAEN apps do not report back to central servers if an exposure notification has been received. The Italian Immuni app, however, allows for back-communication of exposure notifications to central servers on a voluntary

[163] Ministry of Solidarity & Health Directorate General of Health. (2021). Activity Report. TousAntiCovid from 2 June 2020 to 30 November 2021.

[164] About the Effectiveness and Benefits of the Corona-Warn-App. (2021). Retrieved 6 September 2022, from https://www.coronawarn.app/en/science/2021-06-15-science-blog-1

[165] How many active users does the Corona-Warn-App have?. (2022). Retrieved 6 September 2022, from https://www.coronawarn.app/en/science/2022-03-03-science-blog-5/

[166] Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

basis[167]. Countries like Germany rely on data donations to estimate this parameter. Switzerland represents a projection that relies on the number of webform completions and infoline calls made by citizens after receiving a notification exposure to approximate the number of notification exposures generated (although it is only a subset of all the exposure notifications sent, as not everyone who received a notification subsequently contacted the public health authorities).

Proportion testing positive among app users who present to testing services after receiving an exposure notification through the app

An important criterion for the effectiveness of digital contact tracing is that a relevant proportion of the notified cases should be identified as positive, indicating that the apps can identify contacts at risk, and that a part of these cases could not have been identified by manual contact tracers. Overall, countries reported that between 2.3% and up to 41% of the notified persons who got tested were positive. France reported that a proportion of 2.3% of the notified users tested positive on a daily basis in the examined timeframe, whereas Germany, Netherlands, and Malta reported between 6 and 11.7% positive notified users. Significantly higher rates were reported in few studies from Switzerland, where 19% of the notified individuals were positive for the Alpha strain, [compared with 6% in the general population], 29% [11%] in the Delta, and 41% [43%] in the Omicron variant phases[168]. Further data is required to explain the observed heterogeneity and understanding the complex interaction between user behaviour (not all users who get notified will get tested, and not all users who get tested will confirm their positive infection in the app, or codes might not be entered in a timely manner) and regional/national factors and social behaviour (quarantine guidelines, compliance with social distancing rules or lockdowns), as well as having parameters standardised across countries. An interesting observation is that in Malta, although only 0.4% positive tests were recorded among app users, in their survey on a limited sample, they found out that 8.7% of the notified individuals tested positive.

Table 15. Proportion of diagnosed cases among app users who have previously received an exposure notification through the app
Based on availability of data from surveys conducted in six European countries

Country	% downloads	% Peak Active users	Proportion of positive tests among app users (entered codes)	Proportion of positive tests uploaded among app users	Ratio of notifications sent	Proportion of positive cases following exposure notification
Netherlands	33%	18.9%	5.7%	-	Between 0.8 and 1.4	7.5%
Germany	56%	31.3%	20%	70.9%	Between 6 and 19	6% - 11.7%
Finland	56%	45%	6%	68.5%	-	6.8%*
France	87%	27%	16.5%	-	1.9 on average, max 3.4	2.3%
Switzerland	44%	26%	5.9%	-	Between 2.5 and 4	19% - 41%
Malta	22%	-	0.4%	62.1%	-	8.6%

*Preliminary results based on a recent Finnish survey. The analysis is ongoing, and results will be published later.

To contextualise the information and compare it with different interventions, this proportion would need to be compared by random testing and manual contact tracing data. One interesting analysis stems

[167] Immuni documentation. (n.d.). Retrieved 6 September 2022, from https://github.com/immuni-app/immuni-documentation

[168] Daniore, P. et al. (2022). Performance of the Swiss digital contact tracing app over various SARS-CoV-2 pandemic waves: Repeated cross-sectional analyses. *JMIR Preprints*. 12/07/2022:41004. [pdf] Available at: https://preprints.jmir.org/preprint/41004

from Netherlands, where public health authorities investigated the number of tests registered that led to a test that were either triggered by symptoms, manual contact tracing or CTA notification, from end of September 2020 to end of April 2021, when vaccination wasn't readily available yet. The data showed that 72% of the tests were performed because of persons showing symptoms but not being notified by any contact tracing system. Approximately 1.5% of total requests within the period were performed as a result of the CoronaMelder notification. Of the test requests following a message in CoronaMelder 26,008 only (17% of the 152,245 test requests) were also triggered by a warning by the manual contact tracing. Furthermore, the data shows that spontaneously performed tests (having symptoms or being warned f2f / informally) had a 10% positivity rate, MCT had a 18.1% positivity rate, whereas DCT recorded 10.4% positivity rate[169]. Furthermore, the NL app evaluation showed that more than half of the persons who booked a test had not been yet approached by manual contact tracers. Among the people that received a notification via the app and did not have any symptoms, about 3 to 5% of people tested positive (data until April 2021). The detection rate of random screening over the same period is estimated to be lower, i.e., approximately 1% or lower[170].

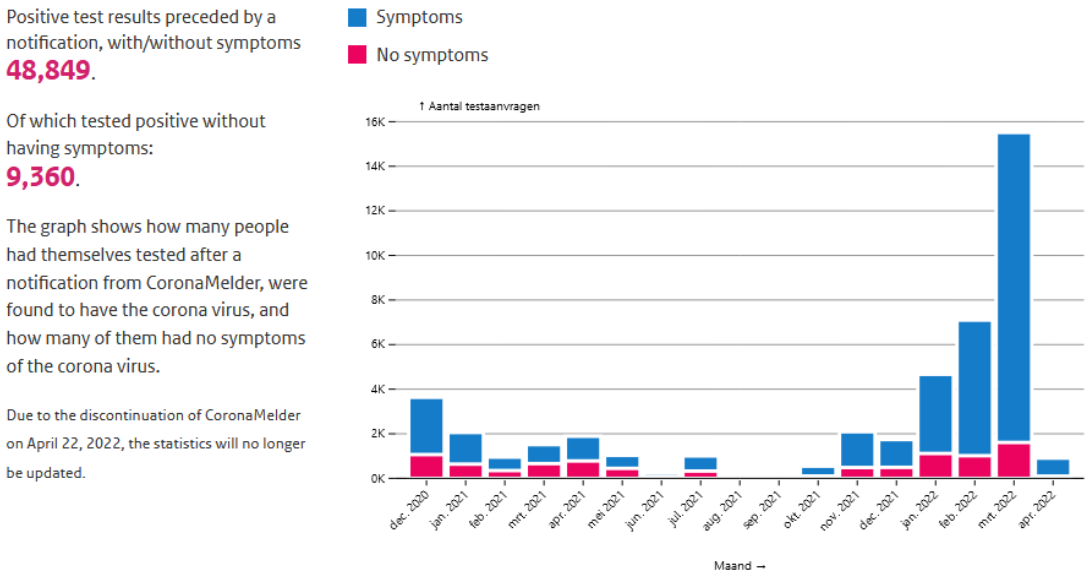

Figure 13. Netherlands. Coronamelder positive test results preceeded by a notification with and without symptoms. Source: https://coronamelder.nl/de/faq/3-2-coronamelder-data-dashboard/

Best practice from Netherlands shows that the contact tracing app consistently identified positive cases without symptoms. Between December 2020 - April 2022 the proportion of persons that were identified positive after receiving a notification via CoronaMelder and had no symptoms ranged between 3 and 11%[171].

The data underlying the table 15 were obtained using very heterogeneous sources. In the Netherlands, the public health authorities implemented an online questionnaire that citizens need to answer when they want to book a test. Data gathered via the survey showed that from 26 September 2020 to 18 April 2021 a number of 152,245 citizens (1.5% of the total test requests within the period) answered that

169 GGD GHOR NEDERLAND. (2021). Tabellenrapport CoronaMelder GGD GHOR Nederland. 6.05.2021.

170 Dutch evaluation on 23 May 2021 in: Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

171 CoronaMelder Daten-Dashboard. Available at: https://coronamelder.nl/de/faq/3-2-coronamelder-data-dashboard/

they booked a test after receiving a notification from the contact tracing app. Out of those, 74,735 had symptoms when they requested the test (49% of the 152,245), compared to 7,563,191 (78% of the 9,700,790 test requests) with symptoms among those not requesting a test following a notification from CoronaMelder[172]. Further survey data showed that by 23 May 2021 188,927 persons booked a test after being notified by the app, out of which 14,154 (approx. 7.5%) were tested positive. Since December, this has resulted in 11,022 positive tests of which approx. 35.3% (absolute number 3,893) people had no symptoms when they asked for the test. The percentage of positive tests in random sample in the same period is estimated to be much lower, namely at or below 1%[173]. The overall data indicated that 77% of the persons who booked a test after exposure notifications from the app had not been approached by regular manual contact tracing at the time of testing. This data was further confirmed by different survey questionnaires, where around 1 person in 20 that decided to get tested due to a notification has also been contacted via manual contact tracing. The authors of the study concluded that 1 in 10 test results (and 1 in 20 positive test results) were due to the CoronaMelder app.

In a German evaluation from March 2021[174] it was reported that 73% (18,099 of 24,958) of citizens were surprised to have received a notification that they were at 'increased risk', and the majority of these citizens that received a red warning (87% (13,515 of 15,540)) also subsequently underwent testing. Furthermore, the survey data showed that around 6% (792 of 13,493) of the tests carried out as a result of a (red) warning tested positive. The latest German evaluation from March 2022 reported that approximately every fifth individual who had received a red warning at the time of the test registration (PCR), tested positive for COVID-19 and that a total of 11.7% of the warned individuals thus tested positive.

A recent Swiss analysis based on a limited sample estimated that between 19% to 41% of notified contacts tested positive, depending on the predominant viral variant (Alpha vs. Omicron)[175].

Malta reported in the survey that the COVID 111 Helpline was voluntarily notified 14,061 times that individuals were notified by the COVID Alert Malta application or that they made active use of the application. Out of the 14,061 notifications they were able to link test data of 4,357 individuals, out of which 375 individuals were either "Detected" on an RT-PCT/Molecular Assay COVID-19 Test or "Reactive" on a COVID-19 Rapid Antigen Test (8.6% positive tests).

France reported that, as of 28.11.2021, 2.3% of the users that declared themselves positive in the app had been previously notified as risk contacts (survey data from users who accepted data collection in the app for anonymous statistics), and that overall, between 10 September and 28 November 2021, a total of 13.5 persons per day that were notified via the app subsequently tested positive. In comparison, through the conventional contact tracing methods established by the Sickness Insurance Scheme, between 17 and 24% of previously identified risk contacts tested positive in the same period, from early September to end November, according to Public Health France[176].

5.4.3 Apps' speed of notifying contacts compared to conventional contact tracing mechanisms

To be able to effectively reduce the number of positive cases, risk contacts need to be notified as quickly as possible to get tested and/or enter quarantine. In manual contact tracing, this implies that a tracer will contact the positively confirmed person to identify all possible close contacts. Usually, persons get

[172] Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

[173] Dutch evaluation on 23 May 2021 in Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

[174] About the Effectiveness and Benefits of the Corona-Warn-App. (2021). Retrieved 6 September 2022, from https://www.coronawarn.app/en/science/2021-06-15-science-blog-1

[175] Daniore, P. et al. (2022). Performance of the Swiss digital contact tracing app over various SARS-CoV-2 pandemic waves: Repeated cross-sectional analyses. *JMIR Preprints*. 12/07/2022:41004. [pdf] Available at: https://preprints.jmir.org/preprint/41004

[176] Ministry of Solidarity & Health Directorate General of Health. (2021). Activity Report. TousAntiCovid from 2 June 2020 to 30 November 2021.

tested when they have symptoms, but because infecting other people is already possible before symptom onset, it may take several days until the close contacts are notified after the exposure event. One of the core questions concerning digital contact tracing is whether CTA is a faster approach to notify contacts at risk than conventional contact tracing methods. There are several sequential steps involved in digital contact tracing: from exposure event to symptom onset, testing, receiving test result and activation code, uploading the activation code in the app, and receiving a notification via the app. Digital contact tracing can accelerate the last step of contact notification, by alerting potential contacts at risk as soon as the infected person receives the positive test result and enters the activation code into the app[177]. To understand the added value of digital contact tracing, a comparison with manual contact tracing is highly relevant, yet, as described in the previous section, relevant data are not available.

Median time between exposure and receipt of exposure notification through the app

An important question is how fast citizens receive an exposure notification through the app after they have been exposed to the virus compared with how fast citizens are approached by contact tracers after having an exposure event with a close contact. One available analysis from Germany reported that, on average, the warning via digital contact tracing with a verifiably infected person was received 4.2 days after the exposure (half of them within 4 days)[178]. Furthermore, warned individuals get tested on average 4.4 days after the warning (half of them in 1.7 days).

Median time between symptom onset of index case and time of entering positive test result in the app

Between symptom onset and date of entering activation code, persons need to get tested, receive their test result, and upload the activation code. To notify others that might have been exposed, the timing to trigger notifications as fast as possible is highly important. According to the French evaluation[179], from 10 September to 28 November 2021, more than 85 % of users who reported positive for COVID-19 in the application entered the date of symptoms. The median time between the start date of symptoms and the declaration in TousAntiCovid of a positive test is 2 days, whereas the average was 2.4 days. By comparison, in the Sickness Insurance Scheme, in week 47 (22 November – 28 November 2021), the average time between the start date of symptoms and the date of positive testing was 1.8 days. In Finland, the median time between symptom onset and entering the activation code was 2.3 days (with an average of 2.4 days). Similar to France, in Switzerland the median time between the start date of symptoms and that of entering the code was also 2 days.

Median difference in notification speed between app and conventional contact tracing

In Switzerland, a research study nested in manual contact tracing of the canton of Zurich observed that contacts with a non-household risk entered quarantine one day earlier after the exposure notification when compared to persons who did not receive an exposure notification[180].

Number of positive test results entered into the app within 24 hours of activation code issuance

Slovenia reported that all entered activation codes are equal to the number of positive test results within 24 hours of activation and they were issued to all persons who tested positive. Whoever decided to enter the code in the app had to do so within 3 hours of receiving the code, since after that time the code expired. Iceland, Cyprus and Portugal also stated that all entered activation codes reported were entered within 24 hours of issuance. In France, over the period from 10 September to 28 November 2021, of the 37,117 COVID-19 case declarations in the application, 4,008 reported a sampling date for

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177 von Wyl, V. et al. (2020). A research agenda for digital proximity tracing apps. *Swiss Medical Weekly*. doi: 10.4414/smw.2020.20324

178 How many active users does the Corona-Warn-App have?. (2022). Retrieved 6 September 2022, from https://www.coronawarn.app/en/science/2022-03-03-science-blog-5/

179 Ministry of Solidarity & Health Directorate General of Health. (2021). Activity Report. TousAntiCovid from 2 June 2020 to 30 November 2021.

180 Ballouz, T. et al. (2021). Adherence and Association of Digital Proximity Tracing App Notifications With Earlier Time to Quarantine: Results From the Zurich SARS-CoV-2 Cohort Study. *International Journal Of Public Health*, 66. doi: 10.3389/ijph.2021.160399

the associated positive test, i.e., 10.80 % of the declarations. For 80 % of users reporting a sampling date (the date of receiving the test result), the average time between the sampling date and the date of declaration of the test in the application was less than one day, as was the median time between these two events. For 90 % of users reporting a sampling date, the average time between these two dates is less than two days. In Germany, on average, test results are delivered 20 hours after test registration (half of the test results are received within 13 hours) and tests are registered in the app 4.4 days after a user has received a warning (half of tests are registered within 1.7 days).

5.4.4 Adherence to guidelines and quarantine

Adherence is a key success factor for effectively breaking chains of infection. The performance and effectiveness of CTAs heavily depends on whether the user of CTAs, when notified, commits to guidelines related to testing and quarantine. Or it depends on whether CTA users anonymously enter positive test results into the CTA in order to warn others. If users don't adhere, then CTAs make little sense.

There are two important reasons why the extent of adherence should be measured.

1. The first is to know whether and when higher adherence should be advocated for, for instance via public campaigns.
2. The second is to single out and to calculate the public health impact of CTAs, i.e., the effect of CTAs on the reproduction number related to other measures such as MCT. For calculating the effect size, the numbers of codes entered, and notifications received don't suffice. To make the proper calculations, one also needs to know the proportion of notifications that lead to desired behaviour: take or apply for a test and self-quarantine.

When measuring adherence, one should focus on both intention to adhere and actual adherence behaviour. Intention can be measured in the early days after implementation. However, once the numbers of entered test results and received notification start to rise, the focus should change to measuring actual behaviour. The Dutch evaluation for example showed that the intention to adhere was high, but the actual adherence after receiving a notification appeared to be significantly lower[181]. This is a forward-looking indicator, apart from the Dutch evaluation, no other evaluations quantified these aspects. A feasible method for measuring is self-report surveys, online or on paper, or a combination of both. The upside of surveys is that they are cost effective and that it is possible to calculate the extent of adherence per target audiences, which may be helpful for designing public campaigns. The downside is that self-report has a negative effect on validity of the results.

5.4.5 Barriers and enablers of contact tracing apps' approaches

Studies on perceptions of contact tracing, reasons for use and non-use of digital contact tracing apps were identified in twelve of the European countries that have developed and deployed contact tracing apps, with an overview offered in Annex V (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Sweden, Switzerland, Luxembourg, and the UK). Most studies used interview-based formats or online questionnaires to collect data. In addition, an Austrian study also conducted a content analysis of newspaper coverage[182]. In all studies, age was the most important exclusion criterion, as in the majority of studies only citizens older than 18 years were interviewed. Additional demographic data was collected, for example to work out socio-demographic correlations in the use and acceptance of contact tracing apps. In specific cases COVID-19 related information was also requested, such as COVID infections in the past or the health status. Most of the interviews addressed, among other things, the

[181] Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

[182] Zimmermann, B. M. et al. (2021). Early perceptions of COVID-19 contact tracing apps in German-speaking countries: Comparative mixed methods study. *Journal of medical Internet research*, 23(2), e25525.

use of contact tracing apps, app acceptance, and trust towards the government, the developers, and the app itself. Two studies from the UK[183] dealt with hypothetical apps, as they were conducted before the official release.

In most EU countries only relatively small proportion of the population had installed contact tracing apps and were, therefore, users of such apps. The reasons for this varied but could partly be explained by lack of trust in the privacy-preserving measures[184]. Other reasons for not downloading a contact tracing app were also identified and included: lack of advantages, no compatible smartphones, fear of surveillance, or no interest in being quarantined. It is striking, that especially in Austria, Belgium, Germany and the UK, contact tracing apps were perceived as a surveillance tool by individuals and/or the media[185]. In addition, studies in Austria, France, the Netherlands and the UK observed that lack of knowledge of the functioning and the scope of contact tracing apps was associated with a tendency of not using the app.

Regarding reasons for use, the level of trust was defined as an important factor for people's willingness to participate and download these apps. In addition, COVID-19 related worries were also associated with the willingness to install contact tracing apps e.g., the COVID-19 perceived risk showed a moderate effect in increasing the likelihood to get a COVID-19 vaccine and a strong effect on the intention to download the CTA Immuni[186]. In another study from Italy, surroundings and social networks were a more decisive factor. The strongest association related to the adoption of Immuni appeared to be having a family member who used it, followed by having a friend who adopted it, and in a more marginal way, knowing someone who relied on it[187].

Table 16. Overview of reasons for use and non-use of contact tracing apps in European countries

Reasons for use of contact tracing apps	Reasons for non-use of contact tracing apps
To support the Government	Lack of advantages/ lack of interest
Civic duty	Data privacy/security concerns
Concerns for own health and health of family/friends	Not having a compatible smartphone
Trust in government/app developers	Not able to download the app
To increase freedom	Fear of being geolocated
To have knowledge about personal risk of infection	Power consumption/Bluetooth activation
Rapid warning and detection of risky contacts while preserving users' privacy	Fear of greater surveillance
The app prevents the spread of the virus	No interest in being sent into quarantine
	Leading to unnecessary mental stress
	No knowledge about the app
	Lack of trust in government/app developers
	Lack of transparency
	Technological limitations

183 Jones, K., & Thompson, R. (2021). To Use or Not to Use a COVID-19 Contact Tracing App: Mixed Methods Survey in Wales. *JMIR mHealth and uHealth*, 9(11), e29181; Horvath, L., Banducci, S., & James, O. (2020). Citizens' attitudes to contact tracing apps. *Journal of Experimental Political Science*, 1-13.

184 Horvath, L. et al. (2022). Adoption and continued use of mobile contact tracing technology: multilevel explanations from a three-wave panel survey and linked data. *BMJ open*, 12(1), e053327.

185 Zimmermann, B. M. et al. (2021). Early perceptions of COVID-19 contact tracing apps in German-speaking countries: Comparative mixed methods study. *Journal of medical Internet research*, 23(2), e25525.

186 Caserotti, M. et al. (2022). Joint analysis of the intention to vaccinate and to use contact tracing app during the COVID-19 pandemic. *Scientific reports*, 12(1), 1-13.

187 Guazzini, A. et al. (2021). What Went Wrong? Predictors of Contact Tracing Adoption in Italy during COVID-19 Pandemic. *Future Internet*, 13(11), 286.

Regarding socio-demographic differences in the use and acceptance of contact tracing apps, studies have shown different outcomes. Studies from Belgium[188], France[189], Italy[190] and Switzerland[191] did not identify significant associations with participants' gender, education level, occupation or income. Conversely, studies from Germany, Ireland and the Netherlands did identify socio-demographic differences between users and non-users. In Germany, participants were more likely to have downloaded the contact tracing app if they were male, 65 years and older, had at least 10 years of schooling with higher education entrance qualification, lived in a town/city with over 20,000 inhabitants, lived in one of the Western federal states of Germany, or had a net household income of 4,000€ and above.[192] In Ireland, a correlation was discovered between male gender and unwillingness to use contact tracing apps as well as the age of the respondents and the willingness to use these apps (e.g. the oldest and youngest groups were most likely to indicate they probably or definitely will install the app.[193]). In a study from the Netherlands, the intention to use the app was related to age, attitude toward technology and fear of COVID-19.[194] In Switzerland, citizenship status (Swiss and second citizenship, non-Swiss citizenship vs. Swiss-citizenship only), and language region (French-speaking, Italian-speaking vs. German-speaking) were associated with lower app uptake.[195]

The most common reasons for using and downloading contact tracing apps identified in the studies were: to support the government, civic duty, concerns for own health and health of family and friends, trust in the government and app developers, to increase freedom, to have knowledge about one's personal risk of infection, rapid warning and detection of risky contacts, and preventing the spread of the virus. Frequently mentioned reasons for uninstalling contact-tracing apps were the lack of use and rapid draining of the phone's battery.

188 Walrave, M., Waeterloos, C., & Ponnet, K. (2022). Reasons for Nonuse, Discontinuation of Use, and Acceptance of Additional Functionalities of a COVID-19 Contact Tracing App: Cross-sectional Survey Study. JMIR Public Health and Surveillance, 8(1), e22113.

189 Touzani, R., Schultz, E., Holmes, S. M., Vandentorren, S., Arwidson, P., Guillemin, F., ... & Mancini, J. (2021). Early acceptability of a mobile app for contact tracing during the COVID-19 pandemic in France: National web-based survey. JMIR mHealth and uHealth, 9(7), e27768.

190 Guazzini, A., Fiorenza, M., Panerai, G., & Duradoni, M. (2021). What Went Wrong? Predictors of Contact Tracing Adoption in Italy during COVID-19 Pandemic. Future Internet, 13(11), 286.

191 von Wyl, V., Höglinger, M., Sieber, C., Kaufmann, M., Moser, A., Serra-Burriel, M., ... & Puhan, M. A. (2020). Drivers of acceptance of COVID-19 proximity tracing apps in Switzerland. medRxiv.

192 Grill, E. et al. (2021). Sociodemographic characteristics determine download and use of a Corona contact tracing app in Germany—Results of the COSMO surveys. *PloS one*, 16(9), e0256660.

193 O'Callaghan, M. E. et al. (2021). A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland. *Irish Journal of Medical Science* (1971-), 190(3), 863-887.

194 Jansen-Kosterink, S. et al. (2021). Predictors to Use Mobile Apps for Monitoring COVID-19 Symptoms and Contact Tracing: Survey Among Dutch Citizens. *JMIR formative research*, 5(12), e28416.

195 von Wyl, V. et al. (2020). Drivers of Acceptance of COVID-19 Proximity Tracing Apps in Switzerland: Panel Survey Analysis. *JMIR Public Health Surveill*. 2021 Jan 6;7(1):e25701. doi: 10.2196/25701.

6 Outlook and recommendations

6.1 Discussion

Technology adoption and use

Data analysis across the investigated countries revealed that, since their launch in 2020 and until July 2022 the apps reached the number of 206 million unique voluntary downloads. The number of active users reached up to 45% of the total population. In six of the studied countries where the apps have been most intensely used (Finland, Ireland, Germany, Iceland, France, Switzerland), the percentage of active users per total population ranged between 26 and 45% and the numbers of peak active users added up to 56 million active users. Up to 70% of app users who were diagnosed positive with COVID-19 entered their test results in the app to warn others. Across the studied apps, over 13.4 million positive tests were entered into the apps to warn other people at risk of infection, with best practices showing that the number of positive tests entered into the app can reach up to 20% of the total number of positive cases in the respective country. Countries reported that between 0.8 and up to 19 exposure notifications per positive entered test into the app were sent to notify contacts at possible risk of infection. Data reported from seven countries[196] revealed that over 177 million warning notifications have been generated.

Digital contact tracing was part of health systems' resilience response to a new situation, developed at a very fast pace related to other innovations, and adopted at a considerable scale in a voluntary manner by a higher than expected amount of the population. This effect is particularly striking, in the sense that not everyone immediately accepts a disruptive idea. In the context of contact tracing apps, an unprecedented large adoption of a new digital public health technology was observed in several countries.

Technology effectiveness

Surveys carried out across the investigated countries found that between 2.3% and up to 41% of app users that got tested due to a notification were found to be positive, showing that the apps have the capacity to detect contacts at risk of infection. The analysis[197] from Netherlands showed that approximately 1.5% of total COVID-19 tests requests within the period of September 2020 to April 2021 were performed as a result of the CoronaMelder notification. Of the test requests that actually led to a test following a message in CoronaMelder, only 17% of the test requests triggered by CoronaMelder were also triggered by a warning by MCT, emphasising the capacity of digital proximity tracing to complement MCT efforts. The data from the same period shows that spontaneously performed tests (having symptoms or being warned in a face-to-face setting / informally) had a 10% positivity rate, MCT had a 18.1% positivity rate, whereas CoronaMelder recorded 10.4% positivity rate. Furthermore, more than half of the persons who scheduled a test after receiving a notification from the Dutch app were not approached yet by the public health authorities at the time of booking a test. Out of those that got tested due to the notification and were declared positive for COVID-19, about 3 to 5% of people did not have any symptoms. At the same time, the detection rate of random screening over the same period is estimated to be lower, i.e., approximately 1% or lower[198]. Until April 2022, the percentage of identified positive contacts that did not present any symptoms out of those that got tested after receiving a

[196] The number of notifications generated was reported by Germany, France, Belgium, Italy, Czech Republic, Ireland, and Latvia.

[197] GGD GHOR NEDERLAND. (2021). Tabellenrapport CoronaMelder GGD GHOR Nederland. 6.05.2021.

[198] Dutch evaluation on 23 May 2021 in: Ebbers, W. et al. (2021). Evaluation CoronaMelder. An overview after 9 months. Small but appreciable added value during lockdown, with greater potential benefit as society reopens. [pdf] Available at: https://coronamelder.nl/media/Evaluatie_CoronaMelder_na_9_maanden_english.pdf

notification via the digital contact tracing app reached 11%.

Ultimately, the effectiveness of contact tracing apps is dependent on the cascade of actions users need to undertake and adhere to; from downloading the app, to using the app, to testing after being notified, self-quarantining until test results, and if so, reporting in the application after being tested positive and isolating themselves. The present findings show that the behaviour of citizens towards digital contact tracing was heterogenous and varied across the studied European countries. Yet best practice examples show that the apps can be a powerful tool to complement conventional contact tracing and support public health processes, by consistently identifying contacts that tested positive which would otherwise be missed by conventional contact tracing (such as contacts that remain asymptomatic). Furthermore, getting test results directly through the app may help persons to quarantine faster and to relieve the workload on traditional processes and services. Every positive contact identified is highly relevant in the context of a pandemic and there are available simulations that show averted hospitalisations and deaths per identified case[199]. While some questions remain regarding whether too many notifications would overwhelm the testing systems, best practice from France[200] shows otherwise: during December 2021, there was an average of 21,049 notifications generated by the French app per day (with a peak of 3.4 notifications sent per positive case confirmed in the app). Upon receiving a notification, app users were recommended to do a self-test, which, only if positive, would trigger a further recommendation to take an official test (the self-tests cannot be entered in the app).

Cost-effectiveness considerations

When it comes to digital health and, in particular digital contact tracing, an on-going debate is related to the cost-effectiveness of such systems. The early expectations reported in the media was that the wide adoption of digital contact tracing would completely stop the pandemic. Once this hope did not materialise, some pundits quickly concluded it to be a loss from a socio-economic point of view[201]. However, to conduct a socio-economic impact assessment, there is a need for a suitable cost-benefit analysis framework, with both quantifiable and non-quantifiable benefits such as lives saved due to averted cases. A tentative analysis of the social costs and benefits of the CoronaMelder suggests that the benefits are in balance with the costs, even if considering only the years of life saved by preventing deaths[202]. The cost-benefit indicators would need further standardisation to compare across countries and some indicators would involve data that cannot actually be acquired and/or that is not readily available. Furthermore, cost-effectiveness is not equivalent to the actual effectiveness of the technology itself, and cost-effectiveness issues and the burden on the system are dependent on the level of healthcare systems' digitalisation and the degree of trust citizens have in such systems. A further dimension of cost-effectiveness considerations pertains to the optimal timing for implementation of contact tracing solutions. It is conceivable that the apps may be particularly efficient in emerging epidemics with starkly rising case numbers, when conventional contact tracing may not have yet been scaled appropriately. Such scenarios were observed during the second COVID-19 waves in several European countries in Fall 2020. Conventional contact tracing became overwhelmed, but health authorities acted quickly by increasing capacities. As the number of new cases subsided, the contact tracing workforce was also reduced. In principle, the more scalable proximity tracing systems could act as a buffer, as it is extremely demanding from a socio-economic point of view to permanently maintain a contact tracing staff on payroll to manage very high caseloads, especially during peak wave incidence.

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199 Boncz, P. (2021). An epidemiological model for contact tracing with the Dutch CoronaMelder App. arXiv preprint arXiv:2105.15111.

200 Ministry of Solidarity & Health Directorate General of Health. (2021). Activity Report. TousAntiCovid from 2 June 2020 to 30 November 2021.

201 Márquez, Á. (2022). Covid-19 contact tracing apps: a €100m failure. Retrieved 6 September 2022, from https://voxeurop.eu/en/covid-19-track-trace-apps-a-100m-failure/

202 Poort, J. P. (2022). De CoronaMelder door een economische lens. *TPEdigitaal*, 16(2), 48-60. [pdf] Available at: https://pure.uva.nl/ws/files/69301295/TPEdigitaal_2022_2.pdf

As the technology is currently readily available and open-source, future costs would mostly be related to the promotion, integration, staff coordination costs, etc., which should be backed by appropriate budgets and efforts. Furthermore, financial incentives for using contact tracing apps and for complying with recommendations in case of exposure notifications might be considered. While such measures would certainly add to the overall costs, they would likely also improve compliance and thus app effectiveness. Many issues regarding these aspects are still unresolved (e.g., how to prevent cheating), but clearly warrant further investigation.

Forward-looking

The study's recommendations include defining evaluation purposes early in the process, performing periodic evaluations, and enabling ways to collect the necessary data from different public health services, including testing facilities and conventional contact tracing, as well as adding opt-in functionalities to collect the number of notifications (e.g., Italy), considering the implementation of privacy-preserving analytics (e.g., Germany) and conducting surveys at the point of testing (e.g., Netherlands). The WHO/ECDC framework serves as a good reference framework for countries and can be used to identify bottlenecks that ultimately affect the effectiveness of the app. For example, some countries showed high app uptake, but a lower percentage of activation codes shared, behaviour that could be addressed through better promotion and digital education. During the course of the study, 12 countries actively participated in validating the revised WHO/ECDC framework and at least two countries (Estonia and Cyprus) have confirmed that they are committed to or are in the process of aligning their evaluation methodology with the framework. To be able to have a meaningful cross-country comparison, there is a need for joint efforts and technical standardisation of the measured parameters.

In some countries the decision to stop promoting the app was taken early, when the vaccination campaigns started. However, all measures like wearing masks, social distancing and lockdowns, conventional contact tracing and vaccination, were conceived as complementary. Further considerations regarding specific configurations of applying them need to be pursued, as it can weaken the effect of digital tracing and vice-versa. For example, digital contact tracing can have only limited positive impact during lockdowns. On the other side, lockdowns have a range of negative societal and economic impacts, which can be mitigated by stronger use of measures like digital contact tracing and stricter mask policies. In order to identify good combinations of and a balance between measures that depend on the pandemic's development, research insights and countries' experiences needs to be examined jointly. This will help to achieve a better understanding of impacts, limitations, and complementarity of measures. In this regard, the study is contributing to the wider picture by being committed to sharing its findings with ongoing studies in the field, including the ongoing EC "Feasibility study on contact tracing tools and applications used at (inter)national and EU level and integration within EWRS, selective exchange module".

The efforts related specifically to digital contact tracing demonstrate the ability of Europe to agree on and deliver an innovative tracing and warning technology to at least tens of millions of users in a privacy-preserving, timely manner, enabled by effective coordination and sharing of experiences between countries, all of which resulted in a system ready to be used in new health and care scenarios.

6.2 Outlook for digital contact tracing in Europe

As of 31 July 2022, 10 apps out of 27 are still active and in use. When asked to reflect on the future of digital contact tracing, countries reported different plans. Germany is investigating the use of the contact tracing app for other use cases. In Slovenia, focused use of the app in a university setting is being proposed and the decision on actual implementation is still ongoing. In other countries like Belgium, where contact tracing is in the competence of regional authorities that are drafting their plans,

some of which will include digital contact tracing and others will not. They consider conventional tracing better suited for new diseases and outbreaks such as monkey pox whereby transmission happens mainly by intensive contact that can be better managed with conventional tracing. In line with the lessons learned, Belgium also wants to focus on 1) strengthening the digital healthcare infrastructure, 2) investing more in continuous communication with healthcare providers, and 3) broader public planning of substantial budget for continuous updates (as the pandemic evolves and insights evolve, the app needs to be updated continuously). Belgium has no specific plans to use its app in other contexts as they believe it to present privacy risks to society and to individual users. Such a risk is justified during a pandemic, but in Belgium's opinion should not be taken for other cases of use such as fighting colds or the flu. Therefore, Belgium plans to put the app in sleep mode if the pandemic settles down (low number of infections or strong reduction in testing).

Countries like Lithuania and France plan to stop the app with the possibility of reuse if need may arise in the future. For the time being, Lithuania has no further plans to invest more in the app.

In the Netherlands, the app is suspended for the time being. If the epidemiological situation requires it, the app can be reactivated. Long-term plans are not yet definitive. Other uses of GAEN beyond the use of fighting infectious (pulmonary) diseases that spread in close proximity are limited.

Norway intends to use the experience and lessons learned from the deployment and use of their app and focus on how such solutions in the future can bring additional value and supplement conventional contact tracing.

Latvia, Malta, Cyprus, Portugal, Estonia, and Finland did not report official plans for the future use of their apps. Estonia has reported however that this decision will be reviewed once the EC and WHO review is completed (incl. the publication of this study report). In Cyprus, there are initial discussions about the potential use and extension of the national app as well. This will take place as part of the implementation of the Cyprus Innovative Public Health ICT System (CIPHIS) that incudes components for monitoring and managing future pandemics.

Table 17. Current status of contact tracing apps

Country / Territory	App	Actual status as of 31 October 2022
Austria	Stopp Corona App	Suspended on 28.02.2022
Belgium	Coronalert	Active
Croatia	Stop COVID-19	Active
Republic of Cyprus	CovTracer-EN	Suspended on 25.07.2022
Czech Republic	eRouska	Suspended on 01.11.2021
Denmark	Smittestop	Suspended on 31.03.2022
Estonia	HOIA	Suspended on 02.05.2022
Finland	Koronavilkku	Suspended on 01.06.2022
France	TousAntiCovid	Active
Germany	Corona-Warn-App	Active
Hungary	VirusRadar	Suspended on 25 June 2021
Iceland	Rakning C-19	Active

Country / Territory	App	Actual status as of 31 October 2022
Ireland	COVID Tracker	Active
Italy	Immuni	Active
Latvia	Apturi Covid	Active
Lithuania	Korona Stop LT	Suspended on 12.10.2022
Malta	COVIDAlert	Suspended on 06.07.2022
Netherlands	CoronaMelder	Suspended on 22.04.2022
Norway	Smittestopp 2	Suspended on 10.08.2022
Poland	STOP COVID	Suspended on 31.03.2022
Portugal	StayAway COVID	Suspended on 27.05.2021
Slovenia	#OstaniZdrav	Active
Spain	Radar Covid	Suspended on 9.10.2022
Switzerland	SwissCovid	Suspended on 01.04.2022
UK – England and Wales	NHS COVID-19	Active
UK – Northern Ireland	StopCOVID NI	Suspended
UK – Scotland	Protect Scotland	Suspended on 29.04.2022

6.3 Recommendations

Based on the literature review, interviews, survey, and data analysis performed in this study, some main recommendations have been derived. These are aimed at ensuring that the European Commission, Member States and other countries exploit the experiences and lessons learned through the application of digital contact tracing in the COVID-19 pandemic. The recommendations are intended to provide support for the ability to deploy digital contact tracing systems in comparable future situations in ways that allow processes and outcomes to be monitored and used by learning health systems.

Complement early on conventional with digital contact tracing
Countries should consider deploying digital contact tracing solutions if they want to address situations that cannot be timely captured by conventional contact tracing or situations in which conventional tracing is overwhelmed and can benefit from digital tracing.

With over of a million confirmed deaths due to the coronavirus in EU/EEA countries alone[203], every person warned of a potential infection is important. Digital contact tracing can capture occurrences which cannot be recorded via manual tracing, such as encounters with strangers (such as nearby passengers in public transportation or visitors in a theatre).

The deployment of such apps, which should be offered to citizens for voluntary use, should also be based on a strategic analysis of the timing of the deployment in order to be most likely to show benefits, i.e., when there are no hard restrictions like lockdowns or when the number of cases are high.

Develop further and keep up to date the common EU Toolbox
The EU Toolbox on mobile applications in the EU's fight against COVID-19 is valued by Member States and should be kept up to date and extended, if necessary, for pandemic preparedness.

Most of the surveyed Member States reported that the EU Toolbox provided useful input to the development of their national app. In some cases, it shortened the app's development time, a critical factor in an ongoing pandemic. The EU Toolbox should, however, be updated to address and document aspects that have emerged since its development. Suggestions for updates are provided in section 4.2 and include a clearer discussion on implications of using different communication protocols, inclusion of guidance about integration with the national public health and tracing ecosystem, and the addition of risk estimation covering also the latest and most widely spread virus variants.

Maintain the dynamic and agile EU collaboration
The flexible and dynamic collaboration of Member States supported by the European Commission should be maintained as a good model and refined based on the lessons learnt, including collaborating on digital contact tracing with interested countries outside the EU.

EU Member States who collaborated and exchanged practices on digital contact tracing through the eHealth Network and its technical working groups, supported by the European Commission, broadly agreed that the collaboration set-up is effective and should be considered in further scenarios in order to benefit from knowledge and practice exchange, (EU) inter-operability by design approach, re-use of

[203] ECDC. (2022). COVID-19 situation update for the EU/EEA, as of 31 August 2022. Retrieved 6 September 2022, from https://www.ecdc.europa.eu/en/cases-2019-ncov-eueea

open-source developments, and continuous collaboration, especially in situations such as pandemics. The collaboration was reported to have enabled fruitful exchanges that were also spilled over into subsequent collaboration activities such as the speedy development of the EU Digital COVID Certificate. Specific areas for improvement of the collaboration are provided in section 4.1 and include better inclusiveness for non-EU countries, as well as better alignment with other relevant platforms and channels like the Early Warning Response System of the European Union.

Sustain the common EU infrastructure and services such as the EFGS

The European Federation Gateway Service is a unique example of a cross-border infrastructure that connects apps developed at MS level.

The EFGS is seen by most Member States as a valuable tool that offers a clear future for rapid agile EU integration based on open standards and agreed protocols. It was set up and agreed on by all but one of the eligible Member States that could connect to it, without the need for a dedicated regulation to be developed beforehand, allowing for a rapid roll-out.

Suggestions for the EFGS' improvement are provided in section 4.3 and include an appeal to broaden its inclusion policy and increase the attractiveness of the platform, more top-down promotional efforts, easy to use onboarding and offboarding supporting materials, and exploring technical solutions for enabling the connection of apps with centralised architectures.

Enhance integration and alignment with overall public health processes

Countries should, within the boundaries of privacy regulations, consider integrating or aligning their digital contact tracing solutions with the services, processes and informational flows of conventional contact tracing and the wider public health ecosystem to achieve a user-friendly experience and increase the attractiveness of the apps.

A key lesson learned was that for effective implementation of digital interventions, it is important to first:

- Strengthen the underlying digital health infrastructure
- Where possible, align data flows and processes to create synergies and added value for public health, e.g., by exploring the linkage between contact tracing apps data and data required for other tools used by public health authorities, such as tools for contact investigation, contact notification and monitoring, or cross-border tools and frameworks such as the Digital Passenger Locator Forms
- Invest more in continuous communication with healthcare providers and the wider public
- Integrate additional features within the app; ordering tests or the ability to use test results through the app can enhance user adoption while streamlining the user experience of persons seeking testing. This should be done in a way that maintains the privacy-preserving character of the app's proximity tracing functionality.

Encouraging self-confirmation of infections may also be a part of any future communication campaign and can be aligned with the manual contact tracing.

Boost promotion early on and invest in further functionalities

Putting more effort into promoting the apps, their features and benefits of and possible incentives for using them will increase their uptake and lead to more effective warning of users about potential infections.

Promotional efforts are important for uptake and effectiveness of the app. Almost every second country reported insufficient promotional activities. Aspects that are seen as critical for a successful promotion of the apps include:

- Delivering clear and coherent messages that are aligned with citizens' level of awareness and sensitivity to the topic of tracing (e.g., using "tracing" vs. "warning")
- Planning for continuous promotion and updates (as the pandemic evolves and insight evolve, the app needs to be updated continuously) and planning a dedicated budget accordingly
- Including additional features (e.g., the covid certificate has been a very positive trigger to promote the app uptake) to move away from a passive app and make it more attractive for continuous use
- Underlining the importance of the contact tracing functionality (some people might only use it for the additional functionalities)
- Addressing digital literacy in the promotional campaigns to enhance uptake in certain populations
- Continuously addressing, through stakeholder engagement and promotion, the privacy and security of the apps and other identified barriers (lack of advantages/ lack of interest, fear of being geolocated, fear of greater surveillance, power consumption/Bluetooth activation, no interest in being sent into quarantine, leading to unnecessary mental stress, no knowledge about the app, lack of trust in government/app developers).

Evaluate and monitor from the onset using common indicators

Planning the evaluation of the apps' use and effectiveness and related metrics should be an integral part in the early app planning and development phase.

Common indicators can be agreed upon using privacy-preserving analytics and the necessary data can be planned to be collected from the onset.

- Think about evaluation outcomes when early in the process and consider periodical evaluation of the app to identify bottlenecks to be addressed
- Consider different opt-ins, data preserving analytics, integrated surveys etc. to gather necessary data
- Joint EU effort is needed to have a standardised way of reporting indicators regarding the effectiveness and uptake in order to assess the impact across each MS
- Examine the impact of digital contact tracing in the wider context of other key preventative measures, bring together results from ongoing impact assessment research to analyse the interplay, complementarity, limitations, timeliness and duration of application, combinations of different measures and containment strategies.

Annex I – Country fact sheets

Digital contact tracing
for COVID-19 in Europe

Austria

In the period March 2020 - February 2022 Austria offered its citizens a digital contact tracing app in its efforts to combat the COVID-19 pandemic. The Stopp Corona app could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. The Stopp Corona App has been downloaded more than 1.4 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	25 March 2020	Suspended	Yes (February 2021 – February 2022)	Link

Main organisations involved

Data controller	Operating system provider	Additional partners
Austrian Red Cross	Accenture GmbH	See app website

Key app functionalities

Notify contacts when positive

Symptom tracker

Diary/ journal

Digital contact tracing
for COVID-19 in Europe

Austria

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Austrian Red Cross

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

In the period February 2021 – February 2022, the Stopp Corona app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. More than 16,500 Austrian keys have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**1.47 million**
App downloads as a share (%) of the population:	**16 %**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. The latest number of downloads for Austria was reported on 12.01.2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Belgium

Coronalert

Belgium's app Coronalert has been developed to combat the COVID-19 pandemic. The app was launched on 30 September 2020 and is currently active[1]. It can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Coronalert app has been downloaded more than 4 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	30 September 2020	Active	Yes	Link

Main organisations involved

Data controller	Operating system provider	Additional partners
Sciensano	Devside supported by Ixor	See app website

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- Diary/ journal
- In-app COVID-19 related statistics
- Navigate to external resources
- Receive test results in app

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Belgium

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Sciensano

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

The Coronalert app is part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Belgium joined the EFGS on 4 January 2021 and has since uploaded more than 467,000 keys.

Available information about use and uptake[3]

App downloads:	**4.2 million**
App downloads as a share (%) of the population:	**36 %**
Number of COVID-19 codes issued:	**336,916**
Number of COVID-19 codes entered:	**118,564**
Proportion of all positive tests that occur among app users:	**8.3 % (issued codes)** **2.9 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**35.2 %**
Ratio of exposure notifications received to positive test results entered:	**Ø 3.6**
Total number of exposure notifications generated:	**425,931**
Number of test results received in the app:	**4,051,165**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for number of COVID-19 codes and positive tests: 30.09.2020 – 05.06.2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Croatia

Stop COVID-19

The Croatian app Stop COVID-19 was launched on 27 July 2020 as part of the country's strategy to combat the COVID-19 pandemic. The app can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Stop COVID-19 app has been downloaded more than 243,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	27 July 2020	Active	Yes	Link

Main organisations involved

Data controller	Software developer	Others	
Croatian Ministry of Health	APIS IT	Bornfight	Croatian Agency for the Protection of Personal Data

Key app functionalities

Notify contacts when positive

Digital contact tracing
for COVID-19 in Europe

Croatia

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Croatian Personal Data Protection Agency

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

Since November 2020, the Stop COVID-19 app has been part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures.

Available information about use and uptake[3]

App downloads:	**243,426**
App downloads as a share (%) of the population:	**6 %**
Number of COVID-19 codes issued:	**81,931**
Number of COVID-19 codes entered:	**87**
Proportion of all positive tests that occur among app users:	**6.9 % (issued codes)** **0.007 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**0.1 %**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection: 27.07.2020 – 08.08.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Republic of Cyprus

COVTRACER-EN

Cyprus developed the Covtracer-EN app to combat the COVID-19 pandemic. The app was launched on 11 March 2021 (with an earlier GPS-version released on 5 April 2020) and has since been suspended. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Covtracer-EN has been downloaded more than 60,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	11 March 2021	Suspended on 25 July 2022	Yes (December 2020 – March 2022)	Link

Main organisations involved

Data controller	Others	Additional partners
Ministry of Health of the Republic of Cyprus	KIOS Center of Excellence at the University of Cyprus CYENS Centre of Excellence Deputy Ministry of Research, Innovation and Digital Policy (DMRID) National eHealth Authority (NeHA)	See app website

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- In-app COVID-19 related statistics
- Reach the call centre

Digital contact tracing
for COVID-19 in Europe

Republic of Cyprus

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Impact Assessment:
Available upon request

Cross-border tracing and warning

In the period December 2020 – March 2022 the Covtracer-EN app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications in case of detected exposures. The app was disconnected due to low usage from the public and subsequently low impact of the app among the Cypriot society.

Available information about use and uptake[2]

App downloads:	**60,958**
App downloads as a share (%) of the population:	**7 %**
Peak number of active users:	**23,395**
Percentage of population who actively used the app (peak):	**3 %**
Number of COVID-19 codes issued:	**197**
Number of COVID-19 codes entered:	**79**
Proportion of all positive tests that occur among app users:	**0.2 % (issued codes)** **0.1 % (entered codes)**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for number of COVID-19 codes and positive tests: 05.04.2020 – 29.10.2021

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Czech Republic

eRouska

The Czech Republic developed the eRouska app to combat the COVID-19 pandemic. The app was launched on 11 April 2020 and has since been suspended. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the eRouska has been downloaded more than 1.6 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	11 April 2020	Suspended on 1 November 2021	Yes (March – October 2021)	Link

Main organisations involved

Data controller	Others	Additional partners
Ministry of Health of the Czech Republic	National Agency for Communication and Information Technologies	See app website

Key app functionalities

Notify contacts when positive

Digital contact tracing
for COVID-19 in Europe

Czech Republic

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Czech Data Protection Authority

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

In the period March – October 2021 the eRouska app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. 65,859 keys were uploaded to the EFGS via the eRouska app.

Available information about use and uptake[2]

App downloads:	**1.6 million**
App downloads as a share (%) of the population:	**15 %**
Peak number of active users:	**500,000**
Percentage of population who actively used the app (peak):	**5 %**
Number of COVID-19 codes entered:	**67,802**
Proportion of all positive tests that occur among app users:	**4.6 % (entered codes)**
Ratio of exposure notifications received to positive test results entered:	**Ø 3.8**
Total number of exposure notifications generated:	**257,086**

1: Check performed on 31 August 2022. The app is interoperable with the German Corona-Warn-App but not connected to the EFGS

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes, positive tests, and exposure notifications: 20.04.2020 – 24.03.2021

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Denmark

Smittestop

Denmark developed the Smittestop app to combat the COVID-19 pandemic. The app was launched on 18 June 2020 and has since been suspended. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Smittestop app has been downloaded more than 2.2 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	18 June 2020	Suspended on 31 March 2022	Yes (November 2020 – March 2022)	Link

Main organisations involved

Data controller	Operating system provider	Others		
Danish Patient Safety Agency	Netcompany	Danish Ministry of Health	Danish Health Authority	Danish Agency for Digitisation

Key app functionalities

- Notify contacts when positive
- In-app COVID-19 related statistics

Digital contact tracing
for COVID-19 in Europe

Denmark

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Danish Data Protection Agency Datatilsynet

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

In the period November 2020 – March 2022 the Smittestop app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Denmark was one of the first Member States to join, with more than 4.8 million keys uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**2.3 million**
App downloads as a share (%) of the population:	**39 %**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Estonia

HOIA

Estonia developed the HOIA app to combat the COVID-19 pandemic. The app was launched on 20 August 2020 and has since been suspended. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the HOIA app has been downloaded more than 300,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	20 August 2020	Suspended on 2 May 2022	Yes (July 2021 – May 2022)	Link

Main organisations involved

Data controller	Operating system provider	Additional partners
Estonian Health Board	Estonian Health and Welfare Information Systems Centre	See app website

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- In-app COVID-19 related statistics
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Estonia

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Estonian Data Protection Inspectorate

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

In the period July 2021 – May 2022 the HOIA app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. 16,715 keys from Estonia have been uploaded to the EFGS.

Available information about use and uptake[2]

App downloads:	**301,585**
App downloads as a share (%) of the population:	**23 %**
Number of infection confirmations in the app:	**8,556**
Proportion of infection confirmations in the app:	**2.6 %**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection: 20.08.2020 – 01.2022. In Estonia, no COVID-19 codes are issued. Instead, the Estonian DCT app HOIA had a mechanism that allowed users to prove their identity to the backend using national electronic identity. The number of infection confirmations is equivalent to number of entered codes in other countries.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Finland

Koronavilkku

Finland developed the Koronavilkku app to combat the COVID-19 pandemic. The app was launched on 31 August 2020 and has since been suspended. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Koronavilkku app has been downloaded more than 3 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	31 August 2020	Suspended on 1 June 2022	Yes (January 2021 – June 2022)	Link

Main organisations involved

Data controller	Backend operator	Others		
Finnish Institute for Health and Welfare	Social Insurance Institution of Finland (Kela)	Ministry of Social Affairs and Health	Solita Oy	DigiFinland Oy	National Cyber Security Centre

Key app functionalities

- Notify contacts when positive
- Integration to symptom assessment
- In-app COVID-19 related statistics
- Navigate to external resources

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Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Finland

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Office of the Data Protection Ombudsman

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

In the period January 2021 – June 2022, the Koronavilkku app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. More than 582,000 Finnish keys have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**2,5 million**
App downloads as a share (%) of the population:	**45 %**
Peak number of active users:	**892,216**
Percentage of population who actively used the app (peak):	**16 %**
Number of COVID-19 codes issued:	**94,461**
Number of COVID-19 codes entered:	**64,742**
Proportion of all positive tests that occur among app users:	**8.7 % (issued codes) 6 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**68.5 %**
Median time between exposure and receipt of exposure notification through the app:	**2 days**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 31.08.20 – 31.05.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

France

France developed the TousAntiCovid app to combat the COVID-19 pandemic. The app was launched on 22 October 2020 and is one of only two EU apps which use a centralised app architecture. The app can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology, based on which the French public health authority can issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the TousAntiCovid app has been downloaded more than 59 million times, making it the contact tracing app with the highest number of unique downloads in the EU.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	22 October 2020	Active	No	Link

Main organisations involved

Data controller	Backend operator	Software developer
INRIA	Capgemini	Lunabee Studio

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- In-app COVID-19 related statistics
- Manage vaccine and test certificates
- Navigate to external resources
- Call button to a call centre
- Check-in with QR code and check-in history

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

France

App architecture

Centralised: the anonymised interactions (keys) are uploaded to a central server operated by the public health authority, which performs the assessment of risk interactions (matching of keys of users who have been in contact with an infected person) directly on that server. It is up to the app of the users to contact the server to get a "contact status" on a daily basis (the server by definition can't contact apps for privacy reasons).

France chose the centralised approach, stating several reasons, which can be grouped under efficiency-related reasons (enabling real-time knowledge of the epidemiological situation, monitoring of the number of warnings sent, full control of warning criteria), sovereignty-related reasons (keeping control of citizens' health data and of the technology) and privacy-related reasons.

Data protection

Data Protection Authority: French Data Protection Authority

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

Currently, apps with a centralised architecture cannot be connected to the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures.

Available information about use and uptake[2]

App downloads:	**59.2 million**
App downloads as a share (%) of the population:	**87 %**
Peak number of active users:	**18 million**
Percentage of population who actively used the app (peak):	**27 %**
Number of COVID-19 codes entered:	**5.5 million**
Proportion of all positive tests that occur among app users:	**16.5 % (entered codes)**
Ratio of exposure notifications received to positive test results entered:	**Ø 1.9, max 3.4**
Total number of exposure notifications generated:	**4.2 million**
Proportion of diagnosed cases among app users who have previously received an exposure notification through the app:	**2.3 %**
Median time between exposure and receipt of exposure notification through the app:	**2 days**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022 and on the Ministry of Solidarity and Health Directorate General of Health Activity Report of TousAntiCovid for the period 02.06.2020 – 30.11.2021. Timeframe of data collection for COVID-19 codes, positive tests and exposure notifications: 22.10.2020 – 12.08.2022. In France COVID-19 codes are generated for all positive tests.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Germany

Germany offers its citizens a digital contact tracing app in its efforts to combat the COVID-19 pandemic. The Corona-Warn-App was launched on 16 June 2020 and is currently active[1]. The app, which can be installed on citizens' smartphones, captures anonymised interactions between smartphones based on Bluetooth technology and issues warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Corona-Warn-App has been downloaded more than 46 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning	Source code
Link	16 June 2020	Active	Yes	Link

Main organisations involved

Data controller	Backend operator	Software developer	Additional partners
Robert Koch Institute	Deutsche Telekom	SAP	See app website

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- Diary/ journal
- In-app COVID-19 related statistics
- Manage vaccine and test certificates
- Navigate to external resources
- Check-in with QR code and check-in history
- Create QR codes for events
- Receive test results in app
- Book tests in app

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Germany

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Federal Commissioner for Data Protection and Freedom of Information (BfDI)

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

The Corona-Warn-App is part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Germany was one of the first countries to have joined the EFGS on 12 November 2020 and has since uploaded more than 57 million keys, or more than 85 % of all EFGS uploads.

Available information about use and uptake[3]

App downloads:	**46 million**
App downloads as a share (%) of the population:	**56 %**
Peak number of active users:	**31 million**
Percentage of population who actively used the app (peak):	**37.2 %**
Number of COVID-19 codes issued:	**9,387,164**
Number of COVID-19 codes entered:	**6,656,979**
Proportion of all positive tests that occur among app users:	**28.1 % (issued codes) 20 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**71%**
Ratio of exposure notifications received to positive test results entered:	**6 – 19 red warnings**
Total number of exposure notifications generated:	**172,474,208**
Proportion of diagnosed cases among app users who have previously received an exposure notification through the app:	**6 % – 11.7 %**
Median time between exposure and receipt of exposure notification through the app:	**warned individuals get tested on Ø 4.4 days after the warning (half of them in 1.7 days)**
Number of test results received in the app:	**209,803,348**

1: Check performed on 15 July 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022 and on the German evaluations performed (About the Effectiveness and Benefits of the Corona-Warn-App and How many active users does the Corona-Warn-App have?). Timeframe of data collection for COVID-19 codes, positive tests and exposure notifications: 16.06.2020 - 26.07.2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Hungary

The Hungarian VirusRadar app was launched on 13 May 2020 and has since been suspended. It is one of only two EU apps which use a centralised app architecture. The app could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology, based on which the Hungarian public health authority could issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the VirusRadar app has been downloaded more than 95,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Not available	13 May 2020	Suspended	No	Not available

Main organisations involved

Data controller	Software developer	Others		
National Centre for Public Health	Nextsense	Ministry of Innovation and Technology in Hungary	Biztributor	Hungarian Government Agency for Development of Informatics

Key app functionalities

Notify contacts when positive

Digital contact tracing
for COVID-19 in Europe

Hungary

App architecture

Centralised: the anonymised interactions (keys) are uploaded to a central server operated by the public health authority, which performs the assessment of risk interactions (matching of keys of users with a confirmed infection) directly on that server and informs users via their smartphones, where necessary. Hungary was one of only two EU countries to choose the centralised approach, alongside France.

Data protection

Data Protection Authority: National Authority for Data Protection and Freedom of Information

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

Currently, apps with a centralised architecture cannot be connected to the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures.

Available information about use and uptake[2]

App downloads:	**95,000**
App downloads as a share (%) of the population:	**1 %**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Iceland

Iceland developed the Rakning C-19 app to combat the COVID-19 pandemic. The app was launched on 2 April 2020. It can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Rakning C-19 app has been downloaded more than 547,000 times.[1]

Rakning C-19

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	2 April 2020	Active	No	Link

Main organisations involved

Data controller	Software developer
Ministry of Justice	Directorate of Health

Key app functionalities

- Notify contacts when positive
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Iceland

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Icelandic Data Protection Authority

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

The Rakning C-19 app was not part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications in case of detected exposures. Despite great interest from non-EU countries, the scope of application of the EFGS was limited to EU Member States.

Available information about use and uptake[2]

App downloads:	**547,937**
App downloads as a share (%) of the population:	**146 %**
Peak number of active users:	**100,000**
Percentage of population who actively used the app (peak):	**27 %**
Number of COVID-19 codes issued:	**5,018**
Number of COVID-19 codes entered:	**2,590**
Proportion of all positive tests that occur among app users:	**2.5 % (issued codes)** **1.3 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**51.6 %**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection: 02.04.2020 – 23.08.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Ireland

Ireland developed the COVID Tracker app to combat the COVID-19 pandemic. The app was launched on 7 July 2020. It can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the COVID Tracker app has been downloaded more than 4.5 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	7 July 2020	Active	Yes	Link

Main organisations involved

Data controller	Software developer	Additional partners
Health Service Executive (HSE)	NearForm	See app website

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- In-app COVID-19 related statistics
- Manage vaccine and test certificates
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Ireland

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Data Protection Commission

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

Ireland was the first country to join in November 2020 the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Since then, more than 85,000 Irish keys have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**4.5 million**
App downloads as a share (%) of the population:	**89 %**
Peak number of active users:	**2 million**
Percentage of population who actively used the app (peak):	**40 %**
Number of COVID-19 codes issued:	**102,000**
Number of COVID-19 codes entered:	**24,857**
Proportion of all positive tests that occur among app users:	**6.3 % (issued codes) 1.5 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**24.4 %**
Ratio of exposure notifications received to positive test results entered:	**Ø 2.1**
Total number of exposure notifications generated:	**50,974**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection: 07.07.2020 – 23.08.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Italy

Italy developed the Immuni app to combat the COVID-19 pandemic. The app was launched on 15 June 2020. It can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Immuni app has been downloaded more than 21 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	15 June 2020	Active	Yes	Link

Main organisations involved

Data controller	Software developer	Additional partners
Presidency of the Council of Ministers	Bending Spoons	See app website

Key app functionalities

- Notify contacts when positive
- Manage vaccine and test certificates
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Italy

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Italian Data Protection Authority (Garante)

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

Italy was one of the first countries to join in November 2020 the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Since then, more than 307,000 keys from Italy have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**2.2 million**
App downloads as a share (%) of the population:	**37 %**
Number of COVID-19 codes entered:	**88,363**
Proportion of all positive tests that occur among app users:	**0.5 % (entered codes)**
Ratio of exposure notifications received to positive test results entered:	**Ø 2.2**
Total number of exposure notifications generated:	**195,045**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection: 15.06.2020 – 30.06.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

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Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Latvia

APTURI COVID

Latvia developed the Apturi Covid app to combat the COVID-19 pandemic. The app was launched on 29 May 2020. It can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Apturi Covid app has been downloaded more than 476,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	29 May 2020	Active	Yes	Link

Main organisations involved

Data controller

Ministry of Health and Centre for Disease Prevention and Control

Additional partners

A consortium of Latvian entities (see app website)

Key app functionalities

- Notify contacts when positive
- In-app COVID-19 related statistics
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Latvia

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Latvian Data State Inspectorate

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

Latvia was one of the first countries to join in November 2020 the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. More than 42,000 keys from Latvia have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**476,512**
App downloads as a share (%) of the population:	**25 %**
Number of COVID-19 codes issued:	**17,016**
Number of COVID-19 codes entered:	**7,787**
Proportion of all positive tests that occur among app users:	**2 % (issued codes) 1.9 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**45.8 %**
Ratio of exposure notifications received to positive test results entered:	**Ø 1.5**
Total number of exposure notifications generated:	**12,004**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 29.05.2020 – 26.06.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

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Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Lithuania

Korona Stop LT

The Korona Stop LT app was launched on 6 November 2020 as part of Lithuania's strategy to combat the COVID-19 pandemic. The app can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Korona Stop LT app has been downloaded more than 410,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	6 November 2020	Active	Yes (May 2021 – April 2022)	Not available

Main organisations involved

Data controller	Software developer	Others	
Lithuanian Ministry of Health	Dizaino Kryptis	Ministry of Health of the Republic of Lithuania	National Public Health Centre under the Ministry of Health of Lithuania

Key app functionalities

- Notify contacts when positive
- Navigate to external resources
- Call button to a call centre

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Lithuania

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Lithuanian Data Protection Inspectorate

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

In the period May 2021 – April 2022 the Korona Stop LT app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. 83,085 keys from Lithuania have been uploaded to the EFGS.

Available information about use and uptake[2]

App downloads:	**410,300**
App downloads as a share (%) of the population:	**15 %**
Number of COVID-19 codes issued:	**40,800**
Number of COVID-19 codes entered:	**11,900**
Proportion of all positive tests that occur among app users:	**3.5 % (issued codes) 1 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**29.2 %**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 06.11.2020 – 31.07.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Malta

The COVIDAlert app is used by the Maltese government to combat the COVID-19 pandemic. The app was launched on 18 September 2020 and has since been suspended. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the COVIDAlert app has been downloaded more than 115,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link (decommissioned)	**18 September 2020**	**Suspended on 6 July 2022**	**Yes** (March 2021 – July 2022)	**Link**

Main organisations involved

Data controller	Software developer	Others		
Superintendent of Public Health	**Malta Information Technology**	**Maltese government**	**Ministry of Health**	**Malta Digital Innovation Authority**

Key app functionalities

- **Notify contacts when positive**
- **Symptom tracker**
- **In-app COVID-19 related statistics**
- **Navigate to external resources**
- **Call button to a call centre**

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Malta

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Office of the Information and Data Protection Commissioner

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

In the period March 2021 – July 2022 the COVIDAlert app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures.

Available information about use and uptake[2]

App downloads:	**115,695**
App downloads as a share (%) of the population:	**22 %**
Number of COVID-19 codes issued:	**737**
Number of COVID-19 codes entered:	**458**
Proportion of all positive tests that occur among app users:	**0.7 % (issued codes) 0.4 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**62 %**
Proportion of diagnosed cases among app users who have previously received an exposure notification through the app:	**8.6 %**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests 18.09.2020 – 06.07.2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
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Digital contact tracing
for COVID-19 in Europe

Netherlands

CoronaMelder is the Dutch app developed as part of the country's efforts to combat the COVID-19 pandemic. The app was launched on 10 October 2020 and has since been put on hold. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the CoronaMelder app has been downloaded more than 5.8 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	10 October 2020	Suspended on 22 April 2022	Yes (December 2020 – April 2022)	Link

Main organisations involved

Data controller

Municipal Health Service (GGD)

Others

Ministry of Health, Welfare and Sports (VWS)

Working groups of the National Institute for Public Health and Environment (RIVM) and the GGD

Key app functionalities

- Notify contacts when positive
- Call button to a call centre

Digital contact tracing
for COVID-19 in Europe

Netherlands

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Dutch Data Protection Authority

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

In the period December 2020 – April 2022 the CoronaMelder app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. More than 1.7 million keys from the Netherlands have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**5.9 million**
App downloads as a share (%) of the population:	**33 %**
Peak number of active users:	**3 million**
Percentage of population who actively used the app (peak):	**19 %**
Number of COVID-19 codes entered:	**455,083**
Proportion of all positive tests that occur among app users:	**5.7 % (entered codes)**
Ratio of exposure notifications received to positive test results entered:	**0.8 – 1.4**
Proportion of diagnosed cases among app users who have previously received an exposure notification through the app:	**7.5 %**
Proportion of app users who have previously received an exposure notification through the app and weren't notified by manual contact tracing at the time of booking a test:	**77 %**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022 and on Ebbers et al., Evaluation CoronaMelder. An overview after 9 months. 28 May 2021. Timeframe of data collection: 10.10.2020 – 22.04.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
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Digital contact tracing
for COVID-19 in Europe

Norway

In the period December 2020 - August 2022 Norway offered its citizens a digital contact tracing app in its efforts to combat the COVID-19 pandemic. The Smittestopp app could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. The app has been downloaded more than 1.3 million times.[1]

Smittestopp

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	21 December 2020	Suspended on 10 August 2022	Yes (February 2021 – August 2022)	Link

Main organisations involved

Data controller	Software developer	Others
Norwegian Institute of Public Health	Netcompany	Horsk Helsenett

Key app functionalities

- Notify contacts when positive
- In-app COVID-19 related statistics
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Norway

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Norwegian Data Protection Authority

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

In the period February 2021 – August 2022 the Smittestopp app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. 280,191 keys from Norway have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**1.3 million**
App downloads as a share (%) of the population:	**24 %**
Number of COVID-19 codes entered:	**48,351**
Proportion of all positive tests that occur among app users:	**3.5 % (entered codes)**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 21.12.2020 – 06.04.2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
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Digital contact tracing
for COVID-19 in Europe

Poland

The Polish app ProteGO-Safe was used in the period June 2020 – March 2022 to help Poland combat the COVID-19 pandemic. The app could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the ProteGO-Safe app has been downloaded more than 2.9 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	9 June 2020	Suspended on 25 March 2022	Yes (November 2020 – March 2022)	Link

Main organisations involved

Data controller	Others		Additional partners
Chief Sanitary Inspector	Ministry of Digital Affairs	GovTech Polska Chief Sanitary Inspectorate	See app website

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- Diary/ journal
- In-app COVID-19 related statistics
- Travel restrictions
- Navigate to external resources

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Poland

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Polish Data Protection Authority (UODO)

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

In the period November 2020 – March 2022 the ProteGO-Safe app was part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. 446,387 keys from Poland have been uploaded to the EFGS.

Available information about use and uptake[3]

App downloads:	**3 million**
App downloads as a share (%) of the population:	**8 %**

1: Check performed on 31 August 2022
2: Last accessed on 31 March 2022
3: Based on the analysis performed in the study at the end of August 2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
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Digital contact tracing
for COVID-19 in Europe

Portugal

Portugal developed the StayAway COVID app to combat the COVID-19 pandemic. The app was launched on 1 September 2020 and has since been suspended. It could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the StayAway COVID app has been downloaded more than 3.2 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	1 September 2020	Suspended	No	Link

Main organisations involved

Data controller	Others				
Directorate-General of Health (DGS)	Institute of Computer Systems Engineering, Technology and Science (Inesc Tec)	Institute of Public Health of the University of Porto	Keyruptive	Ubirider	The Telecommunications Institute	The Robotics and System Engineering Laboratory

Key app functionalities

- Notify contacts when positive
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Portugal

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Portuguese Data Protection Authority (CNPD)

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

Portugal did not connect to the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Portugal cited technical and societal aspects (i.e. the lack of societal confidence in the app's efficiency and effectiveness) as the main reasons for not connecting.

Available information about use and uptake[2]

App downloads:	**3.2 million**
App downloads as a share (%) of the population:	**31 %**
Number of COVID-19 codes issued:	**14,741**
Number of COVID-19 codes entered:	**3,137**
Proportion of all positive tests that occur among app users:	**1.9 % (issued codes) 0.4 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**21.3 %**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 16.04.2020 – 31.09.2021

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Slovenia

#OstaniZdrav

Slovenia developed the #OstaniZdrav app to combat the COVID-19 pandemic. The app was launched on 17 August 2020. It can be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the #OstaniZdrav app has been downloaded more than 475,000 times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	17 August 2020	Active	Yes	Link

Main organisations involved

Data controller	Software developer	Others
Ministry of Public Administration	PC7	National Institute of Public Health

Key app functionalities

- Notify contacts when positive
- Navigate to external resources
- Diary/ journal
- Manage vaccine and test certificates
- Create QR codes for events
- Check-in with QR code and check-in history

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Slovenia

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Slovenian Information Commissioner

Data Protection Impact Assessment[1]: Link unavailable

Cross-border tracing and warning

The #OstaniZdrav app is part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Slovenia joined the EFGS on 10 February 2021 and has since uploaded more than 270,000 keys.

Available information about use and uptake[2]

App downloads:	**475,687**
App downloads as a share (%) of the population:	**23 %**
Peak number of active users:	**107,380**
Percentage of population who actively used the app (peak):	**5.1 %**
Number of COVID-19 codes entered:	**24,906**
Proportion of all positive tests that occur among app users:	**3.3 % (entered codes)**

1: Check performed on 31 August 2022

2: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 07.04.2021 – 30.07.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Spain

Radar **COVID**

The Radar Covid app was developed for the Spanish population to combat the COVID-19 pandemic. The app was launched on 21 August 2020 and is currently active1. The app, which can be installed on citizens' smartphones, captures anonymised interactions between smartphones based on Bluetooth technology and issues warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Radar Covid app has been downloaded more than 8.5 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	21 August 2020	Active	Yes	Link

Main organisations involved

Data controller

Ministry of Health and the Autonomous Communities

Others

General Secretariat of Digital Administration

Secretary of State for Digitalisation and Artificial Intelligence

Ministry of Economic Affairs and Digital Transformation

Key app functionalities

- Notify contacts when positive
- Diary/ journal
- Navigate to external resources

Digital contact tracing
for COVID-19 in Europe

Spain

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Spanish Data Protection Authority (AEPD)

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

The Radar Covid app is part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications (keys) in case of detected exposures. Spain was one of the first countries to have joined the EFGS on 12 November 2020 and has since uploaded more than 287,000 million keys.

Available information about use and uptake[3]

App downloads:	**8.5 million**
App downloads as a share (%) of the population:	**18 %**
Number of COVID-19 codes issued:	**3,324,839**
Number of COVID-19 codes entered:	**123,996**
Proportion of all positive tests that occur among app users:	**25.9 % (issued codes) 1 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**3.7 %**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 21.08.2020 – 29.07.2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

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Digital contact tracing
for COVID-19 in Europe

Switzerland

SwissCovid

In the period June 2020 - March 2022 Switzerland offered its citizens a digital contact tracing app in its efforts to combat the COVID-19 pandemic. The SwissCovid App could be installed on citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. The SwissCovid App has been downloaded more than 3.8 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	25 June 2020	Suspended	Partly	Link

Main organisations involved

Data controller	Operating system provider	Others	Additional partners
Federal Office of Public Health (FOPH)	Federal Office for Information Technology, Systems and Telecommunication (FOITT)	Federal Institute of Technology in Zurich (ETH) Federal Institutes of Technology in Lausanne (EPFL)	See app website

Key app functionalities

- Notify contacts when positive
- In-app COVID-19 related statistics
- Navigate to external resources
- Call button to a call centre
- Check-in with QR code and check-in history
- Create QR codes for events

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Switzerland

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Swiss Federal Data Protection and Information Commissioner (FDPIC)

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

The SwissCorona App was not part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications in case of detected exposures. Despite great interest from non-EU countries, the scope of application of the EFGS was limited to EU and Member States. However, Switzerland and Germany worked together on making their two apps interoperable.

Available information about use and uptake[3]

App downloads:	**3.8 million**
App downloads as a share (%) of the population:	**44 %**
Peak number of active users:	**2.3 million**
Percentage of population who actively used the app (peak):	**26.2 %**
Number of COVID-19 codes entered:	**204,862**
Proportion of all positive tests that occur among app users:	**5.9 % (entered codes)**
Ratio of exposure notifications received to positive test results entered:	**2.5 – 4**
Total number of exposure notifications generated:	**172,474,208**
Proportion of diagnosed cases among app users who have previously received an exposure notification through the app:	**19 % (Alpha) – 41 % (Omicron)**
Median time between exposure and receipt of exposure notification through the app:	**2 days**

1: Check performed on 31 August 2022. The app is interoperable with the German Corona-Warn-App but not connected to the EFGS

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022 and on publications by Daniore et al., 2021: https://publichealth.jmir.org/2021/12/e30004 and Ballouz et al., 2022: https://publichealth.jmir.org/2022/5/e35653. Timeframe of data collection for number of COVID-19 codes and positive tests: 25.06.2020 – 31.03.2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
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Digital contact tracing
for COVID-19 in Europe

England Wales

The digital contact tracing app NHS COVID-19 was developed in support of combatting the COVID-19 pandemic in England and Wales. The app was launched on 24 September 2020. It can be installed on English and Welsh citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the NHS COVID-19 app has been downloaded more than 31 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	24 September 2020	Active	Partly	Link

Main organisations involved

Data controller

Department of Health and Social Care (DHSC)

Software developer

VMware Pivotal Labs

Others

Accenture
Alan Turing Institute
NHS Digital
NHSx
Oxford University
Zuhlke Engineering
The UK's NHS
The UK Government

Key app functionalities

- Notify contacts when positive
- Symptom tracker
- Navigate to external resources
- Check-in with QR code and check-in history
- Create QR codes for events
- Receive test results in app
- Book tests in app
- Self-isolation countdown

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

England Wales

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Information Commissioner's Office

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

The NHS COVID-19 app was not part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications in case of detected exposures. Despite great interest from non-EU countries, the scope of application of the EFGS was limited to EU Member States. However, the app is interoperable with the apps developed for Northern Ireland (StopCOVID NI) and Scotland (Protect Scotland).

Available information about use and uptake[3]

App downloads:	**31 million**
App downloads as a share (%) of the population:	**52 %**

1: Check performed on 31 August 2022
2: Last accessed on 31 March 2022
3: Based on the analysis performed in the study at the end of August 2022.

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Digital contact tracing
for COVID-19 in Europe

Northern Ireland

StopCOVID NI

The digital contact tracing app StopCOVID NI was developed in support of combatting the COVID-19 pandemic in Northern Ireland. The app was launched on 30 July 2020. It can be installed on Northern Ireland's citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	30 July 2020	Active	Partly	Link

Main organisations involved

Data controller	Software developer	Others	
Health and Social Care Northern Ireland, Department of Health	Expleo	NearForm	Department of Health

Key app functionalities

- Notify contacts when positive
- Self-isolation countdown
- Self-isolation certificate

Digital contact tracing
for COVID-19 in Europe

Northern Ireland

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Information Commissioner's Office

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

The StopCOVID NI app was not part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications in case of detected exposures. Despite great interest from non-EU countries, the scope of application of the EFGS was limited to EU Member States. However, the app is interoperable with the apps developed for England and Wales (NHS COVID-19 app) and Scotland (Protect Scotland).

Available information about use and uptake

No information available

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
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Digital contact tracing
for COVID-19 in Europe

Scotland

The digital contact tracing app Protect Scotland was developed in support of combatting the COVID-19 pandemic in Scotland. The app was launched on 10 September 2020 and has since been suspended. It could be installed on Scottish citizens' smartphones to capture anonymised interactions between smartphones based on Bluetooth technology and issue warnings about close contacts with persons who have tested positive for the coronavirus. Since its launch, the Protect Scotland app has been downloaded more than 2.3 million times.[1]

Key facts at a glance

Website	Launch	App status[1]	Cross-border tracing warning[1]	Source code
Link	10 September 2020	Suspended on 29 April 2022	Partly	Link

Main organisations involved

Data controller

Scottish Government

Software developer

NearForm

Others

Public Health Scotland
NES Digital Service
(part of NHS Education for Scotland)
Amazon Web Services
NHS National Services Scotland
Gov.UK Notify
Cello Signal Ltd
Scottish Local Authorities

Key app functionalities

- Notify contacts when positive
- Self-isolation certificate

Digital contact tracing
for COVID-19 in Europe

Scotland

App architecture

Decentralised: the anonymised interactions (keys) are uploaded to a central server, but the assessment of risk interactions (matching of keys of users with a confirmed infection) happens on the user's smartphone only.

Data protection

Data Protection Authority: Scottish Government

Data Protection Impact Assessment[2]: **Download**

Cross-border tracing and warning

The Protect Scotland app was not part of the European Federation Gateway Service (EFGS), which enables apps from different Member States to talk to each other and exchange cross-border notifications in case of detected exposures. Despite great interest from non-EU countries, the scope of application of the EFGS was limited to EU Member States. However, the app is interoperable with the apps developed for England and Wales (NHS COVID-19 app) and Northern Ireland (StopCOVID NI).

Available information about use and uptake[3]

App downloads:	**2.3 million**
App downloads as a share (%) of the population:	**43 %**
Number of COVID-19 codes issued:	**407,081**
Number of COVID-19 codes entered:	**68,355**
Proportion of all positive tests that occur among app users:	**57.9 % (issued codes)** **9.7 % (entered codes)**
Proportion of positive tests among app users that are entered into the app (positive tests uploaded):	**16.8 %**

1: Check performed on 31 August 2022

2: Last accessed on 31 March 2022

3: Based on the analysis performed in the study at the end of August 2022. Timeframe of data collection for COVID-19 codes and positive tests: 10.09.2020 – 25.11.2021

This fact sheet has been developed as part of the study "Lessons learned, best practices and epidemiological impact of the common European approach on digital contact tracing to combat and exit the COVID-19 pandemic" commissioned by the European Commission's DG CONNECT, Unit H3 – eHealth, Well-Being and Ageing and carried out by empirica Communication and Technology Research.
Study team contact: contacttracing@empirica.com; European Commission contact: CNECT-H3@ec.Europa.eu

Annex II – Country research

Austria

Name of the app

Stopp Corona

Website

https://www.stopp-corona.at/

Main institutions involved

The data controller of the Stopp Corona app is the Austrian Red Cross, General ministry and blood donation. The operating system provider is Accenture GmbH, responsible for the app development, operation (hosting/back-end) and software maintenance. Other organisations involved include:

- UNIQA Private Foundation, the Federal Ministry of Social Affairs, Health, Care and Consumer Protection (BMSGPK)[204], funded the app.
- The cloud service Azure by Microsoft is used as a subcontractor to Accenture.
- World-Direct eBusiness solutions GmbH processes the mobile numbers from users[205].

Launch date

25 March 2020[206]

National policies or strategies associated with DCT

Despite statements from experts and civil society organisations, Austria did not introduce specific legal acts for regulating the use of the Stopp Corona App[207]. In June 2020, the Austrian Bioethics Commission advocated for introducing clear regulations on DCT in the national epidemics law (EpidemieG) or as part of special legislations in response to COVID-19[208]. Referring to the Bioethics Commission as well as data security recommendations by the European Commission, the Austrian Data Security Council called on the Federal Ministry for Social Affairs, Health, Care and Consumer Protection to consider a catalogue of data security and protection criteria and principles for DCT apps[209]. The Federal Ministry published a position on DCT apps for the national containment strategy in June, outlining a national criteria catalogue in line with the GDPR and the Austrian Data Protection Act[210].

Participatory processes and stakeholder engagement

According to the Reuters website, Austria launched a website[211] explaining the functionalities of the

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204 Stopp-corona.at. 2022. FAQ "Stopp Corona"-App. [online] Available at: <https://www.stopp-corona.at/faq_stopp_corona_app/> [Accessed 6 September 2022].

205 Technische und Rechtliche Anaylse der Stopp Corona App des Österreichischen Roten Kreuzes Available at: https://noyb.eu/sites/default/files/2020-04/bericht_stopp_corona_app_v1.0.pdf

206 https://de.wikipedia.org/wiki/Stopp_Corona

207 https://www.liberties.eu/en/stories/trackerhub5-legal-acts/43539

208 Contact Tracing in der COVID-19 Pandemie. Stellungnahme der Bioethikkommission. Available at: https://www.bundeskanzleramt.gv.at/dam/jcr:3ee75dfa-8e31-4913-8bee-5c2610b29a52/200617_Stellungnahme_Covid_Bioethik-Contact%20Tracing.pdf

209 Prinzipien für die Verwendung von Contact Tracing und Contact Tracing-Apps vor dem Hintergrund der COVID-19 Pandemie. Republik Österreich Datenschutzrat. Available at: https://www.bmj.gv.at/dam/jcr:d85319c6-1806-485b-9fb0-325393084654/ERL_I_Stellungnahme_des_Datenschutzrates%20zum%20Contact%20Tracing.pdf

210 BMSGPK Position zu Contact Tracing Apps, June 2020. Available at: https://de.readkong.com/page/bmsgpk-position-zu-contact-tracing-apps-stand-10-06-2020-8273684

211 https://www.stopp-corona.at/

apps and inviting suggestions to boost trust and convince more citizens to use it[212].However the article did not include further details. Further, the source code was made accessible to especially engage independent academics and data privacy experts in refining the app[213].

Integration with public health processes and health policy

No knowledge or data on integration with public health processes. Besides the digital contact tracing functionality, the app foresees only symptom checks, but no contact (hotlines) with public health representatives.

Source Code

https://github.com/austrianredcross

Architecture/ Contact Tracing Protocols

Architecture approach: Decentralised

Protocol(s): DP-3T, GAEN [214]

Data Protection, security and privacy measures

The data privacy notice is published on the website: https://www.roteskreuz.at/ich-will-mehr-wissen/datenschutzerklaerung

Data protection Authority/ Responsible for data collection and processing: The Austrian Red Cross is the main data controller authority in processing data accordance with GDPR.

Data Protection Impact Assessment: An official DPIA report was released by the data controller Austrian Red Cross[215] first on 31.02.20220, followed by an update on 04.08.2020.

Other security and privacy checks: a technical and legal analysis of the Stop Corona App was published by the Platform Grundrechtspolitik, in collaboration with NOYB – European Centre for Digital Rights and SBA Research GmbH[216].

App additional functionalities

- Clinically validated symptom checker for daily assessment of health status and reporting suspicion of COVID symptoms
- Notification of contacts after confirmed test, including clearance to contacts after negative test

Significant updates

Based on 25 recommendations from the independent technical and legal review by NYOB, SBA Research gGmbH and the Platform Grundrechtspolitik in April 2020, the Stopp Corona App was updated to a new decentralized architecture[217].

Additionally, automatic registration of a risk contact, the function of a symptom checker, and notification of others by the user itself was added in April 2020.

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212 https://www.reuters.com/article/healthcoronavirus-austria-apps-idUSL8N2EF1BB

213 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

214 https://noyb.eu/sites/default/files/2020-04/report_stopp_corona_app_english_v1.0_0.pdf

215 https://www.roteskreuz.at/fileadmin/user_upload/PDF/Datenschutz/Datenschutz-Folgenabschaetzung-Bericht_OeRK_StopCoronaApp_04-08-2020_V2.0_final.pdf

216 Technische und Rechtliche Anaylse der Stopp Corona App des Österreichischen Roten Kreuzes Available at: https://noyb.eu/sites/default/files/2020-04/bericht_stopp_corona_app_v1.0.pdf

217 Technische und Rechtliche Anaylse der Stopp Corona App des Österreichischen Roten Kreuzes Available at: https://noyb.eu/sites/default/files/2020-04/bericht_stopp_corona_app_v1.0.pdf

Interoperability with EFGS

-Yes.[218]

-Legal basis for processing in EFGS: Consent

-The Austrian Red Cross consented to data processing in the EFGS, but ceased participation on 1 March 2022, with the suspension of the Stopp Corona App[219].

Specific actions for implementation

In order to increase the download and use of the Stopp Corona App, the Minister of Health, civil society organisations, and other existing initiatives repeatedly advocated for the app and addressed data privacy concerns. For instance, the Commuter Initiative (Pendlerinitiative) campaigned for its use, highlighting the importance for frequent travellers in Austria[220].

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out. According to Liberties Research, as of February 2021, the app has been downloaded more than 1.36 million times, and approximately 10.000 users warned their contacts via the app.

Other observations

End date/App was suspended on 28.02.2022.

Belgium

Name of the app

Coronalert

Website

https://coronalert.be/en/

Main institutions involved

The data and joint controller of the Coronalert app is Sciensano, a public health organisation responsible for managing the manual and digital contact tracing infrastructure in Belgian regions and communities. The app was developed based on the open-source code of the German Corona-Warn-App by the start-up Devside with support by the software publisher Ixor. Alignment with security and privacy standards was assessed by Nviso[221].

In April 2020, the inter-federal committee "Testing & Tracing" was established with the aim to harmonise contact tracing and testing strategies between Belgium regions, bringing together experts from Sciensano, federal regions, and the Belgian eHealth platform[222]. The committee oversees the inter-

218 https://www.stopp-corona.at/faq_7/

219 https://ec.europa.eu/health/system/files/2022-03/gateway_jointcontrollers_en.pdf

220 Aufruf der Pendler-Initiative: Mit Rotes Kreuz Stopp-Corona App jetzt mehr Sicherheit im Kampf gegen das Corona-Virus. Available at: https://www.pendlerinitiative.at/aufruf-der-pendler-initiative-mit-rotes-kreuz-stopp-corona-app-jetzt-mehr-sicherheit-im-kampf-gegen-das-corona-virus/

221 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

222 https://www.corona-tracking.info/wp-content/uploads/2020/05/IMC-20200429-oprichting-IC-TT.pdf

federal working group for the development of the Coronalert app, consisting of technical and legal experts from academia and industry.

German open-source Corona-Warn-App served as the basis for the Belgian CTA with 85 per cent of the code being reused[223]. The application has been adjusted to the Belgian environment, mainly by adapting the method of anonymously linking test results to the application. Since the German application is based on the Apache 2.0 license, the Belgian team always had full access to the already audited German code and could decide which changes they would like to incorporate and which not.

Launch date

30 September 2020

National policies or strategies associated with DCT

On 4 May 2020, the Royal Decree of Special Powers No.18 allowed the formation of an integrated database enabling the information flow to the centralized database managed by Sciensano from GPs, hospitals, laboratories and call centers. Despite data protection concerns by the Belgian Data Protection Authority (ADP) regarding the collection and storing of sensitive data in a centralized database, the adopted decree did not introduce legal provisions for DCT[224]. This is due to the fact that the decision whether to deploy DCT was postponed in April and was taken later in June 2020. On 1 July 2020, the Royal Decree No. 44 replaced No.18 setting the legal, technical and functional foundation for a DCT app. Given that healthcare is regulated at multiple levels, the Royal Decree could only be a temporary solution and a collaboration agreement was essential. Thus, later on, No.44 was also complemented with a Cooperation Agreement[225].

Participatory processes and stakeholder engagement

In August 2020, Devside and the inter-federal working group held a public consultation via an online form of KU Leuven for input on the development of the Coronalert app. A second public consultation was held from September to October 2020. Involved stakeholders included academic and non-academic experts in law, social sciences, public health, cybersecurity or app development, civil society organisations, municipalities, as well as citizens. Feedback was gathered on app usage by minors, inclusivity, public trust and understanding, the privacy statement, user-friendliness, as well as the role of medical professionals in app usage, among others. Based on the feedback received, the minimum user age was lowered to 13 years, the privacy statement was updated, and an interdisciplinary, independent oversight committee for assessing the app's effectiveness was formed. Further, the working group engaged with health care providers for feedback, and distributed brochures to inform them about the Coronalert app. Before its public launch, the app was tested by more than 10,000 users[226].

Integration with public health processes and health policy

When getting tested, citizens have the option of pseudonymously receiving the test result in the app, by registering their tests using the PCR code and the test code of the app. Furthermore, if they forget to link the app when testing but still want to notify contacts pseudonymously, they can link the test to the app afterwards via a website (an SMS was sent – clicking on this SMS opened the website). If citizens received subsequently a positive test result, the app would retrieve automatically an authorization code that allows to upload the TEK keys. In June 2021 an option was added to contact the call centre after a positive test result and ask for a 12-digit code (Covicode) that citizens can enter in the app in order to

[223] https://joinup.ec.europa.eu/collection/open-source-observatory-osor/news/belgium-forked-its-covid-19-app

[224] https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

[225] https://www.corona-tracking.info/wp-content/uploads/2020/10/Samenwerkingsakkoord.pdf

[226] https://www.esat.kuleuven.be/cosic/sites/corona-app/wp-content/uploads/sites/8/2020/09/Public_consultation_v1_0_sep25_2020-1.pdf

authorize an upload of the TEK keys[227].

Source Code

https://github.com/covid-be-app

Architecture/Proximity-based protocols

Architecture approach: Decentralised

Protocol(s):DP-3T, GAEN[228]

Data Protection, security and privacy measures

The processing of user's personal data is covered in Article of the DCT applications draft bill. The collected data consists of solely proximity and duration of contact. The design of the app doesn't allow any function creep minimising the risk of further exploitations out of the scope of intended purpose[229].

Data privacy notice: https://coronalert.be/en/privacy-and-data

Data Protection Authority: Sciensano[230]

Data Protection Impact Assessment: The Belgian Data Protection Authority (APD) was in charge of the data protection impact assessment[231]

Other security/privacy checks: After the publication of the draft bill on the use of DCT as mentioned, authorities such as Belgian Data Protection Authority (DPA), Council of State provided concerns and critical feedbacks on the setup of the bill. DPA's revision of the bill included the following points[232]: Necessity and appropriateness of having a contact tracing apps collecting sensitive personal data, The possibility of (re)identified users as one of the concern for DP3T system, The inherent responsibility of Sciensano as data controller, Data administration principle, Data transparency, Violation of voluntary nature of the App, App de-activation period. Moreover, the app was audited in the field of security and privacy by NVISO, on the basis of a public contract. Belgium faced debate over smart video surveillance before the pandemic which contributed to the hurdles of gaining public trust with the CTA[233].

- Critics on Data protection authority: A letter on concerns about digital contact tracing has been written by Ligue des Droits Humains.[234]

App additional functionalities

- COVID-19 Epidemiological Situation Statistics
- Vaccination Statistics
- Test certificates
- Navigate to other sources
- Multiple languages

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[227] https://coronalert.be/en/how-does-it-work/

[228] https://coronalert.be/de/datenschutzerklarung/

[229] van Brakel, R., et al. (2021). Bridging values: Finding a balance between privacy and control. The case of Corona apps in Belgium and the Netherlands. Available at https://research.vu.nl/en/publications/bridging-values-finding-a-balance-between-privacy-and-control-the

[230] https://ec.europa.eu/health/system/files/2021-11/gateway_jointcontrollers_en_0.pdf

[231] https://coronalert.be/wp-content/uploads/2021/07/DPIA_contactopsporingsapplicatie_BelgieV.8__NL_versie_17062021.pdf

[232] The Belgian draft law on the use of digital contact tracing applications: GDPR compliant?. Available at https://www.huntonprivacyblog.com/2020/05/29/belgian-dpa-publishes-opinions-on-draft-laws-for-the-creation-of-a-database-and-for-the-use-of-contact-tracing-apps-for-covid-19-tracking/

[233] van Brakel, R., et al. (2021). Bridging values: Finding a balance between privacy and control. The case of Corona apps in Belgium and the Netherlands. Available at https://research.vu.nl/en/publications/bridging-values-finding-a-balance-between-privacy-and-control-the

[234] https://www.liguedh.be/independance-de-lautorite-de-protection-des-donnees-lettre-au-president-de-la-chambre-des-representants-et-aux-chef%C2%B7fe%C2%B7s-de-groupe/

Significant updates

Following issues related to uploading of randomly generated codes for positive cases onto the app and resulting missed notification of contacts, Coronalert was updated in November. The new version facilitated an easier and more flexible uploading of the codes by users, for instance by linking it with a booking system of a test provider. Additional functions included quarantine certificates via a call centre after high-risk contact.

Interoperability with EFGS

- Yes
- Legal basis for processing in EFGS: Cooperation agreement of 25 August 2020[235]

Specific actions for implementation

According to the website, a large national campaign aimed at encouraging the population to install Coronalert was carried out[236]. There was a broad initial advertising campaign supported by the media, the football league, the railway, public bus companies and the employers (e.g., by Agoria, the technology sector industry association). In late 2021 a media campaign to youngsters via influencers was launched to further increase usage. In addition, video instructions were made to explain how the app works. A messaging functionality was also added to the app in order to broadcast messages to the app users.

Statistics regarding the app use

Information regarding no. of downloads, tests results received, no. of positive test results received, no. of positively tested people shared their keys, % of people who received a positive test result on Coronalert shared their keys: https://www.corona-tracking.info/app/coronalert-counter/

CTA evaluation

A continuous evaluation of the effectiveness has been performed in order to optimise the working of the app and in order to update decision makers; a substantial number of parliamentary questions have been answered. But no detailed report evaluation has been published that covers the whole usage period of the app. An intensive user study has been performed with a small set of users; this study has been submitted for publication.

Other observations

The development of the app was based on the German CoronaWarnApp, reducing the development costs to 1 million euros[237].

Croatia

Name of the app

Stop-COVID 19

Website

https://www.koronavirus.hr/stop-covid-19

Main institutions involved

The app was designed by the APIS IT agency under a government decision[238]. In July 2020, a joint

[235] https://ec.europa.eu/health/system/files/2022-03/gateway_jointcontrollers_en.pdf
[236] Coronalert available for all | Coronavirus COVID-19 (info-coronavirus.be)
[237] Belgium forked its COVID-19 app | Joinup (europa.eu)
[238] https://www.croatiaweek.com/croatia-presents-its-stop-covid-19-app/

conference between the Croatian Agency for the Protection of Personal Data (AZOP), the company APIS IT and representatives from the Ministry of Health was held to discuss the app's technical features as well as its compliance with the GDPR[239]. The digital product development company Bornfight donated the user interface. The development of the application was funded by the European Union from the Emergency Support Instrument within the project "Mobile applications to support contact tracing in the EU's fight against COVID-19: Common EU Toolbox for Member States".[240]

The Croatian Ministry of Health is the developer as well as the main app data controller of Croatia's Stop COVID-19 app. The data processor is represented by APIS IT.

Launch date

27 July 2020

National policies or strategies associated with DCT

The app was developed in compliance with the Decision of the Government of Croatia on the implementation of digital platform and interoperability with the main purpose of monitoring and containing infectious diseases starting from March 18th 2020[241]. The government passed an amendment to the Law on Electronic Communication, which was intended to allow more comprehensive monitoring of citizens' mobile devices for pandemic control. However, the amendment was later withdrawn.

Following privacy concerns about the government's initial amendment of the Law on Electronic Communication, the Croatian Parliament consulted Ombudsman Lora Vidović on the proportionality principle and the need to clearly define the duration and measure of citizens' mobile device monitoring, after which the proposed bill was withdrawn.

Participatory processes and stakeholder engagement

No public knowledge about participatory processes and stakeholder engagement.

Integration with public health processes and health policy

The CTA does not have any functionalities besides the contact tracing function. The codes are generated by public health professionals after receiving a positive laboratory test, it is up to users to decide if they wish to enter the code and alert other users.

Source Code

https://github.com/Stop-COVID-19-Croatia

Architecture/Proximity-based protocols

Architecture approach: Decentralised

Protocol(s): GAEN

Data protection, security and privacy measures

Data privacy notice: https://stopcovid19.zdravlje.hr/html/privacy-policy.html

Data Protection Authority: Croatian Personal Data Protection Agency[242]

Data Protection Impact Assessment: The Croatian Agency for the Protection of Personal Data (AZOP)

239 https://www.liberties.eu/en/stories/trackerhub1-mainpage/43437

240 https://www.koronavirus.hr/stop-covid-19-723/723

241 https://www.ohchr.org/Documents/Events/GoodPracticesCoronavirus/croatia-submission.docx

242 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

was responsible for conducting the DPIA of the Stop COVID-19 app.

DPIA: Only a summary was made available online.[243]

App additional functionalities

The CTA does not have added functionalities, apart from notifying contacts with confirmed test.

Significant updates

The CTA has not been significantly updated since its launch.

Interoperability with EFGS

Yes (since 19th November, 2020)

Legal basis for processing in EFGS: Decision of the Minister of Health on the establishment of cross-border interoperability of mobile application for informing users on exposure to COVID-19

Specific actions for implementation

No specific public campaigns on the CTA were identified.

Statistics regarding the app use

Statistics regarding the app use are displayed on the official CTA webpage. These include no. of downloads, no. of code sent, no. of codes uploaded.

Stop COVID-19 (koronavirus.hr)

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The app is available for users of 12 years and older[244].

Republic of Cyprus

Name of the app

Covtracer-EN

Website

https://covtracer.dmrid.gov.cy/dmrid/covtracer/covtracer.nsf/home_en/home_en?opendocument

Main institutions involved

The CovTracer-EN app was developed by the KIOS Center of Excellence at the University of Cyprus and the CYENS Centre of Excellence under the supervision of the Deputy Ministry of Research, Innovation and Digital Policy (DMRID) in cooperation with the Ministry of Health (MoH) and the National eHealth Authority (NeHA). Collaborators include the PathCheck Foundation, USA that provided the open-source solution for the mobile app and the Centre for Research and Technology – Hellas/Information Technologies Institute (CERTH/ITI), Greece that provided the software module for generating the One-

[243] https://www.koronavirus.hr/uploads/Stop_COVID_19_Data_Protection_Impact_Assesment_Summary_2020_11_16_58dea76816.pdf

[244] Based on the App Store age rating.

Time Passwords (OTP) sent to infected users through SMS.

Launch date

Former GPS-based CovTracer app: 5 April 2020
CovTracer-EN app: 11 March 2021

National policies or strategies associated with DCT

No specific legal framework was introduced to regulate the use of the app.

Participatory processes and stakeholder engagement

No public consultations took place during the development of the contact tracing app.

Integration with public health processes and health policy

The OTP for sharing the infected keys within the app was given to the infected citizen with his/her consent at the end of the MCT interview together with some questions, i.e., if the citizen is using of the app and if he/she received recent exposure notification within the app before becoming infected. A notified user was eligible for a free PCR test by showing the exposure notification on his/her smartphone to the test site. Furthermore, the app facilitated the contact to the call centre.

Source Code

https://github.com/CovTracer-EN/covtracer-en-app

Proximity-based protocols

Architecture approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data privacy notice:

https://covtracer.dmrid.gov.cy/dmrid/covtracer/covtracer.nsf/covtracer02_en/covtracer02_en?opendocument

The DPIA was conducted by the KIOS Center of Excellence and the CYENS Centre of Excellence in their capacity as data processors with consultation from the Office of the Commissioner for Personal Data Protection.

This app has been developed by the KIOS Center of Excellence, University of Cyprus and the CYENS Centre of Excellence on behalf of the Ministry of Health. The roles of each organization on Data and Privacy Management in detail are as follows[245]:

- The Ministry of Health has the role of the national data controller (i.e., is responsible for the processing of personal data collected by the app), as well as the role of the EU-level joint data controller, together with the data controllers in other EU Member States regarding cross-border interoperability with other national CTAs. The user is asked to give the Ministry of Health the access to personal data by clicking on the "Activate Proximity Tracking" button. Entering symptoms date onset or test result date also bases entirely on voluntary basis. Once granted, the user can withdraw the consent decision every time after the consent is given. The processing data of Ministry of Health is regulated under Article 6(1) Sentence 1(a) and Article 9(2)(a) of GDPR.

[245] https://covtracer.dmrid.gov.cy/dmrid/covtracer/covtracer.nsf/covtracer02_en/covtracer02_en?opendocument

- The Ministry of Health engaged both the KIOS and the CYENS Centers of Excellence as data processors to perform the processing of personal data for the operation of the app both at national and EU-level, according to Article 28(3) EU GDPR.

Data protection impact assessment: the DPIA for the CovTracer-EN app was prepared and approved by the Office of the Commissioner for Personal Data Protection after the development of the app. The DPIA was submitted as part of the EFGS onboarding process, and it is available upon request.
Other security/privacy check-ups: Risk assessment and security plan activities were carried out during and after the development of the CovTracer-EN app and back-end/DB systems, e.g., including a pen-test report of the mTLS communication between the CovTracer-EN Back-end Server and the EFGS. These activities were documented in the final technical implementation report of the EU grant CYPRUS – LC-01591248 for funding the connection of CovTracer-EN with the EFGS, which is available upon request.

App additional functionalities

- COVID-19 Epidemiological Situation Statistics
- Exposure History
- Symptoms logbook (removed a few months after the official app release)
- Multiple languages
- Symptoms checker
- Call Centre (for users who receive exposure notification)

Significant updates

- 11th March 2021 – The CovTracer-Exposure Notification (CovTracer-EN) app was presented as the replacement for the previous CovTracer app. In comparison to the previous app which employed the GPS technology, the new version used the Bluetooth technology and other data such as the length of the encounters set up by the Google/Apple Exposure Notifications Application Interface (GAEN)[246].

Interoperability with EFGS

- Yes
- Legal basis for processing in EFGS: Consent[247]

Specific actions for implementation

The app uptake jumped to 2000 new users after the public announcement and press conference on Mar 11th, 2021. The communication and promotion campaign was the result of the joint force between MoH and DMRID. Apart from press releases from official websites, other platforms such as TV, radio channels, news, broadcasts, shows and also through different means of communications techniques through videos, banners Q&A. Also, of highly effective was the use of broadcasting to citizens through SMS which led to a substantial 7,000 new app downloads after two days of the SMS campaign[248]. The promotion of the app was stopped when the vaccination campaign started.

Statistics regarding the app use

No official app statistics are published.

246 https://www.themayor.eu/en/a/view/cyprus-unveils-covid-contact-tracing-app-7433

247 https://ec.europa.eu/health/system/files/2022-03/gateway_jointcontrollers_en.pdf

248 Isaia, P., Laoudias, C., Kamilaris, A. and Panayiotou, C.G., CovTracer-EN: The Journey of Covid-19 Digital Contact Tracing in Cyprus, International Conference on Indoor Positioning and Indoor Navigation (IPIN), 2021, pp. 1-8.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The app is aimed at people who are resident in Cyprus and at least 18 years old.

Czech Republic

Name of the app

eRouska

Website

https://erouska.cz/en

Main institutions involved

The eRouska (eFacemask) app is the result of voluntary work under the management of Czech Ministry of Health with support from National Agency for Communication and Information Technologies[249]. Coming together under the COVID19CZ initiative, the app was a joint activity by different technology and IT companies, namely:

Seznam.cz , *Alza.cz* , *Keboola* , *PaleFire Capital* , *O2*, *Stories.bi*, *DataSentics*, *Dateio*, *Expertkom*, *Actum*, *WMC/Grey*, *Rockaway*, *Invia.cz*, *Daktela*, *Prusa Research* and *Reservio*.[250]

The app and data controller is the Czech Ministry of Health.

Technical supplier of the app is Národní agentura pro komunikační a informační technologie, s.p. (the National Agency for Communication and Information Technologies, hereinafter "NAKIT"). NAKIT also acts a personal data processor under strict, pre-defined contract by the Ministry[251]. Keboola, Dateio, Avast and others were responsible for the development, implementation, and testing processes of the app, whereas Seznam was responsible for marketing campaigns.

Launch date

11 April 2020[252]

National policies or strategies associated with DCT

The app was the product of a larger state-wide initiative COVID19CZ group of experts, developers and IT enthusiasts. COVID19CZ aimed to support Czech state administration in fighting against COVID-19 using custom IT systems and developments[253]. The four keys projects coming out of the initiative were the Infoline 1212, Remembrance Call Center and Active Response Center (ARC), eRouška, and GPS tracking in the Mapy.cz application[254]. The eRouska app is integrated into the chytrá karanténa (Smart Quarantine) Strategy[255]. The Smart Quarantine Strategy was incorporated under COVID19CZ with the

[249] https://erouska.cz/en/tym
[250] https://covid19cz.cz/covid19-cz/manifest
[251] https://smlouvy.gov.cz/smlouva/13430376
[252] https://www.lupa.cz/aktuality/je-tady-erouska-aplikace-od-covid19cz-sleduje-pres-bluetooth-kontakty-s-lidmi/
[253] https://erouska.cz/en/tym
[254] https://covid19cz.cz/covid19-cz/manifest/klicove-projekty
[255] https://covid19cz.cz/covid19-cz/manifest/chytra-karantena

purpose of helping hygienists to speed up the contact tracing process with the help of ICT tools[256]. The two main data point of collections are the position data from mobile phones and place of electronic payments in order to have a view of the map of movement of infected individual[257]. Building on this strategy, the government passed the Resolution No.576 on May 25th, 2020 for implementing the Smart Quarantine 2.0 Strategy as a joint effort between the MoH and the National Agency for Communication and Information Technologies.

Participatory processes and stakeholder engagement

Multiple independent organisations such as FIT CTU and Ackee participated in the auditing and review process of the CTA[258]. Ondřej Veselý is the external R&D ethnics expert for the EC for the expression of trust in the app[259].

Integration with public health processes and health policy

No integration with public health processes was foreseen. Besides contact tracing, the app does not have additional functionalities to support communication with public health representatives. The verification code required for the app is generated by the Rouška server and passed to the information system of the public health service, which is then sent via SMS. The one-time verification code is valid for 12 hours.

Source Code

https://github.com/covid19cz

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures

The data privacy notice is published on the website: https://erouska.cz/en/caste-dotazy#zabezpeceni

Data protection Authority: Czech Data Protection Authority[260]

Data Protection Impact Assessment: No available evidence[261]

Other security and privacy checks: The earlier version of eRouška was reviewed by the Czech IT Agency Ackee and the independent think-tank IDEA (The Institute for Democracy and Economic Analysis). However, the national data protection authority - Office for Personal Data Protection was not fully satisfied, confirming that it was not possible to dispel the ambiguities around the app as they did not receive the data protection impact assessments (DPIAs) of the two versions of eRouška (1.0 and 2.0) from the Ministry of Health.[262] An independent assessment of the app was also performed.[263]

App additional functionalities

- Instructions on how to proceed after positive contact or positive test result

256 https://koronavirus.mzcr.cz/en/government-approves-incorporating-the-smart-quarantine-under-the-ministry-of-health-new-exemptions-from-wearing-masks-and-the-cancellation-of-shopping-hours-for-seniors/
257 https://www.whitecase.com/publications/alert/covid-19-and-data-protection-compliance-czech-republic
258 https://erouska.cz/en/audit-kod
259 https://www.linkedin.com/pulse/aplikace-erou%C5%A1ka-m%C3%A1-moji-d%C5%AFv%C4%9Bru-ond%C5%99ej-vesel%C3%BD/
260 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19
261 https://fra.europa.eu/sites/default/files/fra_uploads/fra-2020-coronavirus-pandemic-eu-bulletin-may_en.pdf
262 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
263 https://erouska.cz/downloads/cvut.pdf

Significant updates

According to public knowledge, the CTA did not undergo significant updates.

Interoperability with EFGS

Yes, but ceased participation in the EFGS on October 29th, 2021, given suspension of the app operation.[264]

Legal basis for processing in EFGS: Consent

Specific actions for implementation

There is a dedicated page with publicly available information and promotional materials (including graphic materials, logo, and videos) of the eRouška application for download and free distribution: https://erouska.cz/ke-stazeni

Furthermore, mobile operators T-Mobile, O2 and Vodafone started sending a request on behalf of the Ministry of Health to install the eRouška application to all their smartphone customers[265]. SMS campaign resulted in 1.23 users downloading the app.[266]

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The operation of the app was suspended at the end of October 2021.

Denmark

Name of the app

Smitte|stop

Website

https://smittestop.dk/

Main institutions involved

The data controller of the Smitte|stop app is The Danish Patient Safety Agency. The Danish IT services company Netcompany is responsible for the process of app development with the support from Ministry of Health, the Danish Patient Safety Authority, the Danish Health Authority[267] and the Danish Agency for Digitisation.[268]

Launch date

18 June 2020

264 https://ec.europa.eu/health/system/files/2022-03/gateway_jointcontrollers_en.pdf
265 https://cnn.iprima.cz/operatori-zacali-rozesilat-vyzvu-k-instalaci-aplikace-erouska-11183
266 https://www.irozhlas.cz/zpravy-domov/rozhovor-dzurilla-erouska-koronavirus-chytra-karantena_2010181816_zuj
267 https://smittestop.dk/en
268 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

National policies or strategies associated with DCT

The Executive Order 1539 of 29 October 2020[269] regulates the digital processing of contact data in the Danish "Smittestop" app to contain the COVID-19 spread.

Participatory processes and stakeholder engagement

An advisory board was established to oversee issues related to privacy and security of the contact tracing app. The board included representatives from the Data Ethics Council, Danish Universities and Cyber Security Council[270]. No citizen or other stakeholder engagement in the development of the app was identified.

Integration with public health processes and health policy

The app does not have additional functionalities to facilitate contact with public health services.

Source Code

https://github.com/Sundhedsdatastyrelsen

Architecture / Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures:

Data privacy notice: https://smittestop.dk/databeskyttelse/

Data protection authority: Danish Data Protection Agency (Datatilsynet)[271]

Data protection impact assessment: In June 2020, a DPIA was performed by Danish Agency for Patient Safety and reviewed by the Data Protection Adviser for the Ministry of Health[272].

DPIA available here in Danish[273] and here in English[274].

App additional functionalities

- COVID-19 Epidemiological Situation Statistics
- Vaccination Statistics

Significant Updates

The CTA was not significantly updated since its launch.

Interoperability with EFGS

Yes. Connected to the Gateway on November 20, 2020 [275]

The legal basis for processing personal data correlating to verification and notification is based on section 3(1) and 3(2) of the Executive Order.

Civil registration number together with system-generated ID are processed by the Danish Patient Safety

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269 https://www.retsinformation.dk/eli/lta/2020/1539

270 https://sum.dk/nyheder/2020/maj/nyt-advisory-board-skal-raadgive-myndighederne-om-den-kommende-danske-smittestops-app

271 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

272 https://www.liberties.eu/en/stories/trackerhub1-mainpage/43437

273 https://www.fhi.no/contentassets/67d72db7c1ba4e2f9a70e9606b1c7ab0/dpia-smittestopp.pdf

274 https://github.com/DP-3T/documents/blob/master/data_protection/DP-3T%20Model%20DPIA.pdf

275 Library of Congress. (2020). Denmark: Health Authority Issues New Guidance for COVID-19 Tracing Including Updated Rules for Danish COVID App. Available at Denmark: Health Authority Issues New Guidance for COVID-19 Tracing Including Updated Rules for Danish COVID App

Authority and uploaded to the European Federation Gateway Service in accordance with Article 6(1)(e) and Article 9(2)(i and (g) of the General Data Protection Regulation as well as section 7(4) of the Danish Data Protection Act (Databeskyttelsesloven)[276].

Specific actions for implementation

The Danish Ministry of Health mainly used Twitter to promote the use of the app, using messages such as "Download the app and help break the chains of infection."[277] Various tweets have been sent out by the authorities ever since to communicate updates about the app.[278]

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

Initially the app was not released under a Free Software license. This was motivated by the government as risking "security breaches". [279]

If a user tests positive for the Coronavirus, they can long into the app using their NemID, a common log-in credential for Danish digital banks, online government services etc.

Estonia

Name of the app

HOIA

Website

https://hoia.me/en/

Main institutions involved

The data controller of the HOIA app is Estonian Health Board. The Estonian Health and Welfare Information Systems Centre (Tervise ja Heaolu Infosüsteemide Keskus) acts as the IT partner for the system and coordinates hosting and development.

Other organisations involved include:

- The technical lead and design of the app – Iglu (lead)
- International collaboration – Cybernetica
- The security analysis, documentation, and related communication – Cybernetica, Guardtime, Clarified Security
- The creation and design of the backend systems – Icefire, TEHIK, and Heisi.
- The development of the mobile application – Mobi Lab (lead), FOB Solutions, Mooncascade, and ASA Quality Solutions

276 https://smittestop.dk/en/data-protection/

277 https://www.berlingske.dk/danmark/app-kan-have-hjulpet-med-at-opdage-814-smittetilfaelde

278 https://cphpost.dk/?p=115021

279 FSFE. (2020). Denmark keeps source code of Coronavirus tracing app secret. Available at https://fsfe.org/news/2020/news-20200629-01.en.html

- Support and marketing – Velvet, Iglu, TEHIK[280].

Launch date

20 August 2020

National policies or strategies associated with DCT

In July 2020, the Estonian government adopted an amendment to Regulation No. 138 Statutes of the Health Information System[281]. The aim of the amendment was to secure the protection of app users' personal data and to ensure the involved responsible parties in the process uphold the standards of safety and transparency.

Participatory processes and stakeholder engagement

The government held a national level poll before app roll out and tabulated the results for top concerns people had. The development of HOIA did not include a public tender from the government or any other sort of "competition" between tech companies. The app was created free of charge by a consortium – an association of 12 Estonian companies that united voluntarily resulting in a public-private partnership.[282] The consortium developed the app until launch on August 20th, 2020, and then provided maintenance and support. Further development was performed from April 2021 under a procurement from TEHIK. The procurement was won by a consortium containing a subset of the former consortium.

Integration with public health processes and health policy

The app provides an authentication mechanism to the national e-Health Information System to confirm COVID-19 diagnoses from PCR tests. Later versions of the app also provided ongoing COVID-19 crisis information. The app also facilitated calls to the call centre.

Source Code

https://koodivaramu.eesti.ee/tehik/hoia

Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: https://hoia.me/privacy/

Data protection authority: Estonian Data Protection Inspectorate[283]

Data protection impact assessment: No Evidence Available[284]

Other privacy/security check-ups: In August 2020, a Security Review was conducted by Ministry of Social Affairs and TEHIK[285] and found the security measures sufficient-enough to not preclude release of the 20 August 2020 version. [286]

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280 Creating HOIA — The story of Estonian coronavirus contact notification application. Available at https://lab.mobi/articles/hoia-covid19-app

281 https://www.riigiteataja.ee/akt/118072020004

282 https://e-estonia.com/estonias-coronavirus-app-hoia-the-product-of-a-unique-private-public-partnership/

283 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

284 https://fra.europa.eu/sites/default/files/fra_uploads/fra-2020-coronavirus-pandemic-eu-bulletin-may_en.pdf

285 https://koodivaramu.eesti.ee/tehik/hoia/documentation/-/tree/master

286 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

App additional functionalities

- Navigate to other sources
- Provide access to ongoing crisis information
- Call Centre

Significant Updates

- 22 May 2020: first draft of the app was proposed. Signing up process began
- 16 September 2020: updated information on app environment[287]
- March 2021: updated version with new attenuation parameters

Interoperability with EFGS

Yes

Specific actions for implementation

A budget of 200.000 EUR was allocated to the creation and distribution of information materials, media advertising, stakeholder involvement and campaign development[288]. The launch was supported by a campaign on TV with key figures supporting, press conferences and more. The app was included in the "standard COVID-19 package" from national communication. Media coverage was done in multiple languages.

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The HOIA app can be used by anyone, including those under 13 years of age. Since the CTA does not process personal data, the use of the app does not require the separate consent of a parent of a child under the age of 13. Children under 13 years old can be marked as infected in HOIA by their parents or legal guardian by using their child's mobile phone and logging in with their own user[289].

"The use of Estonia's e-health electronic health records system, which relies on state-issued personal identification numbers, distinguishes this coronavirus app from similar tools in use elsewhere. "In Estonia, we incorporated the national patient portal's registry into the process of marking yourself infected," noted Iglu's Aiaste. "It's required for the app's user to verify the COVID-19 positive test result with his or her personal id," he said. That way, users can be absolutely sure that the possible exposure notifications are only coming from people with positive test results.[290]"

Finland

Name of the app

Koronavilkku

[287] https://koodivaramu.eesti.ee/tehik/hoia/dp3t-app-android/-/blob/master/README_FOR_DEVELOPMENT.md
[288] https://baltics.news/2020/09/07/estonian-coronavirus-notification-application-hoia-was-downloaded-100000-times/
[289] https://hoia.me/en/
[290] https://e-estonia.com/estonias-coronavirus-app-hoia-the-product-of-a-unique-private-public-partnership/

Website

https://koronavilkku.fi/en/

Main institutions involved

Koronavilkku was produced by the Finnish Institute for Health and Welfare (THL). DigiFinland Oy was responsible for implementing a special interface to the Omaolo service, Finnish national digital service that helps people assess their need for health care, which allowed healthcare professionals to create and send key codes to those with a positive coronavirus infection. The Ministry of Social Affairs and Health, the Social Insurance Institution of Finland (Kela) ensured a proper functioning of a back-end system. Solita Oy was responsible for the technical implementation of the app. The National Cyber Security Centre was responsible for auditing data security of the app. The Finnish Institute for Health and Welfare was the data controller.

Launch date

31 August 2020

National policies or strategies associated with DCT

The Temporary Amendment of the Infectious Diseases Act 1227/2016 of 9 July 2020 established an information system (mobile app and backend) to break up COVID transmission chains and rules for data processing within it[291].

Participatory processes and stakeholder engagement

During development of the app, 500 people tested Koronavilkku on their phones between 4 and 14 August in the cities of Helsinki and Tampere to help the developers to ensure proper functioning of the information system before the official launch.[292]

Integration with public health processes and policy

The app had integration to symptom assessment tool with the possibility to book a laboratory test, links to national COVID guidance, and regional health care contact information.

Source Code

https://github.com/THLfi

Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: https://koronavilkku.fi/en/privacy/

Data protection authority: Finnish Data Protection Authority[293]

Data protection impact assessment: The Finnish Institute for Health and Welfare (THL) assigned Privaon Oy, the leading Finnish company operating in the fields of Privacy and Data Protection, to carry out a data protection impact assessment (DPIA).[294]

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291 https://www.finlex.fi/fi/laki/alkup/2020/20200582

292 https://www.dailyfinland.fi/health/17280/Trial-of-coronavirus-app-Koronavilkku-continues

293 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

294 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

Other privacy/security check-ups: The Koronavilkku app has also been evaluated by the Office of the Data Protection Commissioner, in cooperation with the Cyber Security Centre and found no significant data security risks.[295]

App additional functionalities

- COVID-19 Epidemiological Situation Statistics
- Navigate to other sources

Interoperability with EFGS

- Yes[296]
- Legal basis for operating in EFGS: Communicable Disease Act (1227/2016), Updated disease act to include interoperability with EFGS[297]

Specific actions for implementation

After the launch of the application there has been a promotional campaign encouraging people to download and use the app. Based on a campaign survey on Koronavilkku, 90% of Finnish citizens have heard of the app. According to the survey, reliability and security were the most significant factors for the app users. In total, 1,000 people participated in the online survey commissioned from Norstat by the Finnish Institute for Health and Welfare.[298] In addition, a pro-bono co-operation with the biggest mobile phone operators was done. The operators shared Koronavilkku advertisements and instructed people how to download the application. Koronavilkku was also one of the elements in a massive campaign for educating people about the key means to prevent infections.

Statistics regarding the app use

A weekly report was published, and it included number of users, the number of symptom assessments and the number of key codes used, and the number of COVID-19 cases per week. The report is available here.

CTA evaluation

An evaluation is planned.

France

Name of the app

TousAntiCovid

Website

https://bonjour.tousanticovid.gouv.fr/en

Main institutions involved

INRIA (National Institute for Research in Computer Science and Automation) was commissioned by the government to ensure the operational management of the research and development project. Additionally, INRIA relied on public and private contributions[299].

Its development has also been accompanied by a very close dialogue with all the stakeholders, the

295 https://thl.fi/fi/-/kyberturvallisuuskeskus-koronavilkku-sovelluksessa-ei-havaittu-olennaisia-tietoturvaan-liittyvia-riskeja
296 https://koronavilkku.fi/en/privacy/
297 https://www.finlex.fi/fi/laki/alkup/2021/20211221
298 https://thl.fi/en/web/thlfi-en/-/koronavilkku-has-been-downloaded-more-than-2.5-million-times-widespread-use-increases-the-app-s-effectiveness
299 https://www.inria.fr/fr/stopcovid

Parliament and the National Commission on Informatics and Liberty (CNIL).[300]

The first team included: [301]

- INRIA: coordination and transmission protocol, privacy-by-design
- ANSSI: cybersecurity
- Capgemini: architecture and back-end co-development
- Dassault Systèmes: SecNumCloud qualified sovereign data infrastructure
- Inserm: health models
- Lunabee Studio: development of mobile applications
- Ministry of Health: epidemiology protocols for the app, users experience, contact tracing protocols and coherence with conventional contact tracing protocol, communication and promotion
- Orange: distribution of the application and interoperability
- Public Health France: insertion and articulation of the application in the overall strategy of detection and follow-up of contacts ("contact tracing")
- State Secretariat for Digital Affairs: communication and political promotion of the app
- Withings: connected objects

Launch date

First version (StopCovid): 2 June 2020.[302]

Second version (TousAnTICovid): 22 October 2020.[303]

National policies or strategies associated with DCT

To set a legal basis for digital contact tracing, the Decree No. 2020-650 of 29 May on Data Processing [in] "TousAntiCovid"[304] establishes the TousAntiCovid app for COVID contact tracing, setting out rules for data processing. A full range of digital services to help fight COVID-19, TousAntiCovid is a component of a complete range of digital services designed to help French citizens in their daily lives in the face of the COVID-19 epidemic. As part of the "Test - Alert - Protect" health strategy, the Government is making a set of complementary digital tools available to the public allowing : 1. Easier access to tests : In order to facilitate access to virological tests, the DépistageCovid service offers an interactive map that indicates the laboratories and sampling points located on the national territory and provides practical information on these places (contact details, accessibility for disabled people, waiting times, etc.). This service is accessible on depistagecovid.gouv.fr. 2. An alert for at-risk contacts: The TousAntiCovid application allows people who have been in close proximity to a positive person to be warned so that they can isolate themselves (so as not to transmit the virus in turn if they have been contaminated and are infectious) and be taken care of as soon as possible. 3. Better protection of oneself and others: To find out what behaviour is appropriate for each individual situation, the Ministry of Health has set up the mesconseilscovid.gouv.fr website, which offers personalised advice in 3 minutes to act against the virus according to the living conditions and health of each person. For example, this site allows you to find out what to do if you are at-risk contact and to monitor your symptoms if you are ill.

Participatory processes and stakeholder engagement

The Government has always required the application to comply with the French and European regulatory framework, except for the state of health emergency. The development of the project has

300 https://bonjour.tousanticovid.gouv.fr/en/privacy/anonimity
301 https://www.numerama.com/politique/616687-application-stopcovid-de-pistage-des-malades-que-sait-on-du-projet-du-gouvernement.html
302 https://www.journaldunet.com/media/publishers/1490935-tousanticovid-la-cnil-valide-l-introduction-de-qr-codes/
303 https://www.journaldunet.com/media/publishers/1490935-tousanticovid-la-cnil-valide-l-introduction-de-qr-codes/
304 https://www.legifrance.gouv.fr/loda/id/JORFTEXT000041936881/2022-08-26/ Most recent amendment by Decree 2022-1098 on 22 July 2022.

also been accompanied by a very close dialogue with all the stakeholders, first and foremost the Parliament and the National Commission on Informatics and Liberty (CNIL). On 27 May 2020, the National Assembly and the Senate voted in favour of the deployment of this application to help detect high-risk contacts.

Integration with public health processes and policy

Digital contact tracing is aligned and integrated with the conventional contact tracing, and offers same services in case a person is considered at risk contact through the digital or conventional system. In addition, iIt supports a check-in function and allows users to be alerted in case of exposition to confirmed cases in places. In case of at-risk contact notification, TousAntiCovid offers the recommendations of the Ministry of Health (test, isolation) and allows benefiting from the same support (free access to testing, health leave in case of isolation). The TousAntiCovid Wallet function allows users to store locally the documents necessary for the vaccination or recovery certificate.

Source Code

https://gitlab.inria.fr/stopcovid19/accueil

Proximity-based protocols

Architecture Approach: Centralised[305]

Protocol(s): ROBERT [306]

Data Protection. Security and privacy measures:

Data protection privacy notice: Available here:

https://bonjour.tousanticovid.gouv.fr/en/privacy/anonimity/

Data protection authority: French Data Protection Authority (CNIL)[307]

Data protection impact assessment: The application has been developed under the supervision of the CNIL in order to guarantee the protection of TousAntiCovid users' personal data. In accordance with its independence, the CNIL is informed of the technical choices and specifications made by the project team. The CNIL was asked to evaluate the system a priori and a posteriori on site and on document. The CNIL was therefore consulted for the first time on 20 April 2020 and was able to issue two opinions before the application was launched. It considered that the application was useful in terms of health and proportionate in terms of the protection of freedoms and personal data. Following on from these two opinions, the CNIL carried out several on-site and documentary checks in June 2020. The application was updated on 26 June to comply with the CNIL's requirements. Finally, in its opinion issued on 21 July 2022, the CNIL approved the extension of the application. TousAntiCovid thus fully complies with the principle of minimisation of the data used and with the RGPD as publicly confirmed by the CNIL at the close of its inspection on 3 September 2020.

Other privacy/security check-ups: Security audits were carried out by the National Cybersecurity Agency of France (ANSSI) throughout the development of the application.[308]

App additional functionalities

- Wallet for health certificates (test, vaccine, exemption)
- Pass+: a device for combining certificates with each other, resulting in the certificate

[305] https://www.frontiersin.org/articles/10.3389/fdgth.2021.660823/full

[306] https://arxiv.org/pdf/2103.10113.pdf

[307] https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

[308] https://www.nortonrosefulbright.com/-/media/files/nrf/nrfweb/contact-tracing/france-contact-tracing.pdf?revision=73eb9585-be68-4fde-82fd-d5362607b907

corresponding to the user's actual injections/infections
- The smart wallet: be informed when you are eligible for the booster dose
- Vaccination or screening: find a place near home.
- Key figures: epidemiological statistics, vaccination statistics, application statistics, local health situation.
- News: breaking news on COVID-19
- Navigate to other sources
- Call centre (call button)
- Travel certificate: during curfews and lockdowns, it was possible to generate (at date and time) and then keep its certificates in dematerialized format on its application.

Additional Significant Updates

As of the 22nd of October, the application is updated, rebranded and renamed as the TousAntiCovid in an effort to boost downloads and users' engagement.

Interoperability with EFGS

No, as it follows a centralised architecture which is not supported by the EFGS[309].

Specific actions for implementation

France rebranded the app and renamed it from StopCovid to TousAntiCovid, in an effort to boost downloads. President Emmanuel Macron announced the new version during a live TV interview.

Initially there was a national communication via a public campaign:

- requisitioning of TV and radio
- text message campaign
- amplification by our partners (French national railway system and Autonomous Parisian Transportation Administration) and relays (prefectures, regional health agencies)
- posters
- political support at presidential and ministerial level

The app was also updated to include the health pass feature and have reached 59.2 millions downloads in total.

Statistics regarding the app use

Statistics include no. of downloads, no. of persons declared positive in the application, no. of persons notified through the application (informations available in app).

CTA evaluation

An evaluation of the app was carried by the MoH for TousAntiCovid for the period of June to November[310]. The French application registered 39.4 million app registrations, as recorded on 1 January 2022, and there were approximately 49 million single device downloads. On 1 January 2022, the number of users who declared themselves positive in TousAntiCovid to notify other users represented 25 % of the total number of positive cases reported in France in SI-DEP. Since the launch of TousAntiCovid, that average varied between 5 and 25 %, and stood at 20 % on average throughout December 2021. On 28 November 2021, 35 % of the total number of cases reported in France declared in the application (n = 2309), planned to notify 10 316 users as high-risk contacts via the Robert protocol (contact tracing via Bluetooth). On average, around 21,049 of notifications were sent per day. The ratio of the number of contacts notified via the Robert Protocol to the number of cases reported is 1,9 on average for

[309] https://ec.europa.eu/health/system/files/2021-11/gateway_jointcontrollers_en_0.pdf

[310] Ministry of Solidarity and Health Directorate General of Health. Activity Report. TousAntiCovid from 2 June 2020 to 30 November 2021.

November 2021, which is the same ratio as reported by the sickness insurance scheme over the week from 24 to 30 November 2021. A study carried out by Kantar Public in October 2021 showed that the application as a whole is widely appreciated. Access to the health pass was the main reason for downloading TousAntiCovid for respondents, and the contact tracing functionality (Bluetooth) ranked fourth after the functionality of figures and news and that of the attestations.

Germany

Name of the app

Corona-Warn-App

Website

https://www.coronawarn.app/de/

Main institutions involved

The main institutions involved in the development and deployment of the app are the Robert Koch, the Federal Ministry of Health, Deutsche Telekom and SAP[311]. This app is published by the Robert Koch Institute (RKI) for the German federal government. The RKI is also responsible for ensuring that your personal data is processed in accordance with data protection regulations. The owner of the app software is SAP (Systems, Applications and Products in Data Processing)[312]. The back-end of the app is operated by Deutsche Telekom[313]. The designated controller for the processing of data by the app is the Robert Koch Institute (RKI) but, it is responsible only for the data processed via the app and not for those processed by the smartphones themselves, which might also collect logs of the encounters, in which case Google and Apple remain responsible[314]. The DPIA indicates that the RKI is also the controller in relation to the hotline[315].

Launch date

15 June 2020[316]

National policies or strategies associated with DCT

According to the assessment of the federal government, no additional legal basis for the use of the German app is necessary, neither from a constitutional nor from a data protection point of view, in order to prevent misuse by private third parties[317].

App use is voluntary,[318] but it lacks legal framework as the ruling coalition did not consider it necessary to establish a legal basis for this, arguing that the use of the CWA is voluntary, and the processing of personal data is based on the consent of the app's users[319].

Stakeholder engagement and participatory processes

To stop the spread of COVID-19, Germany hosted a gigantic hackathon in March 2020 with about 28,000 participants, working together on innovative solutions. From this, hundreds of projects were supported,

311 SAP stands for Systems, Applications and Products in Data Processing. It is a German multinational software corporation based in Germany that develops enterprise software to manage business operations and customer relations. (source: https://en.wikipedia.org/wiki/SAP#SAP_SE_era)

312 https://en.wikipedia.org/wiki/SAP#SAP_SE_era

313 https://www.coronawarn.app/en/faq/#general

314 https://www.fiz-karlsruhe.de/de/nachricht/fiz-special-corona-corona-warning-app-germany-data-protection-aspects

315 https://www.fiz-karlsruhe.de/de/nachricht/fiz-special-corona-corona-warning-app-germany-data-protection-aspects

316 https://www.coronawarn.app/assets/documents/cwa-datenschutz-folgenabschaetzung.pdf p20

317 https://www.bundestag.de/webarchiv/presse/hib/2020_10/800446-800446

318 https://www.fiff.de/dsfa-corona-file-en/at_download/file

319 https://www.bundestag.de/webarchiv/presse/hib/2020_10/800446-800446

such as a contact diary app and a heat map that warns of an overload of intensive care unit (ICU) beds, enabling decision makers to react quickly and efficiently distribute patients.[320]

In March 2020, Deutsche Telekom voluntarily handed over telecommunications traffic data to RKI, enabling the institute to track the movement of mobile phone users[321]. This information helps RKI understand what measures can effectively help contain the pandemic[322]. Deutsche Telekom assured that the data is aggregated and anonymous and cannot be traced back to individuals[323]. The German civil liberties NGO Gesellschaft für Freiheitsrechte (GFF) wrote that the move is legal as long as the data remains anonymous[324].

On 20 April, a letter signed by over 300 academics was published strongly supporting a decentralized approach[325]. Four days later, the CCC sent a letter to the government advocating a decentralized approach. Around the same time, the two tech giants Google and Apple developed the Exposure Notification (GAEN) framework and stated that they would only support a decentralized approach. The government decided to change course and opt for the Decentralized Privacy-Preserving Proximity Tracing (DP-3T).[326]

Integration with public health processes and policy

If a person has a positive test result, they can download it by scanning a QR code they receive from the testing laboratory. Other users are then notified of the risk exposure. If the lab is unable to generate the QR code, people who have been diagnosed with COVID-19 can check their test by calling the hotline. The hotline staff generate the TeleTAN after a plausibility check to prevent abuse. The TeleTAN code can be used to confirm a positive test result in the app. The 'increased risk' warning in the Corona-Warn-App informs the user that the proximity and duration of the encounter with the person reporting a positive test result through the app means an increased risk of infection and advises the user to contact either their GP, the health hotline at 116 117 or their local health authority by telephone. Decisions to issue a medical certificate for sick leave and to order home isolation (quarantine) are made by the consulting doctor and the local health authorities after an appropriate assessment. Furthermore, the CTA supports the covid digital certificate and check-in function. [327]

Source Code

https://github.com/corona-warn-app

Architecture/ Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures:

Data protection privacy notice: https://www.coronawarn.app/assets/documents/cwa-privacy-notice-en.pdf

Data protection authority: Federal Commissioner for Data Protection and Freedom of Information

320 https://wirvsvirus.org/
321 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
322 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
323 https://www.telekom.com/en/company/details/corona-prediction-telekom-supports-rki-597114
324 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
325 https://www.sciencemediacenter.de/alle-angebote/rapid-reaction/details/news/offener-brief-zu-kontaktverfolgungs-apps-beim-coronavirus/
326 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
327 https://www.bundesregierung.de/breg-de/themen/corona-warn-app/corona-warn-app-englisch/corona-warn-app-faq-1758636

(BfDI)[328]

Data protection impact assessment: The Data Protect Impact Assessment (DPIA) was conducted by TSI (T-Systems International GmbH) and SAP (Systems, Applications and Products in Data Processing) on behalf of RKI (Robert Koch Institute). Available here in English [329] and here in German.

Critique: A debate sparked around the voluntary aspect of the app. The DPIA highlights that the app's usage is based solely on voluntary consent (Art. 6 GDPR). However, it fails to address the fact that there could be factual circumstances and incentives – such as the government's possible decision to impose further lockdown measures if not enough people use the app – which could render the app's usage de facto compulsory.

App additional functionalities

- Symptoms tracker
- Diary/Journal
- COVID-19 Epidemiological Situation Statistics, Vaccination statistics, App statistics
- Vaccine/Test certificates
- Navigate to other sources
- Call centre (call button)
- Check-in with QR codes
- Venues/Check-in History
- Create QR codes for events

Significant Updates

On 19 October 2020, detection of symptoms and the European Corona-App-Gateways support was added.

On 2 May 2021, the results of rapid tests were integrated into the app.

On June 2021, Proof of vaccination and Digital EU certificates wallet were added to the Corona-warn app.

The detailed list of all updates is available here: https://www.coronawarn.app/en/blog/

Interoperability with EFGS

Yes, since 19 October 2020, it supports the European interoperability gateway service, allowing it to interact with other European apps[330].

Joint Controller: Robert Kock Institute

Legal Basis for Processing in EFGS: Consent

Specific actions for implementation

Ahead of the launch, the government urged the German population to download the app *en masse*. It commissioned its in-house advertising agency with a big promotion campaign to convince sceptics and increase the app's popularity, with success. Within the first 24 hours of its launch, the app was downloaded 6.5 million times. It is the first government app that has ever made it to the top of downloads in the major app stores[331].

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328 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

329 Bock et al. (2020). Data Protection Impact Assessment for the Corona App. Available at: https://www.fiff.de/dsfa-corona-file-en/at_download/file

330 https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/travel-during-coronavirus-pandemic/mobile-contact-tracing-apps-eu-member-states_en

331 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

Statistics regarding the app use

Statistics regarding the app use are published by the Robert Koch Institute on the Corona-Warn App website. These include no. of downloads, no. of support hotline calls, no of active users, no. of tests received, no. of positive tests results received, no. of positive results users agreed to share.

Available at: 20210121_RKI_CWA-Kennzahlen_Onepager_erweitert.indd (coronawarn.app)

See also here: https://www.coronawarn.app/en/science/

CTA evaluation

The evaluation of the German app aimed to examine its effectiveness and benefits associated with the use of the app was carried out in March 2021. The results showed that a large proportion (88%) of users who were tested and received their test results via the CWA reported that their test results were available either within 24 hours or 2 days. A relatively high proportion of users (61%) who registered a positive test result via the CWA and who received their result via the app (771,957) shared their result, and therefore used the app to warn other people (473,974). Several users were surprised to receive a notification that they were exposed to 'increased risk'. The majority of users who received a red warning (data from the EDUS: 87% (13,515 of 15,540) also subsequently underwent testing. Survey data showed that around 6% (792 of 13,493) of the tests carried out as a result of a (red) warning were positive for COVID-19. The data gathered via donation, the app stores and the CWA back end roughly indicated that users who share positive test results via their daily key warn around six other users, i.e., six other users receive a red warning showing them to be at 'increased risk'[332].

See also here: https://www.coronawarn.app/en/science/

Hungary

Name of the app

VirusRadar (original name of app: 'StopCorona!')

Website

https://virusradar.hu/
(Not available)

Main institutions involved

The VirusRadar app developed by Nextsense (North Macedonian software company)[333] is implemented by the Ministry of Innovation and Technology with the support of the Hungarian IT company Biztributor and is managed by the Hungarian Government Agency for Development of Informatics (KIFÜ)[334]. The National Centre for Public Health (NNK) is the data controller[335].

Launch date

13 May 2020[336]

National policies or strategies associated with DCT

On May 21 2020 the Government introduced the Governmental Decree No. 181/2020, which Stipulates electronic control of the official home quarantine through the app, including facial image transmission

[332] About the Effectiveness and Benefits of the Corona-Warn-App. Available at: https://www.coronawarn.app/en/science/2021-06-15-science-blog-1/
[333] The technology was given free of charge by the Northern Macedonian software company NextSense. More information at: https://nextsense.com/
[334] https://nextsense.com/ns-newsarticle-virusradar-a-mobile-contact-tracing-implemented.nspx
[335] https://www.liberties.eu/en/stories/trackerhub1-mainpage/43437
[336] https://github.com/ct-report/HU

and involvement of police to check compliance[337].

Participatory processes and stakeholder engagement

During the first two months of the first wave of the pandemic, there was no announcement of government plans for a contact tracing application and thus no discussion of the introduction of mobile applications to combat the spread of the disease. In addition, the Hungarian Data Protection Authority (National Authority for Data Protection and Freedom of Information, NAIH) was not involved in any way in the development of the app and did not make any public statements related to it. Consequently, as the popularity of the app was low, the media and human rights organisations did not consider the events surrounding the app to be of paramount importance.[338]

Integration with public health processes and health policy

The app does not have additional functionalities to facilitate contact with public health services.

Source Code

Not available

Proximity-based protocols

Architecture Approach: Centralised

Protocol(s): Bluetooth Proximity Tracing from Nextsense Contact Tracing Technology[339]

Data Protection. Security and privacy measures:

Data protection privacy notice: Unavailable since the website of the application (https://virusradar.hu/) is unreachable.

Data protection authority: National Authority for Data Protection and Freedom of Information, NAIH [340]

Data protection impact assessment: Unavailable since the website of the application (https://virusradar.hu/) is unreachable.

Other privacy/security check-ups: Both the National Center for Public Health (data controller) and the National Authority for Data Protection and Freedom of Information (data protection authority) were not involved in the development of the app and did not issue any public statements with regards to its privacy and security measures[341]. According to Nextsense, its contact tracing technology and apps were developed in line with the Joint European Roadmap towards lifting COVID19 containment measures recommendations, the requirements from the Pan-European Privacy-Preserving Proximity Tracing standard (PEPP-PT) and the WHO guidelines on the implementation of contact tracing apps with a special focus on protecting user's privacy[342]. Krehling and Essex (2021) developed quantitative metrics for privacy of the CTAs based on the 10 principles articulated in an open letter widely signed by cyber-security researchers[343], namely independent expert review, simple design, minimal functionality, data minimisation, trusted data governance, cybersecurity, minimum data retention, protection of derived data and meta-data, proper disclosure and consent, provision to sunset. Based on their analysis,

337 https://njt.hu/jogszabaly/2020-181-20-22

338 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

339 https://nextsense.com/contact-tracing-technology.nspx

340 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

341 https://www.liberties.eu/en/stories/trackerhub1-mainpage/43437

342 https://witsa.org/wp-content/uploads/2020/08/MASIT-Nextsense-Nomination-for-MASIT-Awards_Nextsense-Contact-Tracing-Technilogy.pdf p.7

343 Kerschbaum, F.; Barker, K. Coronavirus Statement. Waterloo Cybersecur. Priv. Inst. 2020. Available online: https://uwaterloo.ca/cybersecurity-privacy-institute/news/coronavirus-statement

VirusRadar was given a low ranking of privacy.[344]

App additional functionalities

No public information available.

Interoperability with EFGS

No

Specific actions for implementation

The release of the VirusRadar app was not widely publicised by public institutions or media, hence, the uptake of the CTA was relatively low[345].

In September 2021, Hungarian outlet 24.hu reported that the Ministry of Innovation and Technology (ITM) encouraged university students through the unified education systems to download the app[346].

As of February 2022, there has still not been a governmental campaign or some noticeable governmental push encouraging Hungarian smartphone users to download the app[347].

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The contact tracing app is based on the CTA of the Northern Macedonia (StopCorona!) and the technology was given free of charge by the Northern Macedonian software company NextSense[348].

The app requires to register a Hungarian-only mobile number to enable Bluetooth Proximity Tracing. It doesn't support foreign mobile phone numbers[349].

The website of the app cannot be reached, and the application is unavailable to download. Meanwhile the CTA cannot be found, the home quarantine surveillance app, hazikaranten[350], continues to be available.

Ireland

Name of the app

COVID Tracker

Website

https://www.covidtracker.ie

344 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

345 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

346 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

347 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

348 https://www.sfb1258.de/covid-19-contactum/countries-with-official-contact-tracing-apps

349 https://github.com/ct-report/HU

350 https://hazikaranten.hu/

Main institutions involved

The development of the COVID Tracker began on 22 March 2020 with the Health Service Executive (HSE) contacting Waterford tech company NearForm to build a contact tracing app for Ireland using existing Bluetooth technology in smartphones to support contact tracing[351].

The development and deployment of the application involved representatives from the Department of Health, the Office of the Government Chief Information Officer (OGCIO), the Economic and Social Research Institute (ESRI) and especially the Behavioural Research Unit within ESRI, the Central Statistics Office, the Garda Síochána, the Irish Army and Science Foundation Ireland[352].

Main actors and/or partners involved in project governance and delivery[353]

- Department of Health
- Health Service Executive (HSE)
- Office of the Government Chief Information Officer, Department of Expenditure and Reform (OGCIO, DPER)
- An Garda Síochána

Main actors and/or partners involved in research[354]

- Science Foundation Ireland (SFI)
- Economic and Social Research Institute Behavioural Research Unit (ESRI BRU)
- Irish Government Economic and Evaluation Services (IGEES)
- Decentralized Privacy-Preserving Proximity Tracing (DP3T, Switzerland)
- Massachusetts Institute of Technology - Private Automated Contact Tracing (MIT-PACT)

The HSE is the data controller.

Launch date

7 July 2020

National policies or strategies associated with DCT

No specific legal framework was introduced to regulate the use of the app.

Participatory processes and stakeholder engagement

In April 2020, several civil society organizations, including Digital Rights Ireland (DRI) and the Irish Council for Civil Liberties (ICCL) called for transparency and a privacy-by-design approach in the development process of the COVID Tracker[355]. In addition, they advocated for publishing the source code and the data protection impact assessment (DPIA) by the HSE[356].

Field trials[357] were conducted in June with the members of the An Garda Síochána, Ireland's national police service. Trials' results suggested[358] that the app was able to accurately detect 72 per cent of close contacts. However, in May 2020, researchers from Trinity College Dublin conducted an independent measurement study[359] which demonstrated the unreliability of Bluetooth signal strength for contact

351 https://www.nearform.com/work/covid-app-development/
352 https://www.nearform.com/blog/inside-the-collaborative-effort-behind-irelands-covid-tracker-app/
353 https://www2.hse.ie/services/covid-tracker-app/privacy-and-how-we-use-your-data.html
354 https://www2.hse.ie/services/covid-tracker-app/privacy-and-how-we-use-your-data.html
355 https://www.iccl.ie/news/hse-app-experts-and-public-need-to-see-details/
356 https://www.iccl.ie/news/hse-app-experts-and-public-need-to-see-details/
357 https://www.rte.ie/news/2020/0603/1145200-covid-app-contact-tracing-hse/
358 https://www.gov.ie/en/press-release/bb5d9-department-of-health-and-the-hse-today-announce-the-publication-of-the-covid-tracker-app-data-protection-impact-assessment-and-source-code/
359 https://www.scss.tcd.ie/Doug.Leith/pubs/bluetooth_rssi_study.pdf

tracing, casting doubts about the efficiency of the technology.

On 26 June 2020, the HSE published the DPIA[360] and source code[361] of the app.

In October 2020, a national survey of attitudes conducted in May of the same year[362] was published in the Irish Journal of Medical Science revealing that Irish citizens expressed high levels of willingness to download a contact tracing app.

Integration with public health processes and local health policy

For users who opted in and provided a phone number when registering, a message will be sent to the Contact Tracing department if they receive an exposure notification.

The CTA can be used as a wallet to store the EU Digital COVID Certificate. It also supports a symptoms tracker. However, the app does not have additional functionalities to facilitate services such as ordering or receiving tests via the app.

Source Code

https://github.com/HSEIreland/covid-tracker-app

Architecture. Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures:

Data protection privacy notice: https://covidtracker.gov.ie/privacy-and-data/data-protection/

Data protection authority: Irish Data Protection Commission[363]

Data protection impact assessment: The Department of Health and the Health Service Executive (HSE) issued the DPIA on 29 June 2020[364]. Available here.

Other privacy/security check-ups: Krehling and Essex (2021) developed quantitative metrics for privacy of the CTAs based on the 10 principles articulated in an open letter widely signed by cyber-security researchers[365], namely independent expert review, simple design, minimal functionality, data minimisation, trusted data governance, cybersecurity, minimum data retention, protection of derived data and meta-data, proper disclosure and consent, provision to sunset. Based on their analysis, COVID Tracker was given a medium ranking of privacy.[366]

Critique: In July 2020, researchers at Trinity College Dublin published a report claiming that user privacy is not adequately protected in the COVID Tracker app when used with Google Play Services[367]. The report showed how Google Play Services, used on Android devices, were sending sensitive personal data to Google servers every 20 minutes, including user IMEI, hardware serial number, SIM serial number,

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360 https://github.com/HSEIreland/covidtracker-documentation/blob/master/documentation/privacy/Data%2520Protection%2520Impact%2520Assessment%2520for%2520the%2520COVID%2520Tracker%2520App%2520-%252026.06.2020.pdf

361 https://github.com/HSEIreland/covid-tracker-app

362 https://link.springer.com/article/10.1007/s11845-020-02389-y

363 https://covidtracker.gov.ie/privacy-and-data/data-protection/

364 https://www.dataguidance.com/news/ireland-hse-issues-dpia-covid-tracker-app

365 Kerschbaum, F.; Barker, K. Coronavirus Statement. Waterloo Cybersecur. Priv. Inst. 2020. Available online: https://uwaterloo.ca/cybersecurity-privacy-institute/news/coronavirus-statement

366 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

367 https://www.thejournal.ie/covid-app-privacy-5157476-Jul2020/ , https://www.scss.tcd.ie/Doug.Leith/pubs/contact_tracing_app_traffic.pdf

phone number and Gmail address, potentially allowing phone location tracking based on IP address[368]. The authors of the report called the identified data transfer "extremely troubling from a privacy viewpoint" and the Irish Council for Civil Liberties called it "completely opaque to users and the HSE themselves"[369].

App additional functionalities

- Symptoms tracker
- Heat maps
- COVID-19 Epidemiological Situation Statistics
- Vaccination Statistics
- App statistics
- Vaccine/Test certificates (QR-Code)
- Navigate to other sources

Significant Updates

NearForm was initially working on a centralised version of the CTA that would group users' data together for authorities to study[370], but in May 2020, the team switched to the Exposure Notifications System (ENS) developed by Apple and Google to ensure anonymity and consensual data transfer and processing[371].

Since February 2021, the vaccination headline figures, something many people advocated for on Twitter, were included in the app[372].

In July 2021, the app was updated to allow people to store and display the EU Digital COVID Certificate[373].

Interoperability with EFGS

Yes[374]

Legal basis for processing in EFGS: Consent[375]

On 19 October, the COVID Tracker app became one of the first wave of national apps linked with other countries across the European Union after being linked with similar contact tracing apps from Italy and Germany[376].

Specific actions for implementation

Prior to launch, a national survey of attitudes conducted in May and published in the Irish Journal of Medical Science revealed that Irish citizens expressed high levels of willingness to download a contact tracing app[377].

After the launch of the app on 7th July 2020, the government introduced a national promotional campaign in order to improve the uptake of the app[378]. This resulted in more than 862,000 people downloading the app within the first day[379]. By mid-January 2021, the app had about 1.3 million active

368 https://www.siliconrepublic.com/enterprise/google-play-services-privacy-contact-tracing-apps
369 https://www.irishexaminer.com/news/arid-40019492.html
370 https://www.businessinsider.com/how-nearform-built-ireland-contract-tracing-app-2020-7?r=US&IR=T
371 https://www2.hse.ie/services/covid-tracker-app/technology-the-covid-tracker-app-uses.html
372 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
373 https://www.thejournal.ie/covid-tracker-app-eu-digital-cert-5493722-Jul2021/
374 https://www.thejournal.ie/covid-tracker-app-5237727-Oct2020/
375 https://ec.europa.eu/health/system/files/2021-11/gateway_jointcontrollers_en_0.pdf
376 https://www.thejournal.ie/covid-tracker-app-5237727-Oct2020/
377 https://link.springer.com/article/10.1007/s11845-020-02389-y
378 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
379 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

users and sent close-contact alerts to more than 20,000 people[380].

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The app is available for people aged 16 or older, the age of digital consent[381].

The COVID Radar is interoperable with the Northern Ireland StopCOVID NI and Scottish Protect Scotland CTAs[382].

COVID Tracker was contributed to Linux Foundation Public Health (LFPH) as COVID Green and is in use by 11 public health authorities in the European Union, the United States and New Zealand (components).

Italy

Name of the app

Immuni

Website

https://www.immuni.italia.it/

Main institutions involved

Immuni is the contact tracing app of the Italian Government, which has become a result of collaboration between the Presidency of the Council of Ministers, the Minister of Health, the Minister for Technological Innovation and Digitisation, the Regions, the extraordinary Commissioner for the COVID-19 emergency, and the public companies Sogei and PagoPa[383]. The data controller is the Presidency of the Council of Ministers[384]. The app controller is represented by the Minister of Technological Innovation[385]. Bending Spoons, Italian mobile application developer is the technical coordinator of the CTA[386].

Launch date

15 June 2020[387]

National policies or strategies associated with DCT

On 30 April, Italy's government passed a legal decree that, inter alia, set out the rules regarding the adoption of contact tracing – Decreto Legge 30 April 2020, n. 28, art. 6[388]. It stipulated that the Ministry

380 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
381 https://www2.hse.ie/services/covid-tracker-app/why-use-the-covid-tracker-app.html
382 https://www.bbc.com/news/uk-scotland-54071100, https://www.bbc.com/news/uk-northern-ireland-53599514
383 https://www.immuni.italia.it/faq.html
384 https://www.immuni.italia.it/faq.html
385 https://www.immuni.italia.it/faq.html
386 https://www.immuni.italia.it/faq.html
387 https://www.liberties.eu/en/stories/trackerhub1-mainpage/43437
388 https://www.gazzettaufficiale.it/eli/gu/2020/04/30/111/sg/pdf

of Health is the data controller[389] and that while the data processed through the app can only be used to contain COVID-19, aggregated and anonymised data can also be used for public health or scientific research purposes[390]. In June, the decree was converted into the Law No. 70 of 25 June 2020[391].

Participatory processes and stakeholder engagement

No specific information has been found.

Integration with public health processes and health policy

The CTA can be used as a wallet to store the EU Digital COVID Certificate. However, the app does not have additional functionalities to facilitate services such as ordering or receiving tests via the app.

Open-source code

https://github.com/immuni-app/immuni-documentation

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: https://www.immuni.italia.it/pn.html

Data protection authority: Italian Data Protection Authority (Garante)[392]. From the beginning of the pandemic, Garante participated in discussions on the use of contact tracing apps. On 8th April 2020, the authority expressed its opinion on the use of new technologies to stop the spread of the COVID, while underlining the importance of voluntary use, data minimisation, the need for a well-defined data-retention period and a legally guaranteed purpose limitation. In addition, Garante also consulted the government for the Law Decree no. 28 of 30 April 2020[393].

Data protection impact assessment: As a part of the CTA's developing process, the Ministry of Health sent Garante a data protection impact assessment (DPIA). Based on the DPIA, Garante issued a decision on 1st June stating that the measures taken sufficiently protect the rights of data subjects and thus authorising the use of Immuni. However, it pointed to twelve critical features that the ministry must address within 30 days. In particular, users need to be better informed about how the app algorithm works; they need to be informed that the system can generate exposure notifications that do not always reflect the real risk (false positives); users should be able to temporarily deactivate the app; DPIA needs more information about data subjects' right to cancel; and the role of Bending Spoons, Apple and Google should be clarified based on the principle of accountability. On 21st October, Garante stated that the Ministry had never implemented five of the twelve points. It is stated that the Ministry of Health sent a second DPIA to Garante, though it hasn't been released publicly. As of March 2022, Garante is still accessing the second DPIA. [394]

Other privacy/security check-ups: Krehling and Essex (2021) developed quantitative metrics for privacy of the CTAs based on the 10 principles articulated in an open letter widely signed by cyber-security researchers[395], namely independent expert review, simple design, minimal functionality, data

389 https://www.gazzettaufficiale.it/eli/gu/2020/04/30/111/sg/pdf

390 https://www.gazzettaufficiale.it/eli/gu/2020/04/30/111/sg/pdf

391 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

392 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

393 https://www.gpdp.it/web/guest/home/docweb/-/docweb-display/docweb/9328050

394 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

395 Kerschbaum, F.; Barker, K. Coronavirus Statement. Waterloo Cybersecur. Priv. Inst. 2020. Available online: https://uwaterloo.ca/cybersecurity-privacy-institute/news/coronavirus-statement

minimisation, trusted data governance, cybersecurity, minimum data retention, protection of derived data and meta-data, proper disclosure and consent, provision to sunset[396]. Based on their analysis, Immuni was given a medium ranking of privacy[397].

Critique: In April, the National Association of Operators and Responsible for the Custody of Digital Content (ANORC) including privacy experts and academics wrote an open letter to the Minister for Innovation pointing out to the lack of transparency in the app's deployment[398]. Subsequently, the government published the CTA's source code and conducted the DPIA.

App additional functionalities

- Support for users with visual impairments
- Multiple Languages
- EU Digital COVID Certificate

Significant updates

The update of 19th October 2020 enabled users to receive and share the codes of the people tested positive to COVID-19 between the apps of the countries adhering to the European interoperability gateway[399].

The update on 7th April 2021 introduced a new feature, allowing users to report the positivity for COVID independently[400].

The update of 17th June 2021 featured the possibility of retrieving the EU Digital COVID Certificate independently[401].

Interoperability with EFGS

Yes[402]
Joint Controller: Ministry of Health[403]

Legal Basis for Processing in EFGS: Decree of 7 October 2020, n. 125[404]

Specific actions for implementation

As a part of the promotional campaign, several public dissemination documents have been provided at national level for health professionals (including stakeholders). The Italian National Institute of Health (Istituto Superiore di Sanità) proposed pandemic-related guidelines called the Istituto Superiore di Sanità Covid Report. During the start-up period of the Italian Digital Contact Tracing, three reports were proposed, dedicated or strongly related to DCT, namely the traditional CT, DCT, and the impact of ethics in DCT. This was done in order to inform, update and raise awareness among healthcare professionals. Furthermore, the National Institute of Health proposed special online courses for training of the contact-tracing operators. The general population also received information about the app and how to

396 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

397 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

398 https://anorc.eu/attivita/immuni-anorc-a-pisano-dichiarazioni-non-allineate-faccia-chiarezza/

399 See Versions History https://apps.apple.com/us/app/immuni/id1513940977

400 See Versions History https://apps.apple.com/us/app/immuni/id1513940977

401 See Versions History https://apps.apple.com/us/app/immuni/id1513940977

402 https://techcrunch.com/2020/10/19/eu-switches-on-cross-border-interoperability-for-first-batch-of-covid-19-contacts-tracing-apps/

403 https://ec.europa.eu/health/system/files/2021-11/gateway_jointcontrollers_en_0.pdf

404 https://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2020-10-07&atto.codiceRedazionale=20G00144&elenco30giorni=true

use it through the mass media (internet, radio, newspapers and public posters) [405].

Statistics regarding the app use

App statistics are published by the Italian Ministry of Health. The website displays number of downloads, positive users, and notifications sent. All data is available in CSV and JSON format on github: Immuni - I numeri di Immuni (italia.it)

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

Persons at least 14 years old are allowed to use Immuni. In case, a person is between 14 and 18 years old, they must have the permission of a parent or a legal guardian.

Upon user's consent, the app use epidemiological data for secondary purposes (scientific research). More specifically, it sends such data as, for example, day and duration of exposure, operational information (e.g., the device's platform) to a central server located in Italy and managed by Sogei to help the National Healthcare Service in improving the app's accuracy and optimising resource allocation.

Latvia

Name of the app

Apturi Covid

Website

https://www.apturicovid.lv/#en

Main institutions involved

The Apturi Covid (Latvian for "Stop Covid") CTA was developed by the consortium of Latvian private companies, consisting of LMT, the country's largest mobile operator, software development companies MAK IT, Autentica, Zippy Vision, software testing service TestDevLab and IT security consultancy IT Centrs[406] in close cooperation with science, including experts from the University of Latvia, medical professionals, epidemiologists[407].

Ministry of Health and Centre for Disease Prevention and Control is the provider of the app and the data controller.

Launch date

29 May 2020

National policies or strategies associated with DCT

The Law 2022/110A on the Management of the Spread of COVID-19 Infection[408] sets the basis for data processing, the purposes of contact tracing and the legal basis for processing with the European Federation Gateway. The types of data collected by the app together with the period of storage is

[405] Scrivano, N., Gulino, R. A., & Giansanti, D. (2021). Digital Contact Tracing and COVID-19: Design, Deployment, and Current Use in Italy. Healthcare (Basel, Switzerland), 10(1), 67. https://doi.org/10.3390/healthcare10010067

[406] https://www.apturicovid.lv/iesaistitas-organizacijas

[407] https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

[408] https://likumi.lv/ta/en/en/id/315278

described by the Cabinet's Regulation No. 360 Epidemiological Safety Measures for the Containment of the Spread of COVID-19 Infection[409].

Participatory processes and stakeholder engagement

No specific information has been found.

Integration with public health processes and health policy

The app does not have additional functionalities to facilitate contact with public health services.

Open-source code

https://github.com/ApturiCOVID/apturicovid-android

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: https://www.apturicovid.lv/privatuma-politika

Data protection authority: Latvian Data State Inspectorate[410]

Data protection impact assessment: The DPIA was conducted and can be found here.

Other privacy/security check-ups: According to the Latvian national data protection authority, the Data State Inspectorate (DSI), Apturi Covid is proved to be safe in terms of data privacy: it does not identify a specific person, track location data, or process private information on a user's device[411].

Krehling and Essex (2021) developed quantitative metrics for privacy of the CTAs based on the 10 principles articulated in an open letter widely signed by cyber-security researchers[412], namely independent expert review, simple design, minimal functionality, data minimisation, trusted data governance, cybersecurity, minimum data retention, protection of derived data and meta-data, proper disclosure and consent, provision to sunset[413]. Based on their analysis, Apturi Covid was given a medium ranking of privacy[414].

In April 2020, prior to the development of the app, developers signed a Memorandum of Understanding on Public Participation in Limiting COVID-19[415] with the basic principles and conditions of the app's functioning[416]. Among them are principles of proportionality, transparency and safety of the data. In the Terms of Use[417], creators emphasised data protection as the main priority, identifying the types of data the app should not record and process (location data, personal information etc)[418].

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409 https://likumi.lv/ta/en/en/id/315304

410 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

411 https://www.dvi.gov.lv/lv/jaunums/mobila-lietotne-apturi-covid-neizseko-personas

412 Kerschbaum, F.; Barker, K. Coronavirus Statement. Waterloo Cybersecur. Priv. Inst. 2020. Available online: https://uwaterloo.ca/cybersecurity-privacy-institute/news/coronavirus-statement

413 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

414 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

415 https://www.spkc.gov.lv/lv/media/15178/download

416 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

417 https://www.spkc.gov.lv/lv/media/15181/download

418 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

App additional functionalities

- COVID-19 epidemiological situation statistics
- Navigate to other sources

Significant updates

The update of 30th October 2020 enabled interoperability with other European CTAs[419].

Interoperability with EFGS

Yes

Legal basis for processing in EFGS: Law on the Management of the Apread of COVID-19 Infection

Specific actions for implementation

In order to reach as many people as possible the website of the application is available in Latvian, Russian and English languages. Furthermore, every company in Latvia is invited to take part in the promotion of the Apturi Covid: the app's website features the information material including explainer videos, posters, SMS texts and banners[420].

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Lithuania

Name of the app

Korona Stop LT

Website

https://koronastop.lrv.lt/programele

FAQ for the app available here[421].

Main institutions involved

The Korona Stop LT app was commissioned by the National Center for Public Health (NVSC) and the Ministry of Health (SAM)[422]. The app developed by Lithuanian software development company Dizaino Kryptis is based on the German Corona-Warn-App[423]. The Ministry of Health is the data controller.

Launch date

6 November 2020

[419] https://apps.apple.com/us/app/apturi-covid-latvia-spkc/id1513573144
[420] https://apturicovid.lv/komunikacijas-materiali/
[421] https://koronastop.lrv.lt/en/faq/mobile-app-korona-stop-lt/instructions-of-use
[422] https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
[423] https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

National policies or strategies associated with DCT

The Law on Electronic Communications of 31 March 2020[424] obliges communication providers to share location data of quarantined individuals to a government-authorised body and sets out rules for location data processing.

Participatory processes and stakeholder engagement

The Ministry of Health (SAM) and the National Center for Public Health (NVSC) were two major stakeholders.

Integration with public health processes and policy

The app facilitates the contact with a call centre.

Open-source code

Not available

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy Policy available here.

Data protection authority: Lithuanian Data Protection Inspectorate[425]

Data protection impact assessment: According to NVSC, the National Cyber Security Centre, a data protection impact assessment was performed ahead of the launch of Korona Stop. However, the document has not been published.[426]

According to the app developers, data minimisation is a paramount principle in the implementation of the app[427]. The only inputs that users can and have to provide to the app are: 1) permissions for using the exposure notification framework; 2) TANs for test result verification; 3) consent to upload daily diagnosis keys[428].

App additional functionalities

- Multiple languages
- Navigate to other sources
- Call centre

Significant updates

The update of 7th December 2020 provided English, Russian and Polish language support. The version from 19th May 2021 enabled interoperability with other European CTAs[429].

[424] https://e-seimas.lrs.lt/portal/legalAct/lt/TAP/caba0690734811eaa38ed97835ec4df6?positionInSearchResults=36&searchModelUUID=1425ce09-d4cd-4eff-8f30-8b3eb8ab7563

[425] https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

[426] https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

[427] https://koronastop.lrv.lt/en/faq/mobile-app-korona-stop-lt/privacy-and-security

[428] https://koronastop.lrv.lt/en/faq/mobile-app-korona-stop-lt/privacy-and-security

[429] https://apps.apple.com/lt/app/korona-stop-lt/id1529105760

Interoperability with EFGS

Yes

Legal basis for processing in EFGS: Consent[430]

Specific actions for implementation

To promote the use of Stop Korona LT among the population, the National Center for Public Health (NVSC) organised regularly presentations of the app to municipalities, educational institutions and representatives of various organizations[431]. Furthermore, for each of the app related FAQs, the developers provided explainer videos for people with disabilities.

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The app for Lithuanian users can be used by persons 16 years of age and older (17 and older in App Store)[432].

Malta

Name of the app

COVIDAlert

Website

https://covidalert.gov.mt (decommissioned)

Main institutions involved

The app is run by the Maltese government and was developed by the Malta Information Technology Agency (MITA), in collaboration with the Ministry of Health and the Malta Digital Innovation Authority[433]. The Superintendent of Public Health is the data controller[434]. The Malta Information Technology Agency (MITA) operates the entire software on behalf of the Superintendent of Public Health and provides the necessary technical support service[435].

Launch date

17 September 2020

National policies or strategies associated with DCT

The processing of personal data is governed by data protection legislation, including the General Data Protection Regulation (EU) 2016/679 (GDPR) and Data Protection Act (Cap 586 in the Laws of Malta)[436].

430 https://ec.europa.eu/health/system/files/2022-03/gateway_jointcontrollers_en_0.pdf
431 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
432 https://koronastop.lrv.lt/programele
433 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
434 https://covidalert.gov.mt/privacy-policy/
435 https://covidalert.gov.mt/privacy-policy/
436 https://covidalert.gov.mt/privacy-policy/

The app is also based on Legal Notice 379 of 2020 and Legal Notice 128 of 2021[437]. Subsidiary legislation entitled Contact Tracing and Alerting Mobile Application Order, 2020 was enacted on the 1st October 2020, as amended by Legal Notice 128[438] of 30 March 2021. This legislation provided the basic framework that guided both the deployment and the eventual decommissioning of the Contact Tracing Application together with the relevant steps.

Participatory processes and stakeholder engagement

No specific information has been found.

Integration with public health processes and health policy

COVID-19 Case Managers were providing the codes to Positive Cases if the individuals reported that they used the application and there was a Customer Service-oriented email address (covidalert@gov.mt) from which motivated app users that turned out to be COVID-19 positive (Detected and Reactive) and had not been provided with an activation code, were given this upon request.

Upon receiving an exposure notification, users were recommended to seek testing with the relevant text encouraging them to contact our national COVID Helpline (111) through a push notification and an alert within the application.

Open-source code

https://github.com/GOVMT-MITA

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy Policy available here.

Data protection authority: Office of the Information and Data Protection Commissioner[439]

Data protection impact assessment:) was carried out by the Maltese Information and Data Protection Commission (IDPC) before the app was launched, according to which the data controller had "mitigated any possible risks which with the appropriate measures"[440]. However, the document has not been published[441].

App additional functionalities

- Statistics on COVID-19/Local epidemiologic information
- Multiple Languages

Significant updates

The update of 9th April 2021 enabled interoperability with other European CTAs[442].

437 https://covidalert.gov.mt/privacy-policy/
438 https://legislation.mt/eli/ln/2021/128/
439 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19
440 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
441 https://www.maltatoday.com.mt/news/national/104957/covid19_app_passed_privacy_assessment_commissioner_says#.YhX20y2ZNN0
442 https://apps.apple.com/de/app/covid-alert-malta/id1513522951

Interoperability with EFGS

Yes

Legal basis for processing in the EFGS: Legal Notice 379 of 2020[443] entitled Contact Tracing and Alerting Mobile Application Order, 2020 issued on the 1st October 2020, as amended by Legal Notice 128[444] of 30 March 2021

Specific actions for implementation

An official digital presence and landing page was set up for COVID Alert Malta (covidalert.gov.mt [decommissioned]) that communicated the value of Malta's national contact tracing app with clear calls to action to download the application, to learn about the app features and to understand the policies that govern the use of the application. In addition, social media (Twitter and Facebook) campaigns to promote the use of the app have been carried out.

Statistics regarding the app use

There is no regularly updated statistics concerning the use of app. However, there is a GitHub page available displaying the number of downloads. The last update was in 2021[445].

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

Persons at least 13 years old are allowed to use COVID Alert Malta[446].

Netherlands

Name of the app

CoronaMelder

Website

https://coronamelder.nl/en/

Main institutions involved

The app was developed by the Ministry of Health, Welfare and Sports (VWS), working groups of the National Institute for Public Health and Environment (RIVM) and the municipal health services (GGDs)[447]. The Ministry of Health, Welfare, and Sports (VWS) is the app controller[448] and the Municipal Health Service (GGD) is the data controller[449].

443 https://legislation.mt/eli/ln/2020/379/eng/pdf
444 https://legislation.mt/eli/ln/2021/128/
445 COVID19-Data/COVID-19 Malta - Covid Alert Malta - Statistics Table.csv at master · COVID19-Malta/COVID19-Data · GitHub
446 https://covidalert.gov.mt/faqs/
447 https://coronamelder.nl/en/faq/3-3-hoe-helpt-coronamelder-in-de-praktijk-de-familie-vliet/
448 https://coronamelder.nl/en/faq/3-3-hoe-helpt-coronamelder-in-de-praktijk-de-familie-vliet/
449 https://coronamelder.nl/en/privacy

Launch date

10 October 2020[450].

National policies or strategies associated with DCT

The Temporary Act on notification application COVID-19 approved on 6th October 2020[451] (amending Public Health Act) provided the legal basis for the use of the CoronaMelder app.

Participatory processes and stakeholder engagement

Practical tests of the CoronaMelder were carried out in the Twente region in July 2020[452]. A call for participation among civil servants in the Twente region was published in the local media. A total of 3,900 people registered for the test, of which 1,440 were randomly selected to participate based on their answers to the questionnaires. The participants were consistently positive about CoronaMelder, so that the government was able to introduce the Corona Notification App to the public in October.

Integration with public health and health policy

The CTA facilitates contact to the call centre via a button app.

Open-source code

https://github.com/minvws

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy statement available here.

Data protection authority: Dutch Data Protection Authority[453]

Data protection impact assessment: In August 2020, the VWS Information Policy Directorate conducted the data protection impact assessment (DPIA)[454], where the authority, inter alia, advised Ministry of Health, Welfare and Sports:

1) to complete agreements with Google and Apple considering the data use;

2) to create a legal basis for the use of CoronaMelder, including the prohibition of the involuntary use of the app (for example by employers, shops or catering services);

3) to ensure the "backside" of the app, so as to identify an actor responsible for a server through which the transmission of data takes place.

Other privacy/security check-ups: Krehling and Essex (2021) developed quantitative metrics for privacy of the CTAs based on the 10 principles articulated in an open letter widely signed by cyber-security researchers[455], namely independent expert review, simple design, minimal functionality, data minimisation, trusted data governance, cybersecurity, minimum data retention, protection of derived

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450 https://www.nortonrosefulbright.com/-/media/files/nrf/nrfweb/contact-tracing/the-netherlands-contact-tracing.pdf?revision=e1cf6f70-c01b-4236-957f-4843dc5dd159

451 https://www.eerstekamer.nl/behandeling/20201009/publicatie_wet/document3/f=/vlcqcoql0wxg.pdf

452 https://www.rijksoverheid.nl/onderwerpen/coronavirus-app/documenten/rapporten/2020/07/31/gebruikservaring-coronamelder-testregio-twente

453 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

454 https://www.rijksoverheid.nl/documenten/rapporten/2020/08/24/gegevensbeschermingseffectbeoordeling-dpia

455 Kerschbaum, F.; Barker, K. Coronavirus Statement. Waterloo Cybersecur. Priv. Inst. 2020. Available online: https://uwaterloo.ca/cybersecurity-privacy-institute/news/coronavirus-statement

data and meta-data, proper disclosure and consent, provision to sunset[456]. Based on their analysis, CoronaMelder was given a medium ranking of privacy[457].

App additional functionalities

- Multiple languages
- Support for the people with disabilities
- Call centre

Significant updates

There have been two significant updates after initial launch:

- In May 2021 CoronaMelder switched to GAEN 'Version 2'. The latest version of the framework allowed to use a cumulative approach to risk calculation, i.e. several shorter contact could be aggregated to cross the lower threshold on duration (15 minutes);
- In October 2021 CoronaMelder was integrated with coronatest.nl. This allowed an app user, after testing positive, to activate CoronaMelder on their own, without any intervention by a manual contact tracer which had been the case up until then.

Interoperability with EFGS

Yes

Joint Controller: Minister of Health, Welfare and Sports

Legal Basis for Processing in EFGS: Law on the temporary provisions concerning the use of a notification application in the fight against the COVID-19 epidemic and safeguards against the misuse of it, in effect since 6 October 2020[458].

Specific actions for implementation

Everyone in the Netherlands was being encouraged to download and use the app through radio, television and billboard advertising campaign, as well as an online social media campaign[459]. The campaign makes it clear that using the app is completely voluntary and that the app does not require any personal information or location data to work[460]. The chosen narrative was: 'For whose protection do you download the app', focussing on protecting others around you. Furthermore, a Communication ToolKit for the contact tracing app with ready-made news items, latest news, posters, videos, and social media items was made available on the website[461].

Statistics regarding the app use

Statistics regarding the app use are published and updated regularly on the Ministry of Health, Welfare and Sports webpage[462]. The statistics include number of downloads and active users, number of people who alerted others via CoronaMelder, number of test requests that were preceded by a notification, percentage of positive test results that were preceded by a notification.

https://www.coronamelder.nl/nl/faq/1-13-coronamelder-data-dashboard/

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456 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

457 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

458 https://ec.europa.eu/health/system/files/2021-11/gateway_jointcontrollers_en_0.pdf

459 https://coronamelder.nl/en/faq/4-2-hoe-ziet-de-campagne-over-coronamelder-er-uit/

460 https://coronamelder.nl/en/faq/4-2-hoe-ziet-de-campagne-over-coronamelder-er-uit/

461 https://news.pressmailings.com/hvdm/partnertoolkit

462 https://coronadashboard.government.nl/landelijk/coronamelder, https://www.coronamelder.nl/media/Factsheet_CoronaMelder_latest.pdf

CTA evaluation

There is a number of research on the effects of CoronaMelder published on the official website of the application[463]. They include a Factsheet Ongoing Evaluation led by Professor Dr. Wolfgang Ebbers (Erasmus Univeristy Rotterdam) and consisting of both quantitative and qualitative research[464], CoronaMelder evaluation: an overview after 9 months[465] and its summary[466], Grip on the CoronaMelder – Qualitative Research to Experiences with CoronaMelder Final report, CoronaMelder final report[467].

Poland

Name of the app

STOP COVID (previously ProteGO Safe)

Website

https://www.gov.pl/web/protegosafe

Main institutions involved

STOP COVID (previously ProteGO Safe) is the result of cooperation between several Polish IT companies at the request of the Ministry of Digital Affairs in cooperation with GovTech Polska under the supervision of the Chief Sanitary Inspectorate. The app is controlled and managed by the Ministry of Digital Affairs.

Launch date

First BlueTrace-based version: 29 April 2020

Second version using Apple and Google's Exposure Notifications technology: 9 June 2020

National policies or strategies associated with DCT

The Act on special solutions related to the prevention, counteraction and combating of COVID-19 of 8 March 2020, Article 7e[468] stipulates legal obligation to use Kwarantanna Domowa / home quarantine app to fight COVID-19.

Participatory processes and stakeholder engagement

The government made the source code publicly available from the start, enabling Polish programmers, software testers, graphic designers and data protection experts to discuss the best outcome of the app. A list of public contributors, besides the government bodies, is available on GitHub.[469]

Integration with public health processes and health policy

The app was intended to monitor health and has been integrated with the public health bodies as follows:

1. monitor users' health by completing a Risk Assessment Test.
2. complete the health Diary in a format that allows the results to be conveniently shared with medical staff during an examination.

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463 https://coronamelder.nl/en/faq/3-1-onderzoek-hoe-weten-we-of-coronamelder-helpt-tegen-corona/

464 https://www.rijksoverheid.nl/documenten/publicaties/2022/02/28/coronamelder-factsheet-doorlopende-evaluatie

465 https://www.rijksoverheid.nl/documenten/publicaties/2021/05/28/rapporten-evaluatie-coronamelder-9-maanden

466 https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/publicaties/2021/05/28/rapporten-evaluatie-coronamelder-9-maanden/Samenvatting+Evaluatie+CoronaMelder+Een+overzicht+na+9+maanden.pdf

467 https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/publicaties/2021/04/14/eindrapport-kwalitatief-onderzoek-grip-op-coronamelder-universiteit-twente-open-universiteit/eindrapport_kwalitatief_Grip+op+Coronamelder-UT+en+OU.pdf

468 https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20200000374/U/D20200374Lj.pdf

469 https://github.com/ProteGO-Safe/android/blob/master/CONTRIBUTORS.md

3. receive personalized recommendations on how to proceed, based on the responses provided when completing the Risk Assessment Test.
4. receive notifications encouraging to fill in the Risk Assessment Survey and other preventive behaviours on a regular basis. [470]

Open-source code

https://github.com/ProteGO-Safe

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy Policy available here.

Data protection authority: Polish Data Protection Authority (UODO)[471]

Data protection impact assessment: Yes, link available here.

Other privacy/security check-ups: Security Tests carried out by SEQRED SA, were commissioned by the ministry of Digitization and the reports are available here. [472]

Critique: The DPIA is published but not accessible via the link given on the website. [473]

According to the developers, the application was created in compliance with GDPR regulations including data minimisation, privacy by design, privacy by default, accuracy, integrity, and confidentiality, as well as the guidelines of the European Data Protection Board, the European Commission, and the Toolbox developed within the European Commission's eHealth network[474].

App additional functionalities

- Symptoms/Health status tracker
- Contacts Diary/Journal
- Helpline

Significant updates

- On 20 April 2020, the Ministry of Digital Affairs released the first version of the ProteGo Safe app, which originally only provided information and health monitoring functions[475].

- Only nine days later, it produced a newer version that made use of *Bluetooth technology* and allowed for contact tracing[476].

- On 9 June 2020, after a series of controversies[477] surrounding the previous versions, the Ministry produced yet another version – this time using the *decentralised* application programming interface (API) developed by Apple and Google (previously it had used the BlueTrace centralised approach)[478].

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470 https://www.gov.pl/web/gis/aplikacja-protego-safe

471 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

472 https://www.gov.pl/web/protegosafe/dokumenty

473 https://www.gov.pl/web/protegosafe/dokumenty

474 https://www.gov.pl/web/stopcovid-en/questions-and-answers

475 https://www.gov.pl/web/cyfryzacja/pokonajmy-razem-koronawirusa--poznaj-protego-safe

476 https://www.gov.pl/web/cyfryzacja/protego-safe--pobierz-zainstaluj-przetestuj

477 E.g., https://niebezpiecznik.pl/post/albo-zainstalujesz-rzadowa-aplikacje-protego-safe-albo-nie-wejdziesz-do-sklepu/, https://informatykzakladowy.pl/architektura-aplikacji-protego-safe-kolejne-kontrowersje/

478 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

- In September 2020, the government rebranded the app from *ProteGo Safe to STOP COVID.*

Interoperability with EFGS

Yes[479]

Joint Controller: Główny Inspektor Sanitarny

Legal basis for processing in EFGS: consent[480]

Specific actions for implementation

Promotional work mainly included a website and videos[481] which emphasized that citizens should download and use the app.[482] In an attempt to increase uptake, the government announced that people notified by the app of exposure to corona-positive persons could sign up for a test via the app without having to contact a general physician.[483]

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Portugal

Name of the app

StayAway Covid

Website

https://stayawaycovid.pt/landing-page/

Main institutions involved

App developers: Institute of Computer Systems Engineering, Technology and Science (Inesc Tec), Inesc I&D, Institute of Public Health of the University of Porto, Keyruptive, Ubirider, the Telecommunications Institute, and the Robotics and System Engineering Laboratory[484].

An alternative app[485] was developed by HypeLabs, a startup in Porto, but the government favored the Inesc Tec's digital tracing solution as it followed the DP-3T protocol[486].

Data Controller: Directorate-General of Health (DGS)

Hosting and management of the platform that allows the generation of codes by healthcare professionals: SPMS – Serviços Partilhados do Ministério da Saúde, E.P.E.

479 https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/travel-during-coronavirus-pandemic/mobile-contact-tracing-apps-eu-member-states_en

480 https://ec.europa.eu/health/system/files/2022-03/gateway_jointcontrollers_en_0.pdf

481 https://www.youtube.com/watch?v=v9dtEwz0nY8

482 https://notesfrompoland.com/2020/09/11/uptake-of-covid-contact-tracing-app-under-2-in-poland-among-the-lowest-rates-in-europe/

483 https://www.gov.pl/web/protegosafe/aplikacja-stop-covid--nowosci-dla-uzytkownikow3

484 https://www.inesctec.pt/en/covid-19#psicovida

485 https://www.prnewswire.com/news-releases/hypelabs-contact-tracing-technology-focused-on-privacy-now-available-for-immediate-deployment-at-no-cost-for-all-countries-301039838.html

486 https://stayawaycovid.pt/frequently-asked-questions/

Launch date

1 September 2020

National policies or strategies associated with DCT

The introduction of the Decreto-Lei n.º 52/2020[487] Law of 11 August 2020 has established who is responsible for data processing and set the legal framework for the intervention of the doctor in the STAYAWAY COVID system[488].

Participatory processes and stakeholder engagement

INESC TEC (The Institute for Systems and Computer Engineering, Technology and Science) coordinated the consortium in charge of developing the STAYAWAY COVID in partnership with the Institute of Public Health of the University of Porto (ISPUP), the companies Keyruptive and Ubirider.[489]

Integration with public health processes and local health policy

The CTA has added a symptoms tracker. However, it does not have additional functionalities to support contact with public health services.

Open-source code

https://github.com/stayawayinesctec/stayaway-app

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): DP-3T, GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy Policy available here.

Data protection authority: Portuguese Data Protection Authority (CNPD)[490]

Data protection impact assessment: DPIA was carried out by the Portuguese Data Protection Authority (CNPD)[491], available here.

Based on the DPIA, the CNPD recommended the adaptation of a legal framework concerning the operation of Stayaway COVID. On this account, a legal decree was passed that made the Directorate-General of Health (DGS) the data controller. It also set out that the DGS regulates doctors' intervention in the app. Besides this, the DPIA identified the main risks of the app, such as the re-identification of users. It set out recommendations including data minimization as well as the adaptation of a clear and simple language towards the users.

All source code developed was audited by the National Cybersecurity Centre (CNCS) and is publicly available[492].

App additional functionalities

- Symptoms/Health status tracker

[487] https://dre.pt/home/-/dre/140013521/details/maximized
[488] https://www.liberties.eu/en/stories/trackerhub5-legal-acts/43539
[489] https://www.inesctec.pt/en/news/stayaway-covid-available-for-download#about
[490] https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19
[491] https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
[492] https://github.com/stayawayinesctec

- Multiple Languages

Significant updates

The app has not been significantly updated.

Interoperability with EFGS

No

Specific actions for implementation

The project was promoted by the Foundation for Science and Technology (FCT), within the scope of the National Digital Competences Initiative e.2030, Portugal INCoDe.2030, with the support of the Portuguese Mint and Official Printing Office (hosting of the system), the Portuguese National Cybersecurity Centre (supervision of development and security testing), NOS (mobile devices for research and testing) and Wavecom (equipment and support to Bluetooth research and testing).[493]

In addition, within the scope of the platform dedicated to the healthcare professionals in which codes are generated, several training/awareness campaigns were carried out (e.g., webinars).

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Slovenia

Name of the app

#OstaniZdrav

Website

https://www.gov.si/en/topics/coronavirus-disease-covid-19/the-ostanizdrav-mobile-application/

Main institutions involved

The app #OstaniZdrav was customized for use in Slovenia based on the German Corona-Warn-App by the Slovenian software development company PC7 (previously RSTEAM)[494]. When a user tests positive for COVID-19, they receive a code from the National Institute of Public Health, which they can upload into the app to notify others of the potentially risky exposure. Ministry of Public Administration is the data controller[495].

Launch date

17 August 2020

National policies or strategies associated with DCT

"Act Determining the Intervention Measures to Contain the COVID-19 Epidemic and Mitigate its Consequences for Citizens and the Economy of 23 October 2020", which establishes the legal basis for operating of a voluntary contact trancing app #OstaniZdrav, with the purpose of help in managing the

493 https://www.inesctec.pt/en/news/stayaway-covid-available-for-download#about

494 https://pc7.io/work

495 https://ec.europa.eu/health/system/files/2021-11/gateway_jointcontrollers_en_0.pdf

COVID-19 crisis."[496]

Participatory processes and stakeholder engagement

On 12 July, the government announced a call for tender for the creation of an app.

Six bidders responded to the invitation, and it was the company RSTEAM that ended up signing the contract. It proposed to develop an app using the open-source solution from the German Corona-Warn-App. #OstaniZdrav (#StayHealthy) was finally launched on 17 August for Android, and, since the beginning of September, also for iOS.[497]

Integration with public health processes and health policy

For the majority of the time the app has been in use, every individual who has tested positive for covid-19 received the code for the app by SMS, with instructions to enter the code in the app if they have it installed. Since issued authentication codes are valid for 3 hours, app users who missed the 3 hour time period to enter the code could also generate the code manually, via the shortcut on the app, that redirects users to the website of the National Institute of Public Health. Users can receive a code this way (also by SMS) after entering their information, provided their positive test results are already in the database. Additionally, whenever an individual who uses the app receives a notification of a high risk contact, he is redirected to the website of the National Institute of Public Health, where he is advised to abide by recommendations.

Open-source code

https://github.com/si-covid-19

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy notice available here.

Data protection authority: Slovenian Information Commissioner[498]

Data protection impact assessment: The IC remarked that the government failed to produce a proper data protection impact assessment (DPIA).[499]

Critique: The Slovenian government did not involve the national data protection authority, the Information Commissioner, either in the introduction of the app or in the draft legislation that provided its legal basis[500].

Slovenia initially intended to make the use of a proximity and contact tracing app mandatory by law, but subsequently announced and accepted a legal basis for another app.[501]

As Slovenia understood the terms of Google and Apple, the app stayed developed in a way that no authentication of user is possible.

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496 http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO8190

497 A Bittersweet Victory for Human Rights. Report by Civil Liberties Union for Europe

498 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

499 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

500 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

501 Digital Solutions to fight COVID-19, 2020 Data Protection Report by Council of Europe

App additional functionalities

- Navigate to other sources
- Diary/Journal
- Manage vaccines and test certificates
- Create QR codes for events
- Check-in with QR code and check

Significant updates

The upgraded version, released on 22 January 2021, enabled[502]

- cross-border exchange of tracing keys
- entry of the date when COVID-19 symptoms appeared
- the new intermediate orange level of risk
- a link to a guide in sign language
- more frequent updates (six times in 24 hours, and not only once a day)
- a link to the e-Administration portal (for quarantine orders, and a 10-digit tracing codes for users who tested positive)

Interoperability with EFGS

Yes[503]

Specific actions for implementation

The promotion activities included publications in media, distribution of flyers, visits and presentations by regions, as well as notifications and recommendations sent to organization from the ministries. In September 2020, the government launched a large SMS campaign, offering people to install and use the app[504]. The IC received numerous complaints and questions concerning the legality of this campaign, but they emphasised that it was not their responsibility, as it falls within the competencies of the Agency for Communication Networks and Services of the Republic of Slovenia (AKOS)[505].

In addition, the government regularly promotes the use of the application via television advertisements and at press conferences[506].

Statistics regarding the app use

Statistics regarding the no. of downloads on Android, iOS, and number of issued TAN codes are made available on the Republic of Slovenia website: https://podatki.gov.si/dataset/statisticni-podatki-aplikacije-ostanizdrav

CTA evaluation

No evaluation of effectiveness has been carried out.

502 https://www.total-slovenia-news.com/lifestyle/7668-covid-slovenia-friday-22-01-1-439-new-cases-app-upgraded

503 https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/travel-during-coronavirus-pandemic/mobile-contact-tracing-apps-eu-member-states_en

504 https://siol.net/novice/slovenija/nijz-s-sms-sporocilom-vabi-k-prenosu-aplikacije-ostanizdrav-533957

505 https://www.ip-rs.si/novice/o-zakonitosti-posiljanja-sms-sporocil-za-promocijo-aplikacije-ostanizdrav-s-strani-operat-1202/

506 https://www.gov.si/en/news/2020-10-18-prime-minister-janez-jansa-a-challenging-period-of-colder-months-lies-ahead-an-effective-response-to-the-pandemic-is-needed/

Spain

Name of the app

Radar Covid

Website

https://radarcovid.gob.es/en/

Main institutions involved

Owner of the app: The General Secretariat of Digital Administration (SGAD in its Spanish initials), which reports to the Secretary of State for Digitalisation and Artificial Intelligence of the Ministry of Economic Affairs and Digital Transformation (SEDIA), is the owner of the App.[507]

Data Controller: Ministry of Health and the Autonomous Communities.

Data Processor: The General Secretariat of Digital Administration.[508]

Launch date

27 October 2020

National policies or strategies associated with DCT

The Order SND/297/2020 of 28 March 2020[509] Entrusts State Secretary of Digitalisation with development of an application to manage the COVID-19 crisis.

Following the outbreak of COVID-19, Spain's autonomous communities (CCAA), who are responsible for their own health matters, developed a series of web and mobile phone apps in parallel to the government's Asistencia COVID-19. For example, Andalusia's app was *SaludResponde*; Catalonia's app was *STOP COVID19 CAT* and the Community of Madrid's app was called *CoronaMadrid.* In addition, Catalonia introduced in October its own tracking app *ContactCovid.cat.* The multitude of apps sparked a privacy debate, as several of them violated data subject rights. It took a while before the app (Radar COVID) from the government (SEDIA) was introduced across the country, as the autonomous regions (CCAAs) are responsible for integrating the app into their respective health systems, which took them quite a while to do. [510]

Participatory processes and stakeholder engagement

On 15 June, the State Secretariat for Digitalization and Artificial Intelligence (SEDIA) of the Ministry of Economic Affairs and Digital Transformation SEDIA concluded a contract with the company *Indra Sistemas SA* to develop the contact tracing app Radar COVID.

On 23 June, the Council of Ministers approved the launch of a pilot project on the Canary Island of La Gomera.

On 3 August, the government declared the testing phase a success.

On 9 December, SEDIA concluded a new contract with the company Indra Sistemas SA for about €1,740,101 to continue with the maintenance and update of the app for a period of 24 months, approved again under the emergency procedure, and therefore without a public tender. [511]

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507 https://radarcovid.gob.es/en/terms-and-conditions-use

508 https://radarcovid.gob.es/en/privacy-policy

509 https://www.boe.es/buscar/act.php?id=BOE-A-2020-4162#:~:text=Orden%20SND%2F297%2F2020%2C,ocasionada%20por%20el%20COVID%2D19.

510 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

511 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

Integration with public health processes and health policy

As the Spanish healthcare system is decentralised, and competences are transferred to each autonomous community, each autonomous community needed to integrate its healthcare system with the app separately. For instance, each autonomous community needed to be able to provide the 12-digit codes to PCR-positive cases in an agile and efficient way. Such integration was a critical factor in the deployment of Radar Covid app.[512] This proved to be quite a challenge as either because the system wasn't implemented in the autonomous community or because the employees of the Public Health system didn't know how the application worked.[513] Another challenge was that not all health centres or private doctors knew how to issue diagnostic codes to people with positive test results which lead to inefficient distribution of codes.[514]

Open-source code

https://github.com/radarcovid

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy Policy available here.

Data protection authority: Spanish Data Protection Authority (AEPD)[515]

Data protection impact assessment: The Ministry published a DPIA in the GitHub repository. However, according to liberties.eu, the DPIA has no electronic signature, and it merely indicates a date of completion. [516]

App additional functionalities

- Diary/Journal
- App statistics
- Navigate to other sources

Significant updates

The update of 16 September 2020 enabled the implementation of return to "No risk contacts identified" status for alerted contacts (close contacts) after 14 days, implementation of multi-languages (including co-official languages), adjustments in texts and design to adapt them to the requirements of the Ministry of Health, adjustment of privacy policies and terms of use[517]. The version from 8 October 2020 added inclusion of date of symptoms/PCR tests in communication, inclusion of sending fake positive notifications and DP-3T version upgrade. The update of 30 October 2020 enabled interoperability of the app with other European applications and allowed users to change the language of the app and review new privacy policies and/or terms of use. The version from 19 November 2020 established key sharing with other European CTAs as default option. The update of 19 December 2020 added informative

[512] Rodríguez, Pablo & Graña, Santiago & Alvarez-León, Eva & Battaglini, Manuela & Darias, Francisco & Hernán, Miguel & López, Raquel & Llaneza, Paloma & Martín, Maria & Ramirez-Rubio, Oriana & Romaní, Adriana & Suárez-Rodríguez, Berta & Sánchez-Monedero, Javier & Arenas, Alex & Lacasa, Lucas. (2021). A population-based controlled experiment assessing the epidemiological impact of digital contact tracing. Nature Communications. 12. 587. 10.1038/s41467-020-20817-6.

[513] https://www.xataka.com/aplicaciones/nadie-supo-darme-codigo-caos-radar-covid-codigos-que-no-llegan-notificaciones-retraso-mucho-trabajo-hacer

[514] https://www.xataka.com/aplicaciones/nadie-supo-darme-codigo-caos-radar-covid-codigos-que-no-llegan-notificaciones-retraso-mucho-trabajo-hacer

[515] https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

[516] https://www.liberties.eu/en/stories/app-radar-covid-rights/43524

[517] For all the updates see the Version History in App Store https://apps.apple.com/de/app/radar-covid/id1520443509

counter of days pending quarantine for risk contacts and COVID Radar statistics display. The version from 17 February 2021 allowed for anonymous metrics report in order to measure application efficiency. The update of 14 July 2021 added the record of exposure dates feature.

Interoperability with EFGS

Yes[518]

Legal basis for processing in EFGS: consent

Joint Controller: Dirección General de Salud Pública, Unidad de Apoyo, Ministerio de Sanidad

Specific actions for implementation

Radar COVID homepage provides the public with multiple resources in the form of Banners, QR codes, Videos, Brochures etc to promote the use of the app.[519] Radar COVID has its own Twitter and Instagram account, which SEDIA uses for promotional purposes and to regularly assure people that the app is in line with Spanish and European data protection laws. [520]

Statistics regarding the app use

Statistics regarding the no. of downloads, no. of total users, and no of codes created are published by the Government of Spain:

https://radarcovid.gob.es/estadisticas/descargas-radar

CTA evaluation

The epidemiological impact of the Spanish Radar Covid app was assessed using a 4-week population-based experiment between June and July 2020 in the Canary Islands. To assess the usefulness of the app, KPIs assessing user behaviour (adoption, adherence, compliance, turnaround time, follow-up) and effectiveness (overall detection, hidden detection) were defined. Data was collected from surveys ran through the app and online surveys and data retrieved from the APIs. The researchers estimated that at least 33% of the population adopted the technology and that the app detects 6.3 close-contacts per primary simulated infection, where a significant percentage is represented by the contacts with strangers. Furthermore, there was indirect evidence of a potentially high adherence from survey data: from 735 within-app surveys, 82% concluded that the app was a useful tool, and the question "I will recommend friends and family members to download and use Radar COVID" was given 7.8/10 marks[521].

Other observations

After a successful testing phase on the Canary Island of La Gomera, Radar COVID was introduced in August 2020 in several of Spain's autonomous communities. It took until October, however, until the app was used nation-wide, as the communities had to integrate the app into their health system.[522]

Norway

Name of the app

Smittestopp 2

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518 https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/travel-during-coronavirus-pandemic/mobile-contact-tracing-apps-eu-member-states_de

519 https://radarcovid.gob.es/recursos-de-comunicacion

520 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

521 Rodríguez, P., Graña, S., Alvarez-León, E. E., Battaglini, M., Darias, F. J., Hernán, M. A., ... & Lacasa, L. (2021). A population-based controlled experiment assessing the epidemiological impact of digital contact tracing. Nature communications, 12(1), 1-6.

522 https://portal.mineco.gob.es/es-es/comunicacion/Paginas/20080302_np_radar.aspx

Website

https://www.helsenorge.no/en/smittestopp/

Main institutions involved

App developer: Netcompany

Data Controller: The Norwegian Institute of Public Health

Data processor: Horsk Helsenett and Netcompany process the data.[523]

Launch date

Smittestop 1: 16 April 2020

Smittestop 2: 21 December 2020

National policies or strategies associated with DCT

On 27 March 2020, the Norwegian Government issued a new regulation allowing the Norwegian Institute of Public Health ('NIPH') to establish a system for digital and automated tracing of contacts to persons infected with Coronavirus and information to such persons. The purpose of the regulation was to contribute to rapid detection and dissemination of advice to persons who may be infected with Coronavirus. Through monitoring at population level, the regulation should also contribute to monitoring the spread of infection and assessing the effect of infection control measures. The use of the application was not mandatory for the population but based on voluntary participation and consent from the individuals.[524]The Royal Resolution - Regulations on digital infection tracking and epidemic control in the event of an outbreak of Covid-19 of 27 March 2020[525] authorises the Norwegian Institute of Public Health to establish mobile app as a system for digital contact tracing for COVID-19 and sets out rules for data processing.

Participatory processes and stakeholder engagement

Work on the first version of an app had started in early March. Immediate steps were taken to secure legal advice on the permissibility of avoiding a public tender process. The app was tested in middle-sized urban locations –Trondheim, Drammen, Tromsø (but not in the capital Oslo) starting ten days after the nationwide launch.[526]

The first version of the app did not use GAEN as it was developed ahead of that initiative, but it was suspended as the number of infected individuals declined dramatically and the privacy issues were debated.

The second version, Smittestopp 2, was based on GAEN, developed by Netcompany with support from an independent external technical advisory board.

Integration with public health processes and health policy

The app does not have additional functionalities to facilitate contact with public health services.

Open-source code

https://github.com/folkehelseinstituttet/Fhi.Smittestopp.App

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523 https://www.fhi.no/en/about/smittestopp/use-of-smittestopp-privacy-policy/

524 https://www.dataguidance.com/opinion/norway-coronavirus-application-and-struggle-privacy

525 https://www.regjeringen.no/contentassets/116076d9a39b473a97d97474048e1fb0/kgl.-res.-27.-mars-digital-smittesporing.pdf

526 https://blogs.prio.org/2020/10/chronicling-smittestopp-game-on-game-over-blame-games/

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy Policy available here.

Data protection authority: Norwegian Data Protection Authority[527]

Data protection impact assessment: The DPIA available here: Data Protection Impact Assessment (in Norwegian).[528]

Other privacy/security check-ups: Regarding data security, the Norwegian Institute of Public Health has published an article on 8.12.2020 that also addresses, among other things, common user questions, the functionality of the Smittestopp app and the legal basis for processing personal data.[529]

Critique: The older version of the app was temporarily banned by the Norwegian Data Protection Authority[530] and the new version of the contact tracing app, though has identical name as the old version, is claimed to be completely different with better data protection and privacy protocols.[531]

By combining GPS and Bluetooth (old version), the app was criticized for inadequate security. [532]

The intention to engage in mass data collection on population movements was not clearly communicated to the population. [533]

App additional functionalities

- COVID-19 Epidemiological Situation Statistics
- Vaccination Statistics
- Navigate to other sources

Significant updates

In contrast to Smittestopp 1, Smittestopp 2[534]
- is decentralized
- uses Bluetooth and not GPS
- is used for only contact tracing and not research or analysis
- doesn't collect data that can identify users
- doesn't *automatically* message people who came in contact with the users

Interoperability with EFGS

Yes

Legal basis for processing in EFGS: Consent

Name of Controller: Folkehelseinstituttet / Norwegian Institute of Public Health[535]

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527 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

528 https://www.fhi.no/om/smittestopp/dpia/

529 https://www.fhi.no/en/about/smittestopp/use-of-smittestopp-privacy-policy/

530 https://www.datatilsynet.no/en/news/2020/the-norwegian-data-protection-authority-has-imposed-a-temporary-ban-on-smittestopp-contact-tracing-mobile-application/

531 https://www.helsenorge.no/en/smittestopp/#what-are-the-differences-between-the-new-and-old-smittestopp-apps

532 https://blogs.bmj.com/bmjgh/2020/07/04/the-covid-19-tracking-apps-ecosystem-unraveled-critical-issues-for-global-health/

533 https://blogs.bmj.com/bmjgh/2020/07/04/the-covid-19-tracking-apps-ecosystem-unraveled-critical-issues-for-global-health/

534 https://www.helsenorge.no/en/smittestopp/

535 https://ec.europa.eu/health/system/files/2022-03/gateway_jointcontrollers_en_0.pdf

Specific actions for implementation

Helse norge has developed a website for Smittestopp users that covers all kinds of topics related to this digital contact tracing app (e.g. "How Smittestopp works", technical aspects or data privacy).[536]

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

A study based on modelling using real-world contact data set collected during the rollout of the first Norwegian contact tracing app in the Spring of 2020 estimated the technological tracing efficacy at 80% and that at least 11% of the discovered close contacts could not be identified by manual contact tracing[537].

Iceland

Name of the app

Rakning C-19

Website

https://www.covid.is/app/en

Main institutions involved

The project is a private initiative developed in a close collaboration with the Icelandic Directorate of Health and the Department of Civil Protection and Emergency Management. It was produced by Aranja, Decode, Kolibri, Samsyn, Sensa and Stokkur.[538]

App developer: Directorate of Health[539]

Data controller and Processor: Ministry of Justice[540]

Provider: Government of Iceland.[541]

Launch date

2 April 2020[542]

National policies or strategies associated with DCT

The Act[543] amending the Epidemic Prevention Act No. 19/1997 of 8 February 2021 established the epidemiologist's responsibility to trace infections, considering principles of privacy.

Participatory processes and stakeholder engagement

The development of CTA was a public-private approach with the Office of the Medical Director of Health responsible for it, but the Icelandic companies Aranja, Kolibri, Stokkur, Sensa, Samsýn, programmers

536 https://www.helsenorge.no/en/smittestopp/

537 Elmokashfi, A., Sundnes, J., Kvalbein, A., Naumova, V., Reinemo, S. A., Florvaag, P. M., ... & Lysne, O. (2021). Nationwide rollout reveals efficacy of epidemic control through digital contact tracing. Nature communications, 12(1), 1-8.

538 https://github.com/aranja/rakning-c19-app

539 https://justuseapp.com/en/app/1504655876/rakning-c-19

540 https://bit.ly/3qkZdfQ

541 https://www.sfb1258.de/covid-19-contactum/countries-with-official-contact-tracing-apps

542 https://www.covid.is/sub-categories/iceland-s-response

543 https://www.althingi.is/altext/stjt/2021.002.html

from Icelandic Genetics and Syndis also took part free of charge. The design team was in regular contact with the Data Protection Authority as well.[544]

Integration with public health processes and health policy

The app does not have additional functionalities to facilitate contact with public health services.

Open-source code

https://github.com/aranja/rakning-c19-app

Architecture/Proximity-based protocols

Architecture Approach: Decentralised[545]

Protocol(s): Bluetooth (Formerly GPS)[546]

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy notice available here.[547]

Data protection authority: Icelandic Data Protection Authority[548]

Data protection impact assessment: According to source, a DPIA has been carried out[549] but the mentioned document wasn't found.

Critique: Iceland's Rakning C-19 does not meet three of the privacy principle. A consideration made in the review[550] is that GPS data are highly personal. The source code for the app is available but not the server side, and there was no mention of a review performed before the release of the app. No information was found about how they treat meta-data or what plans there are to sunset the app. Rakning C-19 was given a Low/Medium ranking, according to this review.[551]

App additional functionalities

- Navigate to other sources

Significant updates

11 May 2021, updated version released which uses Bluetooth functionality to trace contact.[552]

Other changes in the updated version include:[553]

- Tracking status is now visible in the app
- Improved functionality for iOS devices
- Calculation made simpler for exposure to infection
- Phone numbers have been removed from the app.

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544 https://www.landlaeknir.is/um-embaettid/frettir/frett/item40650/covid-19-smitrakning-med-adstod-apps

545 https://github.com/ct-report/IS

546 https://www.landlaeknir.is/um-embaettid/frettir/frett/item45855/smitrakningarapp-uppfaert-med-bluetooth-virkni

547 https://www.covid.is/personuverndarstefna

548 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

549 https://www.personuvernd.is/adrar-urlausnir/ymis-bref/radgjof-personuverndar-til-embaettis-landlaeknis-vegna-bluetooth-uppfaerslu-smitrakningarforrits-1

550 Krehling, L.;Essex,A.A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

551 The Directorate of Health and The Department of Civil Protection and Emergency Management. The Directorate of Health and The Department of Civil Protection and Emergency Management (Iceland). Privacy policy Rakning C-19—App. Upplýsingar um Covid-19 á Íslandi. 2020. Available online: https://www.covid.is/app/protection-of-personal-data (accessed on 1 June 2021).

552 https://www.covid.is/tilkynningar/appid-uppfaert-i-bluetooth

553 https://www.covid.is/app/en

Interoperability with EFGS

No

Specific actions for implementation

No public knowledge available.

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Switzerland

Name of the app

SwissCovid App

Website

https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/swisscovid-app-und-contact-tracing.html

Main institutions involved

The SwissCovid app system has been developed on behalf of and in cooperation with the Federal Office of Public Health (FOPH) by the Federal Office for Information Technology, Systems and Telecommunication (FOITT), the Federal Institutes of Technology in Zurich (ETH) and Lausanne (EPFL) and the Swiss company Ubique.[554] Data controller responsible for data processing is the Federal Office of Public Health (BAG).[555]

Launch date

25 June 2020[556]

National policies or strategies associated with DCT

The amendment to the Epidemic Act 818.101 of 19 June 2020[557] Establishes a proximity tracing system for Coronavirus, operated by Federal Office of Public Health, and sets out rules for data processing, with the relevant Ordinances for the contact tracing apps, based on the Epidemics Act and the Covid-19 Act:

- Ordinance on the Proximity Tracing System for the Sars-CoV-2 coronavirus
- Verordnung über ein System zur Benachrichtigung über eine mögliche Ansteckung mit dem Coronavirus Sars-CoV-2 an Veranstaltungen (unofficial translation: "Ordinance on a system for notification of possible infection with the Sars-CoV-2 coronavirus at events")

554 https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/swisscovid-app-und-contact-tracing.html#707372772

555 https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/swisscovid-app-und-contact-tracing/datenschutzerklaerung-nutzungsbedingungen.html

556 https://www.bag.admin.ch/bag/en/home/das-bag/aktuell/news/news-25-06-2020.html

557 https://www.fedlex.admin.ch/eli/cc/2015/297/de . Article 60a, effective until 30 June 2022 and extended to 31 December 2022.

Participatory processes and stakeholder engagement

Before the deployment of SwissCovid, there has been a test phase for a pilot version. In the process, the National Cyber Security Centre (NCSC) accepted reports on security from experts and interested persons since 28 May 2020. A total of 81 reports were received, 11 of which concerned the programme code. According to the NCSC, no reports were received that had to be assessed as critical or systemically relevant. The NCSC, however, claimed to continue accepting reports of test results after the public launch of the SwissCovid app in order to ensure the data protection and security of the app on an ongoing basis.[558]

Integration with public health processes and health policy

If a person has installed the SwissCovid app and they have tested positive for the coronavirus, they receive a Covid code (release code). Covid codes are issued by cantonal authorities, doctors and pharmacists who perform tests, and test centre personnel. The code allows a person to activate the notification function in the app, enabling them to anonymously warn other app users who might have been in a close contact with the infected person (starting two days prior to the onset of symptoms) or who were at the same event as the infected person. Furthermore, the app offers the possibility to contact health representatives via a call button. [559]

Open-source code

https://github.com/SwissCovid

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Data Protection statement can be read here.

Data protection authority: Swiss Federal Data Protection and Information Commissioner (FDPIC)[560]

Data protection impact assessment: The DPIA is available here.[561]

Other privacy/security check-ups: Public security test for the app in the pilot phase was carried out by the National Cybersecurity Centre ('NCSC') on 28 May 2020.[562] Furthermore, there are several technical reports covering privacy and security check-ups including: SwissCovid app: known issues[563], SwissCovid app: Threshold Change[564], SwissCovid app: using of Bluetooth and the API of Apple and Google[565], SwissCovid app: using of Amazon Cloud Front[566], SwissCovid app: Replay attacks and AEM-tampering[567].

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558 https://www.admin.ch/gov/de/start/dokumentation/medienmitteilungen.msg-id-79584.html

559 https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/swisscovid-app-und-contact-tracing.html#-1601404801

560 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19

561 https://www.dataguidance.com/news/switzerland-fdpic-announces-compliance-swisscovid-app

562 https://www.dataguidance.com/news/switzerland-swisscovid-app-enters-pilot-test-phase

563 https://www.bag.admin.ch/dam/bag/en/dokumente/cc/kom/swisscovid-bekannte-probleme.pdf.download.pdf/SwissCovid%20app_Known%20Issues.pdf

564 https://www.bag.admin.ch/dam/bag/en/dokumente/cc/kom/swisscovid-anpassung-schwellenwerte.pdf.download.pdf/SwissCovid%20app_Threshold%20Change.pdf

565 https://www.bag.admin.ch/dam/bag/en/dokumente/cc/kom/covid-19-faq-tracing-app-einsatz-bluetooth-api-apple-google.pdf.download.pdf/SwissCovid%20app_FAQ%20using%20Bluetooth%20and%20API%20of%20Apple%20and%20Google.pdf

566 https://www.bag.admin.ch/dam/bag/en/dokumente/cc/kom/covid-19-faq-tracing-app-einsatz-amazon-cloud-front.pdf.download.pdf/SwissCovid%20app_FAQ%20use%20Amazon%20Cloudfront.pdf

567 https://www.bag.admin.ch/dam/bag/en/dokumente/cc/kom/covid-19-replay-angriffe-und-aem-manipulationen.pdf.download.pdf/SwissCovid_app_Replay_attacks_and_AEM-tampering.pdf

Krehling and Essex (2021) developed quantitative metrics for privacy of the CTAs based on the 10 principles articulated in an open letter widely signed by cyber-security researchers[568], namely independent expert review, simple design, minimal functionality, data minimisation, trusted data governance, cybersecurity, minimum data retention, protection of derived data and meta-data, proper disclosure and consent, provision to sunset. Based on their analysis, SwissCovid was given a medium ranking of privacy[569].

Critique: SwissCovid is allegedly open source[570] but has been criticised for lacking technical details. It has been claimed that there is a misconception on the meaning of open source[571].

According to another analysis report, the source codes have nearly no comment at all and the promised technical specifications can't be found on the suggested GitHub links.[572] According to them, being open source does not only mean that the source code should be available. It also means that anyone should be able to take the source code, to modify it, to compile it, and to use it. However, there are aspects making SwissCovid not open source:[573]

To protect data against unauthorised access, loss, or misuse, the FOPH, in close collaboration with its internal and external hosting providers and other IT service providers, takes appropriate security measures of a technical (e.g. encryption, pseudonymisation, logging, access controls and restrictions, data backup, IT and network security solutions, etc.) and organisational nature (e.g. staff directives, confidentiality agreements, inspections, etc.) in accordance with the requirements of the Federal Administration and Swiss data protection legislation.[574]

App additional functionalities

- COVID-19 Epidemiological Situation Statistics
- App statistics
- Navigate to other sources
- Call centre (call button)
- Check-in with QR codes
- Venues/Check-in History
- Create QR codes for events
- Multiple languages
- Dark mode

Significant updates

The update of 28 July 2020 made the app available in Turkish and Tigrinya[575]. The version from 6 October 2020 added statistics on the use of the app and step-by-step instructions for (re)activating of exposure notifications. The update of 12 March 2021 expanded statistics on case numbers and app usage and provided barrier-free access to the Covid code hotline for the hearing impaired. The version from 23 March 2021 enabled interoperability between the SwissCovid and the Corona-Warn-App in Germany. The version of 1 July 2021 added the Check-In feature which allowed users to check in at a location or

568 Kerschbaum, F.; Barker, K. Coronavirus Statement. Waterloo Cybersecur. Priv. Inst. 2020. Available online: https://uwaterloo.ca/cybersecurity-privacy-institute/news/coronavirus-statement

569 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

570 https://github.com/SwissCovid

571 https://www.ncsc.admin.ch/dam/ncsc/de/dokumente/dokumentation/covid-security--test/INR-4434_NCSC_Risk_assessment.pdf.download.pdf/INR-4434_NCSC_Risk_assessment.pdf

572 https://lasec.epfl.ch/people/vaudenay/swisscovid/swisscovid-ana.pdf

573 https://lasec.epfl.ch/people/vaudenay/swisscovid/swisscovid-ana.pdf

574 https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/swisscovid-app-und-contact-tracing/datenschutzerklaerung-nutzungsbedingungen.html#accordion1644920769504

575 For all the updates see the Versions History https://apps.apple.com/ch/app/swisscovid/id1509275381

meeting and , hence, be collectively alerted if there was a risk of infection.

Interoperability with EFGS

No

Although, there is an agreement between EU countries to make applications compatible[576] , there is no legal basis for the SwissCovid application to be part of this portal even though technically it might be possible.[577] In the future, the other country apps should be interoperable with the SwissCovid app, if at least technically the new Apple/Google Exposure Notification API is used and that there are bilateral agreements between the countries that define the common standards for data protection, processes and data security. Germany for example is working on a solution with this new API. The apps will not interfere with each other; users will later have to choose with which other country apps to communicate for interoperability. [578]

Specific actions for implementation

The Federal Office of Public Health (FOPH) provides a website[579] where users can find information about the SwissCovid app. Among other things, the installation and usage of the contact tracing apps are explained, information on data privacy is explained and FAQs are answered. Furthermore, the Data Protection Statement and the Conditions of Use are made available on this website.

Statistics regarding the app use

Every day (Monday to Friday), the Federal Office of Information Technology, Systems and Telecommunication transmits to the Federal Statistical Office the number of active app users, the number of activation codes entered, the number of calls to the Infoline and the number of guides filled out based on a report of a possible infection. The statistics can be found here.

CTA evaluation

Several analyses were carried out on the efficiency and effectiveness of the SwissCovid app. An analysis from the Zurich SARS-CoV-2 Cohort study of 328 cases and 261 close contacts estimated that contacts notified via the app about their risk exposure entered quarantine approximately 1 day earlier than contacts who did not receive an app notification[580]. A study using data from the COVID-19 Social Monitor from 2403 respondents showed that 29 (1.2%) participants received a SwissCovid exposure notification. Among these, 22 (76%, 95% confidence interval [CI] 60–92%) took at least one mitigative action after receiving the exposure notification. Twenty respondents who received an exposure notification sought testing, among whom 6 (30%, 95% CI 12–54%) were tested positive for COVID-19 afterwards[581]. A simulation study was conducted using aggregated, publicly available data and research data to quantify the effect of the CTA on pandemic mitigation in the Canton of Zurich for the 537 app users who received a positive COVID-19 test result in the month of September 2020. The study estimated that using the app could have led to an equivalent of 5% of all persons in manual contact tracing-mandated quarantine in Zurich to enter self-quarantine as a result of receiving a voluntary quarantine recommendation after an

576 https://ec.europa.eu/commission/presscorner/home/en

577 https://www.bluewin.ch/fr/infos/suisse/l-appli-swiss-covid-a-l-etranger-409553.html

578 https://www.ncsc.admin.ch/dam/ncsc/de/dokumente/dokumentation/covid-security--test/INR-4434_NCSC_Risk_assessment.pdf.download.pdf/INR-4434_NCSC_Risk_assessment.pdf

579 https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-pandemien/aktuelle-ausbrueche-epidemien/novel-cov/swisscovid-app-und-contact-tracing.html#-690395909

580 Ballouz T , Menges D , Aschmann HE , Domenghino A , Fehr JS ,Puhan MA , et al. Adherence and association of digital proximity tracing app notifications with earlier time to quarantine: results from theZurich SARS-CoV-2 Cohort Study. Int J Public Health.2021 Aug;66:1603992. http://dx.doi.org/10.3389/ijph.2021.1603992.PubMed. 1661-8564

581 Use of Venn Diagrams to Evaluate Digital Contact Tracing: Results from a Panel Survey Analysis. JMIR Preprints. Accessed 2021 June 15. https://preprints.jmir.org/preprint/30004

exposure notification. Furthermore, 30 persons tested positive following an exposure notification[582]. One study that pursued to measure population-level effectiveness for Switzerland found out that by 10 September 2020, the SwissCovid app has been downloaded 2.36 million times, the number of active apps per day has been estimated at 1.62 million, and the number of active users to 18.9% of the Swiss population. During the study period, 2,447 Covid codes were released, and 67.2% of Covidcodes were entered into the app. The authors approximated that the entered CovidCodes triggered 1,695 phone calls to the Swiss-Covid hotline[583].

Other observations

The app is interoperable with Germany[584].

UK - England & Wales

Name of the app

NHS COVID-19 app

Website

https://covid19.nhs.uk/

Main institutions involved

The UK's NHS announced the development of a contact tracing app on 12 April 2020, and the app was endorsed by the government as a public health intervention that aims to improve public health, protect the NHS and "save lives". Developers include Accenture, Alan Turing Institute, NHS Digital, NHSx, Oxford University, Zuhlke Engineering and VMware Pivotal Labs.[585]

Data controller: Department of Health and Social Care (DHSC)[586]

Launch date

24 September 2020

National policies or strategies associated with DCT

The government announced on 18th June 2020 the development of an app NHS COVID-19 which is part of a large-scale, combined testing, contact tracing and outbreak management programme across England, called NHS Test and Trace.[587] In addition to Test and Trace, a "Test and Trace Support Payment Scheme" has been linked to the app, in case a user is notified by the NHS COVID-19 app to self-isolate, they can apply for the Test and Trace Support Payment and will be legally required to self-isolate.[588] The Health Protection (Coronavirus, Restrictions) (Self-Isolation) (England) Regulations 2020 of 27th September 2020[589] Provides the legal basis for COVID-19 data processing, additionally to the Data Protection Act 2018. As England and Wales have different legal bases for their digital contact tracing,

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582 Menges D , Aschmann HE , Moser A , Althaus CL , von Wyl V . A Data-Driven Simulation of the Exposure Notification Cascade for Digital Contact Tracing of SARS-CoV-2 in Zurich, Switzerland. JAMA NetwOpen. 2021 Apr;4(4):e218184. http://dx.doi.org/10.1001/jamanet-workopen.2021.8184. PubMed. 2574-3805

583 Zurich Coronavirus Cohort: an observational study to determine long-term clinical outcomes and immune responses after coronavirus infection (COVID-19), assess the influence of virus genetics, and examine the spread of the coronavirus in the population of the Canton of Zurich,Switzerland. [Cited 2020 Sep 4]. Available from: http://www.isrctn.com/ ISRCTN14990068

584 https://apps.apple.com/ch/app/swisscovid/id1509275381

585 https://infogram.com/covid-19-contact-tracing-apps-in-the-eu-full-table-1h8n6m3p58l0j4x

586 https://www.gov.uk/government/publications/nhs-covid-19-app-privacy-information/nhs-covid-19-app-privacy-notice-for-young-people#interoperability-apps-from-different-countries-being-able-to-work-together

587 https://faq.covid19.nhs.uk/article/KA-01107/en-us?parentid=CAT-01040&rootid=CAT-01021

588 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/964378/nhs-test-and-trace-business-plan.pdf

589 https://www.legislation.gov.uk/uksi/2020/1045/made

The Health Protection (Coronavirus Restrictions) (No. 5) (Wales) Regulations 2020 of 18 December 2020[590] provides legal basis for COVID-19 data processing, additionally to the Data Protection Act 2018.

Participatory processes and stakeholder engagement

The NHS COVID-19 app is administered and owned by the UK Health Security Agency, which is an executive agency, sponsored by the Department of Health and Social Care.

The development team includes staff from Accenture, Alan Turing Institute, NHS Digital, NHSx, Oxford University, University of Warwick, VMware Pivotal Lab and Zuhlke Engineering. As the Government's lead technical authority on cyber security, the National Cyber Security Centre has also supported in an advisory role. The Information Commissioner, the National Data Guardian's Panel, the Centre for Data Ethics and Innovation, as well as with representatives from Understanding Patient Data were consulted concerning privacy and data security issues.[591]

Integration with public health processes and health policy

The NHS Covid-19 app is integrated into public health processes. Users can book tests and receive test results within the app. Furthermore, the CTA offers a symptoms tracker and a personalised isolation countdown.

Open-source code

https://github.com/nihp-public/covid19-app-system-public

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy notice available here.[592]

Data protection authority: Information Commissioner's Office (ICO)[593], Elisabeth Denham, the UK Information Commissioner.[594]

Data protection impact assessment: The UK Department of Health and Social Care (DHSC), the data controller of the app, conducted a data protection impact assessment (DPIA). Available here.[595]

App additional functionalities

- Symptom / Health Status Trackers checker / symptoms guidance
- Local and national alert levels
- Statistics on COVID-19/Local epidemiologic info
- A countdown feature when self-isolating for people who test positive
- Check-in functionality (functionality removed on 24 February)
- Book a test and receive results (removed for users in England and Wales at the ending of universal testing offer in each nation)

590 https://www.legislation.gov.uk/wsi/2020/1609/made
591 https://healthtech.blog.gov.uk/2020/04/24/digital-contact-tracing-protecting-the-nhs-and-saving-lives/
592 https://www.gov.uk/government/publications/nhs-covid-19-app-privacy-information
593 https://lsts.research.vub.be/en/european-data-protection-authorities-and-other-national-resources-on-covid-19
594 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
595 https://www.gov.uk/government/publications/nhs-covid-19-app-privacy-information

- Enter test results

Significant updates

The update of 5 November 2020 made the app compatible with similar apps in Scotland, Northern Ireland, Jersey and Gibraltar[596].

The update of 7 April 2021 added the Check-in functionality to the app[597].

Interoperability with EFGS

No

Specific actions for implementation

To incentivise its adoption, major network providers agreed to not deduct any data used by the app from subscribers' monthly mobile fees.[598]

Statistics regarding the app use

Weekly statistics on the NHS COVID-19 app are being published by the NHS. These include no. of app downloads, NHS QR code posters, venue check-ins, venue alerts, contact tracing alerts, symptom reporting, test results

https://stats.app.covid19.nhs.uk/

CTA evaluation

An investigation of the NHS COVID-19 app used in England and Wales from 24 September 2020 until the end of December 2020, based on modelling and statistical analysis, estimated that the app was used by 16.5 million users (28% of the population) and that 1.7 million exposure notification were sent. The secondary attack rate was approximated around 6%, similar to manual contact tracing. The researchers estimated that for every percentage point increase in app uptake, the number of cases could be reduced by 0.8% (using modelling) or 2.3% (using statistical analysis)[599].

UK - Scotland

Name of the app

Protect Scotland

Website

https://protect.scot

Main institutions involved

Protect Scotland was originally developed on behalf of the Government of the Republic of Ireland and further developed[600] on behalf of the Government of Northern Ireland. The CTA was developed from

596 https://gov.wales/nhs-covid-19-app-now-compatible-across-whole-uk-jersey-and-gibraltar#:~:text=Jersey%20and%20Gibraltar-,NHS%20COVID%2D19%20app%20now%20compatible%20across%20whole%20of%20UK,today%20(Thursday%205%20November).

597 https://www.digitalhealth.net/2021/04/nhs-covid-19-app-to-share-users-venue-check-in-data/

598 https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf

599 Wymant, C., Ferretti, L., Tsallis, D., Charalambides, M., Abeler-Dörner, L., Bonsall, D., ... & Fraser, C. (2021). The epidemiological impact of the NHS COVID-19 app. Nature, 594(7863), 408-412.

600 https://protect.scot/transparency

the 'Open Green'[601] resource under the terms of the Apache 2.0 Open Source Licence[602].

There are several main organisations involved in the development, deployment and functioning of the Protect Scotland app[603]:

- Scottish Government is the lead data controller for the app. It decides the means and purposes for the processing of data collected and used by the app and provides the app's strategic direction.
- Public Health Scotland (PHS) helps to ensure the appropriateness of the app for helping the public keep up to date with the latest advice on the COVID-19 pandemic, as well as for planning services and resources. In addition, the PHS is involved in the assessment of the effectiveness of the app for the broad public health purpose.
- NES Digital Service (part of NHS Education for Scotland) is the data processor commissioned by the Scottish Government to manage the digital infrastructure required for the app.
- NearForm is the organisation responsible for developing the app, as well as designing the architecture and delivering essential components.
- Amazon Web Services is responsible for providing and maintaining the cloud infrastructure.
- NHS National Services Scotland (NHS NSS) is responsible for the National Contact Tracing Centre, on behalf of Public Health Scotland. They operate the Case Management System, which shares data (mobile numbers of people with a positive result) with the app. NHS NSS also manages the contract with NearForm and the contractual relationship with app Users (Terms and Conditions) of the app on behalf of the Scottish Government.
- Gov.UK Notify service (UK Government) acts as a data processor for Gov.uk Notify. This service is used to send secure SMS notifications and emails.
- Cello Signal Ltd trading as The Leith Agency (The Leith Agency) is responsible for developing and providing support to the Protect Scotland website and hosting the self-isolation certificate webform.
- Scottish Local Authorities are responsible for management of the personal information received from self-isolation certificates to support self-isolation.

Launch date

10 September 2020[604]

National policies or strategies associated with DCT

The Health Protection (Coronavirus) Regulations 2020 was introduced on the 28 September 2020[605], providing an additional legal basis for processing data related to COVID-19 on top of the Data Protection Act 2018 and the GDPR.

Participatory processes and stakeholder engagement

From the early stages of developing the app, careful consultation was undertaken with relevant Scottish interest and advocacy groups, consisting of[606]:

- The Health and Social Care (Scotland) Public Benefit and Privacy Panel
- The Scottish Privacy Forum
- The Open Rights Group
- The COVID-19 Data and Intelligence Network – Data ethics and public engagement subgroup

601 https://github.com/covidgreen
602 https://www.apache.org/licenses/LICENSE-2.0
603 https://protect.scot/how-we-use-your-data
604 https://www.sfha.co.uk/news/news-category/sector-news/news-article/protect-scotland-app-launches
605 https://www.legislation.gov.uk/uksi/2020/1045/made
606 https://protect.scot/how-we-use-your-data

- Representatives of the public

Furthermore, collaborative work of the CTA's partners and academia resulted in several documents directly contributing to the design of the application[607]. They included:

- Rapid Review of Contact Tracing Methods for COVID-19[608];
- Use of Participatory Apps in Contact Tracing – Options and Implications for Public Health, Privacy and Trust[609];
- Global Examples of COVID-19 Surveillance Technologies: Flash Report[610].

Integration with public health processes and health policy

If a user is tested positive for COVID-19, the National Contact Tracing Centre contacts them. A contact tracer is a person working for the NHS Scotland's Test and Protect service[611]. Their main task is to get in touch with positively tested or those who were in a close contact people. During the call, the Contact Tracer offers a user to receive a text message containing a test code via SMS, so that they can anonymously upload their diagnosis keys and notify other users. The Contact Tracer also discusses with an infected person when symptoms started to define the most relevant date to use when sending the anonymous exposure notifications to other app users. The SMS with a test code is sent via the Gov.UK Notify service[612]. The app can be used to issue self-isolation certificates which can be submitted to employers and local authorities.

Open-source code

https://github.com/NES-Digital-Service/protect-scotland

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Data Protection statement can be read here.

Data protection authority: The Scottish Government[613]

Data protection impact assessment: The DPIA is available here.[614]

Other privacy/security check-ups: Krehling and Essex (2021) developed quantitative metrics for privacy of the CTAs based on the 10 principles articulated in an open letter widely signed by cyber-security researchers[615], namely independent expert review, simple design, minimal functionality, data minimisation, trusted data governance, cybersecurity, minimum data retention, protection of derived data and meta-data, proper disclosure and consent, provision to sunset. Based on their analysis, Protect Scotland was given a medium ranking of privacy[616].

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607 https://protect.scot/how-we-use-your-data

608 https://strathprints.strath.ac.uk/72162/

609 https://core.ac.uk/display/327072301?source=2

610 https://strathprints.strath.ac.uk/72028/

611 https://protect.scot/how-it-works

612 https://www.notifications.service.gov.uk

613 https://protect.scot/how-we-use-your-data

614 https://protect.scot/resources/docs/DPIA-4.0.pdf

615 Kerschbaum, F.; Barker, K. Coronavirus Statement. Waterloo Cybersecur. Priv. Inst. 2020. Available online: https://uwaterloo.ca/cybersecurity-privacy-institute/news/coronavirus-statement

616 Krehling, L.; Essex, A. A Security and Privacy Scoring System for Contact Tracing Apps. J. Cybersecur. Priv. 2021, 1, 597–614. https://doi.org/10.3390/jcp1040030

Besides the DPIA, a number of impact assessments has been done. The Equality Impact Assessment[617] was done in order to evaluate the emerging evidence of the impact of Protect Scotland on inclusion and citizens' engagement. The Children's Rights & Wellbeing Impact Assessment[618] focused on the assessing the impact of the information provided by the app and the actions taken as part of the contact tracing programme on children and young people.

To ensure privacy and security by design, the developers referred[619] to the report of the Ada Lovelace Institute on building public trust[620] and the report of Dr Claudia Pagliari from the Usher Institute "The Ethics and Value of Contact Tracing Apps: International Insights and Implication for Scotland"[621].

App additional functionalities

- Multiple Languages
- Self-isolation certificate proving a person needs to isolate (e.g., for employer or Scottish Local Authority)
- Pause Button feature which enables users to temporarily suspend proximity tracing
- Link to useful resources

Significant updates

The update of 30th September 2020 added the Pause Button feature. The version of 13th December 2020 featured age verification for secondary school age users and the update from 9th February 2021 enabled in-app process for generating self-isolation certificates.[622]

Interoperability with EFGS

No

As the Protect Scotland app is based on an emerging European standard for interoperability between Google / Apple based systems, it is possible to be integrated with any other app that employs the same approach, and discussions are underway in relation to interoperability with the European wide interoperability gateway service[623].

Specific actions for implementation

The CTA's promotional campaign originally ran for 4 weeks in October across TV, radio, press, social media and digital. The second phase of the campaign also lasted 4 weeks focusing on the app being available for those aged 12 and older who are in secondary education.[624]

Furthermore, the developers also circulated a media release[625] explaining how the app works, it's minimal data use, privacy and anonymity settings, and how users would be alerted if they were in a close contact with an infected person. In addition, there is an explainer video[626] available in several languages including British Sign Language (BSL). The partnership and stakeholder page[627] of the app's website provides a range of campaign assets that could help promoting the app.

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617 https://www.protect.scot/resources/docs/EQIA-18-december-2020.pdf
618 https://www.protect.scot/resources/docs/CRWIA-stage-3-december-2020.pdf
619 https://protect.scot/how-we-use-your-data
620 https://www.adalovelaceinstitute.org/our-work/covid-19/confidence-in-a-crisis
621 https://www.research.ed.ac.uk/en/publications/the-ethics-and-value-of-contact-tracing-apps-international-insigh https://protect.scot/how-we-use-your-data
622 https://apps.apple.com/gb/app/protect-scotland/id1526637715
623 https://protect.scot/faq
624 https://protect.scot/stakeholder-and-partners
625 https://protect.scot/resources/news-release-10092020-v2.pdf
626 https://protect.scot/stakeholder-and-partners
627 https://protect.scot/stakeholder-and-partners

Statistics regarding the app use

There is no regularly updated statistics concerning the use of app. However, there is the FOI release[628] "Analysis of Protect Scotland app"[629] on the Scottish Government website featuring the total number of downloads of the Protect Scotland app, the total number of unique test codes generated for the Protect Scotland app by coronavirus testing since the launch of the app and how many of these unique test codes have been input into the app by users since the launch (as of 25 November 2021).

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The app is available for those who are 12 years old and above[630]. Protect Scotland is also interoperable with the equivalent contact tracing apps in England, Wales, Northern Ireland, Jersey and Gibraltar[631].

UK - Northern Ireland

Name of the app

StopCOVID NI

Website

https://covid-19.hscni.net/stop-covid-ni-mobile-app/

Main institutions involved

Northern Ireland's contact tracing app has been developed by NearForm in cooperation with Department of Health and Expleo.[632] The code used to build the StopCOVID NI is based on the COVID Tracker app in the Republic of Ireland[633].

Data controller: Health and Social Care Department of Health, Northern Ireland. The Department of Health is responsible, along with its Data Processors and Sub-Processors, for the development, testing, security, operation and maintenance of the app.

Launch date

30 July 2020

National policies or strategies associated with DCT

The COVID-19 "Test, Trace, Protect, Support" Strategy has been released by the Health Government of Northern Ireland on 28 May 2020. The Strategy was designed to break the chain of transmission of the virus by identifying people with COVID-19, tracing persons at risk of infection and supporting them to self-isolate. The strategy was not aimed to replace the measures that were already in place, but rather to enhance them. As part of the strategy, the development of digital contact tracing was proposed and foreseen as useful adjunct to contact tracing.[634]

628 Information request and response under the Freedom of Information (Scotland) Act 2002
629 https://www.gov.scot/publications/foi-202100257923/
630 https://www.wihb.scot.nhs.uk/protect-scotland-app-now-available-to-anyone-aged-12-or-over/
631 https://protect.scot/faq
632 https://www.bigmotive.com/case-studies/a-collaborative-approach-to-creating-stopcovid-ni/
633 https://www.cdhn.org/what-stopcovid-ni-contact-tracing-app
634 https://www.health-ni.gov.uk/publications/covid-19-test-trace-protect-support-strategy

Participatory processes and stakeholder engagement

An app Steering Committee (see 'Appendix A') has been formed to provide an external oversight and governance function, in relation to the app development, (in terms of expertise to ensure that code and system architecture complies with the ICO guidance- 'COVID-19 Contact tracing: data protection expectations on app development')[635]. At an early stage, prototypes were designed and tested with the public, senior stakeholders and human-rights organisations. This human-centred approach was developed to gather vital feedback and insights which could be implemented iteratively before the final public-facing version was agreed.[636] Further, the Health and Social Care Board met with the children's commissioner, the information commissioner's office and the Children's Law Centre to find extend the use of the app to ages 17 and below.[637]

Integration with public health processes and health policy

The contact tracing app was included in the "Test, Trace and Protect" Strategy and was foreseen as complementary to manual contact tracing. The app includes as features a self-isolation countdown and the possibility of issuing a self-isolation certificate which can be submitted to employers and local authorities.

Open-source code

https://covid-19.hscni.net/stopcovid-ni-open-source/

Architecture/Proximity-based protocols

Architecture Approach: Decentralised

Protocol(s): GAEN

Data Protection. Security and privacy measures

Data protection privacy notice: Privacy notice available here.[638]

Data protection authority: Data Protection Officer (Charlene McQuillan)[639]

Data protection impact assessment: Yes, published on 31 July 2020 available here. [640]

App additional functionalities

- App statistics
- Self-isolation countdown
- Self-isolation certificate

Significant updates

A second version of the app was released on 1 October 2020, increasing the range of age of persons who can use the app (including 11-17 age group). The app was originally launched as an age 18+ app[641]. The updated version of the app released in November offers individualised recommended end date for self-isolation. It will confirm the date when users' self-isolation period will end.[642]

635 https://covid-19.hscni.net/wp-content/uploads/2020/08/DPIA-for-StopCOVID-NI-Proximity-App-31.07.2020.pdf
636 https://www.bigmotive.com/case-studies/a-collaborative-approach-to-creating-stopcovid-ni/
637 https://www.bbc.com/news/uk-northern-ireland-53599514
638 https://covid-19.hscni.net/stopcovid-ni-open-source/
639 https://covid-19.hscni.net/stopcovid-ni-open-source/
640 https://covid-19.hscni.net/stopcovid-ni-open-source/
641 https://www.education-ni.gov.uk/news/education-minister-welcomes-launch-version-20-stopcovid-ni-app-extending-use-11-17-age-group
642 https://www.governmentcomputing.com/technology/news/stopcovid-ni-app/

Interoperability with EFGS

No[643]

Specific actions for implementation

The Department of Health launched a public information and a TV advertisement campaign.[644]

Statistics regarding the app use

No official app statistics are published.

CTA evaluation

No evaluation of effectiveness has been carried out.

Other observations

The app is interoperable across England, Jersey, Republic of Ireland, Scotland and Wales.[645] The StopCOVID NI contact tracing app is free to download and use to anyone who is: aged 11 years and older.

643 https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/travel-during-coronavirus-pandemic/mobile-contact-tracing-apps-eu-member-states_en

644 https://www.youtube.com/watch?v=KU3Yv2qmplA

645 https://www.nidirect.gov.uk/articles/coronavirus-covid-19-stopcovid-ni-proximity-app#toc-4

Annex III – Indicators for the performance of contact tracing apps

According to the existing literature reviewed in the study, the number of published research seeking to assess the digital contact tracing apps' performance and positive impact on and role in the COVID-19 pandemic is rather limited and lacks standardised assessment methods. There is a high heterogeneity in the aims of the evaluations carried out and used methodologies. Data availability varies significantly across countries due to different ways of collecting, measuring, analysing, as well as presenting the data. Furthermore, different countries had different time periods of publishing data, therefore, performing cross-country evaluation of commonly defined indicators of all countries at particular periods poses a significant challenge.

Building on the work of WHO and ECDC

The framework builds on the extensive work of the "Indicator framework for the evaluation of the public health effectiveness of digital proximity tracing solutions"[646] developed by experts from the World Health Organization (WHO) and the European Centre for Disease Prevention and Control (ECDC) and published in June 2021 (henceforth referred to as the WHO/ECDC paper or the WHO/ECDC indicator framework). Of note, the WHO/ECDC framework was developed relatively early in the pandemic (with consultations taking place in late 2020), when only limited evidence of and experiences with digital contact tracing app implementation and effectiveness were available. Therefore, the current endeavour aims to critically review and update the existing framework, as well as to assess its feasibility.

Using the digital contact tracing and notification cascade to illustrate the DCT environment and implications for data availability

Most European countries have developed contact tracing apps (CTA) that follow the decentralised privacy-preserving proximity tracing protocol (DP-3T) which means that proximity contacts are not sent to a central server but stored and evaluated locally on the users' smartphone. The only data that is sent to central servers are pseudonymous, random identifiers of persons with a confirmed infection. The infectious identifiers are periodically downloaded by all other users' phones and compared to the locally stored identifiers to find out which of the proximity encounters were with COVID-19 positive people. To ensure that the digital contact tracing (DCT) is efficient and effective, a seamless flow of information along the notification cascade must take place. This notification cascade not only includes DCT apps but also involves all health- and IT systems that are involved in exposure notification (see figure below).

Most decentralised systems follow a three-step structure that includes: proximity estimation, diagnosis and identifiers upload, and proximity contact notification. There are, however, country-specific variations.

The figure below exemplifies the required steps in the notification cascade (this can vary depending on the country's approach). Person A (Index Case) represents an infected app user who gets tested, receives a positive test result and enters an activation code. After consenting, the app uploads the random identifiers to a (national back-end) server. Person B (Exposed Contact) represents a proximity contact, whose device regularly downloads infected keys. Because of the exposure, person B receives the app notification. After receiving the notification, person B can either call a hotline, gets tested or enters voluntary quarantine (the options depend on the country's approach).

[646] World Health Organization, & European Centre for Disease Prevention and Control. (2021). Indicator framework for the evaluation of the public health effectiveness of digital proximity tracing solutions. Geneva: World Health Organization and European Centre for Disease Prevention and Control. [pdf] Available at: https://www.who.int/publications/i/item/9789240028357

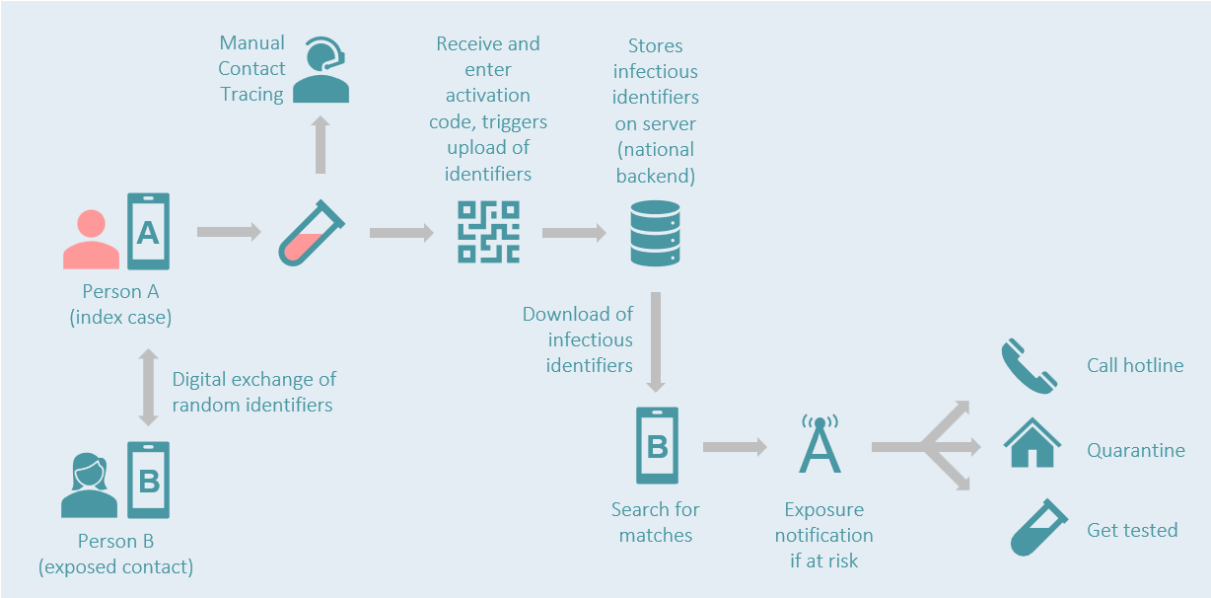
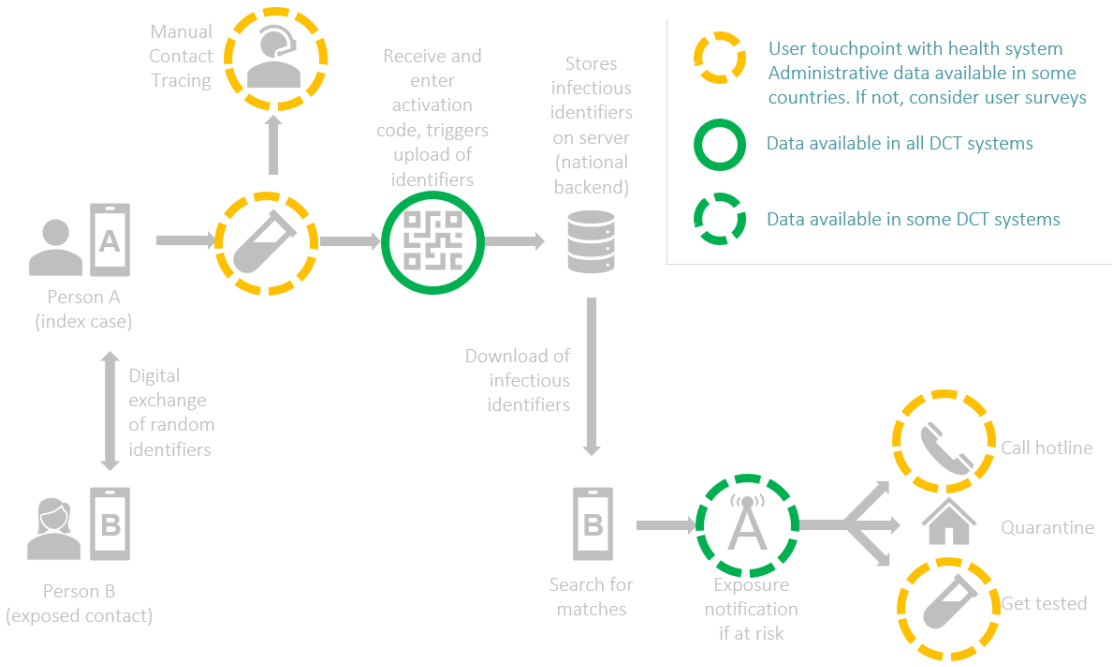


Figure 14. Notification cascade of decentralised proximity tracing systems

Possibilities of reacting after receiving the notifications differ between countries. Adapted from doi.org/10.3389/fdgth.2021.677929

To be able to derive indicators to evaluate the process efficiency and effectiveness of the cascade, the data availability needs to be considered as well as the points at which the user and their smartphone interact with the health system environment (touchpoints, e.g., testing facilities, agencies that are authorised to issue upload activation codes, hotlines, etc.). At some touchpoints data is available for all countries that use decentralised DCT systems because it is provided through the underlying Google Apple Exposure Notification (GAEN) system used. At other touchpoints, the availability of data depends on further design and development choices made in the countries, as well as the level of integration of DCT with MCT and the wider public national health systems.



Adapted from doi.org/10.3389/fdgth.2021.677929

Figure 15. Data availability in decentralised contact-tracing systems

Mapping the WHO/ECDC indicators against the digital contact tracing and notification cascade

A mapping of the WHO/ECDC indicators has allowed to identify possible gaps in the overall process, which may benefit from the definition of dedicated indicators. The figure below presents the mapping results.

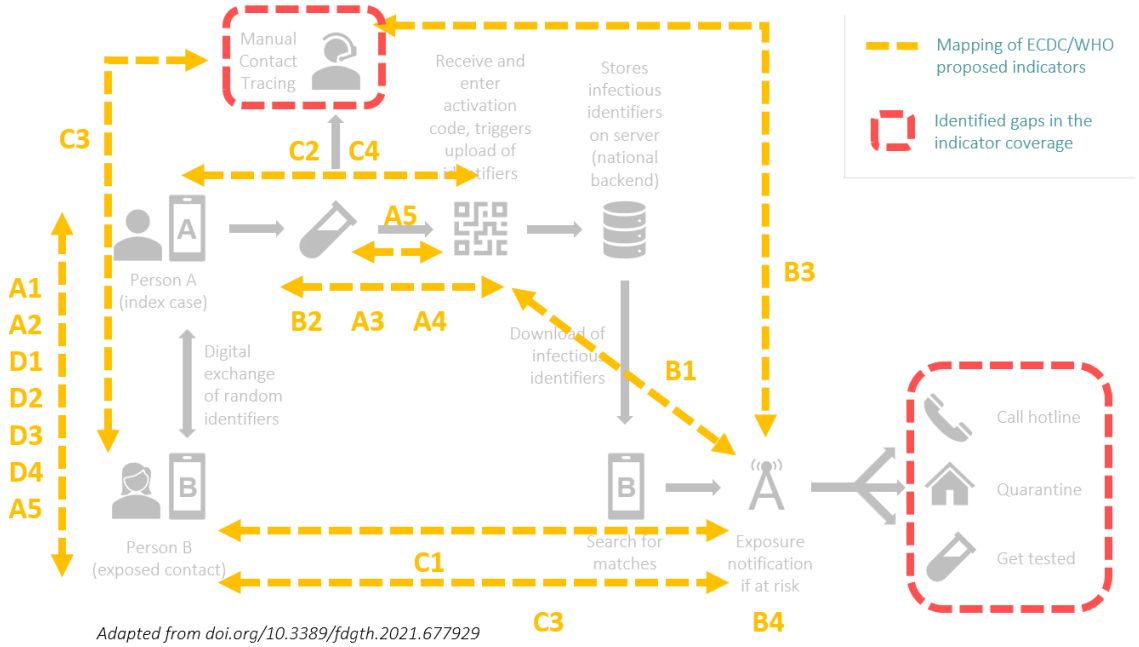


Figure 16. WHO/ECDC indicator framework mapping on the notification cascade of decentralised proximity tracing systems and identified gaps in the indicator coverage

It can be seen that the WHO/ECDC indicators in principle cover well many of the processes in the notification cascade, but also that when it comes to the link between DCT and MCT, as well as the follow-up activities of positive patients, the framework would benefit from specific indicators related to those areas. Furthermore, not all necessary data for indicator development may be readily available in some countries, especially for those indicators that aim to compare digital and manual contact tracing processes.

Refinement of the main indicators

Refining the indicators included proposing additional ones that complement the existing WHO/ECDC indicators (e.g., addressing the gaps identified during the mapping), as well as refining aspects of the WHO/ECDC framework which have implications for the practical collection of data from all countries.

Concretely, three new indicators have been proposed to be added: two relating to the adherence of users to testing and quarantine guidelines, and one linked to the cross-border exchange of notifications among some Member States through the European Federation Gateway Server.

In addition, several of the WHO/ECDC indicators have been refined.

Definition of contextual indicators

In addition to the main indicators, the study team has defined several contextual, qualitative indicators that can help to contextualise the other indicators for easier interpretation of the results and to explain indicator differences between countries. For example, the choice of architecture of the app (centralised vs. decentralised) has significant implications for the availability of data available for populating the indicators. Other contextual indicators are, for example, related to the technical scrutiny applied in the development of the apps, and the promotion of the apps among citizens, which is an important factor that facilitates their use and uptake.

Consultation and validation

The modified version of the framework was discussed with and validated with a wide group of experts in the field, including the authors of the WHO/ECDC report, members of the eHealth Network of Member States and associated national experts, and any other experts with policy, technology, academic and legal background that have been identified as part of the study's literature review. The consultation mode chosen was collecting written expert feedback for a defined time, after which the feedback was reviewed by the study team and presented and further discussed at an online validation workshop.

Consultation

The consultation was announced in the eHealth Network Technical Working Group Meeting on 16 March 2022. All countries received individual files and were asked to provide written expert feedback by involving needed experts from their teams. The discussion focused on the following questions:

- Q1. Do you believe that the proposed framework will help you in understanding and analysing the use and performance of your app? Feel free to leave a comment.
- Q2. Do you have specific comments for any of the indicators, e.g., do you feel there is an important indicator missing, or have suggestions for refinement of any of the indicators? Please provide your comment.
- Q3. Would you like to share anything else with the study team? Please provide your comment.

Feedback was received from Belgium, Estonia, Malta, Finland, and Cyprus. There was a general agreement with the framework and belief that the indicators are useful and will provide value to the extent they are available within the system, especially for the long-term maintenance of CTAs. An overview of the consultation feedback is provided in Annex I.

Validation workshop

A validation workshop took place on 8 April 2022, with a total of 28 participants from 11 countries (Cyprus, Italy, Ireland, Slovenia, Croatia, Germany, Norway, Finland, Netherlands, Malta, and UK). The team presented the aims of the study and the updated monitoring framework, followed by an open discussion to facilitate reflection on the framework use in context of own (national) evaluation plans and on data availability to fill in the indicators and best approaches on data collection.

Overall, the feedback was positive and certain countries expressed their interest in using the framework to perform respective national evaluations. The discussion concerned legal perspectives that might influence the data availability. One participant suggested to consider the user journey from app download to uninstall and indicators on practical matters (e.g., website views), and generally to employ the use of privacy-preserving app analytics. Furthermore, participants believed that the cross-border indicator is important and necessary to show the value of the EFGS infrastructure and that currently the E1 indicator was an attempt to standardise the information. Yet given the diversity in how data was imported and the variability in the average value of keys, currently the indicator is an approximation, and it can be improved. Participants were also interested in understanding how changes in the development of the CTAs were influenced by the different pandemic waves, as well as finding out how certain communication activities were carried out by the different countries on the app use and benefits.

Proposed indicators

Following the development and refinement phase, the following contextual and qualitative indicators have been proposed as a comprehensive set that enables countries to monitor and measure the use and performance of the digital proximity tracing apps. It should be noted that this indicator set is a forward-looking one, aiming to cover the various important aspects necessary to assess the apps' use and performance. The study team is aware of lack of data available in some countries for some of the quantitative indicators and will make the best attempt at collecting all available data that can be used

for the study. Where data is unavailable or different approaches and formats are used across countries, the study team will aim to promote existing good practices and seek dialogue with the other countries about adaptations that can be made to enable this data to be collected in the future.

Overview of main indicators

Table 18. Overview of main indicators

ID	Title
A: Indicators related to adoption and use of contact tracing apps	
A1	Proportion of population who have downloaded the app
A2	Proportion of population who actively uses the app
A3	Proportion of positive tests among app users
A4	Proportion of positive tests among app users uploaded
A5	Rate of positive tests among app users vs. rate of positive tests in general population
B: Indicators related to the digital contact tracing apps' capacity to detect contacts at risk	
B1	Ratio of exposure notifications received to positive test results entered
B2	Proportion of diagnosed cases among app users who have received exposure notification
B3	Proportion of diagnosed cases notified only through the app among all diagnosed cases
B4	Proportion testing positive among app users who present to testing services after exposure notification through app
C: Indicators related to the speed of notifying contacts compared to conventional contact tracing	
C1	Median time between exposure and exposure notification through the app vs conventional tracing
C2	Evolution of average time between symptom onset and upload of app keys
C3	Median difference in notification speed
C4	Proportion of new positive test results uploaded within 24 hours of code issuance
D: Indicators related to barriers and enablers of digital contact tracing approaches and adherence to apps	
D1	Reasons for use
D2	Reasons for non-use
D3	Socio-demographic characteristics of app vs. non-app users
D4	Risk behaviour of app vs. non-app users
D5	Adherence to testing guidelines
D6	Adherence to quarantine guidelines
E: Indicators related to the **cross-border level impact** of digital contact tracing and warning apps	
E1	Proportion of cross-border notifications to national infections

Overview of contextual indicators

Table 19. Overview of contextual indicators

ID	Title	Options
1	Choice of communication	- Centralised

	protocols / architecture	- Decentralised
2	Scope of technical review activities linked to ensuring security, privacy and accessibility	- Some activities but not mandated by the government or initiated by the app developer/controller, such as independent academic work and evaluations - Clear involvement of relevant bodies responsible for oversight, such as national Data Protection Authorities - DPIA or equivalent assessment conducted prior to app launch and reports publicly available to ensure transparency
	Level of integration of DTC into public health systems	Scale: 1. Low (all touchpoints are navigated through in separate / different environments[647]) 2. Medium (at least two touchpoints are navigated through in the same environment/system) 3. High (all touchpoints are navigated through in the same environment/system)
3	Scope of additional features[648] beyond proximity tracing	- less than 3 main features - 4-8 main features - more than 8 main features)
4	Promotion of digital contact tracing and warning apps	- Little to no promotional activities linked directly to the contact tracing app - Dedicated promotional activities / campaigns but not continuous - Continuous promotional activities / campaigns linked directly to the contact tracing app)
5	Availability of national-level app impact analyses	- Not available - Not available, but planned / in progress - Available
6	Contribution to cross-border tracing and warning[649]	- Yes - No

[647] The typical touchpoints in the notification cascade from the viewpoint of the user interacting through their smartphone with the systems are: 1) data exchanges at the point of testing (e.g. some countries require online forms to be filled in before getting tested, other do not), 2) at the point of receiving an activation code following a positive test (e.g. in some countries the codes are issued by manual contact tracing; in other countries code delivery is integrated into the app), 3) at the point of entering the activation code and thus releasing infectious keys used to alert close contacts, 4) at the point of receiving exposure notification and following up either by quarantining, contacting the respective authorities, or scheduling a test.

[648] Example main features include: integrate and view vaccination certificate; contact to hotlines or health authorities; clinically validated symptom checker for daily assessment of health status and reporting suspicion of COVID symptoms; receive results tests via the app; generation of QR codes; view official statistics (epidemiological, vaccination, app usage)

[649] Linked to the connectivity to and use of the European Federation Gateway Service

Detailed presentation of main indicators

Table 20. Detailed presentation of main indicators

ID	Title	Significance	Variables and calculation	Comments	Data sources
A1	Proportion of population who have downloaded the app	How many persons have downloaded the app? Provides information about the awareness and acceptance of the app among the population. The higher the indicator, the more effective the app is likely to be in terms of better complementing manual contact tracing and avoiding some virus transmissions.	Number of cumulative app downloads (1) / Total country population above certain age group (2)	- Based on WHO/ECDC indicator A1, but modified - Proposed age group for denominator is 16y - The value of that indicator becomes weaker as the pandemic progresses, because the apps can be deleted and re-downloaded multiple times, and because a download does not translate into active use - Can lend itself only in a limited way to cross-country comparison - The total country population which uses smartphones can vary across countries due to different laws for minimum age - Expected data frequency weekly	- For 1: data from operating system provider platform for app distribution - For 2: ITU (see notes), alternatively: Eurostat
A2	Proportion of population who actively uses the app	How many people are actively using the app? Provides information about the uptake and adoption of the app among the population. Most meaningful indicator to measure uptake.	Number of apps that are in active use (1) / Total country population above certain age group (2)	- Based on WHO/ECDC indicator A2, but modified - Proposed age group for denominator is 16y - Requires standardisation in the way active use is calculated - The way active use is calculated varies across countries; for example, in Switzerland the app makes an automatic contact (configuration request) with the data centre 4 times per day. At the end of a day, the total number of automatic configuration requests from all apps of the past 24 hours is divided by 4. Other countries may have other configurations as to the frequency of the automatic contact. In any case, accounting for the fact that some apps may be in flight mode and or without access to the Internet for an extended period of time, the numbers are only an approximation and represent a conservative estimation (underestimation) - Expected data frequency weekly	For 1: data from operating system provider platform for app distribution For 2: ITU (see notes), alternatively: Eurostat
A3	Positive tests among active app	How many people that are using the app are tested positive?	Number of activation codes entered into the app (1)	- Based on WHO/ECDC indicator A3, but modified – proposed to use the number of activation codes	For 1: data from operating system provider platform

ID	Title	Significance	Variables and calculation	Comments	Data sources
	users		/ Number of all positive tests reported by national public health authority (2)	entered instead of the number of activation codes issued - In most EU countries activation codes are issued to all persons, not just to the ones who have the app; the app users are only a subset of all who received an activation code - Even if activation codes are only issued upon positive tests, it has been described that not all activation codes are entered (e.g., in Switzerland, only 2 out of 3 codes were entered). Therefore, a correction factor may be considered (see A4) - Expected data frequency weekly	for app distribution For 2: Data from the public health authority
A4	Proportion of positive tests among app users that are entered into the app (positive tests uploaded).	How many people that are using the app and are tested positive enter the code to trigger a notification warning? Upon receipt of a positive test result, not all app users take the action to upload (scan) the result and launch the notification process through the app's uploading of relevant user keys. Consequently, a higher user engagement following a positive test suggests that more people are reached and warned, and more further virus transmissions are avoided.	Number of activation codes entered into the app / Number of activation codes issued	- Based on WHO/ECDC indicator A4 - Expected data frequency weekly - This indicator attains a different meaning in settings where activation codes are issued for all tests (i.e. not only positive tests). In those settings, A4 may reflect test positivity rather than activation code upload compliance.	For 1: data from operating system provider platform for app distribution For 2: Data from the public health authority
A5	Rate of positive tests among app users relative to the rate of positive tests reported in the general population.		Number of activation codes issued per week/100 000 active users versus Number of positive tests reported by national PHA per week/100 000 population	- Expected data frequency: weekly - Same issue as for A3/A4: if activation codes are issued for all persons who get tested (and not just for those who test positive), then the meaning changes. In fact, the indicator rather reflects testing frequency among app users, and the general population comparator may also be changed to number of tests performed in the numerator (rather than number of positive tests).	Population data Data from app controller Data from public health authorities
B1	Ratio of exposure notifications	Indicates the average number of contacts who were notified by the	Number of exposure notifications received	- Expected data frequency: weekly or bi-weekly - In decentralised settings the number of received	Data from app controller

ID	Title	Significance	Variables and calculation	Comments	Data sources
	received to positive test results entered	app per diagnosed case entering their positive test result into the app.	/ Number of positive test results entered	exposure notifications is not always available. Standard GAEN apps do not report back to central servers if an exposure notification has been received. An example for an exception is the Italian Immuni app, which allows this type of back-communication of exposure notifications to central servers on a voluntary basis (https://github.com/immuni-app/immuni-documentation). - The interpretation of this result should take into account country-specific settings and temporal changes in the exposure notification settings programmed in the app, such as the time and distance settings that would generate the notifications. Other factors such as population density, social behaviour, etc. may have an impact on this parameter.	
B2	Proportion of diagnosed cases among app users who have previously received an exposure notification through the app	Indicates the overall effectiveness of the app in identifying and notifying people at risk among the population using the app.	Number of people with a positive test who were notified through the app that they had an exposure event within the 14 days preceding symptom onset (or sample collection if asymptomatic) / Total number of app users with a positive test	- This data can only be collected in countries where the DPT app displays the date of exposure to the contact - The 14-day period is derived from the incubation time for COVID-19 which is up to 14 days in most cases. Note that it is the date of exposure, not the date when the exposure notification is received that is of interest	Survey e of newly diagnosed cases among app users, conducted via testing facilities, an online questionnaire accessible through the app or during the conventional contact tracing team interview
B3	Proportion of diagnosed cases previously notified only through the app (but not through conventional contact tracing) among all diagnosed cases	Estimates the additional contribution of apps in identifying people at increased risk of infection who were not Identified through conventional contact tracing	Number of people with a positive test who were previously notified through the app (but not through conventional contact tracing) that they had an exposure event within the 14 days preceding symptom onset (or sample collection if asymptomatic) / Total number of positive tests	- This data can only be collected in countries where the DPT app displays the date of exposure to the contact	Survey of newly diagnosed cases conducted via testing facilities or an online questionnaire accessible through the app
B4	Proportion testing	Indicates the capacity of apps to	Number of people who present to	- This indicator may be affected by the calibration	Survey of newly diagnosed

ID	Title	Significance	Variables and calculation	Comments	Data sources
	positive among app users who present to testing services after receiving an exposure notification through the app	detect people at risk among app users.	testing services after receiving an exposure notification through the app and who test positive / Total number of app users who present to testing services after receiving an exposure notification through the app	parameters of the apps, which can influence their specificity and sensitivity in detecting contacts at risk of infection - Interpretation of this indicator should take in consideration national testing policies for symptomatic vs asymptomatic contacts	cases among app users conducted via testing facilities
C1	Median (IQR) time between exposure and receipt of exposure notification through the app versus median (IQR) time between exposure and notification of contacts by conventional contact tracing services	Contact tracing aims to notify contacts as soon as possible. This would indicate whether DPT apps can shorten the time between exposure and exposure notifications, relative to conventional contact tracing. This indicator can further provide insights about scalability of MCT and DCT. Past experiences in many countries has shown that a high incidence also puts MCT under strain (thus possibly leading to notification delays or case prioritization). By contrast, automatized DCT systems should scale more seamlessly.	Date of exposure notification via app – Date of exposure versus Date of exposure notification via conventional contact tracing – Date of exposure	- Notification delays in both DPT and conventional contact tracing could be affected by various factors such as: delay between symptom onset and getting tested; test processing delays; test result issuance delays, incidence (and case load at manual contact tracing) - Notification delays in DPT could be affected by various factors such as: authentication code generation delay; delay between code receipt and entering it into the app - Notification delays in conventional contact tracing could be affected by various factors such as: delay in interviewing cases; delays in notifying contacts - If not possible to obtain timeliness data for conventional contact tracing, there is still value in measuring the timeliness of DPT apps on their own, without the comparison	Survey data or data collected as people call public health services. Data from public health authorities on conventional contact tracing performance
C2	Evolution of average time between symptom onset and upload of app keys	Date of entering activation code into the app – Date of symptom onset (encoded in upload authentication codes)	Data from app controller (via metadata embedded in the test result authentication code, which can include symptom onset date).	- Based on the WHO/ECDC indicator C2, but modified - Focus on distributional changes over time, which may be indicative of emerging bottlenecks in the app notification cascade (e.g. access to testing, receipt of upload authentication code) - This benchmark may also be influenced by viral characteristics: it has been described that persons with the Omicron variant and/or fully vaccinated persons test positive later than unvaccinated persons or persons infected with other variants of concern. - Although higher proportions are better, there is no absolute benchmark. Therefore, longitudinal	Data from public health authorities

ID	Title	Significance	Variables and calculation	Comments	Data sources
				monitoring is recommended to identify potential bottlenecks and system deterioration.	
C3	Median difference in notification speed between app and conventional contact tracing	Indicates whether digital proximity apps can shorten the time between exposure and exposure notification, compared to conventional contact tracing	Date of notification via conventional contact tracing – Date of exposure notification via the app		Survey of contact persons who are notified via conventional contact tracing and asked if they have the app, if they received a notification from the app, and if so, how much earlier the notification came, compared to notification through CTA
C4	Proportion of new positive test results entered into the app within 24 hours of activation code issuance	Provides an estimate of the proportion of positive tests reported in the app in a timely manner.	Number of positive test results entered into the app within 24 hours of activation code issuance / Number of positive test results entered into the app	- Note that this timeliness can be affected by the duration of the activation code's validity	Data from app controller
D1	Reasons for use	This will identify the key enablers of app use in the general population.	Frequency distribution of reasons associated with use of app.	- Examples of reasons for use: trust in science, perceive app as useful, think the pandemic is a serious issue, smartphone ownership, etc.	Survey of people using the app who will be asked about the reasons associated with their decision
D2	Reasons for non-use	This will identify the key barriers to app use in the general population.	Frequency distribution of reasons associated with non-use of app.	- Examples of reasons for non-use: data security and privacy concerns, trust in government, smartphone ownership, inertia, battery usage, lack of awareness of the app, perceive app as not useful, etc.	Survey of people using the app who will be asked about the reasons associated with their decision
D3	Socio-demographic characteristics of app vs non-app users	This will identify differences in the key socio-demographic characteristics between app users and non-app users.	Frequency distribution of key socio-demographic characteristics of app users vs. non-app users	- Examples of socio-demographic factors: Age, gender, profession, smartphone ownership, nationality, ethnicity, employment status, income level, etc.	Survey (cross-sectional) of the general population (including app and non-app users) who will be asked about their socio-demographic characteristics
D4	Risk behaviour of	This will identify differences	Frequency distribution of risk	- Examples of risk factors: Smoking, use of protective	Survey (cross-sectional) of

ID	Title	Significance	Variables and calculation	Comments	Data sources
	app vs non-app users	between app users and non-app users in key risk behaviour.	behaviour of app users vs. non-app users	mask, adherence to hand hygiene, adherence to social distancing, etc.	the general population (including app and non-app users) who will be asked about their risk factors.
D5	Adherence to testing guidelines	Upon receipt of an exposure notification, not all app users take the action to get tested. Consequently, they run higher risks of infecting other people as they may already have coronavirus. Consequently, the more users adhere to testing guidelines upon exposure notification, the more of the main intended effects of CTA's is realised, namely braking the chains of infections.	Number of persons applying for a test and naming the reason for that being an exposure notification received / Number of persons receiving exposure notifications	- Sensitive personal health data. Best collected via scripted public health authority (PHA) questions when applying for a test (best practice available in NL) or anonymous self-report surveys (best practice available through Switzerland), - Some people receive more notifications over time, as such adherence may vary over time and people may forget over time what exactly they did per notification. For empirical-practical reasons the questionnaire should inform on the LAST notification someone received. - Some people receive more triggers related to one exposure. For example, next to an exposure notification people may also receive a call from MCT and/or for example from personal contacts (such as family and friend). Please be aware of this, and make a distinction if possible. - For future references: testing guidelines may vary over time. For example, some countries may move to home testing. Some countries may change guidelines into 'you can only apply for a free test when also having symptoms'. In that case, the variable will possibly have to be somehow adapted in the future.	Data from questionnaires (more easy) or database answers of scripted public health authority (PHA) questions (are reliable, but this needs full cooperation of PHA and more implementation effort)
D6	Adherence to quarantine guidelines	Upon receipt of an exposure notification, not all app users take the action to for the time being (until reception of negative test result and/or until a certain minimal time period has passed) go into quarantine and/or optional* (if reception of positive test result) go into isolation accordingly. Consequently, they run higher risks	1) Number of exposure notifications received 2) The extent to which users that receive an exposure notification go into quarantine (such as: not leaving the house, not receiving visitors, not being at close distance with members of the same household) until they receive a negative test result and/or until a	- Sensitive personal health data. Best collected via anonymous self-report surveys. - Is very difficult for citizens to fully apply to the guidelines. For instance, there are people who don't have others doing groceries or who don't have enough room to avoid close contact with members of their household. Therefore, questions should not be binary (i.e., did you or did you not), instead, always inquire about 'to what extent did you'. - Although self-report in itself is a methodological	Data from questionnaires

ID	Title	Significance	Variables and calculation	Comments	Data sources
		of infecting other people as they unknowingly may already have coronavirus. Consequently, the more users adhere to quarantine guidelines upon exposure notification, the more one of the main intended effects of CTA's is realised, namely braking the chains of infections. *optional, because in the total cascade of getting infected and going into isolation, only the quarantine part can really be assigned to the notification, but not so much the isolation phase of the cascade. Latter is also caused by PHA guidelines in general.	certain minimal time period has passed 3) Optional (*see above) The extent to which users that receive an exposure notification go into quarantine and subsequently receive a positive are going into isolation. Calculations relate to the method proposed: self-report questionnaires. "Extent to" can be broken done into percentages, or 5 or 7 categories to the extent people report they adhered to guidelines. Calculations can then be made stating: Of the X number of people that have received one or more exposure notification, AND related to the last notification received: X% adhered to quarantine guidelines to the extent of Y, etc.	limitation, given privacy regulations such data are best be collected via anonymous self-report surveys. - Some people receive more notifications, as such adherence may vary over time and people may forget over time what exactly they did per notification. For empirical-practical reasons the questionnaire should inform on the LAST notification someone received. - Guidelines that relate to quarantine are formulated and operationalized in slightly different ways per country. This means that the questionnaires should contextualized per country. - Also, quarantine guidelines per country may vary over time, e.g., because of the vaccination programs.	
E1	Proportion of cross-border notifications to national infections	This indicator aims to depict the contribution of cross-border notification sharing that enables potential infections to be identified across borders.	Number of keys uploaded daily to the EFGS / Average number of keys per user / Daily infections reported by PHA * Proportion of population who actively uses the app (A2)	- Average number of keys per user is an approximation. It can range between 1 and 14 depending on, e.g. when the user has installed the app (e.g. just 1 day prior to receiving testing positive and releasing their keys), and how far back exposures are collected (i.e. how many days preceding the date of symptom onset, but available sources suggest that a proxy of 10 keys on average per person is reasonable - Note that in some cases in which the number of upload keys for a given country and a given day are very small, for privacy reasons dummy data is added, which can lead to some distortion	- Data from the EFGS - Data from Public Health Authorities

Annex IV – Source of Data Protection Impact Assessments by different countries

Country	App	DPIA	Conducted by	Sources
Austria	Stopp Corona App	Yes	Data controller Austrian Red Cross (the team at the Research Institute - Digital Human Rights Centre)	https://www.roteskreuz.at/fileadmin/user_upload/PDF/Datenschutz/Datenschutz-Folgenabschaetzung-Bericht_OeRK_StopCoronaApp_04-08-2020_V2.0_final.pdf; https://www.stopp-corona.at/faq_stopp_corona_app/l-6-lightbox.html
Belgium	Coronalert	Yes	The Belgian Data Protection Authority	https://coronalert.be/wp-content/uploads/2021/07/DPIA_contactopsporingsapplicatie_BelgieV.8__NL_versie_17062021.pdf
Croatia	Stop COVID-19	Yes*	The Croatian Agency for the Protection of Personal Data (AZOP)	https://www.koronavirus.hr/uploads/Stop_COVID_19_Data_Protection_Impact_Assesment_Summary_2020_11_16_58dea76816.pdf
Republic of Cyprus	CovTracer-EN	Yes	The KIOS Center of Excellence and the CYENS Centre of Excellence in their capacity as data processors with consultation from the Office of the Commissioner for Personal Data Protection.	Available upon request
Czech Republic	eRouska	N/A[650]	-	https://fra.europa.eu/sites/default/files/fra_uploads/fra-2020-coronavirus-pandemic-eu-bulletin-may_en.pdf
Denmark	Smittestop	Yes	The Danish Agency for Patient Safety	https://github.com/DP-3T/documents/blob/master/data_protection/DP-3T%20Model%20DPIA.pdf; https://www.fhi.no/contentassets/67d72db7c1ba4e2f9a70e9606b1c7ab0/dpia-smittestopp.pdf
Estonia	HOIA	N/A	-	https://fra.europa.eu/sites/default/files/fra_uploads/fra-2020-

[650] Not available, only audits https://erouska.cz/downloads/cvut4.pdf

Country	App	DPIA	Conducted by	Sources
				coronavirus-pandemic-eu-bulletin-may_en.pdf
Finland	Koronavilkku	Yes	Privaon Oy[651]	https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
France	TousAntiCovid	Yes*	CNIL	https://www.cnil.fr/en/publication-cnils-opinion-french-contact-tracing-application-known-stopcovid
Germany	Corona-Warn-App	Yes	TSI[652] and SAP[653]	Bock et. al (2020) Data Protection Impact Assessment for the Corona App. Available at: https://www.fiff.de/dsfa-corona-file-en/at_download/file
Hungary	VirusRadar	N/A	-	-
Ireland	COVID Tracker	Yes	Health Service Executive (HSE Ireland)	https://github.com/HSEIreland/covidtracker-documentation/blob/master/documentation/privacy/Data Protection Impact Assessment for the COVID Tracker App - 26.06.2020.pdf
Italy	Immuni	Yes, but not found	Ministry of Health	https://www.garanteprivacy.it/home/docweb/-/docweb-display/docweb/9356588
Latvia	Apturi Covid	Yes	Latvian Data State Inspectorate	https://www.dvi.gov.lv/lv/novertejums-par-ietekmi-uz-datu-aizsardzibu-nida
Lithuania	Korona Stop LT	Yes**	The National Cyber Security Centre	https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
Malta	COVIDAlert	Yes, but not published	Maltese Information and Data Protection Commission (IDPC)	https://www.maltatoday.com.mt/news/national/104957/covid19_app_passed_privacy_assessment_commissioner_says#.YhX20y2ZNN0; https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
Netherlands	CoronaMelder	Yes	Ministry of Health, Welfare and Sports (VWS)	https://www.eerstekamer.nl/overig/20200828/dpia_corona_melder_app/meta
Poland	ProteGO Safe	Yes	-	https://www.gov.pl/web/protegosafe/dokumenty

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652 T-Systems International GmbH

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Country	App	DPIA	Conducted by	Sources
Portugal	StayAway COVID	Yes	Portuguese Data Protection Authority (CNPD)	https://stayawaycovid.pt/wp-content/uploads/AIPD_STAYAWAY_v2.0_09_2020.pdf; https://dq4n3btxmr8c9.cloudfront.net/files/c-5f-T/Liberties_Research_EU_Covid19_Tracing_Apps.pdf
Slovenia	#OstaniZdrav	Yes**	National Institute of Public Health (NIJZ)	
Spain	Radar Covid	Yes***	Department of Health and Social Care (DHSC)	https://github.com/RadarCOVID/radar-covid-documentation/blob/main/EIPD.pdf
Norway	Smittestopp	Yes	National Institute of Public health (FHI)	https://www.fhi.no/om/smittestopp/dpia/
Iceland	Rakning C-19	Yes, but not found	-	https://www.personuvernd.is/adrar-urlausnir/ymis-bref/radgjof-personuverndar-til-embaettis-landlaeknis-vegna-bluetooth-uppfaerslu-smitrakningarforrits-1
Switzerland	SwissCovid	Yes	EPFL (Ecole polytechnique fédérale de Lausanne) and id est avocats Sàrl[654]	https://www.edoeb.admin.ch/dam/edoeb/de/dokumente/2020/Volltext API DE.pdf.download.pdf/Volltext API DE.pdf
UK - England and Wales	NHS COVID-19	Yes	UK DHSC (Department of Health and Social Care)	The NHS COVID-19 app (Early October 2021 release): Data Protection Impact Assessment. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1028998/NHS_COVID_19_App_DPIA.pdf; https://www.england.nhs.uk/publication/data-protection-impact-assessment-nhs-covid-19-data-store/
UK - Northern Ireland	StopCOVID NI	Yes	Department of Health-NI	https://covid-19.hscni.net/wp-content/uploads/2020/08/DPIA-for-StopCOVID-NI-Proximity-App-31.07.2020.pdf
UK - Scotland	Protect Scotland	Yes	DHCD (Digital Health and Care Directorate)	https://protect.scot/resources/docs/DPIA-16-september-2020.pdf;

*Only summaries were published

[654] Archives

** Not publicly disclosed (saved in Archives)

*** the DPIA has no electronic signature, and it merely indicates a date of completion. [655]

[655] https://www.liberties.eu/en/stories/app-radar-covid-rights/43524

Annex V – Surveys conducted in EU/EEA countries on reasons for use and non-use of CTA

Table 21. Surveys conducted in EU/EEA countries on reasons for use and non-use of CTA

Country	Study	Methodological approach	Key findings
Austria	Early Perceptions of COVID-19 Contact Tracing Apps[656]	Qualitative Interviews with 159 individuals in Germany, Austria and German-speaking Switzerland. Participants were recruited through online advertisement and with attention to sample of different demographics. Researcher-developed interview guide. Content Analysis of Newspaper Coverage with predominant topics, concepts, concerns. Comparative framework analysis for country-specific interpretations/comparisons.	Interviews: Uncertainty about the function and scope of contact tracing apps Contact tracing apps as governmental surveillance tools. Surveillance was framed in different ways → control of individual compliance, surveillance tools that helped contain the pandemic, "Controlling is not necessarily a threat". Comparison with "totalitarian states", tools were incompatible with democratic values and rights. Factors that the participants found crucial for a contact tracing app to be compatible with democracy: trust, privacy, voluntariness, a time limit on data retention and use. Level of trust towards these authorities as an important factor for people's willingness to participate. Also fear of the installation of long-term surveillance systems by the government. Distrust of authorities especially by Austrian participants, lack of transparency on how location and movement data were analysed. Austrian participants feared penalties for noncompliance or the loss of privacy. Contact tracing apps as a resource for the common good, to contribute to the containment of the viral spread and protect at-risk individuals or to increase people's freedom to move around or a tool that "makes us all more flexible". Content Analysis of Newspaper: German and Austrian newspapers critically reported political discussions to use non-anonymous data. Swiss newspapers reported predominantly positive

[656] Zimmermann, B. M., Fiske, A., Prainsack, B., Hangel, N., McLennan, S., & Buyx, A. (2021). Early perceptions of COVID-19 contact tracing apps in German-speaking countries: Comparative mixed methods study. Journal of medical Internet research, 23(2), e25525.

Country	Study	Methodological approach	Key findings
			aspects. Swiss and German newspaper discussed tracing as a possible assistance tool for contact tracing. Data protection and privacy issues were discussed, proximity tracing was introduced to potentially overcome these issues. All three countries compared nationally discussed solutions of contact tracing apps with international applications. In all three countries, tracing/tracking apps were connected to totalitarian surveillance states, where surveillance apps were used as containment strategies.
	Tracing Covid-19 – Older Adults' Attitudes Toward Digital Contact Tracing and How to Increase Their Participation[657]	Eight-week study with eight older adults aged 65+ (four female, four male) Longitudinal interview study vie telephone. Five interviews per participant, which is due to the different topics. "These included the awareness of the countermeasures against the spread of the coronavirus and how the lockdown affected their lives." Focus especially on the usage and attitude towards the "Stop Corona" app. Interesting topics: • Familiarity with technology • Trust and privacy • Social influence • Provider	Unsureness about the functionality and how the collected data was being used by the participants. Majority had no or only minor concerns about "Stopp Corona", mentioning that data misuse could never be completely avoided. Only two participants had already installed the app. Only one respondent viewed the app in a strictly negative way. Another participant would accept the mandatory use of a contact tracing app, if it reduces the virus spread effectively. Statements regarding data protection were heterogeneous. Participant 1 is not afraid of data breaches since "he has nothing to hide." He would approve unrestricted access to his personal health data by health professionals. "A large proportion of participants agreed that they would accept the risk of data misuse if it served themselves or the greater good." P7 was strongly against the app and very critical of the GDPR. P2 did not worry about the misuse of contact tracing data, she thought her health data would only be of interest to third parties if it contributes to economic profit. Trust in Providers – only few concerns about "Stopp Corona" because of the positive image of its provider (the Red Cross). Government is also viewed rather positively as a potential provider, same goes for universities.
Belgium	Reasons for Nonuse,	Online survey – 18- to 64-year-old respondents	64,9% of respondents were nonusers of CTA. No sociodemographic

[657] Wagner, P., Winkler, A., Paraschivoiu, I., Meschtscherjakov, A., Gärtner, M., & Tscheligi, M. (2021). Tracing COVID-19-Older Adults' Attitudes Toward Digital Contact Tracing and How to Increase Their Participation. In Mensch und Computer 2021 (pp. 349-353).

Country	Study	Methodological approach	Key findings
	Discontinuation of Use, and Acceptance of Additional Functionalities of a COVID-19 Contact Tracing App: Cross-sectional Survey Study[658]	Sample of 1850 respondents with the following criteria: (1)resident of Belgium (2)aged between 18 and 64 years (3)speaking Dutch Sociodemographic characteristics of gender age, education level, employment status and medical condition "Chi-square analyses and t tests were performed to test between-group differences among users and nonusers." Afterward descriptive analyses to assess the different reasons for not using the app.	differences between users and nonusers. Main reasons for not downloading and using the app were a perceived lack of advantages (31,1%), worries about privacy (29,3%) and not having a smartphone (18,5%). Reasons for not installing the app that were worries about the involvement of the government, the usage of the collected data by the government and that the government would be able to follow users' movements. Most important contributions of the app for users were as follows: helping the government in its fight against the pandemic, the app diminishes the spread of the virus, rapidly alerts and a CTA detects risky contacts while preserving users' privacy. Users of CTA agreed more with the potential of such apps to mitigate the consequences of the pandemic (e.g. making an appointment, getting advice, having contact with a health professional, receiving statistics, getting access to a questionnaire to assess COVID-19 symptoms). Among users, acceptability tended to differ. Functionalities relating to access and control were less accepted than functionalities focusing on informing citizens or making an appointment to get tested.
Finland	The main reasons for downloading the Finnish COVID-19 contact tracing app Koronavilkku[659]	Telephone interview (n=1001) Target group: 15-79 years old persons	The main reasons for downloading the Koronavilkku app (67%): sense of civic duty and the recommendation of the Finnish Institute for Health and Welfare (THL). Other reasons: concern for their own health (16%) or health of their family and friends (14%), usefulness in preventing the spreading of the coronavirus (14%). People who have downloaded the app: women, under 50s, Uusimaa residents, employees, experts and persons in leadership positions, families with children. Reasons for not downloading: no necessity (33%), not able to download the app (16%), no suitable telephone (14%).
France	Health care students' knowledge of and attitudes, beliefs, and practices toward the	Field-survey. Paper questionnaire administered face-to-face by five interviewers. Sample of 300 respondents, be representative of the overall population of students	77,3% already heard about the app (mostly (87,8%) through media and secondly (15,9%) through family and friends) 4,7% of students were using the app at the moment of the survey.

658 Walrave, M., Waeterloos, C., & Ponnet, K. (2022). Reasons for Nonuse, Discontinuation of Use, and Acceptance of Additional Functionalities of a COVID-19 Contact Tracing App: Cross-sectional Survey Study. JMIR Public Health and Surveillance, 8(1), e22113.

659 https://privaon.com/publications-news/press-releases/covid-19-contact-tracing-app-koronavilkku/

Country	Study	Methodological approach	Key findings
	French COVID-19 app: cross-sectional questionnaire study[660]	in the health domain. 5 steps: 4 different scenarios and a final questionnaire, common to all students. 1. The student has already heard about the app and has downloaded it 2. The student has already heard about the app and has not downloaded it 3. The student has never heard about the app but would download it 4. The student has never heard about the app and would not download it	Main reasons for uninstalling the app: not useful (66,7%), the respondent forgot to activate the Bluetooth (23,8%), drained the phone battery (19%), ineffective app (19%, cause too few people were using it) Some of the students also reported that it was easy to use and that it was reassuring. Reasons for not downloading the app: lack of interest, neither effective nor useful given its limited diffusion, not having time to think about it, distrust in data security and fear of being geolocated. Main reasons for downloading the app: curiosity and to protect one's family and oneself from possible infection. Concerning the function of the app 83,3% of the respondents thought that they were able to explain it. "However, when further asked about geolocation, access to contact information, and how data were transmitted and stocked, the respondents answers were mostly incorrect." Factors for increasing the use of the app: better communication strategy (71,4%), making the app compulsory (14,2%), registering more COVID-19 cases (9,4%), more information and explanations about the app (6,6%), better technical features (3,1%) and other (20,1%).
	Early Acceptability of a Mobile App for Contact Tracing During the COVID-19 Pandemic in France: National Web-Based Survey[661]	Sample of 1003 internet users aged 18-75 years. Sampe was drawn from an access panel, by respecting the French population structure (sex, age, regions,…). "Web-based survey collected information on respondents' sociodemographic characteristics, perception of health, health literacy, navigation in health system." Focus on analysing the sociodemographic data of the survey respondents.	"No significant association between app-reluctance and sociodemographic factors except for financial deprivation, with participants reluctant to use such apps reporting higher financial deprivation scores." "Trust in political representatives, scientists and doctors was positively associated with the acceptability of a contact tracing app during a pandemic." The two groups, that were willing to use a contact racing app, showed a lower level of financial deprivation and a higher perceived usefulness of a mobile app to send doctors answers to health questionnaires. "App-supporters that were 60 years and older, felt more concerned about the situation of the COVID-19 pandemic, trusted political representatives, and had

[660] Montagni, I., Roussel, N., Thiébaut, R., & Tzourio, C. (2021). Health care students' knowledge of and attitudes, beliefs, and practices toward the French COVID-19 app: cross-sectional questionnaire study. Journal of medical Internet research, 23(3), e26399.

[661] Touzani, R., Schultz, E., Holmes, S. M., Vandentorren, S., Arwidson, P., Guillemin, F., ... & Mancini, J. (2021). Early acceptability of a mobile app for contact tracing during the COVID-19 pandemic in France: National web-based survey. JMIR mHealth and uHealth, 9(7), e27768.

Country	Study	Methodological approach	Key findings
			a perfect level of KT-COVID-19 (Level of knowledge of the transmission of COVID-19)."
Germany	Sociodemographic characteristics determine download and use of a Corona contact tracing app in Germany[662]	Cross sectional survey of the general population aged 18 to 74 years in Germany. Data was collected by online questionnaire. A total of 4960 participants. Questionnaire is pretested with about 30-50 participants.	36,5% had downloaded CWA. Persons who had downloaded CWA were significantly older than those who had not. "Participants were more likely to have downloaded CWA if they were male, 65 years and older, had at least 10 years of schooling with higher education entrance qualification, lived in a town/city with over 20,000 inhabitants, lived in one of the Western federal states of Germany, or had a net household income of 4000€ and above." Persons belonging to a minority group and persons whose main language wasn't German were less likely to have downloaded the app. Of those downloaded CWA, 91,7% found it easy to install, 87,7% found it easy to use and 61,4% thought that it is doing a good job. Also 60,3% would quarantine after receiving the information from the app (of those who had not downloaded the app, only 35,5% would definitely quarantine). Willingness to quarantine increased with age. 83% of participants with download were convinced that CWA complied with data protection laws (not downloaded: 31,7%). Trust in data protection compliance was again significantly higher in older adults as well as in adults with higher income.
	Psychological factors shaping public responses to COVID-19 digital contact tracing technologies in Germany[663]	Four representative online samples of German participants were recruited regarding age (>18 years), gender, and region. Four waves of data collection. Timing of data collection was determined by two main criteria. First, the development of digital contact tracing technology in Germany and worldwide. And the second criterion was the development of the pandemic and changing infection numbers in Germany. "Two assessments when infections were peaking	"The acceptability of privacy-encroaching measures that could hypothetically be implemented by the government was fairly high, but tended to decrease over time. The acceptability of all privacy-encroaching measures tended to decrease from thereon, as reflected in the decreasing percentages of people who deemed these measures "very" or "somewhat" acceptable." In wave 1 68% of participants considered government access to citizens' medical records to be "very" or "somewhat" acceptable. This circumstance dropped in each wave. Acceptability of collecting people's location tracking data followed the same pattern. Across all four waves, the acceptance of collecting data on people's contacts

662 Grill, E., Eitze, S., De Bock, F., Dragano, N., Huebl, L., Schmich, P., ... & Betsch, C. (2021). Sociodemographic characteristics determine download and use of a Corona contact tracing app in Germany—Results of the COSMO surveys. PloS one, 16(9), e0256660.

663 Kozyreva, A., Lorenz-Spreen, P., Lewandowsky, S., Garrett, P. M., Herzog, S. M., Pachur, T., & Hertwig, R. (2021). Psychological factors shaping public responses to COVID-19 digital contact tracing technologies in Germany. Scientific reports, 11(1), 1-19.

Country	Study	Methodological approach	Key findings
		(waves 1 and 4) and two when they were decreasing (wave 2) or had been low for some time. (wave 3)" All surveys shared the same basic structure (perceived risks, scenario, attitudes toward the scenario presented, attention check, and worldview).	and interactions stayed below 50%. Acceptability of all three tracking technologies that were presented in the hypothetical scenarios (mild, severe and Bluetooth) was above 50% in both waves. "The reported percentage of downloads of the Corona-Warn App in this sample was smaller than the acceptability of the hypothetical scenarios. This low number of reported downloads is consistent with the actual download rates for the Corona-Warn-App in Germany." (At later stages of the pandemic, the people could be less likely to find tracking technologies acceptable.) Although participants thought the Corona-Warn-App (CWA) presented only a low risk of harm and were also pessimistic about its effectiveness, which includes its ability to reduce the spread of the virus. Participants showed only moderate levels of trust in the Corona-Warn-App's security. "People's perceptions of the risks and benefits of the CWA differed depending on whether or not they already had downloaded the app." The majority of users rated the app's security higher than its risk of harm. Main reason for downloading the app: desire to protect their health and the health of others. The two leading reasons for not downloading the app were the belief that the app is not effective and privacy concerns.
	How Identification with the Social Environment and with the Government Guide the Use of the Official COVID-19 Contact Tracing App: Three Qunatitative Survey Studies[664]	Participants were invited via a university email to complete a brief survey on their perception of the current situation. They received basic information about the respective study, provided informed consent, completed the main measures as indicated below, entered demographic information, were debriefed, confirmed their consent to use their survey data and were finally given the chance to take part in a lottery. 355 participants completed Survey 1. 308 nonoverlapping participants completed Survey 2.	Focus on this question: When are people motivated to use a contact tracing app? "The more people identified with their social environment (the beneficiaries) and the more they identified with members of the government (the source), the greater their app acceptance (ie, intentions and app installation)." Identification with members of the government was linked to greater app acceptance via more trust in the government – so "this outlines that trust in the source may be an important aspect that contributes to the acceptance of new technology and that identification with the source may serve as a

[664] Scholl, A., & Sassenberg, K. (2021). How Identification With the Social Environment and With the Government Guide the Use of the Official COVID-19 Contact Tracing App: Three Quantitative Survey Studies. JMIR mHealth and uHealth, 9(11), e28146.

Country	Study	Methodological approach	Key findings
		Survey 3 involved another separate sample of 381 participants. Measures: • Identification: "Identification with (1) people in their social environment and (2) members of the government were measured with six items each." • Trust: Trust in the government as a mediator • App Acceptance: "App acceptance as a first outcome was operationalized as low perceived privacy infringement." • Intention to use the App: Was assessed with one item: "To which extent would you be/are you willing to use this contact-tracing app?"	predictor of said trust."
	Utilizing Health Behavior Change and Technology Acceptance Models to Predict the Adoption of COVID-19 Contact Tracing Apps: Cross-sectional Survey Study[665]	Cross-sectional online survey. Recruitment via social media, press outlets and personal communications. Survey was pretested for clarity, readability, accessibility, and functioning. Measurement of individual age, gender, number of persons in one's household, current level of education, current personal income, region and migration background. Inclusion of COVID-19 related information on risk perception.	593 persons participated in the survey, after excluding participants (completion in less than 10 minutes or showing of monotone response patterns) 349 participants remained. 19% reported current use of a COVID-19 contact tracing app (an average frequency of several times per week). App use was much higher after the launch. Equal usage across regions. "App users reported significantly more positive attitudes and fewer concerns than nonusers but also had a lower relative frequency of COVID-19 experiences." "Frequency of current tracing app use was negatively correlated with education and urban region, indicating that fewer educated participants living in metropolitan or rural areas reported more frequent tracing app use." Adoption intentions and use frequency were moderately correlated. Frequency of current tracing app use had similar correlations and was also positively associated with knowledge about tracing apps. "This study aimed to investigate the utility of health behaviour theories and technology acceptance models for explaining adoption intentions and current use of a contact tracing app during the COVID-19 pandemic in the German

[665] Tomczyk, S., Barth, S., Schmidt, S., & Muehlan, H. (2021). Utilizing health behavior change and technology acceptance models to predict the adoption of COVID-19 contact tracing apps: Cross-sectional survey study. Journal of medical Internet research, 23(5), e25447.

Country	Study	Methodological approach	Key findings
			population."
	Investigating Barriers for the Adoption of the German Contact-Tracing App and the Influence of a Video Intervention on User Acceptance[666]	Questionnaire based on a well-established framework for technology acceptance, to gain insights about the effect of the official video on user acceptance. "Recruitment of only participants with no prior experience to target more skeptical users but also to control for experience with the functionalities." After filling out the pre-questionnaire (brief introduction about the topic of the research instrument and a screening question for selecting appropriate participants), participants had to watch the official video about the CWA (published by German Federal Government, explains the main functionalities, data protection mechanisms and benefits). Then manipulation check question, to check if the participants watched the video attentively. After this questions, same items as in the pre-questionnaire were asked. "122 respondents took part in the study, 38 of whom were active users of the app and were excluded from data collection. Three respondents failed in manipulation test. This resulted in 81 valid data sets. The age of respondents ranged from 18 to 60."	Results RQ1 (Does a video-based intervention can increase the acceptance of users with nor prior experience with the CWA): Pre and post-video acceptance. • H1: Perceived ease of Use (supported by the participants) • H2: Perceived Usefulness (supported) • H3: Behavioral intention (Present) (rejected) • H4: Behavioral intention (Future) (rejected) • H5: Computer Self Efficacy (supported) "Significant differences between groups with different anxiety-levels about an infection with COVID-19, different anxiety-levels about transmission of COVID-19, different levels of informedness about COVID-19 and informedness about the CWA." The mean rating for behavioural intention (BI) was higher for users with higher levels of anxiety about a COVID-19 infection. The mean rating for BI of respondents with higher levels of anxiety about transmission of COVID-19 was lower than for respondents with lower levels of anxiety about transmission. The Behavioural Intention was greater for users with higher levels of informedness about COVID-19 and the CWA. Reasons for not installing the contact tracing app: no benefits, power consumption/Bluetooth activation, privacy concerns/no location sharing, … Disadvantages of using the contact tracing app: Privacy concerns, mental stress, Battery consumption, false sense of security, … Five times the respondents used the term "Surveillance" to express their feelings towards the app. Advantages of the contact tracing app: advantages for others (e.g. elderly or vulnerable people) Respondents knew the theoretical advantages but perceive them as not very beneficial for them personally → reasons for perceiving the app as "not useful".

[666] Böhm, V., Wolff, C., Geiselhart, C., Karl, E., & Kleindienst, N. (2021). Investigating Barriers for the Adoption of the German Contact-Tracing App and the Influence of a Video Intervention on User Acceptance. In Mensch und Computer 2021 (pp. 330-337).

Country	Study	Methodological approach	Key findings
Ireland	A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland[667]	37-item online survey. The survey was released through social media plattforms, the University of Limerick website, and university e-mailing lists and via WhatsApp. Aged 18 or older. "Chi-squared tests for association were carried out to investigate whether gender, age group, education level or level of worry regarding COVID-19 were related to willingness to install."	Total of 8088 complete responses. Reasons that would make it more likely for you to install the App: protection of family and friends, sense of responsibility to the wider community, acknowledge of the risk of being affected, personal protection, … Reasons that would make it less likely for you to install the App: fear of greater surveillance after the pandemic, fear of getting hacked, data privacy, … 41% of the respondents could see no reason not to install the app. The remaining 59% of the respondents selected at least one option. 58% of respondents "definitely will install" the App. 25% "probably will install" the app. 8% "may or may not install". 3% "probably won't install". 6% "definitely won't install". "Males more likely to respond that they probably or definitely will not install the app. The oldest and youngest groups most likely to indicate they probably or definitely will install the app. Covid-related worry was associated with willingness to install."
Italy	Joint analysis of the intention to vaccinate and to use contact tracing app during the COVID-19 pandemic[668]	Online data collection. 448 participants. "The questionnaire investigated participants' intention to download the national CTA Immuni and to get a vaccine against COVID-19." "Two different explorative factorial analyses were performed: the first one on the respondents' scores of the likelihood of being infected, severity and scariness for COVID-19, the second one on the trust in international institutions, national institutions and scientific committees."	Participants were mainly female. The adult age-class reported more doubts about vaccinations as well as those with the lower educational level. A small proportion of respondents reported being entrepreneurs; this percentage increased among those who had many doubts about vaccinations. "The willingness to get a COVID-19 vaccine was greater than that to download the CTA Immuni." "Trust in politics and science was higher among participants with no or few vaccine doubts." "The likelihood to get the COVID-19 vaccine was highly correlated with the likelihood to download CTA Immuni." Being vaccinated with the flu vaccine in the season 2019-2020 increased the intention to get the COVID-19 vaccine and download CTA Immuni. "The COVID-19 perceived risk showed a moderate effect in increasing the likelihood to get a COVID-19 vaccine and a strong effect on the intention to download the CTA Immuni."

667 O'Callaghan, M. E., Buckley, J., Fitzgerald, B., Johnson, K., Laffey, J., McNicholas, B., … & Glynn, L. (2021). A national survey of attitudes to COVID-19 digital contact tracing in the Republic of Ireland. Irish Journal of Medical Science (1971-), 190(3), 863-887.

668 Caserotti, M., Girardi, P., Tasso, A., Rubaltelli, E., Lotto, L., & Gavaruzzi, T. (2022). Joint analysis of the intention to vaccinate and to use contact tracing app during the COVID-19 pandemic. Scientific reports, 12(1), 1-13.

Country	Study	Methodological approach	Key findings
			"A high perception of COVID-19 risk decreased CTA Immuni/Covid-19 vaccine concordance compared with a lower risk perception, as did a medium trust in politics and science compared with low trust." "Variability in the intention to download the CTA Immuni increased with increasing trust in politics and science and age." "The intention to take a measure against COVID-19 was lower among those who declare to do it for themselves rather than for others, while the motivation of getting vaccinated for COVID-19 was three times higher than to download the CTA Immuni. A negative effect on the motivation was reported by age and by having conspiracy beliefs." Trust in politics and science and COVID-19 perceived risk highly increased the importance given to the preventive measures and the intention to download the CTA immuni
	What went wrong? Predictors of Contact Tracing Adoption in Italy during COVID-19 Pandemic[669]	Anonymous online survey. Survey was structured in 16 sections with a total of 166 questions. Completion time 20min. Recruiting through online posts on social networks sites. 501 participants, average age of 34,61. Online survey investigating the participants' sociodemographic characteristics, personality traits, self-efficacy, well-being, and social connectedness. The survey was composed on the following tools: Sociodemographic form, affective arousal, immune "general" form, attitudes towards contact tracing systems, trust in government, cognitive factors of risk perception for COVID-19.	Of the 501 respondents, 329 reported using Immuni, while 172 did not download the application. The adoption of Immuni is related to the perceived efficacy of CT systems and both components of people's attitudes toward CT systems (i.e. fear and acceptance). The participants that downloaded and used the Immuni application also had higher trust in government and its actions against COVID-19, risk perception and experienced more fear compared to individuals that did not adopt the app. No differences regarding participants age. 70,2% of Immuni adopters have at least one family member who used the application. 24,4% of the participants did not use the app, despite one or more members of the family adopting it. Similar result considering whether or not a friend downloaded and used Immuni. No significant associations with participants' gender, education level, occupation or income. The strongest association related to the adoption of Immuni appeared to be having a family member who used it, followed by having a friend who adopted it, and in a more marginal way, knowing someone who relied on it. People's

[669] Guazzini, A., Fiorenza, M., Panerai, G., & Duradoni, M. (2021). What Went Wrong? Predictors of Contact Tracing Adoption in Italy during COVID-19 Pandemic. Future Internet, 13(11), 286.

Country	Study	Methodological approach	Key findings
			attitudes towards contact tracing and their perception of Immuni as an effective way of dealing with the COVID-19 outbreak, appeared to shape Immuni adoption.
Netherlands	The Dutch COVID-19 Contact Tracing App (the CoronaMelder): Usability Study[670]	Scenario-based usability tests with additional interview questions and the Dutch User Experience Questionnaire. Participants from the following target groups were included: Youth (<21 years) with a lower and higher level of education, Youth with an intellectual disability, migrants, Adults (40-64 Years), older adults (>65 years). Test protocol: Pandemic impact, Scenarios (App introduction, App activation, Receiving a notification, Sharing a key), interview questions about the attitude toward the app and willingness to use it, UEQ-Dutch.	In total 44 participants. The mean age was 40 years, ranging from 13 to 79 years. Research questions: Is the CoronaMelder user-friendly, understandable, reliable and credible and inclusive? "The majority of the participants were positive about the user-friendliness, reliability, and credibility of the app." "Participants from all target groups indicated more negative comments than positive ones regarding the understandability of the working mechanism of the CoronaMelder" (i.e. the app was inconsistent in the ways it referred to the coronavirus and to the key that should be shared after testing positive). "A clear definition was lacking within the app about what it means to be exposed or at "increased risk" of a COVID-19 infection." "None of the participants, regardless of age and education, understood when they were at increased risk for possible infection." Trust in the app's reliability because it was a government app. "The explanation about data storage and anonymity earns trust and adult participants in particular applauded the fact that the app does not require personal data." "Adults assessed the app as trustworthy, youth in the lower-education group did not understand how the app guarantees privacy." General reasons for using the app: protecting themselves and their loved ones, creating sufficient support for the app, helping to get COVID-19 under control and ease nationwide measures. "Doubts and fears were expressed regarding privacy, usefulness and consequences of the CoronaMelder." Reasons not to use the CoronaMelder: perceiving the app as useless, thinking the coronavirus and corresponding measures were overrated, not wanting to be in quarantine, and limited phone

[670] Bente, B. E., Roderick van't, J. W. J., Schreijer, M. A., Berkemeier, L., van Gend, J. E., Slijkhuis, P. J. H., ... & van Gemert, J. E. W. C. (2021). The Dutch COVID-19 contact tracing app (the CoronaMelder): Usability study. JMIR formative research, 5(3), e27882.

Country	Study	Methodological approach	Key findings
			memory or battery capacity.
	Predictors to use the mobile apps for monitoring COVID-19 symptoms and contact tracing: Survey among dutch citizens[671]	Online survey consisted of 4 parts. "First part included questions on demographics, the second part contained questions related to perceived health, the third part consisted of questions related to the fear of a COVID-19 infection and the final part included questions to assess the intention to use the 2 suggested mobile apps."	238 Dutch citizens completed the survey. Fear of a COVID-19 infection: The majority opinion on this topic was neutral (80,7%), 16% of the respondents were afraid for a COVID-19 infection, and 3,4% were not afraid. The majority's intention to use for both apps (for the symptom app and the tracing app) was neutral. Significant difference between the apps; the responders were more willing to use a mobile app for COVID-19 symptom recognition and monitoring compared with a mobile app for contact tracing. "The intention to use the symptom app was related to income level, attitude toward the technology and fear of Covid-19. The intention to use the tracing app was related to age, attitude toward technology and fear of COVID-19." 41,2% of the Dutch adults appear to be willing to use this mobile app. Main reasons to use the symptom app: control the spread of the Covid-19 virus, monitor own complaints, gain more insight into the spread and symptoms of the COVID-19 virus. Main reasons to use the tracing app: control the spread of the COVID-19 virus, gain more insight into the spread and symptoms and for one's own health. Main reasons not to use the mobile apps: Privacy/not willing to share information with government, doubting usefulness, fear of becoming over aware of the situation and its potential consequences, leading to unnecessary stress.
Switzerland	Drivers of acceptance of COVID-19 proximity tracing apps in Switzerland[672]	Based on a survey data from the swiss Covid-19 Social Monitor project (cohort study). Three standardized questions to gather information about the usage of the Swiss digital proximity tracing app. Additional data on media use and trust in government, health authorities or science. The primary data source for these analyses was wave 10.	The wave 10 yielded 1511 responses. Median age was 48 years and 48,8% were females. 46,5% reported to have the app installed. "Citizenship status (Swiss and second citizenship, non-Swiss citizenship vs. Swiss-citizenship only), and language region (French-speaking, Italian-speaking vs. German-speaking) were associated with lower app uptake." "A higher monthly household income, more frequent internet use, better adherence to mask wearing recommendations and being a non-smoker were

671 Jansen-Kosterink, S., Hurmuz, M., den Ouden, M., & van Velsen, L. (2021). Predictors to Use Mobile Apps for Monitoring COVID-19 Symptoms and Contact Tracing: Survey Among Dutch Citizens. JMIR formative research, 5(12), e28416.

672 von Wyl, V., Höglinger, M., Sieber, C., Kaufmann, M., Moser, A., Serra-Burriel, M., ... & Puhan, M. A. (2020). Drivers of acceptance of COVID-19 proximity tracing apps in Switzerland. medRxiv.

Country	Study	Methodological approach	Key findings
			associated with increasing app uptake." "Increasing levels of trust in government and health authorities were also associated with a higher app uptake probability, whereas the inclusion of trust in science did not improve the multivariable model fit." Reasons for non-use of app: perceived lack of usefulness of the app (36,8%), not having a suitable smartphone or operating system (22,8%) and concerns of privacy (22,4%) and other reasons (not knowing the app, doubts about technological reliability, concerns about excessive battery usage).
Sweden	Perceived Privacy Problems Within Digital Contact Tracing: A Study Among Swedish Citizens[673]	Web-based survey. In the beginning of the survey was a description of contact tracing apps, which was followed by two question sections. Firstly demographic questions, and secondly one Likert scale with five statements for each of the six included dimensions of privacy concern. Stratified sampling approach.	453 respondents. The participants had to rate on a 5-point scale (1=Do not agree at all and 5=Fully agree). The results reflect that the respondents were concerned about privacy risks in all themes. The results for most themes (surveillance, identification, aggregation, disclosure, stigma) were above 3, which signifies a neutral standpoint. The concerns for secondary use of data were close to 4, suggesting that the respondents were concerned about their data being used for other purposes that contact tracing. Only 34,44% of the respondents would use a contact tracing app. Statistically significant differences between the gender groups or level of education could not be identified. Younger respondents were more concerned about privacy aspects than older respondents. Respondents who were positive towards using an application for contact tracing were less concerned with privacy issues in all six dimensions (surveillance, identification, aggregation, secondary use, disclosure, stigma).
Luxembourg	Determinants of Acceptability of Contact Tracing Apps for COVID-19: Initial Results from Luxembourg[674]	Representative, longitudinal dataset to study people's likelihood of adopting contact tracing apps. Online survey, takes about 10min to respond. Includes respondents': acceptability of the app-based system of contact tracing; preferences on different installation regimes; socio-demographic characteristics; trust in government; and other characteristics.	38% of respondents would install a tracing app if one was made available, and 34% would probably install it. 11% of respondents would definitely not install the app. These figures indicate a high support for a tracing app in Luxembourg. "Despite wide support for such technology, the apps' adoption rates remained lower than what was indicated by surveys (information from surveys conducted in Germany, France, Italy and UK)." Main reasons for not installing the app: fear of greater surveillance, fear of

673 Padyab, A., & Kävrestad, J. (2021, June). Perceived Privacy Problems Within Digital Contact Tracing: A Study Among Swedish Citizens. In IFIP International Conference on ICT Systems Security and Privacy Protection (pp. 270-283). Springer, Cham.

674 Riillo, C., Peroni, C., & Sarracino, F. (2020). Determinants of acceptability of contact tracing apps for COVID-19: initial results from Luxembourg. Economie et Statistiques, 1-31.

Country	Study	Methodological approach	Key findings
		They run the survey twice on the same set of respondents, with a slightly modified questionnaire, to obtain a longitudinal dataset.	mandated self-isolation without a legitimate reason, fears that the app might be hacked. Main reasons for installing the app: responsibility towards the community, protecting family and friends, chance of stopping the epidemic, knowledge about personal risk of infection. Respondents prefer a decentralised system to a centralised one. Privacy concerns could at least partly explain the discrepancy between intentions and observed installation behaviours in European countries. Respondents prefer European apps to global apps. Respondents prefer a voluntary installation regime (64%). Respondents prefer data to be used for research (65%) to prepare for future epidemics. 34% of respondents would prefer to delete all data.
UK	Public Adoption of and Trust in the NHS COVID-19 Contact Tracing App in the United Kingdom: Quantitative Online Survey Study[675]	"The recruitment was carried out vie email to a nationally representative sample, based on age, gender, and region, drawn from a randomly selected pool of participants who met the relevant criteria." A sample of 1001 members of the UK aged 16 to 75 years took part. Series of demographic questions. Major sections of the survey: Section 1 (Knowledge and experiences of COVID-19 and the NHS Test and Trace App), Section 2 (Reasons for downloading and experiences of using the app), Section 3 (App functionality and the technology involved), Section 4 (Levels of trust in distinct aspects of the app).	"96,2% had heard of the NHS COVID-19 mobile phone app, of which 50,9% had downloaded the app and still had it on their phone. 13,3% had not yet downloaded it but intended to. 27,4% did not to intend to download it and 8,4% had downloaded it but since deleted it." Reasons not to download the app: desire not to be tracked, not thinking it would be effective, not wanting to take part in contact tracing in that way, lack of trust in those who built the app. Reasons to download the app: help the NHS or to protect friends/family/themselves, reduce the spread of the virus and to help protect broader society. Participants who had downloaded the app agreed that they knew how the app worked, that it was easy to use, that it was useful to them and to wider society. "Participants who deleted the app showed significantly more concern about how their data were used and were more likely to have been frustrated by a notification from the app."

[675] Dowthwaite, L., Fischer, J., Vallejos, E. P., Portillo, V., Nichele, E., Goulden, M., & McAuley, D. (2021). Public Adoption of and Trust in the NHS COVID-19 Contact Tracing App in the United Kingdom: Quantitative Online Survey Study. Journal of medical Internet research, 23(9), e29085.

Country	Study	Methodological approach	Key findings
			Those who still have the app had trust in various aspects of the app. "Those who chose not to download the app had significantly less trust, feeling neutral regarding trusting that the data were used responsibly and stored securely, that the app does what it is supposed to do and that the app is basically trustworthy. They were also significantly more likely not to trust that their data would be deleted when the app said it would be." "Trust was thought to be important for all participants to feel comfortable using the app, although significantly less so for those who chose not to download it." App users agreed that they trusted most of the stakeholders involved in the NHS Test and Trace system. "BAME (Black, Asian and minority ethnic) participants were more concerned about how their data would be used, felt more strongly that they had no choice but to download it."
	To Use or Not to Use a COVID-19 Contact Tracing App: Mixed Methods Survey in Wales[676]	Anonymous survey among 4000 HealthWise Wales participants. "All survey questions were in a closed or structured format apart from those about reasons for being willing or unwilling to use a contact tracing app." The survey was released before the NHS COVID-19 contact tracing app was rolled out in England.	Total of 976 full survey responses were received (in Wales). 94% of the respondents indicated that they were familiar with symptom tracking apps and 37,7% used the app ("the Zoe App", a common symptom tracking app used in the UK, operated by the COVID Symptom Study). 73,9% indicated that they would use a contact tracing app. "No significant differences in the willingness to use a contact tracing app based on ethnicity or main postcode area. Females were more likely to be willing to use a contact tracing app than males. Younger age groups tended to be less willing to use a contact tracing app than older age groups." Reasons for being willing to use a contact tracing app: to control spread of the virus, to mitigate others' and own risk, to increase freedom. Reasons for being unwilling to use a contact tracing app: mistrust in the government, concerns about data security, data privacy, doubts about app efficacy. What would change the mind from being willing to be unwilling to use a contact tracing app: nothing would, security breach, ineffectiveness of the app, misuse of data.

[676] Jones, K., & Thompson, R. (2021). To Use or Not to Use a COVID-19 Contact Tracing App: Mixed Methods Survey in Wales. JMIR mHealth and uHealth, 9(11), e29181.

Country	Study	Methodological approach	Key findings
			What would change the mind from being unwilling to being willing to use a contact tracing app: nothing would, decentralisation of the app, provision of suitable tech and an assurances of data safety.
	Understanding Public Perceptions of COVID-19 Contact Tracing Apps: Artificial Intelligence-Enabled Social Media Analysis[677]	AI-based sentiment analysis to understand public views and concerns. Analysis of data from Facebook and Twitter. Contextual filtering for COVID-19 - and contact tracing app – related keywords.	"The sentiments were computed by utilizing our ensemble-based AI model to predict the overall polarity of each post as positive, negative and neutral. The average positive sentiments (76%) were found to far outnumber the negative sentiments (12%)."
	Understanding the perceptions of UK COVID-19 contact tracing app in the BAME community in Leicester[678]	Six virtual focus group sessions with 28 participants. Recruiting via a registration system. Each session had between 5 and 10 participants aged 18 and above. The researchers developed detailed guidelines with defined responsibilities so as to facilitate structured and consistent discussions.	The majority of the participants were not willing to download and use a contact tracing app. Concerns centred on legal and ethical considerations, socio-economic factors and technical concerns. "Three participants expressed their willingness to download the app based on the positive impact it might have for public health." "Majority of the participants expressed concerns bordering on privacy and security of personal data." Concerns for the decentralized and also the centralized approaches. Another reason for not downloading and using the app, was the lack of trust in the institutions (public and private). Strong feeling that there are underlying objectives of the app that the government is not making public. Another reason for not using the app: Lack of transparency. "The participants also raised technical concerns bordering on the reliance of this app."
	Adoption and continued use of mobile contact tracing technology: multilevel explanations from a three-wave panel survey and linked	Sample of 2500 respondents across three waves of data collection. "While the NHS COVID-19 app is used by citizens living in England and Wales, [they] needed to restrict [their] study to England's population on the funder's request." Wave 1 – Demographics	Uptake in 2020 November was 41%. Of the initial adopters, 12% of respondents no longer used the app by wave 3. Of those initially not adopting, 7% reported usage by wave 3. Of those not using the app in wave 2, 36% reported that they did not own a suitable device, 1% that they were discouraged to use it by their employer, while the rest may be linked with other reasons. The initial enthusiasm to adopt the app was

677 Cresswell, K., Tahir, A., Sheikh, Z., Hussain, Z., Hernández, A. D., Harrison, E., ... & Hussain, A. (2021). Understanding public perceptions of COVID-19 contact tracing apps: Artificial intelligence–enabled social media analysis. Journal of medical Internet research, 23(5), e26618.

678 Akintoye, S., Ogoh, G., Krokida, Z., Nnadi, J., & Eke, D. (2021). Understanding the perceptions of UK COVID-19 contact tracing app in the BAME community in Leicester. Journal of Information, Communication and Ethics in Society.

Country	Study	Methodological approach	Key findings
	data[679]	Wave 2 – Attitudes, trust, mobility, compliance in App usage	higher in urban locations. Older respondents are less likely to be adopters in both waves but not more likely to drop out of usage.
		Wave 3 – Trust, mobility, compliance in App usage	"Those who had concern about the lack of transparent evidence were more likely to drop out of usage." Trust in the UK government was predictive of new adoption in wave 3. Overall concern about privacy is a powerful predictor of non-adoption
	COVID-19 contact tracing apps: UK public perceptions[680]	35 semi-structured qualitative interviews via telephone or online. A researcher-developed interview guide was used. "If interviewees had not heard of contact tracing apps, they were provided with a brief explanation of their purpose and function."	Those who had heard of contact tracing apps, were supportive of the idea of an app to help control the spread of the virus. Interviewees felt the use of an app could help contain the virus. For a few interviewees the potential benefits brought by an app were so great that it was proportional for individuals to give up key liberties relating to being able to choose whether or not to use such an app.
			Interviewees raised concerns about the feasibility and perceived social or practical limitations of contact tracing apps associated with adherence, misuse and behaviour and also about the technicalities and "functionality" of apps.
			Worries associated with infringements of privacy and surveillance. Perhaps because of interviewees' misunderstanding of digital tracing apps as geo-location trackers.
			"Those supportive of suing the app explained away concerns about surveillance by noting that the apps were a short-term measure and for the "common good"."
			"Interviewees wanted more clarity and information about any potential UK app, and the data protection mechanisms that would be in place."
	Citizens' Attitudes to Contact Tracing Apps[681]	Study 1 used an online panel 1504 respondents. Study 2 used a smaller panel (809). During the period of data collection, the UK had no official contact tracing app available for public use.	Study 1: "Across all attributes, respondents do not systematically prefer more privacy. The NHS led centralised system is preferred in 55,94% compared with the centralised system led by the UK government (45,85%) and the decentralised system (47,63%)."
		"In Study 1 conjoint experiment, respondents were	High trust in the NHS strengthens preferences for an NHS-led centralised

679 Horvath, L., Banducci, S., Blamire, J., Degnen, C., James, O., Jones, A., ... & Tyler, K. (2022). Adoption and continued use of mobile contact tracing technology: multilevel explanations from a three-wave panel survey and linked data. BMJ open, 12(1), e053327.

680 Samuel, G., Roberts, S. L., Fiske, A., Lucivero, F., McLennan, S., Phillips, A., ... & Johnson, S. B. (2021). COVID-19 contact tracing apps: UK public perceptions. Critical Public Health, 1-13.

681 Horvath, L., Banducci, S., & James, O. (2020). Citizens' attitudes to contact tracing apps. Journal of Experimental Political Science, 1-13.

Country	Study	Methodological approach	Key findings
		asked to choose one of two COVID-19 contact tracing apps to install, with their data privacy and security attributes varying." "In Study 2, the dependent measure is the respondents' preferred amount of human involvement in the process of COVID-19 contact tracing."	system. "Within centralised systems, trust in the NHS motivates respondents to give up more privacy." "Satisfaction with the government's performance in handling COVID-19 moderated preferences given to a centralised system maintained by the UK government." Study 2: The majority of citizens prefer a mixture between human-led and digital.
	Belief of having had unconfirmed Covid-19 infection reduces willingness to participate in app-based contact tracing[682]	Participants in this study were individuals with a previous healthcare event or encounter. "The data analysed in this study were derived from a single questionnaire that was part of a longitudinal, weekly series implemented at the beginning of lockdown as a direct care tool for patients to keep track of their wellbeing." "The questionnaire used for this study included the addition of a question to measure a participant's willingness to participate in app-based contact tracing."	A total of 12,434 participants included in the analysis. Measuring determinants of willingness to participate in the anticipated NHS app for COVID.19 contact tracing. Overall, 60% would be willing to participate in app-based contact tracing. "Of those who responded no (17,1%), 67,2% stated that this was due to privacy concerns, 21,9% did not have a smartphone, and 10,9% didn't feel able to download the app." Responses for yes and no did not offer significantly by sex or age. "Sex, being tested for COVID-19, receiving a positive or negative test result or awaiting results, and reporting COVID-19 symptoms were not significantly associated with a willingness to participate." "A low understanding of government advice was associated with less willingness to download the app." "Difficulty in understanding government rules around lockdown was strongly associated with being less willing to download the app." "72,4% of those who believed that they had had and recovered from COVID-19 being willing to participate in contact tracing compared to 78,1% who did not."
	Ecologies of Public Trust: The NHS COVID-19 Contact Tracing	Interviews with residents of the Isle of Wight (only location where the first NHS COVID-19 app was trialled). "Interviews asked about interviewees' information-sourcing relating to the app, their decision to download	Most interviewees disagreed that the government had provided appropriate and clear information about the app. "Little access to information about the organisations responsible for the app's development, as well as to information about how exactly the app worked." Despite most interviewees raised these

[682] Bachtiger, P., Adamson, A., Quint, J. K., & Peters, N. S. (2020). Belief of having had unconfirmed Covid-19 infection reduces willingness to participate in app-based contact tracing. NPJ digital medicine, 3(1), 1-7.

Country	Study	Methodological approach	Key findings
	App[683]	the technology, experiences of using the app, perceptions about the benefits and harms, and views more generally about the app and contact tracing more broadly." 15 phone/online interviews. Inclusion criteria: over 18 years old	concerns, most interviewees were still accepting the technology and downloaded the app. "Reasons for not downloading the app included technological limitations and critical beliefs about the app and the UK government." Political trust is important but not essential for App acceptance. "For most interviewees who tended to speak more supportively of the app, tended to speak in more supportive terms about the government." "For a minority who were exceptionally critical of the government's decisions during the pandemic, they were concomitantly worried about the government's handling of the app development." Anxious that the app was being developed by government to control society. Several interviewees described that politicians were not the best individuals to "sell" the app to the public. "Accepting the app became a filtering and balancing process of pre-existing ideas about the UK government with existing knowledge, as well as information from the social networks and social media sites." "Nearly all interviewees were hopeful that the app would bring an end to the pandemic by helping control the spread of the virus." Concept of an app as "a good idea", "a very useful tool" and as a "technological solution".
	Exploring the acceptability of digital contact tracing for UK students[684]	Qualitative research with 22 participants. Usage of mock interfaces of digital contact tracing apps. Two study components: • A short questionnaire covering general background demographics, "Fear of COVID-19 scale", overview if living situation, … • A video interview 11 "home" students from the UK/EU and 11 "international" students from China.	The fear of Covid scale indicated a medium level of concern. Feedback on the mock interface screens: • Data protection: Reluctant to share full movement records or contacts. • Data sharing: Worries about commercial processing and government overreach. • Battery life – a clear issue Most participants found this sort of app beneficial. General willingness of installation. Presenting additional information was a positive thing. Personal protection as reason of supporting contact tracing apps. Civic duty.

683 Samuel, G., Lucivero, F., Johnson, S., & Diedericks, H. (2021). Ecologies of public trust: The NHS COVID-19 contact tracing app. Journal of bioethical inquiry, 18(4), 595-608.

684 Murray-Rust, D., Soares, L., Gorkovenko, K., & Rooksby, J. (2022). Exploring the acceptability of digital contact tracing for UK students. arXiv preprint arXiv:2201.08650.

Country	Study	Methodological approach	Key findings
			App as a part of a pathway towards a better quality of life. Concerns about digital contact tracing: Bluetooth and battery life. Daily notification could feel stressful (as reminders that the app was working in the background). Privacy issues. Lack of trust in data use and functioning. Reasons for uninstalling the app: "if Covid was finished", concerns relating to security, usability, privacy and trust. Many people understood self-isolation as a part of their civic or moral duty, after receiving such an instruction from a contact tracing app.
Cross-country comparison	The Roles of General Health and COVID-19 Proximity in Contact Tracing App Usage: Cross-sectional Survey Study[685]	Respondents aged between 18 and 70 years from Spain, Italy, Germany and the Netherlands. Data were drawn from the LWCV survey, filled out by web respondents. Collects data about family structure, COVID-19 testing, self-perceived health status and depressive and anxiety symptoms. Contains also questions about individuals' willingness to use a COVID-19 tracing app.	Respondents who supported contact tracing apps: Italy (50,2%), Spain (37%), Germany (16,2%) and Netherlands (17,8%). Higher willingness in using a contact tracing app: older individuals, partnered individuals who also live in the same household, individuals with medium and high levels of education. "Individuals who are not active in the labor force and those who lost their job or income during the COVID-19 pandemic are less likely to use a contact tracing app." "In Italy the most important socioeconomic factors are labor market status and urbanicity." "In Germany, individuals who recently experienced a job loss or income loss are less likely to use a contact tracing app than employees." COVID-19 proximity: all COVID-19 proximity factors (especially having contracted COVID-19, exhibiting depression, anxiety symptoms, being tested) had significant positive associations with respondents' support for a COVID-19 tracing app. The relationship between COVID-19 proximity and the willingness to use a COVID-19 tracing app varied across the four countries. "Having a family member who has ever contacted COVID-19 was the only indicator that yielded a significant positive marginal effect on contract tracing support across all countries." Poorer health statuses are associated with significantly higher support for COVID-19 contact tracing apps.

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