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	Compte-rendu de fin de projet	
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COVoM

COVID19 ON MY MOBILE: TO WHAT EXTENT CONTACT-TRACING APPS BECOME A TOOL IN POLICYMAKERS' AND CITIZENS' HANDS?

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Programme Résilience Covid19

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A RESUME CONSOLIDE PUBLIC

A.1 RESUME CONSOLIDE PUBLIC EN FRANÇAIS

Les applications de traçage des cas contacts : un instrument de politique publique ?

Une étude comparative et pragmatique sur les applications du traçage des contacts depuis l'intention jusqu'à la mise en œuvre et l'épreuve par l'usage : France, Japon et Colorado

Plus que toute autre crise, la pandémie de COVID19 a nécessité l'articulation de politiques publiques de différents domaines et avec les comportements individuels et collectifs des citoyens. Considéré comme un point de passage pour soutenir les institutions de santé publique et compléter les outils épidémiologiques traditionnels, le traçage numérique des contacts à l'aide des smartphones a été une innovation fondamentale en réponse à la pandémie de COVID-19. Conçue, développée et mise en œuvre rapidement, avec de nombreuses corrections apportées en phase d'usage, cette solution a ouvert de nombreux débats sur les questions de confiance et de confidentialité, essentielles à son efficacité. A travers une approche pragmatique, le projet COVoM propose une étude comparative internationale des stratégies des acteurs publics et des attitudes des citoyens vis-à-vis de ces solutions, étudiant les différentes trajectoires « d'adoption » de ces applications, depuis l'intention politique jusqu'à la mise en œuvre. L'objectif est de comprendre dans quelle mesure les choix gouvernementaux peuvent façonner la décision des citoyens d'utiliser ou non ce type d'outils de technologie numérique pour la santé. Le projet aidera les décideurs politiques, les concepteurs d'applications, les opérateurs de prévention et les professionnels à identifier les conditions dans lesquelles la numérisation des contacts peut être pertinente dans la lutte contre les pandémies.

La combinaison d'études qualitative et quantitative déployées dans les trois pays d'étude

La méthodologie s'appuie sur trois work packages principaux et combine des enquêtes qualitatives et quantitatives en France, au Japon et au Colorado. Les deux premiers lots de travail abordent les processus de conception d'innovations politiques, techniques et organisationnelles qui soutiennent le fonctionnement des applications de traçage de contacts (ATC). Dans un premier temps, nous avons analysé, à travers une grille commune, des données publiques (articles de journaux, rapports institutionnels, sites internet et controverses sur les réseaux sociaux) pour identifier comment les pouvoirs publics et les institutions en charge de la pandémie de covid19 ont intégré les outils d'applications mobiles dans leurs stratégies de lutte contre la pandémie, en particulier dans le cadre de leur politique « Tester, Tracer et Isoler ». Ensuite, des entretiens semi-directifs avec des membres des équipes de conception des ACT dans chaque pays ont révélé les défis et choix technologiques, les compromis de conception et les aspects pratiques, tels que les problèmes d'efficacité de l'alerte.

Le troisième volet de travail était dédié à l'adoption par les utilisateurs et les non-utilisateurs sur la base d'une enquête par panel en population générale, pour identifier les dimensions explicatives des choix des citoyens. Respectivement, 2 000 personnes ont répondu au Japon et en France et 1 000 au Colorado. Nous avons effectué une analyse multinomiale pour régresser la probabilité d'utilisation de l'application sur les variables explicatives relevant de sept dimensions : socio-démographie, sensibilité à la pandémie, confiance, facilité numérique, influence sociale, pratiques de protection contre la pandémie et vie quotidienne.

Résultats majeurs

Il existe des disparités entre les trois pays concernant l'intégration des ACT dans les stratégies de test, de traçage et d'isolement. La France a favorisé les tests de masse et a financé un isolement à grande échelle. Le Japon a restreint l'accès aux tests et n'a soutenu que l'isolement des patients déclarés covid19. Le Colorado a mélangé des mesures d'accès massif et gratuit aux tests et un soutien timoré à l'isolement. De profondes différences dans la culture numérique des systèmes de santé et dans la compréhension des questions de confidentialité ont influencé le choix d'une solution souveraine publique (France) ou privée (Japon, Colorado), avec des conséquences sur la capacité de contrôle et sur l'évaluation de l'efficacité des applications. Ces choix de politique et de design ont impacté le processus d'adoption et d'utilisation : 44,3% des 1 000 Coloradiens interrogés n'ont jamais entendu parler de l'ACT, 36% des 797 Japonais interrogés ayant téléchargé l'ACT l'ont désinstallée et 20,6% des 967 utilisateurs français de l'ACT n'ont jamais activé la fonction de traçage. Dans les trois pays, quatre dimensions semblent associées à l'adoption des ACT par les citoyens : les caractéristiques sociodémographiques, la confiance, l'influence sociale et la sensibilité à la pandémie. Il existe également une corrélation avec le respect des instructions de test, d'isolement et de traçage manuel. En revanche, des contraintes de la vie quotidienne, les pratiques de protection contre le covid19 et les habitudes numériques n'influencent pas significativement l'adoption d'une ACT.

La recherche COVoM offre les prémisses et la base de données pour explorer des questions fondamentales concernant les relations des individus aux risques infectieux. Il contribue également à la sociologie de la digitalisation de l'action publique et de l'innovation « de crise », principalement via les technologies numériques. Ce projet a permis la participation de l'Université de Grenoble Alpes à d'un consortium international de chercheurs travaillant sur le sujet avec lesquels un projet de réseau scientifique est en cours de construction (Suisse, Norvège, Belgique, Allemagne, Pays-Bas, Royaume-Uni, Finlande, Italie, Inde et Corée du Sud). Un nouveau projet de recherche basé sur un partenariat avec l'Université de Genève a été financé en 2023 par les Régions Auvergne-Rhône Alpes et le Genévois pour étudier la prise en compte des dimensions transfrontalières dans la conception des ACT.

Production scientifique et brevets depuis le début du projet

A des fins de valorisation et de diffusion de la recherche au grand public comme aux experts, le projet de recherche COVoM (design de la recherche et résultats détaillés) est accessible à l'adresse suivante <https://covomm.hypotheses.org/>

Les résultats ont été présentés lors de deux conférences en juin 2023, spécialisées dans le domaine Science and Technology Studies (STS). Un premier article présenté lors de la 6e Conférence nordique STS à Oslo analyse la manière dont la conception des ACT a conduit à une évaluation impossible de leur efficacité. Le deuxième article, présenté à la conférence STS Italia à Bologne, a mis en lumière le rôle de l'anticipation des risques échecs d'adoption des ACT dans le processus de conception.

Informations factuelles

Le projet COVoM est un projet de recherche fondamentale coordonné par Céline Cholez (Université Grenoble-Alpes. Il associe aussi l'INRIA, l'Université de Denver (Colorado-USA) et l'Université de Kyoto (Japon). Le projet a commencé en juin 2021 et a duré 24 mois.

A.2 RESUME CONSOLIDE PUBLIC EN ANGLAIS

Contact case tracing applications: a public policy instrument?

A comparative and pragmatic study on contact tracing applications from intention to implementation, and test by use: France, Japan and Colorado

More than any other crisis, the COVID19 pandemic has required the articulation of public policies in different fields, and with individual as well as collective behaviors. Considered as a passage point to support public health institutions and complete traditional epidemiological tools, digital contact tracing using smartphones has been a core innovation in response to the COVID-19 pandemic. Designed, developed, and put into service quickly, with many corrections made during the stage of final use by the citizens, this innovation opened debates regarding trust and privacy issues, both essential to its efficiency. Through a pragmatic approach, the COVoM project proposes an international comparative study of the strategies of public actors' and of the attitude of the citizens vis-à-vis CTAs, with focus on the different "adoption" trajectories, from the phases of intention, conception to final stage of implementation and use. The goal is to understand to what extent government choices can shape the citizens' decision to use or not such a health digital tool. The project will help policy makers, app designers, prevention operators, and professionals to identify the conditions under which digitalizing contact tracing can be relevant to the fight against pandemics.

The mix of qualitative and quantitative studies deployed in the three countries cases

The methodology is based on three main work packages and combines qualitative and quantitative surveys in France, Japan, and Colorado. The first two work packages tackle the policy content, and the technical as well as the organizational processes of innovation design that support the operation of digital contact tracing. First, we analyze, through a common grid, public data (newspaper articles, institutional reports, websites, and social network controversies) to identify how public authorities and institutions in charge of the covid19 pandemic have integrated mobile application tools within their strategies against the pandemic, especially within their "Test, Trace and Isolate" policy. Second, semi-directive interviews have been conducted with design teams of contact tracing applications in each country, which revealed the technological challenges and choices, the design trade-offs, and practical aspects such as the warning function efficiency.

The third work package is dedicated to users' and non-users' adoption, based on a general population panel survey to identify the explanatory dimensions of people's choices. Respectively, 2,000 people responded in Japan and France and 1,000 in Colorado. We processed a multinomial analysis to regress the probability of app use on the explanatory variables related to seven dimensions: Socio-demography, pandemic sensitivity, trust, digital ease, social influence, pandemic protection practices, and everyday life.

Major results

The analyses show major national differences between the three countries as to the integration of the CTA into their "Test, Trace, and Isolate" strategies: France favored mass testing and financed large isolation, Japan restricted access to testing and only supported the isolation of

declared covid19 patients, and Colorado mixed massive access to testing with a moderate support for isolation.

Deep differences in the digital culture of health systems and in the understanding of privacy issues have influenced the choice of a sovereign public (France) or private (Japan, Colorado) solution, with consequences for monitoring capacity and efficiency assessment. These choices impacted the adoption process and use: 44, 3% of the 1,000 Coloradoan respondents have never heard of the CTA, 36% of the 797 Japanese respondents who had downloaded the CTA have uninstalled it, and 20,6% of the 967 French app user respondents never enabled the tracing function. In the three countries, four dimensions appear as associated with the adoption of CTAs' by citizens: sociodemographic characteristics, trust, social influence, and pandemic sensitivity. There is also a correlation with adherence to the instructions for testing, isolating, and *human* tracing. The daily life constraints, the protective practices against covid19, and digital habits do not significantly influence the CTA's adoption.

The COVoM research offers the premises and the database to explore fundamental questions concerning the relationship of individuals to contamination risks. It also contributes to the sociology of public action digitalization and to the "crisis" innovation studies. This project fostered the constitution of an international consortium of researchers working on the subject and with whom a scientific network project is being built (Switzerland, Norway, Belgium, Germany, Netherlands, UK, Finland, Italy, India, and South Korea). Furthermore, a new research project, based on a partnership with the University of Geneva, has been funded in 2023 by both the Auvergne-Rhône Alpes and Geneva Regions to study cross-border CTA systems.

Scientific production

For promoting and disseminating research to the general public and experts, the COVoM research project (research design and detailed results) is accessible at the following address: <https://covomm.hypotheses.org/>

The results were presented at two conferences in June 2023, specializing in the Sciences and Technologies Studies field. A first paper at the 6th Nordic STS Conference in Oslo analyzes how the initial design of CTAs framed an *impossible* efficiency assessment. The second paper, presented at the STS Italia Conference in Bologna, shed light on how the anticipation of possible adoption failures framed the CTAs design processes.

The COVoM project is a fundamental research project coordinated by Céline Cholez (Grenoble-Alpes University). It also associates INRIA, the University of Denver (Colorado, USA) and the University of Kyoto (Japan).

B SCIENTIFIC REPORT

B.1 ISSUES AND PROBLEM, STATE OF THE ART

More than any other crisis, the COVID19 pandemic has required the articulation of public policies in different fields, and individual as well as collective citizens' behavior, which are firmly anchored in what constitutes the most ordinary of social life (Boin, Lodge and Luesink, 2020; Yan *et al.*, 2020). It opened up to vast issues of governmentality, trust, expertise, and decision-making processes, and the involvement not only of vulnerable populations but of all citizens (Beck, 2009; Foucault, Davidson and Burchell, 2010; Bargain and Aminjonov, 2020; Devine and al., 2021).

In the spring 2020, the public authorities of more than 40 countries around the world placed their hopes in digitalized COVID-19 contact tracing via mobile application solutions – a digital technology development promising to alleviate human contact tracing, encourage individual contacts-cases to get tested and quarantined, and thereby curb the contagion to facilitate a return to the normal. As contact tracing apps (CTAs) require a significant investment of public actors as well as of private tech companies, and build on an efficient participation of citizen, they represent a particularly relevant case for analyzing how the digitalization of crisis management (Hagar, 2010) could improve public action and align public responses with citizens' participation.

The COVoM project aims to take stock of these initiatives footing on mobile-based solutions and linking both a policymakers and a citizens' perspective. It proposes an international comparative study on public actors' strategies and citizens' attitudes vis-à-vis CTAs, through a pragmatic approach that studies the different "adoption" trajectories from policy intention to implementation.

Indeed, the state-of-the-art highlights the need for a better understanding of public actors' and citizens' concrete decision-making and implementation processes (Lascombes and Le Galès, 2018) regarding the testing, tracing, and isolating issues, within their relevant context and culture (Chen and al., 2021; Farzanegan and Hofmann, 2022). The COVID-19 crisis shook up many given-for-granted processes of crisis management: the governance between policy levels (national, regional, local) and between different actors (public, private, agencies, scientists); the public trust regarding institutions (governments, health systems) and the modes of citizens' involvement.

CTAs stood at the core of these issues. First, they required unprecedented coordination between many actors and institutions (computer experts, biological labs, physicians, public health as well as medical care institutions, traditional contact-tracing organizations, and law and rule enactment actors). Second, in light of the privacy invasive measures introduced in several Asian countries from March 2020 onwards (Singapore, South Korea, China), most computer science and public health experts have early expressed concerns regarding the willingness of individuals to download such applications due to the fear of "being traced"(European Commission, 2020; Cairney and Wellstead, 2021). Issues of privacy and public trust framed the subsequent academic and public debates regarding these solutions, and led to many expectations concerning the assessment of CTAs' effectiveness, in order to balance the infringements of privacy they could represent (WHO, 2020; CNIL, 2020; European Commission, 2020). Nevertheless, two years later, in their report on 27 contact tracing applications developed in the EU, Prodan *and al.* (2022) observed that the apps' monitoring remained incomplete and evaluation insufficient to the point where there was no accurate

data to conclude. Our study is a contribution to the analysis of failure and success factors for such solutions in three advanced democracies: France, Japan and Colorado (USA).

B.2 SCIENTIFICAL AND TECHNICAL APPROACH

The COVoM projet was led by an international (France, Japan, US) and multidisciplinary team (sociology, policy sciences, information sciences, and economics). The research approach was oriented by a pragmatist approach focusing on the actors' strategies, in order to understand both policymakers and citizens' adoption processes through the same theoretical line (Callon, Lascoumes and Barthe, 2001). This line is inspired by the pragmatist approach of policy design and the sociology of innovation (Lascoumes, 2004; Zittoun, 2017): giving importance to the way actors qualify problems and solutions, try to integrate CTAs in a coherent way within their different actions and values, and adapt their response and practices according to unexpected disruptions or misalignment.

Addressing the adoption by public actors and by the citizens of a new digital public health tool.

The research combines two goals: on the one hand, we draw a comparative understanding of how public authorities and institutions in charge of the COVID-19 pandemic integrated CTAs within their tracing policy and, more generally, their strategies to fight the pandemic, and follow the process from policy intention to implementation. On the other hand, we explore how and to what extent government choices shaped citizens' decisions to adopt and use the apps.

The consortium gathers three kinds of expertise: academic (policy sciences, sociology of innovation, consumption economics, communication, informatics), methodological (qualitative and quantitative), and related to crisis management, especially in the COVID-19 context of the three selected countries.

The three countries have been selected for several reasons. In light of the Asian privacy invasive geo-localized tools introduced in March 2020 (Singapore, South Korea, China), these three democracies experienced controversies about citizen surveillance, apps technical disruption, and efficiency mistrust, which finally resulted in few cases and notifications reported via the apps. They also had in common a long experience of human contact tracing, historically developed to fight epidemics as tuberculosis, AIDS, and more recently Ebola or the H1N1 flue.

Regarding our research questions, comparing France, Japan, and Colorado also strengthens our analysis related to important issues such as governance (centralized or decentralized), trust in government and/or society, attitudes towards private or public platforms, and the national differences in the "test, trace, and isolate" strategies.

Qualitative and quantitative compared analysis.

The methodology is based on three main work packages and combines qualitative and quantitative surveys implemented in the three countries. The first two WPs tackle the policy content, and the design processes of the technical and organizational innovations that supported the CTAs' design and operation.

WP1 addresses the decision-making and implementation processes of the "test, trace and isolate strategies" (considering CTA as a device among others in this strategy). Based on a

collectively established grid, and defining the critical information to share, each country's research team has collected public data (newspaper articles, institutional reports, websites, and social network controversies) to specify communication, policies, and decisions about the "test, trace, and isolate" strategy, and the evolution of pandemic figures over time. Three timelines have been built to represent different national dynamics.

WP2 explores the innovation process from the device perspective and its ecology. The goal was to identify technical trade-offs that may have shaped the design of the apps and of their environment (human and technical support). Based on semi-directive interviews (same interview guides for the three countries), with stakeholders involved in the apps' development project, its operation, maintenance, and evolution, WP2 aims at a qualitative analysis of the CTAs' innovation trajectory.

WP3 is dedicated to the analysis of users and non-users, based on a general population panel survey to identify factors that influenced apps' adoption, and to what extent these factors varied according national and cultural contexts. The survey started in December 2021, via Internet by the research company Kantar, with respondents drawn from the company opt-in panel and quota sampling. The population of interest was defined as all persons aged 20 and over and currently resident in a private household respectively in France, Japan and Colorado, regardless of their nationality. The quota variables were supposed to be related to the subject of interest. The survey design was based on control for sociodemographic features: gender, age, annual net income, region (in France and Japan) and size of urban unit (only in France). Benchmark for population margins were based on official data sources from national agency of statistics: Statistics Bureau and National Tax Administration Agency in Japan, INSEE for France, US Census Bureau for Colorado. The share of contact-tracing app's users was also considered as a quota and defined as 40% for France and Japan, but only 35% for Colorado due to the low downloading rate in this State. The French and the Japanese panels contain 2000 respondents, the Coloradoan only 1000.

The COVoM team developed a questionnaire containing 60 closed-ended questions (that is 100 items-variables). The samples corresponding to the 3 countries were administered a set of common questions, dealing with the 7 major dimensions of the study: Variable to explain= adopting the apps (11 variables); Explicative variables= Digital ease (4 var.), Social influence (12 var.), Pandemic sensitivity (18 var.), Pandemic protection practices (13 var.), Everyday life constrains (10 var.), Trust (12 var.), Socio-demographic variables (10 var.).

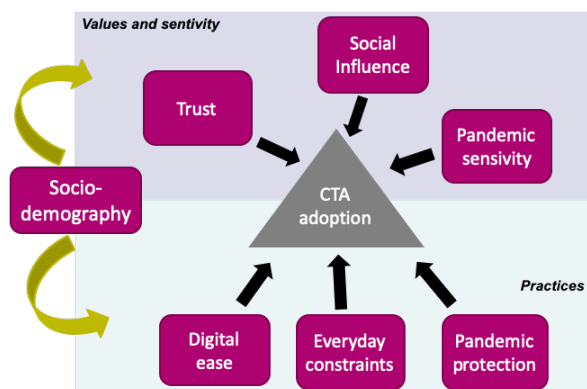


Fig1: 7 dimensions (explanatory variables) to explain CTA adoption

The analysis was then performed in two steps. First, a bivariate association analysis was performed using correlation (or Chi-squared test and Cramer's V depending on the variable type). We evaluated association between app use and each variable of the seven explanatory dimensions, and also between each variable in each dimension to evaluate their potential association. Second, a multinomial analysis then investigated the probability of app use on the explanatory variables for each of the seven dimensions. Such multinomial analysis allows to evaluate simultaneously the different impacts of each variable on the probability of app use, and to consider simultaneously the impact of all other variables. Hence, the effects of the different variables on the probability of app use can be compared.

B.3 RESULTS

B.3.1 *DESIGNING AND DEPLOYING A CONTACT TRACING APPLICATION: HOW DIFFERENT POLICIES PROFOUNDLY SHAPED THE CTAS' OPTIONS AND OUTCOMES*

This section presents the results of WP1 and WP2.

The digitization of contact tracing builds a tool for individual accountability, the effectiveness of which is based on its articulation with the testing policy (massive, accessible, or limited) and support for isolation (financial support for all or restricted). WP1 comparatively explored the "test, trace, isolate" strategies and questions the place the CTA took into this strategy. There are extreme disparities between the three countries on this point: France favored mass testing and financially supported the isolation of all -even, as soon as symptoms occurred, at the peak crisis; Japan preferred to restrict access to the test and funded isolation only of declared COVID-19 patients, citizens having to use their paid holidays whilst waiting for the test results; Colorado mixed massive access to free testing and soft communication about public supports for isolation.

Different Test-Trace-Isolate policies

These differences in the "test, trace and isolate" strategies are rooted in each country's public health system: structure, economic situation, and epidemiological history. Illustration for Japan: On the one hand, the distribution of tasks between physicians, local health centers, and epidemiology centers, between public and private healthcare insurance; and on the other hand, Japan's long economic crisis, and its previous experience with the H1N1 flu made the Japanese government give preference to a strategy based on citizen responsabilization ("self-restraint", see Wright, 2021), and to a "clinical" approach of the COVID-19 management, based on physicians. As a result, access to PCR tests was selective, on medical prescription only, and remained chargeable (more than 30 euros on average) throughout the pandemic. The tracing Japanese strategy was based on "back-tracing" at the very beginning of the pandemic -to better understand spreading conditions- with advising citizens to avoid infection by the "three C": "avoid Closed places, Crowdy places, Close contacts". Local health centers and physicians had to select who should go to test, and to closely monitor COVID-19 diagnosed patients. The government finally added financial support to the economy encouraging Japanese citizens to "go to travel (a governmental initiative to support national tourism). Thus, the tracing application, the effectiveness of which relies on a mass detection policy, has not found a coherent place in the public pandemic management system in Japan.

By contrast, France has made the CTA an essential instrument for its “test, trace and isolate” policy. The design and the agile-mode deployment (e.g. the “State start-up model”) of the French solution benefited from substantial institutional investment, the cooperation of the various public health actors, and the centralized operation of public health (Chevallier, 2020). In Colorado, the massive testing strategy has been supported through communication campaigns (oriented toward community protection), public money and human resources. But communication about the financial support for isolation remained low, thus opening ambiguity about the objectives of testing and unequal conditions of isolation.

Differences in public services digitalization

Profound differences in terms of the digital culture of public services and the understanding of privacy protection issues have influenced the choice of a sovereign public (France) or semi-private solution (Japan, Colorado with GAEN api). Developing a sovereign application in France has represented a major industrial policy issue, in a general context of the French government challenging the GAFAM (Pizzul and Veneziano, 2023). The dual supervision of the French contact tracing app “*Tousanticovid*” -Ministry of Health/Ministry of the Economy-Digital State Secretariat- underscores a dual challenge of public health and of digitization of government, public administration and services (Jeannot, 2020).

In Japan and Colorado, previous failures in public digitalization (mycolorado.gov, or the contested Japanese digital identity) led to favor private companies (Microsoft, Google, and Apple), believed to be more relevant and competent than public services in developing such tools. In the two countries, the IT and health services' resources remained concentrated on developing internal and professional information systems, dedicated to COVID-19 rather than to the general public, which was considered riskier and more controversial (Asia Pacific Initiative, 2020). However, privatizing digital tracing has opened the door to developing competing solutions in the context of political games and competition between public/private areas (Colorado), and between territorial levels (Japan). In Japan, several prefectures launched their own contact tracing applications, disturbing the users' understanding of guidelines.

Subcontracted or sovereign solution

The WP2 allowed us to deeply approach how these CTA projects were carried out in each country, leading to different designs. Tracing apps were designed, developed, and implemented in a short period, with many corrections made during the stage of final use by the citizens : according to a member of a French engineer team we interviewed: « this was the first mass deployment of a prototype ». In the three cases, the design phase, initially supported by health and digital public actors or volunteers, quickly revealed complex technological issues to address major matters related to privacy and constraints imposed by mobile phone operating systems and download platforms. The different policy options for supporting the application described in WP1 resulted in funding, human and institutional resources, and forms of projects that were very uneven between the three countries, whilst the ability to cope with the technical issues depended on this public investment.

From the first stage of the design, two distinct perspectives on privacy (Sharon, 2021) were vigorously discussed among the international computer science and epidemiologist communities (Lanzing, Lievevrouw and Siffels, 2021). France supported a fully “sovereign solution”, called a “centralized solution”, when Switzerland defended a “decentralized system” developed by Google and Apple. The two protocols defining the data, their move, and

the calculation processes are built on two critical questions: who do you fear and mistrust most, and what privacy threats do you focus on. In the Google and Apple system (GAEN), the health data of infected people move along mobile phones and the central server. Exposure calculation is done on each mobile phone. Google and Apple promoters defended this solution as being privacy-preserving because the system didn't provide any new data to government institutions (the latter being the health data producer). The GAEN system was built on the idea that the threat could come from the State which could thus gain access to citizens' information like their networks and social relations. In Europe, 25 countries chose the GAEN system; Google and Apple have also convinced Japan and Colorado. But for the French design team, the threat would rather come from possible hackers and the GAFAs themselves. The design of the French system is therefore based on a high protection of health data, which should not move along the system, while interactions would. Exposure calculation was processed on a centralized server, under public authorities' control. In this system, the "State" is considered as protective.

Issues in working around IT international giants

By opting for a sovereign and autonomous solution, the French engineering teams faced many technical issues as Apple and Google were reluctant to collaborate. First, France had to give up interoperability of its application with the other European (GAEN) applications. Second, despite much engineering research, the Apple mechanism, which puts Bluetooth to sleep when two iPhones meet, could never be bypassed. The French team preferred to degrade the app's effectiveness, even when they finally found a solution, but one which required a message displayed about geo-localization. Third, mobile phone operating systems, designed to put background apps to sleep for battery optimization, required extensive repair work (Jackson, 2014) involving numerous engineers, whose daily tasks were to align the French application with the constant systems updating.

This led the French team to invent the "multifunctionality concept": more than tracing. The app offered many other services to make users open it (and thus technically avoid the app "to sleep"), such as COVID-19 information, vaccination appointment and certification. This contributed to the high download rates in France. But, although the French government obtained from the CNIL, the consent to treat analytics, the French app efficiency assessment remained sketchy. Analytics finally only informed on digital fluency, but never on epidemic efficacy, i.e. on the concrete actions triggered by the receipt of a positive test or contact notification. The multifunctionality has increased the download figures but it remains impossible today to conclude on its contact-tracing, e.g. epidemiological efficiency. Our quantitative survey for WP3 reveals that only 37,7% of French people in the sample constantly activated the tracking function, compared to 53,6% of Japanese and 65,8% of Coloradans.

Subcontracted CTA: "blinded public health"

Few countries (UK, Germany) engaged in a standoff with Apple, to introduce some functionalities and data collection (such as the users' zip codes at the registration). This was not the case in Japan and Colorado, which completely delegated the design and the management of the solution to private companies. This delegation seriously impacted monitoring capacity (no data was available to monitor and evaluate the app's use and efficiency). In Japan, for example, the Cocoa contact tracing application experienced a three-months default (See Asahi Digital, 2021) on Android (disconnected notification system). This was detected by citizens, who then created a public affair that convinced many users to

uninstall the application (11,7% of Japanese respondents in our survey said they had uninstalled the application compared to 3,6% of French respondents and 7,5% of Coloradoans). In both countries, privatization of the apps system deprived the public authority of multiple data and severely reduced the capacity to assess the use and the efficiency of the tool.

Regarding CTAs, the IT and public health departments in Colorado and Japan remained dedicated to organizing promotional campaigns encouraging downloading. In Colorado, the IT department spent time to elaborate the communication strategies with each county. This investment in negotiation with the various local communities and institutions made it possible to involve local communities in the project and avoid the proliferation of community solutions. However, our statistical descriptive analysis (WP3) shows that in Colorado, the two main obstacles to adopting the CTA were the lack of information on the CTA's existence, and the fear of being traced.

To conclude, these two work packages revealed that the adoption of these contact tracing digital solutions by public actors depends, on the one hand, on the cultures and organizations of public health, shaping different forms of fighting pandemics and of cooperation with the plurality of actors involved in this type of crises (communities, institutions, and health professionals in particular), and on the other hand, on the industrial strategies regarding digital technologies.

Japan stands out by adopting a "test, trace, and isolate" strategy in contradiction with a primary requirement for CTA's effectiveness and efficiency (a massive access to testing). The Japanese case is characterized by a lack of public human resources assigned to the project, an institutional under-investment, a deficiency in monitoring the solution, and, ultimately, the emergence of competing territorial solutions. Taken together, this could explain the low level of confidence among citizens in the tool, perceived as useless and dysfunctional.

In contrast, France made the CTA an essential instrument for its "test, trace and isolate" policy. However, by renouncing the solution proposed by Google and Apple, the design team faced many technical issues, and extensive engineering work to align the French application with the mobile phones systems. The app's multifunctionality (including the vaccination certificate integration) created something else than a contact-tracing app. It led to a high download rate (one of the best in Europe) that finally obscured the real epidemiologic efficiency.

Colorado could be at the center of this public investment continuum. The Colorado Government Health Department quickly considered CTA as a complementary tool to human tracing, potentially overwhelmed by the contagiousness of COVID-19. The massive test and trace strategy they embraced was aligned with CTAs' requirements, but the support regarding quarantine was insufficient. As in Japan, the public actors' distrust of public services digitalization favored a form of privatization, this choice resulted in a lack of data regarding the diffusion and impacts of the application.

B.3.2 ADOPTING A CONTACT TRACING APPLICATION AS CITIZENS: MINOR CULTURAL DIFFERENCES, MANY COMMONALITIES

The WP3 addressed the citizens' perspective. The multinomial analysis of the factors influencing a CTA adoption highlights, in all three countries, the importance of four dimensions: sociodemographic characteristics, trust, social influence, and sensitivity to the pandemic. There is also a correlation between adopting a CTA and adherence to the instructions for testing and isolation, and about human tracing. In contrast, the constraints of daily life, protective practices against COVID-19 (apart from vaccination status), and digital habits do not significantly influence the CTA's adoption.

Before presenting the results of the multinomial analysis of the CTA adoption question, we offer some illuminating results from the descriptive study.

Interests in CTA and its uses vary depending on the country.

Compared to the French and the Japanese panel, the Coloradoan one appears less informed about the CTA's existence. 44,3% of this panel had never heard of it at the moment of the survey (8,6% for France and 20,2% for Japan), and public campaigns only reached 34,5% of the Coloradoans panel (64,6% for France and 66% for Japan). As seen before, communication campaigns were yet the most important public investment by the Coloradoan government.

Reasons for not downloading suggest cultural factors

In the three countries, around 20% of the panel did not download the CTA because they considered it unnecessary as they did not leave their homes, and about 30% of the Coloradoan and Japanese samples did not feel concerned about the digital solution (compared to 16,4% of the French). In France and Colorado, privacy issues appear to be the most important reasons for not downloading a CTA, among panel respondents (in France 50,7%; in Colorado 43,1% checked it; whereas only 13,8% did so in Japan). In Japan, the low citizens' involvement is the mostly checked case: 34,3% did not download the CTA because they thought it was not used enough by other citizens to be effective. Moreover, 32,9% of the Japanese panel said they did not know anyone who downloaded the application, compared to 25,1% of the Coloradoan, and only 15,1% of the French. If the French have downloaded the application more -in absolute value (see Prodan *et al.*, 2022) and within our panel- their use, however, appears to be less effective with regard to tracing: only 37,7% of the French respondents said they kept the tracing function turned on all the time, compared to 53,6% of Japanese, and 65,8% of Coloradoans.

The French more confident in human contact tracing, but more reluctant to be tested and isolate themselves in the event of symptoms

The French respondents look the most favorable to giving their contact to a human tracer (74% said they would, compared to 57% of the Coloradoan and only 37% of the Japanese respondents). However, they are also more likely to declare that they have never gone to be tested or never isolated themselves when having symptoms of COVID-19 (34%), compared to 29% of Japanese (for whom test access was restricted), and 19% of Coloradoan respondents.

The Japanese less secure concerning the pandemic

The Japanese respondents felt less well informed about the pandemic (level 8 and above on a scale of 10 = 20,3%) than the French (=56,7%) and Coloradoans (=65%). They also seem to feel

more insecure at work: the feeling of having been protected at school or work during the pandemic is lower in Japan, where only 21,3% of the panel answered “yes”, compared to 47,4% of French respondents, and 50,3% of Coloradoan respondents). This can be explained by the weakness of teleworking within the Japanese sample (28%, compared to 43,3% for the French, and 58,7% for the Coloradoan panels). Government trust is distributed relatively closely in the three countries except the lowest trust level (chosen by more than 17% of French and Coloradoan respondents, compared to only 9,4% of Japanese ones). The Japanese respondents' level of confidence in the healthcare system appears to be lower than that of the French and Coloradoans (levels 8 and above = 14,3% of the Japanese panel, compared to 40,4% of the French, and 36,6% of the Coloradoans one).

We now present the results of the multinomial analysis identifying the factors of adoption of a CTA, according to the countries.

Socio-demographic differences according to countries: cultural effect?

Gender, age, and employment status appear to be significant variables in the three countries. But their effects on the likelihood of using CTAs may differ from country to country. Men thus have a greater probability than women of using the app in the Coloradoan and French sample, while they have a lower chance in the Japanese one. France presents a particularity regarding age, with less use in the intermediate age groups (35-49 years and 50-64 years) and greater adherence among young people (20-34 years) and older people (more than 65 years). Increasing age plays against the use of the CTA in Colorado and Japan. In all three countries, the probability of using the application decreases for employment statuses of unemployment, disability or illness, and unpaid work at home. The likelihood of using the application increases with income and educational level in France and Colorado (but no effect is shown in our Japanese panel).

By comparison, we tested all of the variables on two other questions to be explained: adherence to human tracing (measured by the self-assessed chances of giving their contacts directly to a public health agent), and the instructions for testing and isolation in case of covid19 symptoms. All the variables work similarly with CTAs adoption for these two questions, except those related to socio-demography. Women are more likely to give their contacts in France and to isolate themselves in France and Colorado (for the CTA *adoption*, it was the male gender that prevailed in these two countries). Age effects don't seem to play a role in giving contacts; in Japan, they even play slightly in the opposite direction (you are more likely to share your contacts when you are old). As for testing and isolation, all categories over 35 are less likely to comply with this recommendation than the youngest (20-34) in France and Colorado. Note that the level of income or education hardly seems to influence compliance with the test and isolation instructions in the three countries, but a little more the fact of giving your contacts (in France and Colorado).

An equal effect of opinion and representations: institutional trust, social influence and pandemic sensitivity

Trust in institutions with regard to the pandemic situation plays a significant role in the adoption of the CTA: the higher the respondents consider their feeling of confidence vis-à-vis the government, the health system, and conventional medicine, the greater their chances of adopting the application. In all three countries, the legitimacy of the State in the fight against the pandemic appears to be associated with the adoption of CTA. The role of individual actions in the fight against the pandemic would only play in the French sample.

Regarding the role of social influence on the decision to adopt the CTA, only variables directly related to the app seem to play a role. Thus, we are all the more likely to be a user of the app if we have users around us. In France and Japan, the chance of adopting the CTA decreases if we have been informed about its existence through an advertising campaign. Being aware of the existence of this solution via a professional caregiver provides you with a better chance of being a user in France and Colorado.

In the three countries, there is even less chance of being a user of the CTA for those who do not feel concerned at all by the risk of contaminating those close to them nor by the threat of contaminating society. Conversely, the more one feels concerned by the risk of kins contamination, the more likely one is to be a user of the CTA. On the other hand, the level of concern about *one's own* contamination does not seem to influence the adoption of the CTA. In all three countries, considering oneself or a kin at risk of COVID-19 or being aware of a severe COVID-19 condition of a kin confers a greater chance of being a user of the CTA. Feeling well or very well informed about the pandemic also increases the chances of CTA's adoption.

No influence of practical dimensions (everyday constraints or pandemic protection practices)

Among the dimensions the least significantly correlated with the CTA's use, few variables seem positively associated with it. Among the practices for protection against the COVID-19 pandemic in the three countries, only (declared) vaccination status appears as increasing the chance of using the app. Concerning the constraints of daily life, only the isolation instructions, in the event of a COVID-19 symptoms or of a positive test seem to influence the use of the CTA: we are all the more likely to use the application if we can easily respect the isolation instructions. Finally, in France and Japan, moderate daily mobile use makes it less likely to be a CTA use. In France and Colorado, accepting cookies works the other way around.

To conclude, our analysis suggests that adopting a contact tracing application has represented, for citizens, a civic good thing to do, a respect for government and public health leaders' guidelines, and a way to protect oneself and kins and, ultimately, society from the pandemic. Socio-demographic variables have a different influence according to the country, suggesting a cultural dimension of trust and risk sensitivity. A deeper analysis, modeling the links between gender, age, and educational or revenue levels with trust and risk sensitivity, would be enlightening.

B.4 OUTCOMES ON « USE »

Our proposal targeted to answer the following questions:

1) To what extent does citizens' adoption depend on CTA policy strategies?

→ *Our study shows that the success of the contact tracing application did not depend only on its design as a technical object, but on its alignment with all “test, trace, and isolate” public policies. Japan is a meaningful example (of failed alignment).*

- What impacts do the CTA's public or private property have on citizens' confidence and data public management?

→ *Choosing a private or sovereign application mainly had effects in terms of design, public investment, and the capacity of the public actor to monitor, and maintain the device. The*

complete delegation of the CTA to large international companies has deprived national governments and public health agencies of any assessment capacity. Our study doesn't identify differences in citizens' mistrust of privacy issues, whatever the system and the property.

- Does offering different functionalities on the CTAs favor adoption mechanisms in line with better citizens' resilience?

→ The multifunctionality, especially the possibility of integrating the vaccination certificate, has probably favored CTA adoption in France. However, it is not possible to establish its epidemiological effectiveness, on the one hand, because it is impossible to know the share of notifications having led to testing and isolating actions; on the other hand because, according to our study, the percentage of users who never or only partially activated the tracing function could be very high (more than 60% of our sample).

2) Beyond policy strategies, what are the factors favoring CTA adoption?

→ Socio-demography, trust in institutions, pandemic sensitivity, and social influence are the main factors influencing CTA adoption in the three countries.

- How do socio-demographic and cultural factors impact adoption and use strategies?

→ Gender, age, income, and educational level influence CTA adoption differently depending on the country. Deeper models are required to understand their link to the sensitive variables.

- Does the greater or lesser proximity to the risk increase adoption?

→ Yes, you have more chance of adopting the app if you or your kins are at risk regarding COVID-19.

3) From implementation complexity to the user experience.

- How do breaks in actors' chains, technical or organizational disruption, or a lack of coherence between policy intentions and communication impact users' experience? And what lessons can be learned?

→ The methodology did not allow us to address this question from the citizen's perspective. However, Japan's lack of policy consistency has affected citizens' trust in the digital solution.

4) CTAs integration into daily life.

- Do the coexistence of several public, para-public, and private solutions impact citizens' understanding of the value of CTA solutions and their efficient use?

→ The methodology has not addressed this question because it requires more investigations.

- Is using CTAs correlated with higher protection practices against the pandemic?

→ We have not identified any influence of everyday practices, including pandemic protection, on CTA adoption. However, the opportunity to easily isolate gives you more chance of adopting a CTA.

5) CTA evolution

- What are the possible changes in using these solutions in less acute phases of the pandemic?

- Under what conditions can these solutions constitute an instrument of epidemiological surveillance in the medium term?

→ If we cannot affirm that multifunctionality has enabled epidemiological effectiveness, a qualitative survey among users we carried out in the exploratory phase in France suggest that

the app Tousanticovid constituted a fundamental instrument of awareness and communication about COVID-19. Under the flood of information, some interviewees said they only referred to the data and information disseminated by this application to stay informed about COVID-19 and avoid fake news. In this sense, the application would have played a public health role in sensibilization. However, given the priority to privacy that deeply framed the design, the CTA never constituted a device for epidemiologic surveillance.

B.5 DISCUSSION

The COVoM project carries some limitations.

First, we have identified substantial outcomes for each work package. We unfold links between epidemiological history, public health organization, policy content, design and use, but this would require more exploration. Especially the relations between policies or design and adoption factors would require more specific investigations.

Second, we met difficulties with the WP2 survey in Japan and Colorado as the CTAs were very controversial at the data collection stage. The Japanese and American members of the CTA design and deployment were unwilling to tell the story of a "public failure." Interviews were conducted with individuals behind the project, peripheral but not at the core of the management.

Third, the quantitative survey among citizens met the constraint of a very low download rate in Colorado, which obliged us to lower the quota from 40 to 35% of users. Conversely, we agreed to increase the rate to 48% in France.

Finally, the multinomial analysis in the WP3 allowed us to identify adoption factors, but how do these factors play together? Which are the most important interactions? Following this perspective, we would like to build a mathematical model to test the relationships between critical factors.

The COVoM project also opens to stimulating perspectives.

In November 2022, a European report (Prodan *and al.*, 2022) was published aiming at taking stock of contact tracing applications, within the European Community. Based on a questionnaire survey among authorities and teams in charge of CTA in their country as well as an academic state of the art, it highlights the same findings as ours about, on the one hand, the absence of data collected by health authorities and in doing so, the *impossible* assessment of these solutions, and on the other hand, the relevant adoption factors (age, gender, level of education and income, fear of the pandemic, trust in government and civic sense). To note, most of the quantitative studies, cited in the report, have *not* covered as many dimensions as we did.

A review of the studies carried out after the deployment of the CTA points out that our study offers a complete approach to the challenges of digitalization of public action, in particular public health and the innovation process in a crisis situation. In line with recent studies (Machida *et al.*, 2021; Horvath, Banducci and James, 2022; Schultz *et al.*, 2022), we provide the potential for modeling the relationship of citizens to public health policies, in the context of an acute pandemic crisis. From an academic point of view, our study offers the premises and a database to explore fundamental questions concerning individuals' relationships to

collective risk. Pursuing multifactorial analyses could allow us to understand the relationships between the different dimensions that structure sensitivities and practices regarding risks, cultural differences, and the digital devices specificities, particularly regarding gender differences.

This research also contributes to the sociology of digitalization of public action, and of "crisis" innovation. Tracing applications has been made possible by meeting the modeling sciences of epidemiology and computer sciences, which were able to share a common conception of human behavior in crises (according to which information leads to appropriate behaviors). In that sense, the CTA has been designed as a nudge for chains of actions that persuasive contact tracing agents have long carried out. Putting tracing applications into perspective with regard to the history of epidemiological surveillance opens up stimulating questions, in particular on the distribution of roles among the different health professionals (public health actors, physicians, hospitalists) and between health professionals and risks managers, in the management of the contamination risks (Fairchild, and al.,2007).

The results of this research were presented at two conferences in June 2023, specializing in the STS field. This was the opportunity to meet other international researchers working on the subject with whom a scientific network project is being built (Switzerland, Norway, Belgium, Germany, Netherlands, UK, Finland, Italy, India, and South Korea). A new research project based on a partnership with the University of Geneva was funded in 2023 by the Auvergne-Rhône Alpes and Geneva Regions to study the consideration of cross-border dimensions in the design of CTAs.

B.6 CONCLUSIONS

This internationally comparative and interdisciplinary study of digital contact tracing using smartphones (CTAs) *opens the black box of public policy making and its outcomes*, in the still under-researched but political and socially most important field of managing contagious disease. Limiting infection requires policies capable of enhancing collective behavioral changes. The study therefore covers the entire process: from the policy choice for a new tool, the CTAs, and their operational implementation down to their final use by the individual citizens. This latter part has been precisely investigated via an important quantitative study using a large number of variables. Altogether, the extent of the comparative analyses, the mixed methodology based on a pragmatic approach, and the unprecedented edge-cutting case (implementing an electronic tool in the context of an acute epidemic), have allowed to identify the multiplicity of actors and sectors involved, to unravel the complexity of the policy problems and strategies, and to identify the interwoven causal factors at the intersection of political, institutional, organizational, technical and social issues.

The results contribute to public policy, sociological studies, crises management, public health and digitalization of public services: confirming, infirming or deepening previous hypotheses, and proposing new ones:

- *Contrarily* to what one could have expected from research on non-take up in other social policy or public service studies, the impact of daily constraints on CTA use appear rather minor.

- *In line* with general public policy studies, notably on welfare state and health systems, and particularly on “success and failure in public policy” (Bovens, ‘t Hart P., and Peters G.B., 2001), the CTA case reveals strong impact of the institutional and organizational factors structuring the relevant sector(s) or sub-sector(s) in which a case is anchored. The CTA study shows how this institutional and organizational context (public vs private CTA support; health sector vs. electronic industry) shaped policy choices and technical design, which then enhanced technical problems and other limitations that in turn impacted on the use of CTA. The success of CTAs depended directly on a precise sectoral policy of large free testing and public support for effective isolation, which also would have inspired peoples’ confidence in the usefulness of the CTA tool. Considerable differences between the three compared countries in this strategic policy led to national variation in CTA use.

- *The new results highlight contemporary issues* impacting public health practice and capable of influencing, negatively or positively, the necessary upgrading of traditional public health and epidemiology towards a modern science of population health. Whereas experts and governments focused on privacy issues as brake to CTA adoption, the CTA study shows how significant such factors are as trust in institution, the social environment, the knowledge of the risk and sensitivity to COVID-19, the sense of civic responsibility and the usefulness of the apps. This latter factor highlights the possible negative impact of the diagnosed “impossible evaluation” of the policy and the tool in terms of epidemiological efficiency. This contradiction closes the circular trajectory from policy intent to use, and back from doubts on the usefulness to the yet unmet need of policy evaluation.

The findings of this study open up to further perspectives pointing to important future scientific and socio-political issues:

- Results converge towards the importance of appropriate public communication strategies to improve public knowledge on contamination risks. Personal responsibility for not-transmitting infections occurred as favorable for CTA use, a factor on which education should focus, because population health and pandemic preparedness can only work effectively among *health-conscious citizens*. In this line, the findings of the CTA study point to the importance of multi-professional collaboration, and the necessity to de-corporatize, de-silorize public health policy making (Steffen, 2001). As stated above, the anti-Covid apps “cuts through it all, horizontally and vertically”.

- Findings showed the critical brake in CTAs' success, which was not mainly related to citizens' disapproval. First, as electronic devices are necessarily rooted in electronic professions, public action digitalization depends on the digital industry's cooperation, especially the major international actors, such as the GAFA, with States. Digital governance appears at the core of any State's digitalization ambition. Second, the CTA study recalls the frequent mistakes associated with technological promises. The CTA was designed as a nudge (an informative tool to foster behaviors) that "invisibilizes", on the one hand, citizens' thinking and acting in a health crisis, and on the hand the support role of health professionals in infectious risk management. The findings document the still long way to go for digitalization, not only of healthcare but also of public health strategies, and the need to involve the final users in designing the tools they are supposed to use

Altogether, our study provides the potential for modeling the relationship of citizens to public health policies, in the context of an acute pandemic crisis, and in a larger sense of population

health. It offers the premises and a database to explore fundamental questions concerning individuals' relationships to collective risks, and invites to further study the digitalization of public action, crisis management, and which information strategies would help to foster appropriate behaviors.

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For more information and results about the research see: <https://covomm.hypotheses.org/>