3 Societal impact of Artificial Intelligence in Medicine and Healthcare: key relevant aspects in the coronavirus pandemic

Emilio Gómez-González and Emilia Gómez.

AI can be of great benefit to medicine and healthcare but also carries a number of risks, often related to how the data it needs is collected and used.

As indicated in the previous Section, the advent of Artificial Intelligence (AI) into Medicine and Healthcare is an ongoing revolution combining the potential of disruptive advances and extraordinary benefits with many unknowns and questionable ethical and social issues.

From early 2020, the devastating consequences of the worldwide spread of the SARS-CoV-2 (corona)virus and the associated COVID-19 disease indicate that the post-COVID-19 world is likely to be different at all societal levels, even if the pandemic 'comes to an end' like previous outbreaks of similar coronaviruses (e.g. the SARS-CoV-1 outbreak between 2002 and 2004). In the current situation there are still many uncertainties. They range from clinical questions, short and long-term effects, potentially associated ailments, new waves of contagion and mutations, to economic and cultural changes, alterations in citizen's daily lives and individual and social rights. In this context, the European Union (EU) faces significant challenges from the health, economic, political and societal points of view.

An extensive structured review by the authors (Gómez-González & Gómez, 2020) of over 600 references shows that AI can play a key role in the fight against the pandemic and in the shaping of the post-COVID-19 world at all levels of society. The coronavirus pandemic has fostered AI applications, particularly in medical and clinical areas, as AI-mediated technologies lay at the main core of the response to the worldwide health crisis. There is a growing arsenal of AI-related developments addressing the coronavirus pandemic from many different approaches. Some of these applications can be listed as follows:

- Data-driven knowledge extraction techniques are being exploited in a variety of areas, from direct medical diagnosis, epidemiology, and management and optimization of clinical and logistical pathways. In public health management, the integration of heterogeneous sources of information –including data from personal devices and medical records– with machine learning techniques offers great potential for the detection of patterns and the prediction of future scenarios, and the prevention and forecasting of disease outbreaks and routes of spreading.
- Computer vision techniques already developed for medical imaging are being adapted for image-based diagnosis of coronavirus related features (e.g. through the analysis of chest scans).
- Massive analysis of genetic data is being employed to speed-up the development of vaccines and treatments.
- Data from social media and community-generated platforms is being used to monitor the spread and the public perception of the disease.
- Robotics, telemedicine and virtual doctors are adopted to replace human-human interaction in contaminated environments. Companion robots, for instance, help to reduce the 'human gaps' created by physical and social isolation.
- AI-mediated tools are being used to detect and fight misinformation and fake news.

As recently pointed out in the analysis of AI in Medicine and Healthcare (Gómez-González & Gómez, 2020), applications in these fields become a double-edged sword in the current health emergency: while providing strong benefits and potential to fight the disease, there are controversial societal aspects to be considered and this balance has been strongly affected in the last few months. In a declaration issued at the beginning of 2020, the World Health Organization also highlighted some of these worrying issues as 'urgent health challenges for the next decade' (Ghebreyesus, 2020). We present this tension and the changes it is generating in the societal view of eight AI-related topics that we consider most relevant in the context of the COVID-19 crisis.

3.1 The boost of telemedicine

Telemedicine has experienced a strong boost during the COVID-19 health emergency because of several significant contributions. On the one hand, telemedicine can reduce the number of people visiting medical services, from general practitioners to hospitals, therefore decreasing risks of contagion and spreading of the disease. On the other hand, it serves to optimize the use of medical resources (e.g. imaging scans, lab test) in 'common pathologies', freeing resources for the priority of the pandemic. Since there are patients who fear visiting clinical facilities, telemedicine is also helpful to reduce incidences related to certain diseases which can be managed remotely. Several current technologies have a strong potential for telemedicine that is not yet fully exploited: from wearables and internet-of-things (IoT) devices for health monitoring, to virtual reality environments for human-human interaction.

However, there are also challenges in using telemedicine in the current pandemic. Among them, there is a need for physicians to adapt to a new scenario without the physical presence of the patient. In addition, there is a risk of individuals being remotely guided to perform certain medical procedures that should be carried out by a trained professional. The lack of direct contact with the patient is of particular relevance for a correct diagnosis in many clinical areas, since physicians extract important information from physical contact (e.g. through palpation) and from visual perception (e.g. gait disturbances, skin appearance). The current impossibility of tactile, haptic feedback is an active drawback to be solved for remote diagnosis platforms and tools.

3.2 Benefits and risks of data-driven algorithms

Data-driven algorithms have been widely exploited to fight the pandemic in four main different areas:

1. medical diagnosis based on processing tests and imaging scans (Baraniuk, 2020) and on the analysis of data from personal devices (mobile phones, wearables) (Menni et al., 2020) (Jacobs, 2020);
2. epidemiological studies to predict pandemic outbreaks, temporal and geographical spread and evolution;
3. enhancement of societal and individual welfare, through social networks and recommender systems to promote social bonding, connect isolated patients and provide recommendations such as personal trainers, newspapers and health support tools; and
4. clinical management of the pandemic: data-driven methods support the optimisation of medical resources under very high pressure (Intensive Care Units, ICUs), logistics (Hao, 2020a), help to generate scientific evidence from multiple data sources, and act as a decision support tool for treatments and the use of equipment.

Some of these applications show extraordinary benefits in terms of efficiency, and are being adopted to fight COVID-19. However, we shouldn't forget the related social and ethical concerns as widely discussed in recent analyses (Gómez-González & Gómez, 2020). Among them, the lack of standards for evaluation and international coordination, and the issues of data selection and curation for training of systems. 'Small', biased datasets used to build and train models may have deep consequences in their performance in real-world scenarios. Even well-established AI tools in other areas present abnormal figures when dealing with new, untested behavioural patterns of people under severe restrictions for many daily activities (Heaven, 2020). The consequences of algorithmic bias in health care need to be carefully assessed, especially regarding their detrimental impact on equity, for example as a consequence of racial and gender bias. In the context of a health emergency, the urgency to find solutions may produce a 'reduction of controls'. What are proper benchmarking strategies? Can we trust new, not well-established systems? Should an AI tool for clinical applications be evaluated by a potentially error-prone human or by another potentially more effective autonomous system? (Gómez-González & Gómez, 2020) (McKinsey & Company, 2020).

Given the state of the art, we cannot yet trust an algorithm on its own to support decisions influencing human lives (e.g. deciding on who gets admitted to intensive care units, or taking life or death decisions (Scudellari, 2020)). Such 'limit' to AI applications presents many challenges in terms of human supervision and oversight that still need to be addressed.

3.3 Robotics: from fear to new roles and acceptance

The public perception of robots, seen by many as unwanted substitutes of humans and 'job takers' in the pre-COVID-19 situation, has drastically changed during the current health emergency. Automated machines (robots, drones) were part of equipment used by human physicians (e.g. robotic surgery assistants and devices (Graur et al., 2018)), already performing some relatively autonomous activities in hospital and clinical facilities. However, they were mostly restricted to dangerous tasks (e.g. the disinfection of facilities with toxic chemicals or high-energy ultraviolet lights) and repetitive, physically demanding duties (e.g. displacement or storage of equipment). 'Companion robotics' also started to be tested in certain clinical environments (Shishehgar et al, 2018), proving to be very useful, combined with other assistive devices, to provide human-human communication in situations of physical isolation

Nevertheless, in the post-COVID-19 context, autonomous machines are now seen as useful 'operators' which can replace humans in many other types of tasks (Thomas, 2020). Some of them are close to law enforcement (e.g. monitoring the social distancing or the quarantine orders (Su, 2020)) but others include activities that were traditionally considered to need the 'human touch' but have now become too risky for humans. They include patient control and triage, temperature measurements, and the delivery of tests and medication in virus-contaminated environments. Such new roles may evolve into extended care of functionally-impaired patients (e.g. residents in nursing homes). The change in the public perception of robotic platforms in the COVID-19 context can drastically boost their adoption in many areas in the near future.

3.4 Personalised medicine

In the fight against the COVID-19 pandemic it is critical to improve our understanding of the mechanisms of immunity, how human cells battle the virus and how drugs and vaccines may interact. Artificial Intelligence lies at the core of massive data analysis employed to decipher the genetic features required for successful diagnosis and treatments in the paradigm of 'precision medicine', while advanced data integration and mining call for the concept of 'extended personalized medicine' (Gómez-González & Gómez, 2020). These technologies bring in new powerful tools in the fight against COVID-19 (Wakefield, 2020).

Computational biology and virology accelerate the search for treatments and vaccines exploring drug candidates, risk factors and the prediction of side effects (Health Europa, 2020). AI-enabled tools allow for advanced computational models (Biozentrum, 2020), identifying genetic signatures and studying their interaction in highly complex biochemical and biological environments. Real experiments can be strongly boosted by numerical simulations, saving time and resources in the search for new, effective therapies. Patterns of contagion in cells and the analysis of antibody binding sites can be analysed trying to determine which regions of the viral proteins can be more effectively targeted by drugs and vaccine candidates (Fast & Chen, 2020). However, important questions also persist. Personalised medicine aims to develop targeted treatments at the individual level while currently established methodology to generate and accept 'scientific, clinical evidence' relies on group averages and population statistics (Gómez-González & Gómez, 2020). New methodological, testing and regulatory tools are needed.

3.5 A difficult balance: individual rights vs public health

Living a global, world-wide public health emergency, many countries have restricted individual rights implementing such measures as imposed quarantine, confinement of population and social distancing. In this context AI-mediated technologies have proven to be key elements for the control of individuals (Kim, 2020) and societies. They include tools for massive digital surveillance (e.g. computer vision techniques for facial recognition, traffic cameras for population monitoring, temperature monitoring (Schectman et al., 2020) (Lin & Martin, 2020)), merging clinical and social data (Mickle et al., 2020) (Timberg & Harwell, 2020) to provide information to health authorities, the creation of mobile apps for evaluating the exposure of individuals to the virus and digital contact tracing (Kahn & Hopkins, 2020), the programming of algorithms for citizens disease-tagging, even to evaluate the return to work places (Horowitz, 2020) (Rossignol & Lenoir, 2020), and the use of

wearables to control social distancing (e.g. wristbands (Doffman, 2020) or the app developed by the Robert-Kockh Insitute[11]).

Although such applications of technology are justified by authorities and governments as required to fight the pandemic in a fast and effective way (Chandran, 2020), many controversial aspects arise as related to the limitation of individual rights in democratic regimes during peacetime. Among them, privacy and data-protection concerns are increasingly being raised by scientists (Joint Statement on Contact Tracing, 2020) (Bengio et al, 2020), general media (The New York Times, 2020) and even by European Governments (Albergotti, 2020) and the European Union Agency for Fundamental Rights (European Union Agency for Fundamental Rights, 2020). This agency warns on the effects of an uncontrolled use of technology on individual rights, from privacy to freedom of movement and assembly. It also highlights that the use of data-based technology to overcome the pandemic should safeguard those rights, and raises the question of establishing limits on the time and scope of the extraordinary measures taken by the EU Member States. Many additional questions emerge or need to be revisited in these extra-ordinary times (Gómez-González & Gómez, 2020): Should personal (health, location, contacts) data be anonymised or erased after the pandemic is controlled? Can they be made available to private companies (e.g. for medical research?). In June 2020, considering their low infection rate, but in the midst of a controversy between health and data protection authorities, Norway announced halting its app for track and trace data collection, and erasing all the recorded information, on privacy concerns. Should others follow? (Reuters, 2020) (for further discussion on contact tracing apps and their implications see Sections 7 and 8).

3.6 Psychographics and the control of information

Psychographics is a recently coined term that refers to the extraction of psychological and cognitive attributes of humans as related to their opinions and attitudes, including cultural, religious and political, and the analytical characterisation of values, habits and other figures well beyond those data included in common demographics and economic statistics (CB Insights, 2020b). In recent years, it has become a new tool and target for social influence and control, from tailored advertising and nudging consumer's habits to manipulating political orientation, and it is linked to new modalities of 'digital aggressions' and even (cyber)war (CB Insights, 2018). Psychographics relies on AI-mediated massive data collection and analysis and, in the current situation generated by the coronavirus pandemic, it is at the center of the already mentioned boost of data gathering and the struggle for the control and use of information.

In a context of population confinement or with many restrictions to physical displacement and direct social interaction, digital tools for communication and social networks become preferred channels for massive exchange of data including those related to health in any format files, voice, video and in real-time individual and group interactions. In many cases, they rely on very loose security and privacy settings, being therefore open to 'listening' by external parties and to receiving inputs under many appearances. Moreover, these platforms are almost exclusively non-European (see also Section 10).

Recent studies show that the analysis of data in social media allows for evaluating the psychological situation of societal groups and even the emotions of individual people and entire populations in real time (Jaidka et al, 2020). Simultaneously, massive amounts of data about health status, including genetics, physical location, tracing of contacts and many other topics are being collected and processed. This brings to the public debate some undiscussed, controversial issues about 'old and new' concepts, from data property and inheritance (who is the owner of health, genetic data when a person dies?) to AI-mediated technologies for the common good (in Medicine and Healthcare) and the role of regulation and legislators. How will the collected information (of individuals) be used after the pandemic? Might it be used for 'monitoring' political opponents? Or to 'induce' social demands and changes in certain environments?

3.7 The control of information. The risk of an additional 'infodemic'.

Health-related information is critical at the time of pandemics. The extraordinary capabilities of AI-mediated tools can multiply the beneficial effects of trusted, reliable information but also expand the negative consequences of misinformation (wrong information) and disinformation (purposely false, misleading information) spread in society. A specific term ('infodemic') has been defined as the combination of 'information' and 'pandemic' to describe this new risk (Richtel, 2020; Mooney and Juhász, 2020).

Certain relatively obvious negative uses of the AI tools relate to the online, web-based promotion of unproven even clearly harmful remedies for the coronavirus disease and to the 'digital updates' of health scammers

[11] https://play.google.com/store/apps/details?id=de.rki.coronadatenspende&hl=en&gl=de

(Gómez-González & Gómez, 2020) (Popular Science, 2020). Their extent and impacts, including human lives, of such scams (Spring, 2020) led the United Nations Educational, Scientific and Cultural Organization (UNESCO) to issue a warning stating that 'During this coronavirus pandemic, 'fake news' is putting lives at risk' (UN News, 2020) and the European Commission to step up its work addressing health concerns and warning consumers against rogue traders (European Commission, 2020d).

The motives for spreading malicious digital content about the virus and COVID-19 disease to citizens can be many, and include the intention of generating social divide and discontent (Hao, 2020b), disturbances (Cimons, 2020), cyberespionage and cybercrime (Canadian Centre for Cyber Security, 2020), and bioterrorism (Council of Europe, 2020) (see also Section 11)

The heterogeneous mixture of real-world concerns and the multitude of false, misleading information available throughout the Internet creates a strong demand for transparent, reliable information from public authorities about the pandemic itself and explaining the need for, scope and duration of the controversial measures applied during the crisis. Some of the new threats derived from disinformation related to the COVID-19 pandemic have been identified by the European Commission as instigated and supported by foreign state actors opposing the basic pillars of the European Union, and a definite response has started towards a stronger and more resilient EU (European Commission, 2020e). There is an essential role for governments to provide the population with reliable information, avoiding the spread of fake news, misinformation and disinformation, while keeping the fundamental principles of individual and social freedom

3.8 New opportunities for AI.

The current health emergency has generated novel opportunities for AI technologies in many different contexts and unexpected applications have emerged. Some relate to monitoring of physical distancing of people in public spaces, from streets and commercial areas to recreation spaces, even in natural environments (parks, beaches). Other AI-mediated tools play new roles in addressing needs related to healthcare and wellbeing as meditation apps (Cummins, 2020) to reduce stress and anxiety, particularly of patients and caregivers.

Moreover, AI-based technologies offer a strong way forward to explore new methods to fight this and, perhaps, other potential pandemics. Innovative approaches include diagnostic tools based on Internet searches of symptoms or the analysis of voice and sounds (Lubell et al., 2020), and imaging techniques to detect contaminated surfaces and reduce the risks of contagion. Within an international push to promote research and innovation at all societal levels (CB Insights, 2020a) and a number of expanding platforms to foster international cooperation in clinical, scientific, and technological advances to fight the pandemic, Europe is playing a leading role in many of them (European Commission, 2020f) (ELLIS Society, 2020)

3.9 Conclusions

The COVID-19 crisis has created new needs and scenarios at all levels of society, and will produce some paradigm shifts with significant changes in daily life. The development and adoption of AI-mediated technologies has boosted many areas related to Medicine and Healthcare, and we need to take advantage of their benefits, carefully navigating the balance with the associated risks and the expected societal impact that they will bring. As the way data is generated, collected, analysed and used is central to many issues we have highlighted in this Section, the next one discusses some of the economic aspects of access to private data.