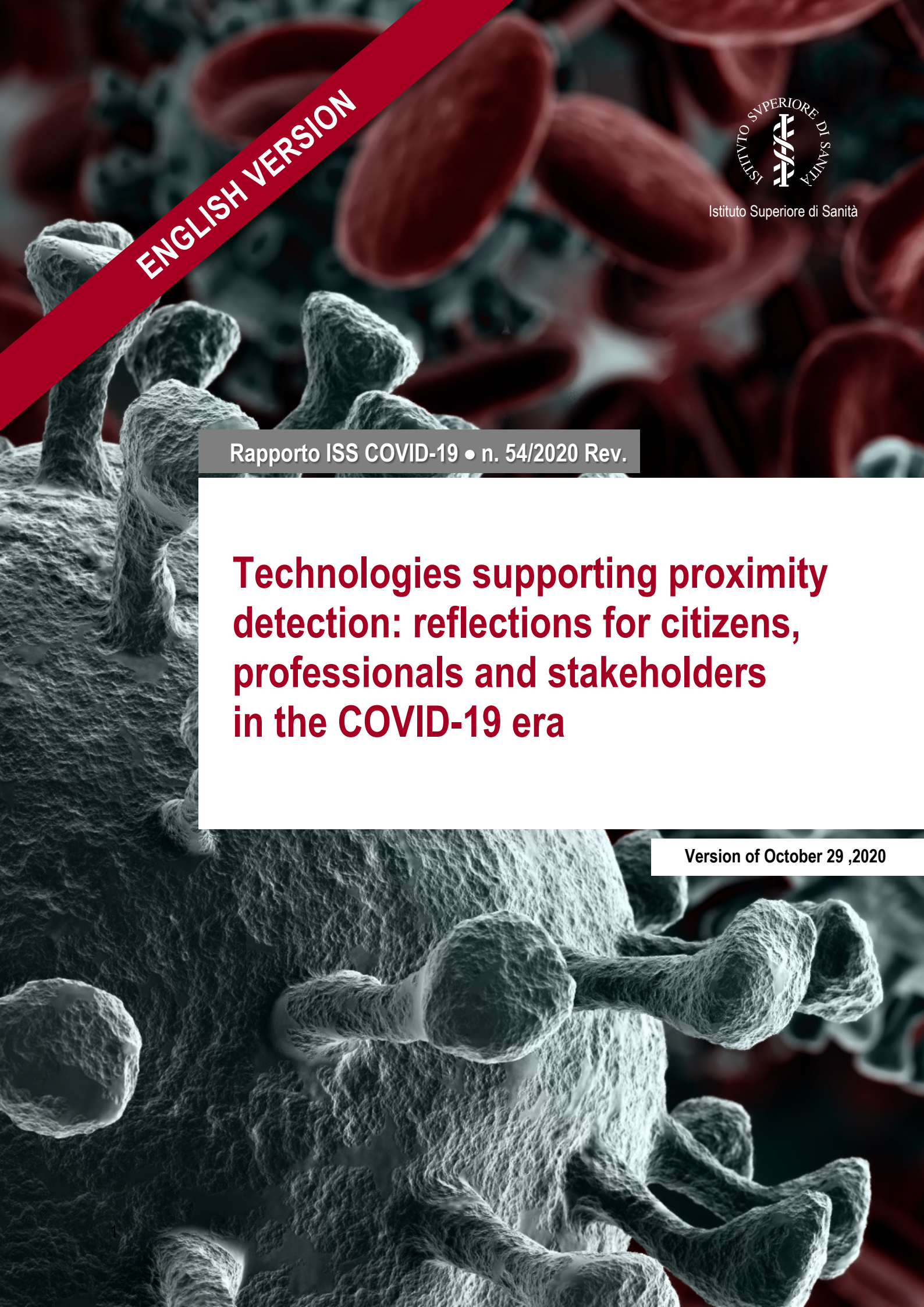
ENGLISH VERSION

Istituto Superiore di Sanità

Rapporto ISS COVID-19 • n. 54/2020 Rev.

Technologies supporting proximity detection: reflections for citizens, professionals and stakeholders in the COVID-19 era



Version of October 29 ,2020

Technologies supporting proximity detection: reflections for citizens, professionals and stakeholders in the COVID-19 era

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Daniele GIANSANTI (a), Giuseppe D'AVENIO (a), Mirko ROSSI (a), Alessandro SPURIO (a), Luigi BERTINATO (b), Mauro GRIGIONI (a)

(a) Centro Nazionale Tecnologie Innovative in Sanità Pubblica, ISS

(b) Segreteria Scientifica Presidenza, ISS

Istituto Superiore di Sanità
Technologies supporting proximity detection: reflections for citizens, professionals and stakeholders in the COVID-19 era. Version of October 29, 2020.
Giansanti Daniele, Giuseppe D'Avenio, Mirko Rossi, Alessandro Spurio, Luigi Bertinato, Mauro Grigioni
2020, 20 p. Rapporto ISS COVID-19 n. 54/2020 Rev. English version

The report, addressed to citizens and professionals, addresses the introduction of technologies supporting the proximity detection on a smartphone App to face the COVID-19 epidemic. The study has three points of view. The first one introduces contact tracing, starting from the definition of the World Health Organization, independently from the digital techniques and is actually divided into three important steps: contact identification, contact listing, contact follow-up. The second point of view highlights the innovations of mobile technology based on smartphones not available during the diffusion of the pandemic caused by the virus SARS-CoV in 2003. The third point of view addresses the diffusion and evolution of these Apps through a state-of-the-art analysis. The report is also a dynamic tool updated on the basis of the evolution of technological solutions and the evidence emerging from the international scientific literature.

This version is an update of the previous one with some revisions on the diffusion status of the App for proximity tracing.

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The reports translated in English are available from: **https://www.iss.it/rapporti-iss-COVID-19-in-english**

For information: mauro.grigioni@iss.it

Cite this document as follows:

Giansanti D, D'Avenio G, Rossi M, Spurio A, Bertinato L, Grigioni M. *Technologies supporting proximity detection: reflections for citizens, professionals and stakeholders in the COVID-19 era. Version of October 29, 2020.* Roma: Istituto Superiore di Sanità; 2020. (Rapporto ISS COVID-19 n. 54/2020 Rev. – English version).

The responsibility for scientific and technical data lies with the authors, who declare that they do not have any conflict of interest.

Editing and graphics: ISS Scientific Communication Unit (Sandra Salinetti and Paola De Castro)

viale Regina Elena, 299 –00161 Roma

Table of contents

Introduction

This report represents a first step in the world of technologies that have had or will have an impact in countering the current SARS-CoV-2 pandemic (coronavirus that causes COVID-19). In the current phase of the pandemic, the technologies deemed capable of responding to the demand for relaunching economic, work and social activities, necessary to promote the recovery of life interrupted by the lockdown phase, have been highlighted. Among these, the most important to combat the contagion is the digital technology to support traditional contact tracing activities (called analogical by many) carried out by proximity detection technology in the form of software applications (App). There has been much talk about this on the web, on social networks and in the media.

We want to provide useful information to citizens and healthcare professionals to extricate themselves between the different approaches to the problem of effectively and promptly monitoring close contacts of patients positive for the SARS-CoV-2 coronavirus (Annex 1 to Circular 6360 of 27 February 2020) to counteract the re-ignition of new outbreaks.

The report is divided into three points of view. *First*, the definition of contact tracing will be introduced, starting with the definition by the World Health Organization (WHO), which has faced previous epidemic crises, such as Ebola, in which digital techniques were not available. The *second point* of view is to outline some particularities of the context and addresses the substantial differences regarding the technological aspects between the current COVID-19 epidemic and the previous SARS (Severe Acute Respiratory Syndrome) of 2003 due to the virus SARS-CoV. Actually, in the previous epidemic there were no smartphones, multifaceted devices capable of providing multiple functions; for example, thanks to sensors (including movement ones), connections to the data network, positioning, peer to peer type short-range transmission, software applications (Apps) that dramatically expand the possibilities of various types of experiences and the use of services. It is therefore highlighted how the technological characteristics of this device make it possible to perform digital contact tracing. The *third point of view* concerns the evolution of the App in the field of contact tracing. The commentary tool is used, which through sequential narration addresses the evolution of digital contact tracing solutions. We began by reviewing the Apps used in the Asian world, where the epidemic had its first impact, and where the measures taken together with the adoption of these tools allowed a first, in some cases rapid, containment of the epidemic (there have been new outbreaks in recent weeks), with a strong sacrifice of citizen privacy and a strong impact on the social sphere, leading in some cases to the stigmatization of positive patients. A U.S. App was added to the review which addresses concern for privacy of Asian Apps, orienting towards greater transparency (the designers have made available online the White Paper of great interest to designers and stakeholders included in the bibliography). *Finally*, the report concludes with some indications of current technologies to complement the use of a *contact tracing* App, using different approaches, both on the national and international scene.

In Italy alone, several hundred proposals were submitted to the national call for the choice of the Italian App. The report, in line with the objective in the introduction, does not aim to identify the App or the best of the bunch technological solution (this task is up to others) but to inform and update all the actors involved. Furthermore, the choice of the use of the commentary is due to the rapid succession of news and releases of new solutions as well as a slow development of a robust scientific bibliography on these Apps, on the potential and related validation, while there is the propensity to privilege releases of agency and social media news to gain attention.

Contact tracing: characteristics and problems

Generality on the contact tracing

In public health, contact tracing and management is the process of identifying people ("contacts") who may have come into contact with an infected person and subsequent collection of further information on those contacts, as well as the monitoring of the contact for 14 days after exposure to ensure that they are observing the quarantine in a safe, sustainable and effective manner to prevent further transmission. Additionally, it involves checking for any onset of symptoms, even mild ones, and quickly identifying secondary cases of infection, test them, isolate them and treat them. In this way the public health action aims to reduce contagion and therefore infections in the population. The infectious diseases for which contact tracing is commonly performed are numerous, ranging from tuberculosis to Ebola. Contact tracing was applied to the SARS-CoV epidemic and is currently being applied to COVID-19 (i.e., the disease associated with the SARS-CoV-2 virus). The exact definition of contact tracing can be found starting from the 2014 WHO guidelines (1):

> "Contact tracing is defined as the identification and follow-up of persons who may have come into contact with an infected person."

The objectives of the contact tracing are:

- Stop the transmission in progress and reduce the spread of an infection.
- Notify contacts of the possibility of infection and offer preventive advice or prophylactic care.
- Offer diagnosis, advice and treatment to people who are already infected.
- In case of treatable infection, help prevent reinfection of the originally infected patient.
- Know the epidemiology of a disease in a particular population.

Let's see in detail the three essential activities of contact tracing:

- *Contact identification*
  It is an essential part concerning the epidemiological investigation and is performed according to standard procedures concerning this discipline, starting from cases that can be identified as suspicious, probable or confirmed. Naturally it is also carried out starting from cases of death attributable to the epidemiological factor investigated.
- *Contact listing*
  It concerns all people who have had significant exposure (falling into the categories described above). They will therefore have to be listed according to standard procedures. Particular attention must be paid to identifying each contact listed and providing them with information on their contact status and the correct instructions to follow.
- *Contact follow-up*
  It is an intensive activity related to contact tracing that involves numerous professionals (from epidemiology, public health, law enforcement, the community, government bodies, medicine and safety at work, volunteering, information and communication technology), and takes time for interviews in which attempts are made to reduce misidentification and status attribution by direct interview. Contact tracing is often confused with this activity. An efficient contact tracing system depends on a relationship of trust with the community, which in turn promotes optimal cooperation, an essential factor also in the use of the App.

Implications of contact tracing

It is understandable that in contact tracing activities problems can arise relating to the sphere of privacy and confidentiality, due to the processing of sensitive information. On the one hand, healthcare professionals have a social and ethical duty to warn an individual about His or Her exposure, supported by legal devices that allow them to take action to contain a communicable disease. On the other hand, infected people still have a recognized right to general and medical confidentiality.

Healthcare professionals, following the indications of the GDPR (General Data Protection Regulation, EU Regulation 2016/679), reveal the minimum amount of information required to achieve the goals of contact tracing. For example, contacts are only told that they were exposed to a particular infection, but not informed of the person who was the source of the exposure. It has also been noted that contact tracing may discourage people from seeking medical care for fear of losing confidentiality and fear of being stigmatized. Therefore, the objectives of contact tracing must be achieved without generating distrust on the part of the community and maintaining maximum sensitivity in individual situations.

The comparison of the measures taken in different countries will make it possible to highlight how the processing of sensitive information has been dealt with or which containment actions it has allowed to be used. In this regard, there is widespread consideration that the need for Europe to maintain unaltered rights of citizens (typically cited in the constitutions of democracies) using the GDPR can lead to the potential loss of effectiveness of contact tracing activities, however it must also be recognized that the communicative narrative plays a fundamental role in creating trust in the solutions undertaken and keeping the population highly motivated.

The new technologies and contact tracing in the COVID-19 era

SARS-CoV-2 and SARS-CoV

The SARS-CoV-2 pandemic of 2019-2020 first manifested itself in December 2019 in the city of Wuhan, the capital of the Chinese province of Hubei, and, as it is well known, it subsequently spread to various countries around the world.

The spread of the SARS-CoV-2 coronavirus has pushed all affected countries to analyse all of the opportunities offered by current technology, which generated both a high number of solutions and a great debate on their actual ability to face the challenges promoted by pandemic spread. Previously, an epidemic caused by a coronavirus (SARS-CoV), the SARS (Severe Acute Respiratory Syndrome) of 2003, which first appeared in November 2002 in Guangdong province (Canton) in China, had been addressed. The epidemic lasted over a period of time from November 2002 to July 2003.

Managing and controlling the expansion of infections of the COVID-19 pandemic requires the reduction of contacts as much as possible through contact tracing. The substantial difference between the potential methods of contact tracing in 2003 during the SARS epidemic and the current ones are considerable. During the previous pandemic, current mobile technologies were not available and in particular the smartphone as we know it today was not available.

In fact, only in 2008 did we gradually witnessed the development of mobile technologies (2) as we know them today, thanks to the smartphone, which has, compared to previous mobile technologies, some peculiar characteristics. In general, the smartphone differs from the basic mobile phone due to the presence of the following features:

1. the increased memory, a higher computing capacity, a much more advanced data connection capacity due to the presence of dedicated operating systems.
2. a great potential for the production and management of multimedia content such as taking high-resolution photos, producing video clips.
3. the ability to easily install free and/or paid features and/or applications (Apps).
4. the provision of a high-resolution touch screen.
5. the ability to use/operate a virtual keyboard to interact with the various functions of the device (from the address book to the notepad), with the web, with the various applications installed and with the so-called social networks.
6. the integration with sensors such as accelerometers, gyroscopes, magnetometers, thermometers and even in the most advanced models: photoelectric sensors, laser depth sensors, hall effect sensors, proximity sensors, barometers.
7. the possibility of tethering (i.e. providing internet access to other devices through hot spots) over the wireless network, Wi-Fi or Bluetooth, to devices such as other smartphones or mobile phones, laptops or fixed computers.
8. the availability of GPS sensors.

Among the various components of the smartphone useful in the context of the problems that will be described below, we find in particular:

- the ability to easily install Apps;
- the availability of technologies that use Bluetooth, GPS and Wi-Fi and data network in general;
- some sensors such as accelerometers and magnetometers;
- the accessibility to large databases.

Bluetooth is a technical-industrial data transmission standard for Wireless Personal Area Networks (WPAN), a technology widely used by bioengineering to be able to carry out measurements of vital parameters or in any case relating to activity or health using sensors placed in various body parts and return them to a summary web page.

Wi-Fi is a family of Wireless Local Area Network (WLAN) technologies that use devices based on the IEEE 802.11 standards and it is used to connect systems like the one described above to the internet and transfer information to a server.

In telecommunications, the Global Positioning System (GPS) is a US military satellite positioning and navigation system. Through a dedicated network of artificial satellites in orbit, it provides a mobile terminal or GPS receiver with information on its geographic coordinates and its time in all weather conditions, anywhere on earth or in its immediate vicinity, where there is the possibility of unobstructed communication, with at least four satellites in the system. The localization takes place through the transmission of a radio signal by each satellite and the processing of the received signals by the GPS receiver.

Technological insights for contact tracing

Among the transmission and reception technologies mentioned above all over the world, the choice fell to Bluetooth Low Energy (BLE) because although not designed for contact tracing, it is able to pair two devices and determine their distance in the interval required by the definition of close contact. Bluetooth is a standard for short-range communications between electronic devices. The recent BLE version was introduced in 2011 in order to ensure communications between devices using a low amount of energy. BLE is not only able to easily allow the communication between two devices, even very different ones, but allows to deduce the distance between the coupled devices from the power measurement used; it is a technology that has aroused a lot of interest as regards the measurement of the mutual distance between devices.

Historically, Bluetooth has been studied for the localization of single devices, exploiting the presence of several fixed transmitters (beacons), of known position, and analysing the signals received by the device being located. In particular, the so-called RSSI (Received Signal Strength Indication), a quantity linked to the power of the received signal, has often been used. The inherent difficulty with such measurements is that the RSSI is not a linear function of the distance from the transmitter. Furthermore, the RSSI value is quite variable, even at a constant distance between transmitter and receiver. Finally, multi propagation usually occurs indoors, due to reflections, which further complicates the accurate calculation of the distance between the device and the transmitter. With a sufficient number of fixed transmitters, in any case, it is already possible to achieve an accuracy in localization of about 30 cm, with particular methods of analysis (3).

Probably in the future there will be a marked improvement in localization via BLE, through standardization of the hardware implementations of RSSI (4).

If one is interested in the distance of a device from another device (proximity measurement) rather than the location of a device, as is the case with software applications for contact tracing, it should be noted first of all how the maximum distance between two BLE devices depends on the environment in which they operate: outdoors this distance can even reach 1000 m in direct connection (Bluetooth 5 LE), while indoors, due to the absorption of electromagnetic radiation, it is a few tens of meters.

The RSSI can be used also in the measurement of the mutual distance between two devices (ranging), which however greatly limits the accuracy of the measurement in closed environments.

Better performance than those relating to measurements via RSSI can be obtained with time-of-flight techniques (5), which measure the time elapsed between the sending of a message and the receipt of the response message by the second device. However, these methodologies do not seem feasible with BLE, at least at the moment, since this standard does not offer sufficiently accurate time stamping techniques.

App for tracking and tracing

Contact tracing and mobile technology

Contact tracing ideally allows for an interruption in the chains of contagion. Traditional contact tracing is an activity that requires many resources, both of time and of specialized personnel. On the other hand, it allows for more detailed information on the positive person and his contacts.

In the case of the current pandemic, the possibility of tracing the contacts of a given person (typically, a COVID-19 positive subject) via mobile devices has been much studied. The greatest challenge in this regard is probably not of a technical nature (mobile technologies have long made it possible to identify the user's position, either when the user is aware or not), but the need to avoid fragmentation into many Apps, more or less equivalent, but not interoperable.

By exploiting mobile technologies, contact tracing can now be implemented automatically. Smartphones can be programmed to keep track of the places in which their owner has passed (e.g. through maps of the routes followed). Once the positivity to the virus of the latter has been ascertained, in principle the analysis of the temporal trace of her or his movements can allow to trace other persons who had been standing at a distance below a given threshold (a few meters), in the period of potential contagiousness. Clearly it is necessary for this reason that the potentially infected are in turn equipped with a software residing on the smartphone, identical (or at least compatible) with that of the subject tested positive. The tracking of the subjects (which is assumed to have the consent of the interested parties) can be carried out with various technologies, as mentioned in the previous section, possibly also in combination.

Genesis of the App for tracing

Prior to use in the epidemiological field, there have been several examples of Apps to locate people or things, often there are definitions of App for tracing and App for tracking; it should be borne in mind that in engineering the term tracking is used for continuous tracking of the position. Among the first experiences of creating and using Apps of this type we find:

- Applications for monitoring subjects during the execution of remote routes (not only used as one might think by "trekking lovers", but also for the safety of solo workers), for example in the mountains.
- Applications for monitoring children. Browsing the internet, it is still possible to find several blog sites that deal with these applications.
- Applications that can manage bracelets (wearable devices) that with various technologies (ultrasound or Bluetooth) can provide an alarm if you get too close to an object or another person with a similar device.
- Applications for the monitoring/tracing of animals, in particular of pets. In this context, the National Centre for Innovative Technologies in Public Health of the Istituto Superiore di Sanità (ISS, the National Institute of Health in Italy) has specifically dealt with the development and testing of systems for tracking and motor monitoring of dogs (6), with counting of steps and alarm in case of the exit from a geographic domain.

In general, these applications can let us know the exact location of a device and to get its position in real time. This can allow one to remotely observe the position of monitored subjects. Of course, this also allows one to keep track of a lost device. It is also possible to get the location history of the device to know the

routes a person has taken recently. By applying geographic domains, it is possible to receive instant alerts on entry and exit from certain areas.

Although *tracing* and *tracking* are generally considered to be synonymous, *contact tracing* is usually referred to as epidemiological surveillance activities.

Utility of Apps for tracing to contain the epidemic

Being able to develop a method to allow complete traceability with very low privacy risk is the strategy in using it in a pandemic control capacity, not only when a slowdown in the contagion is being recorded, but especially during the reopening phase when the state of immunity of the population is unknown.

Figure 1 represents the processing of data obtained by the Civil Protection up to 04/04/2020. It shows how the containment measures have changed the initial trend from the typical exponential trend. The logistic curve model, which provides for a final plateau, certainly represents a better approximation of the observed data. Referring to the exponential model, the doubling time as of April 4, 2020 is equal to 16.20 days. By contrast, at the end of the so-called "red zone" in the municipalities of the province of Lodi (8 March 2020), the doubling time was much shorter, 4.37 days. This confirms the effectiveness of the measures implemented to contain the epidemic spread, which have significantly increased the doubling time of the infection.

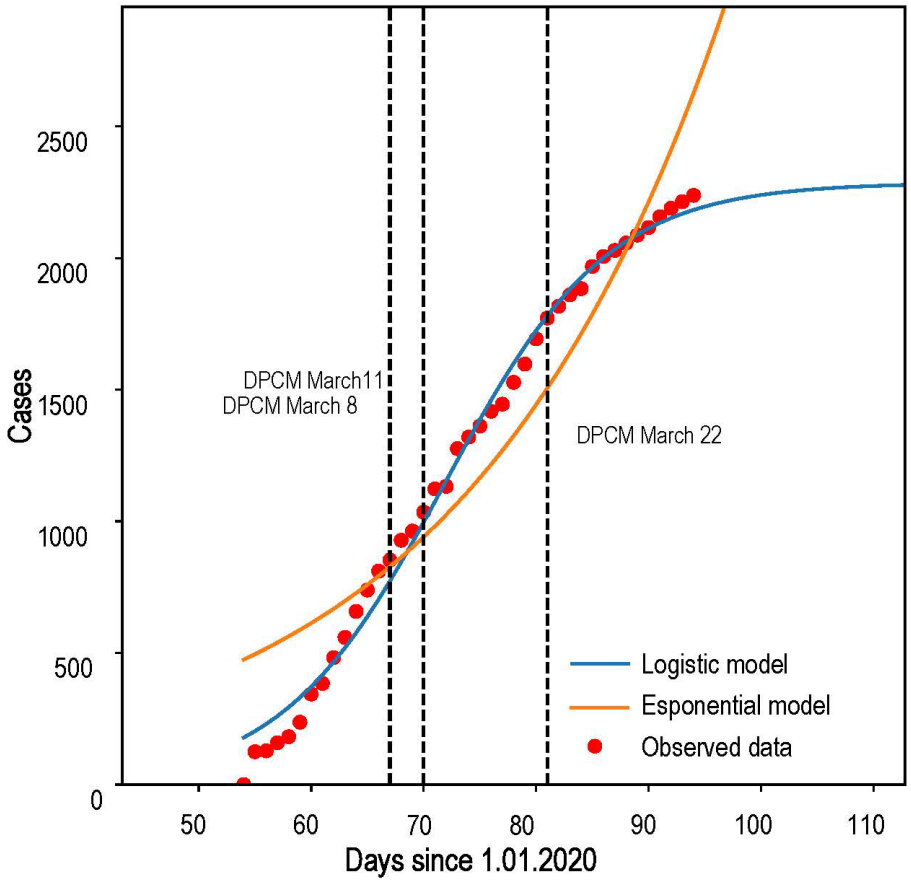

Figure 1. Trend in the total number of cases (positive, cured and deceased) in the province of Lodi

As anticipated in the introductory paragraph, the goal of *contact tracing* is to contain the contagion curve. The usefulness of the Apps was then also shown in retrospect. In general, Asian containment models, based on an "iron digital localization", have shown a positive impact for the containment of the epidemic, as illustrated in a recent scientific article entitled *Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing* (7) in which the combined impact of two interventions was modelled: isolation of symptomatic individuals and *contact tracing* with the quarantine of symptomatic cases via App. The authors of the article analysed the key parameters of the spread of the epidemic to estimate the contribution of different transmission routes and determine the requirements for case isolation and contact tracing process needed to stop the outbreak; and highlighted how a contact tracing App similar to the Asian model, which creates a memory of proximity contacts and immediately notifies the contacts of positive cases, can achieve control of the epidemic if used by a sufficient number of people.

Possible negative consequences of digital contact tracing

The COVID-19 pandemic is a global public health emergency that requires a coordinated and large-scale response from governments around the world. From this perspective, contact tracing is undoubtedly a very promising weapon to contain the exponential spread of the contagion. However, the risks involved in the massive application of population control techniques, that can lead to the problems highlighted in the introductory section, relating to the violation of privacy and social stigmatization, must also be taken into consideration. In the course of an emergency such as this, now widespread throughout the world, intolerant behaviours of citizens towards forms of invasive digital surveillance are foreseeable, with the risk that emergency measures are not accepted except with an appropriate communicative narrative.

The risk that the coronavirus epidemic involves unpopular choices or limitations of civil rights (8) is tangible - not only in countries governed by authoritarian regimes. In a recent paper (9), a number of international organizations ask governments to show their leadership in addressing the pandemic in a way that ensures that the use of digital technologies to track and monitor individuals and populations is carried out in respecting the rights of the individual herself or himself. It is difficult not to agree with what is stated in the aforementioned document, i.e., "the decisions that governments make now to confront the pandemic will shape what the world looks like in the future".

A series of conditions must therefore be set as a fundamental criterion for respecting the rights of the individual:

- Surveillance measures taken in response to the pandemic must be compatible, necessary and proportionate with the law.
- Governments must act transparently, so that measures taken are monitored and, if appropriate, withdrawn in the future.
- If the emergency requires the expansion of control and surveillance, these measures must be limited in time.
- States must ensure that the increase in the collection, storage and aggregation of citizens' personal data is limited in time, and aimed exclusively at containing the pandemic in progress.
- Any use of digital surveillance technologies must take into consideration the possibility that they are used to promote discrimination against ethnic minorities or other marginalized strata of society.
- Appropriate control mechanisms must be put in place against possible abuses in surveillance. This activity must be scrutinized by independent bodies.

- Responses associated with the COVID-19 pandemic, particularly those involving the collection of personal data, should include mechanisms for free, active and meaningful stakeholder participation (in particular public health experts and representatives of the most marginalized groups of the society).

Role of location technology in era COVID in the Asian countries

In consideration of the continuous spread of the Italian App, as required by the "Cura Italia" decree (Decree-Law 17 March 2020 n. 18), it is useful to carry out a brief analysis on the use of the App for contact tracing abroad (10). Italy, like other countries in Europe and the United States, has chosen a less technological path for the so-called first phase: a lockdown of activities to flatten the curve of the pandemic. In Asian countries, where the COVID-19 epidemic occurred earlier, there has been an attempt at containment through approaches characterized by a strong use of technologies associated with very different containment measures (11). In China, very strict lockdowns were carried out, while the South Korean approach made it possible to avoid resorting to social isolation measures as the epidemiological surveillance network was very developed, however also using digital technology (App) to support the contact "analogic" tracing.

The Singapore model

Singapore used a broadcasting model and was able to detect nearly three times more cases than the global average, thanks to its disease surveillance system and accurate digital contact tracing. The system was centralized on servers of the National Center for Infectious Diseases. The App, called *Trace Together* (https://www.tracetogether.gov.sg/) and prepared by the government, is relatively simple and functional, and it is used only on those who have entered the Digital Contact List (DCL) after the appropriate phase of Digital Contact Identification. Individuals in DCL can be called several times a day and must activate a click on an online connection that shares the location of their phone. Spot checks and hefty fines do the rest.

The China model

The Chinese response to the SARS-CoV-2 pandemic has focused on both social distancing and coercive measures. It is estimated that in the Hubei area up to 57 million people have been placed in strict quarantine, with a very strict "red zone". In addition to these traditional measures implemented very vigorously, the virus has become a catalyst in China for further expansion of surveillance technologies. A Chinese peculiarity is the large use of *WeChat* (used pervasively by citizens such as our *WhatsApp* offering countless functions suitable for everyday use) and *Alipay*, *Alibaba*'s payment system as these two platforms have conquered the habits of the population. The Chinese government's strategy was not to create an additional App, but to integrate a tool with the two popular Apps. In this way the government can know "who you have travelled with", "where you have been" through the data provided by *WeChat* and *Alipay* to the tool. The tool created specifically by the Chinese government for contagion control is the system called *Alipay Health Code* (10). Spyware, Wi-Fi sniffers, car license plate trackers and facial recognition systems linked to these technologies were used. *Health Code* automatically assigns people one of three colour codes (*green, yellow and red*) in relation to their exposure status to the pandemic. Each of the codes allows for freedom of movement or placement in a DCL that provides two different forms of quarantines. It should be noted that without this tool it would not have been possible to monitor usage of public transportation and that the tool through the two popular Apps is also integrated with Google Maps.

The South Korea model

South Korea also has digital Apps for contact tracing. The *Corona 100m* App, for example, crosses the user's geolocation data (GPS) with those provided by the government, and was launched on 11 February. The *Corona 100m* App (10, 11) sends a notification (SMS) when one stands within 100 m of a suspect or infected person. With regard to the Korean *contact tracing* approach, it should be noted that:

1. Korean law allows authorities to access camera data, GPS tracing data from phones and cars, credit card transactions and other personal data for disease control purposes.
2. The Korean system provides a website where information to be disclosed to the public converges. On this site you will find all the useful information from contact tracing including statistics on infections, deaths, the healed, and obviously all hygiene advice. But also, the movements (in some cases too detailed) of the infected people.

In any case, it should be emphasized that the containment strategy followed by South Korea, which can be considered the best among all those implemented in the international field so far, makes use of the technological support of the App in the framework of a very well organized epidemiological surveillance system, for which the identification of potential contacts is immediately followed by the appropriate test and possibly the measures of social isolation. The large quantity of tests carried out from the beginning with mobile stations was the element that characterizes South Korea compared to the rest of the world. The result is certainly positive, with relatively few cases even in the absence of lockdown measures such as those imposed in Europe in the past months.

App for tracing in the USA: an example of an App for localization in respect of privacy

The United States has also used technological innovation to cope with the epidemic. These efforts involve the study and development of technological solutions for *contact tracing* of subjects who are positive or isolated for the risk of having the virus. Some of these efforts have been to study solutions that overcome the privacy problems encountered by the Apps used in the Asian world. A research experience from the Massachusetts Institute of Technology (MIT) has led to the creation of the SafePaths PrivateKit App (https://safepaths.mit.edu/) which has had a great prominence both in the media and scientifically thanks to the *White Paper* (12) available to the designers. This App is available from March 17 on the *Google Play* and App Store.

This App allows to monitor personal movements in full respect of privacy, and allows to reconstruct the network of contacts of those infected with COVID-19. Users can download location information of positives (whose identity is hidden from users via encryption) so that they can self-determine their likely exposure to COVID-19. The App can do this without collecting user information in an external cloud and thus prevents the government from surveillance. The App provides information on the contact. The transparency initiative of the designers to make the *White Paper* available also offers experts, politicians and stakeholders the opportunity to verify the choices and technological aspects.

Further developments: the European way in the approach to contact tracing and the Italian choice

Further developments on the international scene

The research activity for technological solutions in the world starting from the Asian experience is still large and diversified. As it is easy to verify, for example, on the sites of the two giants Apple and Google, these multinationals have launched a complete solution that includes programming interfaces (Application Programming Interface, API) and technologies at the operating system level, to facilitate the activation of tracking contacts. Users will be able to receive alerts if they come in contact with someone who tests positive for COVID-19.

The initiative is relevant in consideration of the fact that most smartphones use the IOs and Android operating systems that rely respectively on Apple and Google for technologies and for virtual App stores made available (Apple store and Play store).

Many nations in different parts of the world have moved towards the creation of apps for contact tracing, with a different approach to privacy. Making a list is impossible as we are witnessing an hour by hour update.

Here are some examples. In the USA, other Apps are being developed as in the case of New York where the *STOP COVID NYC* was released (https://icahn.mssm.edu/research/hpims/covid19-taskforce). In Israel, the *HaMagen* App (https://govextra.gov.il/ministry-of-health/hamagen-app/download-en/) allows monitoring of the history of users' locations. If a person is infected, the users' and the infected person's location histories are linked to see if there has been potential exposure. The latest added to the list is the Indian government which has officially launched an App for tracing the infection. The Indian App, translated from Sanskrit "*A bridge of health*", through Bluetooth and phone location (GPS) assesses whether a user has been close to a person with COVID-19. The data remains on the device in an encrypted, i.e. anonymous, form and is shared with the government only in the event that a user is positive for coronavirus or has come into contact with a person deemed positive, but is not shared with third parties (13). The same thing is happening in many other countries around the world, from Russia to the UK.

The European direction and the Italian choice

Europe has offered at least two digital *contact tra*cing application models, one described with the acronym DP-3T (Decentralized Privacy-Preserving Proximity Tracing) (https://github.com/DP-3T/documents) with calculation on the mobile phone, and the other with the acronym PEPP-PT (Pan-European Privacy-Preserving Proximity Tracing) (https://www.pepp-pt.org/) with calculation on a central server.

The latter can be represented as follows: the App stores locally on the device all the Bluetooth codes of other devices equipped with the same App (whether they are smartphones, smart watches or stand-alone devices such as bracelets); encryption and pseudo-anonymization systems prevent the code from being associated with the identity of the owner of that device.

1. Features are triggered when a citizen is detected positive after a coronavirus test.
2. With a positive test, the operator generates a code with a different App with which the citizen can upload the data collected by his or her App to a server, which stores the list of Bluetooth codes with which he or she has had contact.

3. The server calculates for each of these codes the risk that there has been a contagion (proximity, contact time) and then sends a notification to the devices of people potentially at risk, again through the App.
4. The notification has a message set by the health authorities and asks to follow a protocol (isolation, contact emergency numbers for swab tests).

An alternative scheme should also be remembered, the DP-3T, which is based on a decentralized mechanism. The memory of the mobile phone is unlocked by the same patient who was found positive, voluntarily, leading to the personal notification of the contact, which should voluntarily be tested. In this case, the information indirectly reaches the organization in charge of contact tracing.

Italy has chosen Immuni from Bending Spoon and the Santagostino Medical Center, selecting it from several candidate apps for proximity tracing. The process of selecting the official App for proximity tracing has been made public, through the report of the activities carried out by the work subgroup engaged in the Ministry of Technological Innovation operating in the identification of "technologies for emergency management" (in particular proximity tracing through evaluation of 319 different technological solutions received with a call for contribution from 24 to 26 March) (online documentation) (14).

The App selected by the Italian government follows the decentralized model, in accordance with the DP-3T protocol. The Ministry of Innovation published the *Immuni back-end code* on the Github platform on May 28, 2020, after making public the part relating to the user interface (*front-end*).

A brief update on the state of use of the Immuni App

As far as citizen-oriented information on the Immuni App is concerned, please refer to the website: https://www.immuni.italia.it/, where other information dedicated to professionals, through other specific addresses, is also available, such as the code (https://github.com/immuni-app/immuni-documentation). It should also be noted that both the App and the site have a FAQ section as well as useful information, that we reproduce here for convenience:

- The toll-free number active from 7 to 22 is **800 91 24 91**.
- The email support for citizens is cittadini@immuni.italia.it
- E-mail support for health care personnel is personalesanitario@immuni.italia.it.

With regard to training initiatives, we would like to point out the activation by the ISS of a distance learning course through EDUISS, the platform dedicated to Distance Learning (FAD) in public health of the Institute. This course called in Italian "Emergenza epidemiologica COVID-19: elementi per il contact tracing" ("Epidemiological emergency COVID-19: elements for contact tracing") is dedicated to professionals who perform contact tracing activities in the health emergency (https://www.eduiss.it/course/info.php?id=307). The citizen, the expert and the contact tracing operator can also have a continuous update on the status of use of the Immuni App for various aspects such as:

- the downloading status (number of citizens who have installed it);
- the number of notifications;
- users who have communicated their positivity.

This update by the Ministry of Health is available at https://www.immuni.italia.it/dashboard.html.

The Quick Response code (QR code) (Figure 2) of this address and the print screen (Figure 3) of this address updated at the time of drafting the update of this report are reported for the reader's convenience.

Figure 2. Quick response code associated with https://www.immuni.italia.it/dashboard.htm

Figure 3. Print screen from the address https://www.immuni.italia.it/dashboard.html updated on the date of finalization of the update of this report

Important notices for the use of the Immuni App

As far as privacy is concerned, great attention was paid to its protection in the development of Immuni. Many measures have been taken to protect it, such as the following (from https://www.immuni.italia.it/faq.html):

> "The App does not collect data that allow others to trace your identity. It does not ask, nor is it able to obtain, your name, surname, date of birth, address, telephone number or email.
>
> Your movements are not tracked or traceable in any way.
>
> The random codes that smartphones exchange via Bluetooth do not contain information either about your device or about you.
>
> To protect your privacy, these random codes change several times every hour.
>
> The data saved on your smartphone and the connections between the App and the server are encrypted.
>
> All data saved on the device or server will be deleted when no longer needed.
>
> Your data is collected by the Ministry of Health and will be used only to contain the COVID-19 epidemic or for scientific research purposes.
>
> The data is saved on servers in Italy and managed by public entities. "

In addition, the free availability of the code of the various components of Immuni on the Github platform is a further measure of guaranteeing compliance with current regulations on the protection of personal data.

Like any technological solution for proximity detection for the purpose of containing the COVID-19 epidemic, the Immuni App must also be integrated into the national system for manual contact tracing. To achieve this purpose, together with the protection of the information of the subjects, the need for human intervention (voluntary notifications) has been emphasized, so the role of health professionals and of the users of the App becomes relevant.

In fact, it should be emphasized that, after the test for SARS-CoV-2, any positive result is not automatically known to the Immuni platform, but it is necessary for the user to report it, following the instructions of the app and with the assistance of the operator. sanitary

Using the "report positivity" function, the user allows the App to upload their own random codes.

> "The health worker who communicates the positive result of the test will assist you by telephone. He will ask you for the single-use code displayed on the screen and will use it to authorize you to upload your data" (from https://www.immuni.italia.it/faq.html).

Each mobile device compares the data in the local memory with the shared codes, and informs the user of any potential contagion, inviting him to consult his general practitioner.

It is evident that the optimal functioning of the system implies the civic sense and the collaboration of individuals who, only after their communication of having been notified by Immuni as a contact at risk, will be taken over by the GP (General Practitioner) and therefore by the NHS (National Healthcare System), similarly to what happens with traditional contact tracing.

Similarly, the report of positivity is based on the active collaboration of the user to provide their key code.

We underline some possible precautions to avoid incorrect use of the system:

- A health worker (or health personnel from the Prevention Department of the Local Health Unit (LHU) or from hospitals) can communicate by telephone the positive result of the test, then he must also invite the subject to open the Immuni App and provide the key code for unlocking the data (for this purpose in the DPCM of October 18, 2020, there is an obligation on the part of the healthcare worker to upload the key code, in the presence of a positive case)
- The subject can perform the positivity test at a private facility, which is not responsible for enabling the communication of the positive subject's data to the Immuni system. The private structure, on the other hand, has the obligation to report any positivity to the LHU, which is responsible for reporting to the Immuni platform: this report can only be made by contacting the interested party.
- The acquired negativity is not automatically registered by the system, but can only be voluntarily notified by the user (from https://www.immuni.italia.it/faq.html: "Your reference LHU submits you to one or more swab tests to confirm that you are no longer positive for COVID-19. When you receive confirmation of negativity from your LHU, you can update your health status within Immuni. Just tap "Have you recovered? Update your status" and "I am COVID-19 negative").

Finally, it is noted that the involvement of the GP, following the notification to the Immuni user that he is a contact at risk, is relevant for the outcome of the systematic application of Immuni, despite the fact that GPs are currently very busy in the epidemic emergency. In this regard, support is provided by the recent establishment of the National Telephone Answering Service for Health Surveillance, sanctioned by the Decree-Law of 28 October 2020, n. 137 (15).

Conclusion

This report has focused on technologies to support proximity tracing in order to complement traditional (analogic) contact tracing activities. It was intended to provide a description, as accessible as possible, without compromising the technical description, to a wide audience, as a contribution to achieving at least 60% use of the App chosen by our government, a threshold identified as effective in allowing us to intercept new possible outbreaks of infection, and ensure the regular occurrence of working life and in general of everyday activities with sufficient personal safety. In other words, we will be ourselves the strength of the action of the whole nation using this App.

As explained in the introductory rationale, this report aims to be: (a) a tool capable of updating citizens, professionals and stakeholders on the developments in progress; (b) a tool for cultural mediation between the information that revolves around this issue and (c) a tool for disseminating essential information and updating (*see* last update subsection on the Immuni App). Following this rationale, this report represents a brief review and update of the previous version of 31 May 2020 which will be followed by further updates as medical knowledge and technological experience evolve in this area with the production of further scientific documentation relevant in this area. As anticipated in the previous review of the report, a first update present here concerned the state of use of the Immuni App chosen in Italy through a public procedure and documented through a public report (14).

In conclusion, it is emphasized that digital applications offer the opportunity to strengthen contact tracing for COVID-19, potentially facilitating contact tracing, improving data management, and contact follow-up and monitoring. Proximity tracking apps can be seen as complementary and not a substitute for traditional contact tracing

Traditional contact tracing works all the better the earlier interventions are decided, during an ongoing epidemic. In the current Italian context (October 2020) we are witnessing the so-called second wave of the epidemic, with a rapid increase in test positives, for which the traditional contact tracing is no longer able to intercept all the contacts of an index case. In this context, the automatic identification of at-risk contacts using proximity detection techniques can play a fundamental role in containing the SARS-CoV-2 epidemic.

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Rapporti ISS COVID-19 (ISS COVID-19 Reports)

ISS COVID-19 Reports are mainly addressed to healthcare professionals to cope with different aspects of the COVID pandemic. They provide essential and urgent directions for emergency management and are subject to updates. All reports have an English abstract.

The complete list is available at **https://www.iss.it/rapporti-COVID-19**.

Some reports (highlighted below) are also translated in English and are available at **https://www.iss.it/rapporti-iss-COVID-19-in-english**

1. Gruppo di lavoro ISS Prevenzione e controllo delle Infezioni. *Indicazioni ad interim per l'effettuazione dell'isolamento e della assistenza sanitaria domiciliare nell'attuale contesto COVID-19.* Versione del 24 luglio 2020. Roma: Istituto Superiore di Sanità; 2020 (Rapporto ISS COVID-19, n. 1/2020 Rev.)
2. Gruppo di lavoro ISS Prevenzione e controllo delle Infezioni. *Indicazioni* ad interim *per un utilizzo razionale delle protezioni per infezione da SARS-CoV-2 nelle attività sanitarie e sociosanitarie (assistenza a soggetti affetti da COVID-19) nell'attuale scenario emergenziale SARS-CoV-2.* Versione del 10 maggio 2020. Roma: Istituto Superiore di Sanità; 2020 (Rapporto ISS COVID-19, n. 2/2020 Rev. 2)
3. Gruppo di lavoro ISS Ambiente e Gestione dei Rifiuti. *Indicazioni* ad interim *per la gestione dei rifiuti urbani in relazione alla trasmissione dell'infezione da virus SARS-CoV-2.* Versione del 31 maggio 2020. Roma: Istituto Superiore di Sanità; 2020 (Rapporto ISS COVID-19, n. 3/2020 Rev. 2)
4. Gruppo di lavoro ISS Prevenzione e controllo delle Infezioni. *Indicazioni ad interim per la prevenzione e il controllo dell'infezione da SARS-CoV-2 in strutture residenziali sociosanitarie.* Versione del 24 agosto 2020. Roma: Istituto Superiore di Sanità; 2020 (Rapporto ISS COVID-19, n. 4/2020 Rev. 2) Available also in English.
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10. Gruppo di Lavoro ISS Ambiente-Rifiuti COVID-19. *Indicazioni ad interim su acqua e servizi igienici in relazione alla diffusione del virus SARS-CoV-2 Versione del 7 aprile 2020.* Roma: Istituto Superiore di Sanità; 2020. (Rapporto ISS COVID-19, n. 10/2020).
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