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THE SYSTEMIC DIMENSION OF SUCCESS (OR FAILURE?) IN THE USE OF DATA AND AI DURING THE COVID-19 PANDEMIC. A CROSS-COUNTRY COMPARISON ON CONTACT TRACING APPS*

by Margherita Russo, Claudia Cardinale Ciccotti, Fabrizio De Alexandris, Antonela Gjinaj, Giovanni Romaniello, Antonio Scatorchia, Giorgio Terranova

During the Covid-19 pandemic, public attention turned to contact tracing apps as a possible solution to the spread of the virus. Many countries have moved in this direction, thereby adopting contact tracing apps while respecting personal data protection. EU countries also adhered to a number of fundamental principles: voluntariness, interoperability, regulatory coverage, purpose specification, minimisation, transparency, protection, security, and timeliness. In spite of timely public policy efforts, tracking apps have not been a success in many countries, and it seems appropriate to open a reflection on the unsuccessfulness of a public policy that has resolutely supported the use of digital technologies for public utility purposes.

Durante la pandemia da Covid-19, l'attenzione pubblica si è rivolta alle app di tracciamento dei contatti come possibile soluzione alla diffusione del virus, e molti Paesi si sono mossi in questa direzione. Nel rispetto della protezione dei dati personali, i Paesi dell'UE hanno aderito a una serie di principi fondamentali: volontarietà, interoperabilità, copertura normativa, specificazione dello scopo, minimizzazione, trasparenza, protezione, sicurezza e tempestività. Nonostante i tempestivi sforzi delle politiche pubbliche, le app di tracciamento non sono state un successo in molti Paesi, ed è quindi opportuno aprire una riflessione sull'insuccesso di una politica pubblica che ha sostenuto con decisione l'uso delle tecnologie digitali per scopi di pubblica utilità.

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This paper proposes a comparative analysis of nine OECD countries: Australia, France, Germany, Ireland, Italy, New Zealand, Russia, South Korea, and Spain. It outlines the specific factors in each country's public policy that made the use of tracking apps possible. In terms of policy design, it deals with: objectives, instruments, public procurement selection criteria, resources, and the context in which the policy was implemented. The paper focuses on three lessons learned from the comparative analysis: the privacy paradox, the choice of a public interest technology, and the systemic interweaving that the implementation of a public policy must consider to enhance the effectiveness of a public interest action.

Keywords: STI policy, big data, Covid-19, privacy, app, information, users, contact tracing, developers, Australia, France, Germany, Ireland, Italy, New Zealand, Russia, South Korea, Spain.

Il presente articolo propone un'analisi comparata su nove Paesi dell'OCSE: Australia, Corea del Sud, Francia, Germania, Irlanda, Italia, Nuova Zelanda, Russia e Spagna. Delinea i fattori specifici della politica pubblica di ogni Paese che hanno reso possibile l'uso delle app di tracciamento. Vengono presi in esame: obiettivi, strumenti, criteri di selezione degli appalti pubblici, risorse e contesto in cui la politica è stata attuata. L'articolo si concentra su tre lezioni apprese dall'analisi comparativa: il paradosso della privacy, la scelta di una tecnologia di interesse pubblico, e l'intreccio sistemico che l'implementazione di una politica pubblica deve prendere in considerazione per migliorare l'efficacia di un'azione di interesse pubblico.

Parole chiave: politica in materia di scienza, tecnologia e innovazione, *big data*, Covid-19, privacy, app, informazioni, utenti, tracciamento dei contatti, sviluppatori, Australia, Corea del Sud, Francia, Germania, Irlanda, Italia, Nuova Zelanda, Russia, Spagna.

1. Introduction and context

During the Covid-19 pandemic, public attention turned to contact tracing apps as a possible solution in collecting and using information to contain the spread of infections (WHO, 2020). At the onset of the pandemic, there was already extensive evidence on the potential effectiveness of contact tracing in reducing contagion[1] and – when complemented by selective measures of moderate physical distancing and self-isolation – in mitigating the impact of the pandemic on economy. Its inherent criticality on the rate of uptake[2] and on individual data collection was immediately pointed out (Kwok *et al*., 2019; Galeotti *et al*., 2020; Prettner *et al*, 2021)[3]. With regard to individual data collection (Kende, 2020), Snower (2020) points to the need to equip individuals with digital property rights (Snower, 2020), as embraced by EDPB's guidelines on tracking apps (EDPB, 2020).

The interest aroused by the success in some countries – Singapore (OPSI, 2020) and South Korea in particular (Shendruk, 2020) – has promptly fuelled the expectation in other countries that an effective solution essentially required an appropriate technology, a population willing to be tracked[4], and a public policy that activated tracing as an

[1] Scientific papers provide data on its effectiveness for contagion reduction (Kwok *et al*., 2019; Braithwaite *et al*., 2020; Prettner *et al*., 2021). Sun and Viboud (2020) build their conclusion on the SARS-CoV-2 experience in Shenzhen and other settings. Plank *et al*. (2020) present an age-structured branching process model of the transmission of Covid-19 in different settings to estimate the potential of manual contact tracing and digital tracing systems to help control the epidemic. A brief history of pandemics is given in Baldwin (2020), as drawn from Baldwin and Weder di Mauro (2020).

[2] Based on an extensive review of studies of automated or semi-automated tracking of infections in various epidemic contexts (Ebola virus, SARS, and MERS), Braithwaite *et al*. (2020) conclude that automated tracking apps are effective when there is high uptake (56-95% of the population).

[3] Applying mathematical models of transmission at the individual level, Kucharski *et al*. (2020) find that automatic tracking apps are less effective than manual tracking (47% versus 57%), but have obvious speed advantages in collecting results that could therefore support reduction of infections through selective measures of moderate physical distancing and self-isolation.

[4] For example, the survey conducted by Milsom *et al*. (2020) in Italy, France, Germany, and the United Kingdom

integrated programme in the contagion containment plan. The fact that things were more complicated than expected was observed by various authors as early as the summer of 2020. Among them, van der Leeuw (2020) opens with the general theme of information in addressing measures to contain the pandemic; a contribution proposed by Savona (2020) highlights, on the one hand, the criticality inherent in the very idea of a technological solution for the collection of infectious tracking information without a social context aligned to the solution, and, on the other hand, the need to open a critical discussion on the main technological players involved in the development and use of tracking apps, namely Apple and Google.

The opportunity to resort to the use of tracking systems to stop the spread of secondary infections has fully entered the scientific as well as media debate, leading many countries to commit themselves to their adoption. According to Bending Spoons, who developed the Immuni app adopted by Italy (Immuni, 2021), there have been numerous questions raised by citizens with regard to privacy, an issue that was immediately grasped by the European Data Protection Board (EDPB) (EDPB, 2020), which promptly highlighted the need to field "modern techniques" for the fight against Covid-19 "in the interest of humanity", also highlighting the necessary respect of all human rights, even in emergency contexts, not least those related to the sphere of individual privacy, as expressly protected by the same Charter of Fundamental Rights of the European Union (Articles 7, 8, and 52) (European Union, 2016). Moreover, it was on this basis and in consideration of the other specific European disciplines on the protection of personal data that the fundamental principles that the EU Member States should have complied with were first identified and then better specified: voluntariness, interoperability, regulatory coverage, clarification of the purposes, minimisation, transparency, protection, security, and temporariness (EDPB, 2020).

In this paper, we build on these premises and, in addition to what has already been discussed in other contributions (see, in particular, Savona, 2020), we focus on the relevant dimensions in enhancing the success of a public policy that supports the use of contagion tracking apps. The case study on this science, technology, and innovation (STI) policy concerns a significant innovation, not so much for the specific technical solutions proposed by developers in the various countries, but for the objective of their use – a social goal whose importance has been accelerated in a period of a few months – and for large-scale adoption for public utility purposes.

The target for success of contact tracing apps was assumed to be an uptake of at least 56% (Sun and Viboud, 2020; Braithwaite *et al.*, 2020; Wynants *et al.*, 2020), but most countries were far below that minimum threshold. What were the causes of such a failure? By comparing data from 13 countries, Sussman (2020) rejects a common explanation that associates the low use of apps with the lack of trust in the Government. The evaluation document of Canada – the only country for which evaluation of the policy is available –[5] describes differences across provinces, and relates the flop of the policy to its implementation (Canada, 2020; Government of Canada, 2021). A cross-country analysis

in March 2020 showed that the appreciation rate towards the tracking app solution would have been very high, i.e., over 80%. See a summary in Blasone and Nosenzo (2020).

[5] With respect to the United Kingdom, the Alan Turing Institute (2020, p. 2) reports an extensive reflection "to capture the successes and challenges experienced by the UK's data science and AI community during the Covid-19 pandemic, and the community's suggestions for how these challenges might be tackled", but no critical analysis on the implementation in the United Kingdom of automatic tracing of contagion was available at the time of the publication.

of the reasons behind the low use of contact tracing apps is then of considerable interest, even more so today, when countries with a higher vaccination rate are starting to contain the spread of the infection, with tracking apps that will be able to identify and contain specific outbreaks.

The essay offers a comparative analysis on innovation policies supporting the adoption of contact tracing apps in nine member countries of the Organization for Economic Co-operation and Development (OECD): from France, Germany, Italy, and Spain, among the countries in Europe most affected by the virus, to Ireland, which has one of the highest uptakes in Europe. Australia, New Zealand, Russia, and South Korea, have been identified as a reference to non-European countries that have used different systems and methods for tracking. To contextualise the patterns of adoption of tracking apps (download and use) and to enhance the potential that these technologies will have in the next phases of containment of the pandemic, it is appropriate to consider the changed scenario of the spread of infections, which was made initially possible by the practices of containment of social interactions that limited mobility and economic and social activities and by the administration of vaccines.

The structure of the paper is as follows: Section 2 outlines a longitudinal cross-country perspective on the changes that occurred during the pandemic; Section 3 presents the sources of information and data used in the comparative analysis; Section 4 describes the main features of the contact tracking apps that characterise the nine countries; Section 5 concludes with three main lessons learned from the comparative analysis, while Section 6 outlines possible developments of the analysis. Annexes are available at: http://hdl.handle.net/11380/1256823.

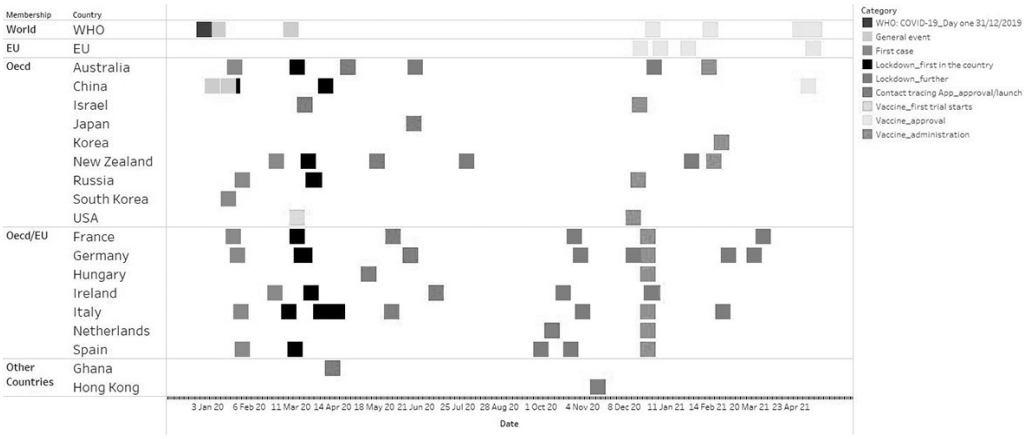
2. A longitudinal perspective: December 2019 – June 2021

The announcement by the World Health Organization (WHO), of the spread of the Covid-19 pandemic was accompanied by strategic indications on the containment of infections: hygiene rules, social distancing (then implemented through lockdown measures of entire cities, regions, and countries), diagnostic tests, therapies aimed at combatting acute manifestations, and development of medical technologies for assisted breathing. These appeared in many of the countries affected by the pandemic at different times as the intensity of the phenomenon increased. Vaccine research was the field of action on which many specific resources were concentrated in countries that had research capacities and production centres of pharmaceutical industries. The international scientific community has achieved results that were unthinkable under normal conditions. Suffice it to say that, in tackling the race against the pandemic, an open-access collection of documents relating to the Covid-19 virus and of online interrogation tools for digital documents in text format was created from scratch (Lu Wang *et al.*, 2020)[6]. In March 2020, the US medical library launched the largest open-access initiative ever, involving researchers

[6] The conference organised by OECD-WPTIP (Working Party on Innovation and Technology Policy) on "Open data and AI analytics in times of Covid-19: the CORD-19 initiative" (30 November 2020) documented the potential of a change of mindset with respect to open access, particularly in the contributions to the conference by Jerry Sheehan (Deputy Director at the National Library of Medicine – National Institutes of Health), Kathryn Funk (Programme Manager for PubMed Central at the US National Library of Medicine), and Sebastian Kohlmeier (Senior Manager of Programme Management and Business Operations at the Allen Institute for AI (AI2)).

from all countries. Significant publishers of scientific journals have signed an agreement to share their publications in text format; Google provided the query platform, and developed the text query algorithms. In two months, the scientific community had access to the information already available with *ad hoc* interrogation tools: an unprecedented collaborative effort that supported the intensification of the activity of scientists in academic research laboratories and pharmaceutical industries, and had great results in the development of vaccines. Just think of the very short time interval between the WHO announcement of the start of the Covid-19 epidemic, and the start of the Moderna trial, just four months later: a record so extraordinary that it can be compared to the moon landing (Sky TG24, 2020).

Figure 1. Activation of the use of contact tracing apps, lockdowns, launch of vaccine trials, and general events



Source: authors' elaboration from various sources[7].

Figure 1 shows the series of events that took place from 31 December 2019 to 9 June 2021 for various countries. The information collected makes it possible to outline – for the countries in question – a longitudinal perspective on the information taken into consideration. The narrative unfolds along four themes: general information on the pandemic and the first case declared in each of the countries, the lockdowns, the adoption of tracking apps, the launch of the first trial of a vaccine against Covid-19, and the initiation of large-scale vaccinations.

Five phases are evident: the announcement of the pandemic, and the reporting of case 0 (or case 1) in each country were followed by the first series of lockdown decisions. Within a few months, all countries launched the use of tracking apps, which, as we have seen, have had a moderate or low level of use, and in the third phase the countries all proceeded with

[7] Data source is available in Annex 2 online.

subsequent lockdowns, which are aimed at containing infections in regions or areas, thus making it possible to limit outbreaks.

A year after the WHO announcement on the new Coronavirus, there was a series of vaccine approvals. In EU countries such as France, Germany, Italy, Spain, the Netherlands, and Hungary, 27 December 2020 was chosen as the symbolic date on which the first vaccine was administered. The USA, Russia, and Israel preceded Europe by a few days: 15, 19, and 20 December, respectively. In February 2021, several countries, such as Australia, Japan, New Zealand, South Korea, and Hong Kong, began their vaccination process.

3. Information available and data sources

The countries considered in this comparative analysis allow us to have a first reference framework of the determinants and specific social and institutional features that have characterised the European and non-European context in the use of a contact tracing technology to contain the spread of the pandemic contagion. The cross-country comparison of the implementation of the contact tracing apps refers to countries with different economic and demographic characteristics that may have affected the capacity and speed of response to the emergency in healthcare: the size of the countries, the resident population, the growth rate of GDP, and the deficit of the individual countries may have been a source of factors limiting or facilitating the effectiveness and speed of the fight against the pandemic.

Following Sussman (2020), the paper then explores other dimensions that were pointed out as critical in the implementation of automatic tracing, namely privacy and communication.

If the problem was privacy, we need to understand how the different apps dealt with it. The analysis therefore concerns the technological aspects that characterise the different apps, but also the context of choice of technology by the policy maker (skills of the suppliers) and funds assigned to the policy. In order to assess whether different adoption rates are influenced by communication, we compared advertising campaigns and their timing to the stages of contagions. In the descriptive analysis, we focus on technological features of the various apps: when and who developed them, on behalf of whom they were developed, where (place and company/startup/research centre) they were developed, whether development has received public funding, and, if so, how much.

So as to evaluate whether different adoption rates are influenced by communication, we analyse when the apps came into operation, data on their use, public information, and advertising campaigns. Scientific research accelerated data analysis on the pandemic and the production of vaccines and tests. We have no data yet on the effects on the public, of communicating the results of scientific research during the pandemic, but results from field experiments conducted by van der Bles *et al.* (2020) show that it is not true that communicating the uncertainty that is inherent in scientific research reduces public confidence about science. So, it would seem that the problem is not one of communication *per se*.

For each country, other than specific sources of information, we integrate two main data sources: Norton Rose Fulbright (NTR, 2021) and the public database Covid Tracing Tracker, created by O'Neill, Ryan-Mosley, and Johnson (2020), available on the *Technology Review* website of the Massachusetts Institute of Technology (MIT).

Norton Rose Fulbright (NTR, 2021) allows us to consider some of the countries analysed in our work – Australia, France, Germany, and Russia – regarding three areas: how the Government of each country has acted to monitor and control the spread of the virus through the use of tracking technology; the main problems related to the use of this technology; and a detailed description of the main contagion tracking apps. With reference to Australia and Germany, we integrated the information – on the characteristics of the technological platforms used and on the policy decisions – drawing on De Michele (2020). Other sources were also scrutinised for a broader picture of South Korea, New Zealand, Ireland, and Spain.

As for the Covid Tracing Tracker, the main motivation that prompted the US media company to undertake the project of public collection of information on contact tracing lies in the vast proliferation of apps available globally as a result of the pandemic, and the relative difficulty of finding comprehensive official information about their applications. To build the database, O'Neill, Ryan-Mosley, and Johnson (2020) used government sources, news outlets, and interviews directly with application developers to understand the technologies and policies involved[8]. Although it provides useful information for international comparisons, the database Covid Tracing Tracker does not cover information on South Korea, Russia, and Spain.

Detailed information by country is available in Annex 1 online.

4. Contact tracking apps used in nine countries

In this section, we first describe the contact tracing technologies and who were the developers in the nine countries under analysis, then we present the results of the comparative analysis (details in Annex 3 online).

How contact tracing apps work

Contact tracing apps differ primarily in information management. The "centralised" type apps (Pan-European Privacy-Preserving Proximity Tracing – PEPP-PT – type), in which the data are consolidated in a system, and removed from the peripheral devices, differs from the technological infrastructure developed and made available jointly by Apple and Google (A/G platform), in which repositories and data retention are managed by the same smartphones, according to a solution considered "decentralised" (Decentralised Privacy-Preserving Proximity Tracking – DP-3T – and A/G solution), in which all or almost all of the data remain on personal devices[9].

Concerning the tracking technologies and information management, we found that Australia, France, New Zealand, and South Korea have adopted apps that use different data transmission technologies (Bluetooth, A/G, and QR codes), though with centralised information management; Germany, Ireland, Italy, and Spain have

[8] For each country, in addition to the name of the tracking app used, the following information is shown: who the developers are, the number of users, the penetration and the penetration target of the app in terms of percentage of users on the total population, the type of technology used, whether or not citizens have the right to choose about the use of the applications, whether there are limitations on how the data are used, whether the data will be destroyed after a certain period of time, whether the app collects only the information it needs to operate efficiently or whether it collects additional information to what is stated, whether the user's true identity is anonymised or not, whether a decentralised or centralised architecture is adopted, and, finally, whether the application has been launched or not.

[9] See Savona (2020) for a summary of these technologies and the implications for privacy.

instead chosen technologies with Bluetooth data transmission and A/G protocol with decentralised data management; no information was found on the technology of the app adopted in Russia.

Who are the developers? Identikit of a competence network

Overall, the development of tracking apps has put in place a network of skills that embraces software developers (both giants of the calibre of SAP, and small companies such as Webtek), telecommunications companies (such as Orange in France, and Deutsche Telekom in Germany), academic researchers working in many fields, university spin-offs, and civil hackers. In the world of software developers, new skills are pooled around young developers, with high international mobility, as in the case of Bending Spoons (the developer of Immuni in Italy). In the field of academic research, consortia have been created for the development of strategic research alliances with private companies. In some cases, the app has been designed for non-profit purposes (Australia and Italy), while in the other cases it is a public contract, although the terms of the contracts are not easily available.

Comparative analysis of the implementation of policies for the use of infection tracking apps

In addition to the technologies that characterise the tracking apps used by the nine countries, the comparison proposed in this paper covers four main dimensions of the policy implementation of the tracking apps.

i) Selection of the app, resources, management, and regulation about the information collected

Implementing the tracking app policy primarily involves how the app is selected. The Italian Government has launched an open call to select the developers. Governments in France, Germany, and Ireland have relied on a company or coalition of companies in charge of development. The public resources invested for their use and maintenance are clearly identifiable only for Germany. For the other countries, we have not been able to trace that information.

Using the categories proposed by O'Neill, Ryan-Mosley, and Johnson (2020), the policies associated with the use of apps have been classified according to five main characteristics of information management and regulation. With the exception of South Korea and Russia, the comparative results highlight that: all the apps require a user's explicit consent and a person can choose not to use it without negative effects; policies are in place to ensure that tracking does not survive specific use to combat Covid-19; technology and policies ensure that data are deleted when they are no longer needed for public health purposes; user identification is masked or anonymised; policies exist to ensure that only necessary information is collected; sharing data with external entities is prohibited; Government and technology are transparent about what data are acquired, from where they are acquired, how they are used, and who has access to them.

ii) Integration of the information collected

Regarding the integration of the information collected through the tracking app associated with the health system, we did not find information relating to France, Germany, Ireland, and Spain. We have found that, in Australia and Italy, there is an integration with the local health system, while in New Zealand, Russia, and South Korea, the central Government manages the information directly, also in concert with the health authorities. The levels of integration, where present, are considered poor.

iii) Communication and information campaign

Regarding the characteristics of the information campaigns implemented in the nine countries, we currently have found information only about Italy. The campaign had the following objectives: to promote the use of Immuni and to contribute to the increase of downloads; to inform people about the functioning, usefulness, safety, and reliability of Immuni; and to promote a sense of personal responsibility and belonging to the national community. Promoted on TV, press, radio, and social media, the campaign lasted four months in 2020, divided into three phases: the launch in June, a maintenance phase in July-August and early September, and a third phase in the autumn. The coordination of the campaign, both for creativity and for planning, was handled by Groupe Publicis (a French multinational marketing and communications company also based in Italy), which made teams and resources available completely free of charge, coordinating a real alliance among the media involving RAI, Mediaset, Sky, Apple, Google, Facebook, Mondadori, ItaliaOnline, Il Messaggero, RCS, Gedi Group, public figures, startups, and companies. The continuity of the information campaign ended precisely in the acceleration phase of the infections, i.e. autumn 2020, in a context in which the opposition parties of the Government declared themselves opposed to Immuni, or simply claimed they would not download it, while the parliamentarians of the ruling coalition (and Forza Italia) were instead generally in favour; some of them showed that they had downloaded and activated it on their smartphone, inviting everyone to do so.

iv) The citizens' response

The response of citizens of different countries to the use of tracking apps can be summarised by the data available in the database by O'Neill, Ryan-Mosley, and Johnson (2020): the percentage of use concerns about 26.6% of the population in Australia, 26.3% in Ireland, 21.7% in Germany, around 16.2% in Italy, and just 3.3% in France. Data are not available for New Zealand, Russia, South Korea, and Spain.

5. Lessons learned and further developments of the analysis

The aim of contact tracing apps was outlined by WHO (WHO, 2020) as a means to contain contagions. Despite the use of apps in many countries, there seems to be no evidence to date that they have had an effect. Even in countries such as Iceland, which as of 6 October 2020 registered about 40% of citizens (however insufficient) with the application downloaded, or Switzerland, where more than 1.6 million people on a population of 8.5 million use SwissCovid, tracking showed no performance that could be used as a model for the other countries.

The fact that the effectiveness of tracking is inversely proportional to the number of infections seems to be a relevant issue. Now that vaccines are supporting the challenges of further variants in many western countries, apps could become useful for tracking them and for controlling the contagion with complementary measures of self-isolation, a condition that calls for attention to the importance of public investments in the use of this technology and to the need to integrate data on hygiene and surveillance with socio-economic data.

The comparative analysis proposed in the paper suggests that some conditions seem to explain the failure of those policies. In these concluding remarks, we propose three main lessons learned concerning: *i*) the privacy paradox; *ii*) the choice of a technology of public interest; and *iii*) the systemic intertwining of these, which the implementation of a public

policy must take into account so as to enhance the effectiveness of an action of public interest.

Lesson 1 – The paradox of privacy, and the social dimension of technology

The main similarities between countries do not lie in the technical features of the applications – often also connected to Apple and Google as seen in Germany, Italy, and Spain – but in the reception that the population has reserved for such a policy strategy. Distant or culturally unrelated countries have encountered similar difficulties on the part of citizens in accepting the use of tracking apps, with political interventions that have negatively influenced public opinion often even before the apps became downloadable.

As to the EU and non-EU countries that we have examined, all countries have based the tracking software on a mandatory rule: the right to the protection of privacy, which in the EU is governed by Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 (General Data Protection Regulation, GDPR), specifically for Covid-19 data (EDPB, 2020). As obvious as it may seem, it is actually a very strong signal of the shared interest in keeping individual movements anonymous. Yet, social networks, which often track the location of the mobile phone, or of digital payment means, which track activities in precise ways, both spatially and temporally, are widespread today, with no concern on the privacy issue being expressed by the majority of individuals. So why do people care so much about the privacy level of a contact tracing app when our data are continuously transmitted from cloud to cloud around the world? The explanation seems to reside in the different point of view people have with regard to social media and the market sphere (closely connected), on which they seem to rely without hesitation as users/consumers, and the sphere of the state intervention, which citizens seem to regard with distrust. This is "a privacy paradox". Big companies have modelled social media and consumers' confidence without transparency in their actions. Democratic Governments, as in Europe, have regulated the privacy issue in a transparent way, but have failed to create consensus on the collection and use of individual data. Companies use information to outline the profile of the social/consumer/user with the goal of increasing the profits deriving from advertising for commercial purposes (for a critical analysis on this issue, see Trzaskowski, 2021). The Governments could use the information to control citizens, knowing what they do and where, even in relation to domains that do not concern a pandemic, but other spheres of private life. Although such control can be approved when criminals are being controlled, the mere idea that everyone could end up under that control widens distrust of tools that offer individual data to the State[10].

An interesting exception to citizens' hesitations over the use of tracking apps seems to be Czechia, which has employed Smart Quarantine, as designed by geo-locating credit card movements to create "memory maps" with places where an individual has spent their time in the past five days, and who they have come into contact with (Santaniello and

[10] This sensitivity is by no means new. One of the most striking events that caused discussion in this sense was the massacre in San Bernardino, California, on 2 December 2015, when two people, husband and wife, entered the Inland Regional Center, a social centre for people with disabilities, and opened fire, killing 14 people, and injuring dozens. That event shook the West, not only because of the Islamic matrix – which is met with strong feelings in the USA after 9/11 –, but also because Apple refused to create and deliver to the US Department of Justice the software needed to decrypt the passwords of the mobile phones, with the goal of finding in those mobile phones more information on the two criminals. That software would have allowed for the unlocking not only of that particular iPhone, but theoretically of all of them, making the US Government essentially free to use the data of about 50% of Americans, plus other users of the Apple brand around the world (Canu, 2020), for a total of about 1.5 billion potential devices (Migliorino, 2020).

Martini, 2020). Similarly, Israel uses its Shield to track and combine the different positions to then report any quarantines.

While accepting that their personal data are under the control of internet companies, most citizens seem unamenable to sharing their data for the public interest. We argue that the privacy paradox[11] deserves special attention with respect to conditions for dialogue in order to inform citizens and to build a sense of collective interest in objectives that require individual commitment to be fully achieved, but also paves the way to "digital property rights", as Snower calls them (2020), thus endowing individuals with the property rights in relation to the digital information concerning them.

The overall issue is addressed in terms of "democratic compromises and digital surveillance" (OECD, 2021), but it would be useful to analyse the privacy paradox from a slightly different standpoint. If we were merely rational beings, we would take every measure available to preserve ourselves, including using an app that tells us whether we have come into contact with positive people; what makes us so unwilling to download a contact tracking app necessary to contain the spread of the pandemic? We are talking about an app that is born, serves, and is linked to a context of strong negative feelings: fear, anger, sadness, and anxiety. In the short term, it offers – with respect to those basic functionalities – no individual benefit. It is thus not surprising that the different contact tracking apps have turned out to be a little-used tool viewed with distrust.

A public policy that invests in tools such as the tracking app to contain contagions should therefore accompany public action by creating the necessary conditions to discuss, inform, and build a sense of collective interest on objectives that require a particular commitment to individual behaviour in order to be achieved. Achieving this result requires adequate tools that have an impact not only on communication in general, but also on the participation of citizens in undertaking individual decisions for a collective interest (Bonifati, 2021). The commitment of citizens must be nurtured in normal times to be effective even in emergencies, as also demonstrated by the field experiment conducted by Pancotto's research group on citizens' participation in seismic emergency contexts and different social propensities to participate (Pancotto and Righi, 2021). Enhancing citizens' commitment requires new narratives (Costa-Font, 2021) and new practices that involve the community and civil society as essential components of social transformation, as Bowels and Carlin argued (Bowels and Carlin, 2020).

A complementary way to incentivise the individual use of a contact tracing app is to limit users' freedom of daily life, such as access to shops and malls or to cultural and recreative activities. Although a holistic policy would remain a reference for those measures, such incentives leverage on the consumer sphere, and regulation would be essential to increase the timely adoption of tracking apps (Sussman, 2020). This might have a short-term impact, but it does not address the necessary shift of individual behaviour towards a collective goal: an investment that social institutions (not necessarily the State) should foster for many collective goals to be achieved (Bonifati, 2021), such as the United Nations Sustainable Development Goals (UN SDGs) entering the agenda of most countries for the post pandemic recovery.

[11] With respect to the consumption sphere, Chen *et al.* (2021, p. 1) refer to the "data privacy paradox" specifically as "a general disconnect between consumers' self-stated privacy preferences and their actual privacy-seeking behaviour", a phenomenon that, in this paper, we consider for the implications beyond the consumption sphere.

The privacy paradox is then not only a matter of technology and regulation; it highlights that the social dimension of technology is just as important as the strictly technical dimension.

Lesson 2 – How do policy makers choose a technology of public interest?

If the social dimension we discussed above is central in implementing a public policy, so is the technical dimension concerning the competence network it relies on. The substantial differences in the tracking apps adopted by the countries examined concern the information transmission technology (Bluetooth, QR codes, A/G, and GPS) and the information collection technology (decentralised or centralised). Countries have adopted different approaches in the selection of the apps, with respect to both the technology to be adopted and the network of competence to rely on. Australia was the only one of the analysed countries to use an app developed by academic researchers from several internationally renowned institutes, including the University of Queensland (Australia), the University of Auckland (New Zealand), MIT (USA), and the Delft University of Technology (Netherlands). The rest of the countries have relied on private companies. France and Germany have selected the national reference company for the development of the app; indeed, whilst TousAntiCovid was developed with the French telephone operator Orange SA and the French public search system of INRIA, the German Corona-Warn-App was developed by SAP and Deutsche Telekom. The Italian Government has instead launched a selection open to many alternatives, including an app created by Bending Spoons, a mobile phone app development company. The Irish Government has relied on Near Form in collaboration with Apple and Google. Similarly, the Russian Government said it availed itself of the collaboration of Apple and Google to develop the app. In South Korea, New Zealand, and Spain, input from their respective Governments was essential: in South Korea the tracking app Corona 100m was developed by the Ministry of the Interior and Security, in New Zealand the Ministry of Health intervened, in Spain the Ministry of Economic Affairs and Digital Transformation did.

A public policy that uses data collection and analysis technologies for public purposes, as in the case of the data necessary for tracing infections, makes specific choices that orient public procurement towards technological solutions that are based on the enhancement of skills that exist in the country, or attract skills that exist in other countries. In the current political and economic context, in which the technological sovereignty of a country returns as a central element of public policies – also in Europe (Edler *et al.*, 2020; Darnis, 2020; European Commission, 2020; VDE, 2021) –, the question of the choice of technology for a public need requires a reflection on the choices underlying the creation or consolidation of national competencies in countries, which go beyond the contingency of this pandemic. For example, does Italy have the same skills as France or Australia, and could it have activated them quickly?

Therefore, the choice of a technology of public interest calls for a reflection on the choices of consolidating or creating new internal competencies in countries, an issue that goes beyond this pandemic.

Lesson 3 – How important are interconnections for the success/effectiveness of policy implementation?

In order to be effective, a public policy that uses data collection and analysis to address

an issue of collective concern must outline the relevant direct, and possibly indirect, interconnections.

A first area, which might seem essentially technological, concerns precisely the compatibility with the mobile devices necessary for data collection. In various countries, many potential users could not use the contact tracking app due to software incompatibilities, such as Portugal, where almost 10% of the population does not have a device compatible with the reference app (Adnkronos, 2020). A technological development is not the best one if it does not consider users' characteristics, such as the structure of the population in terms of income, and propensity to consume digital products.

Another interconnection concerns an infrastructure aspect: the intertwining between a technology – destined to tackle a health problem – and the health system, with which the tracking app must enter into dialogue for effective transmission and recording of the data. We have not been able to find adequate documentation to develop a reflection on this issue, which we intend to deepen with direct interviews with public organisations in the health system in different contexts. In Italy, health is a constitutional right guaranteed by the national health system with organisational autonomy on a regional scale. This decentralisation impacts in different ways the adoption of an app that is designed regardless of those specificities, including the absorption/processing/integration of the collected data for health surveillance. Such an area of reflection deserves special attention if the tracking app is to be used in the exit from the pandemic.

Another issue that impacts the effectiveness of adopting a technology concerns the information campaign: no adequate evidence could be found regarding this issue. In Italy, the advertising campaign, which was made possible by the voluntary effort of a large group of private actors (from both the media and the software development sector) had a modest temporal coverage, leaving the field when the difficulties of downloading the app and its functioning would have required a specific commitment of information. The theme of public communication, therefore, returns as an issue that cannot be separated from the implementation of a policy, intertwining success/effectiveness not so much with the technology that has been chosen, but with its adoption, which must be supported with specific social actions beyond the media.

Last but not least, there is the issue of resources allocated to the implementation of the policy. The fact that we were only able to find information for Germany may indicate the difficulty of accessing that information, which should also be in the public domain. The number of resources invested monthly by Germany for the maintenance and development of its tracking app – around 3 million € per month (Brady, 2020) – should make it clear that the digital world has a material dimension (of specific goods and services) that is often overlooked by decision makers: public policies that rely on the use and analysis of data do require investing additional resources once the software application has been developed.

6. Discussion and further research developments

In June 2020, the contribution of the scientific advisors of the European Commission on the Covid-19 pandemic clearly outlines the critical issues that policy makers will have to address: knowing the virus and its causes, managing the pandemic for its health aspects, supporting the development of vaccines, implementing measures to counteract the economic and social effects of the pandemic, and understanding the complexity and

uncertainty of the crisis (European Commission – Directorate General for Research and Innovation *et al*., 2020). Although complexity and uncertainty make it difficult for everyone (scientists, policy makers, and the public) to delineate what actions to take, the advisors point to five directions: addressing complexity with a multidisciplinary approach; sustaining public trust by offering arguments on the different positions (it is not enough to "follow the science", but to understand the uncertainties of science to design appropriate policies and to communicate them well to citizens); acting on uncertainties concerning the legal and ethical dimension; simple messages are not suitable in a complex situation, and it could be difficult to define effective messages in counteracting fake news and manipulation by political figures or celebrities; and science should not be used to cover the choices of policy makers.

In this framework, the nexus among science, public policy, and communication is clear. The case of contact tracing apps makes evident that it was in the implementation phase that the difficulties encountered by the measures of containing infection through the use of tracking apps have played out. A systemic perspective, which would not be new in the analysis of science, technology, and innovation policies[12], can support more effective policy recommendations grounded on analyses of multilevel interactions and feedback loops in policy implementation (Browne and Wildavsky, 1984; Geyer and Rihani, 2012; Gray, 2015; Hjern and Porter, 1981; Tenbensel, 2015).

An important aspect of policy implementation concerns the possibility of accompanying the optimal measure with other measures. While automatic tracking on a systematic scale would provide the optimal solution for controlling the spread of the pandemic, other information could be used to encourage targeted actions supported on a voluntary basis (Mesnard and Seabright, 2020) on segments of the population that pandemic epidemiological studies indicate as more vulnerable due to their characteristics (age, household size, employment status, etc.)[13], family ties (Di Gialleonardo *et al*., 2020), or previous health conditions. Testing for the virus could be encouraged on these groups, on a voluntary basis, with isolation of positive cases[14].

Here, we enter the issue of using data for epidemic analysis, individual actions on a voluntary basis, and measures that require systemic interventions designed in collaboration with the health system, as observed also by Plank *et al*. (2020). An excellent example of the virtuous circle that can be fuelled by such dynamics has been enhanced in Australia with a focus on the integration of data from different sources with different levels of granularity, creating a protocol to optimise information sharing of health data while protecting privacy and confidentiality, named "differential privacy" (Dyda *et al*., 2021). A first use for health purposes in Australia is the development of a proof of concept dedicated to making data access and queries effective for multiple users (from general practitioners to policy makers).

The multilevel interaction and cross-disciplinary analysis advocated also by the scientific advisors of the European Commission, as mentioned above, calls for new tools for policy analysis. The comparative analysis between the countries considered has highlighted the

[12] See, for example, the OECD-WPTIP projects on system transformation, knowledge triangle, and co-creation: https://www.oecd.org/sti/inno/working-group-on-innovation-and-technology-policy.htm.

[13] Kucharski *et al.* (2020, p. 1151) argue that selective interventions on manual tracing out of school or work "could have an effect on transmission reduction similar to that of detailed contact tracing".

[14] The effectiveness of testing to control the spread of contagion has been verified in the most recent phase of the pandemic, for example in Italy, when the certificate (green pass) required to access public places was activated.

different institutional and organisational contexts as well as the specific STI policies that have promoted the use of contact tracing apps. Broadening the set of countries on which to carry out a comparative analysis would be interesting, not only to validate and collect more evidence, but also to test the analytical framework proposed in the comparative analysis explored in this paper. This requires a look from the inside – adopting an ethnographic approach (Agar, 1996 and 2006) – as a participant observer (Bobbio *et al*., 2017; Vino, 2018), elaborating a massive overdetermination pattern of information, and highlighting rich points to outline a new framework in which the comparative analysis can be interpreted, and the policy recommendations become more effective.

In such a development, it is essential to carry out interviews with experts and managers of the institutions and organisations involved in the development of contagion tracking apps. To deepen the technical and operational nature of the tracking apps and their uses and to fill the lack of press sources or scientific literature, it is considered appropriate to resort to direct, targeted interviews with the representatives of various companies and institutions mentioned in this preliminary work, also regarding the choices of the advertising campaign relating to tracking apps. In the case of Italy, among the possible alternatives to the Immuni app, the analysis of the developments undertaken by the developers of diAry – Digital Arianna, from the University of Urbino (Università degli studi di Urbino, 2020), require particular attention, as they would offer a case to analyse whether and in what direction its development is proceeding in terms of collaborations, and what the next objectives will be, as well as the application on the tracing of infections.

With reference to the health system, field research and interviews with experts from regional to national level would make it possible to outline the reasons and implications of the choices made in the different countries and to understand the functioning of the entire process of adopting the tracking apps for an effective containment of infections. In Italy in particular, an analytical gap remains to be filled regarding the technological and organisational infrastructures of the regional health systems. In the new phase of contagion containment that has been implemented thanks to the massive administration of vaccines, health infrastructures could have derived important operational advantages by integrating the information detected through the tracking apps and data from hygiene, prevention, and surveillance authorities. A comparative analysis of the organisational changes that the regional health systems have implemented may therefore be of great interest to understand which structural changes have been stimulated by the pandemic, and made also possible by new ways of data collection and analysis for policy implementation.

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