Medicine of the Future: The Power of Artificial Intelligence (AI) and Big Data in Healthcare[1]

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ABSTRACT: Artificial Intelligence (AI), Robotics and Big Data revolutionized the world. Digitalization opened unprecedented opportunities and potentials in healthcare. No other scientific field grants as much hope in the determination of life and death and fastest-pace innovation potential with economically highest profit margin prospects as does medical care. The currently ongoing digital disruption enabled big data-driven tailored personal medical care. Efficiency, precision and better quality work are beneficial advancements of AI and big data in the healthcare sector. Decentralized preventive healthcare and telemedicine open access to personalized, affordable healthcare. The currently ongoing COVID-19 crisis draws attention to international differences in healthcare. The article presents digitalization in the healthcare sector in North America and Europe in order to derive inferences on opportunities to establish a leadership in digitalized, tailored healthcare solutions for individual well-being and public care.

KEYWORDS: Access to healthcare, Advancements, Apps, Artificial Intelligence (AI), Coronavirus, Corruption-free maximization of excellence and precision, COVID-19, Big data, Decentralized grids, Economic growth, Europe, Healthcare, Innovation, Market disruption, Market entrance, North America, Pandemic, Robotics, Targeted aid, Telemedicine

We live in the age of big data. Information sharing has grown exponentially in the last decade. In the medical sector, big data allows early disease intervention and reduces adverse reactions of patients due to lowered medical errors and better understanding of co-morbidity. Novel technology can cross-link healthcare providers and professions and intensify research collaborations through social networks. Disease prevention is enabled through the pre-identification of risk factors for populations. Heightened patient safety is offered through directly delivered information and better prediction of outcomes by understanding demographic challenges and health trends around the world. Transmission pathways and knowledge dissemination improve the efficiency and effectiveness of healthcare (Puaschunder 2019b, 2020b).

The AI healthcare revolution features unprecedented big data generating, computational power and information storage capabilities. Big data and computational power hold unprecedented scientific and financial opportunities, such as sophisticated

crowd understanding, trends prediction and preventive healthcare control, e.g. genetic testing. The use of big data has improved the effectiveness and quality of healthcare to unprecedented dimensions (Puaschunder 2020b). In the currently ongoing introduction of algorithmic analysis of healthcare data, the emerging potentials of automated control hold extraordinary opportunities for improving human life (Puaschunder 2019a). Big data and decentralized information sharing grids grant access to targeted aid to a wider community as ever before (Puaschunder 2019c, d). Novel technologies offer luxuries of affordability and democratization of access to services as they will be – on the long run – commercially more affordable and readily available to serve all humanity in ways outperforming any human ever having lived (Hayes 2018).

With AI and inferences derived from big data serving economic purposes with unprecedented excellence, the question arises how to reap the benefits of AI but also regulate this new market development to handle potential societal downfalls and minimize risks, such as privacy infringements and social stratification based on big data insights? As emerging global trend, big data derived inferences raise high expectations but also grave concerns (Cellan-Jones 2018; Sofge 2015; United Nations 2017). In the healthcare sector, novel technologies open gates to unprecedented genetic monitoring capacities that coupled with social monitoring through biometric screening implies novel ethical predicaments. With the dramatic growth in diversity and entrance of emerging technologies in today's societies, the socio-economic and ethical complexity of these challenges is on the rise (Meghdari & Alemi 2018). Scientists, policy makers and practitioners have turned to demand the creation of a framework on AI ethics.

The big data revolution in the healthcare sector varies in the international arena. This report addresses AI and big data in the healthcare sector from an international perspective covering North America and Europe and a particular focus on the European Union being at the forefront of developing guidelines on the use of AI for the benefit of humankind (https://digitales.wien.gv.at/site/stadt-wien-entwickelt-strategie-zum-einsatz-kuenstlicher-intelligenz/). Technical advancements and big data insights – at the same time – increase costs for a whole-roundedly healthy lifestyle. Particularly in Western Europe, the currently tipping demographic pyramid of an aging population coupled with obstacles to integrate migrants long-term to rejuvenate the population and boost economic output impose challenges for policy makers and insurance practitioners alike to finance public healthcare. Studies in the US found that 70% of all health related costs are accrued during the last few weeks of peoples' living. In Austria, healthcare cost are expected to double in this decade. This predicament of rising costs of digitalized medical care of an aging Western world population, demands for innovatively generating funds and fiscal space to finance the most innovative global healthcare solutions. The following article addresses innovations and advancements of AI, big data and robotics in Europe and North America in order to derive inferences about the diversified advantages but also shed light at ethical cliffs we may want to face in the introduction of digitalization for global healthcare.

Europe

In Europe, the European Union is at the forefront to create a responsible, trustworthy AI, which falls in line with key ethical and legal principles to uphold highest social standards (Renda 2019b). The European Union accounted for 8 percent of global AI equity investment in 2017, which is 1 percent of this investment in 2013. However, member states varied widely in terms of investment levels. Start-ups in the United Kingdom received 55 percent of the European Union total investment between 2011 and mid-2018, followed by German (14 percent) and French ventures (13 percent). This means the remaining 25 countries shared less than 20 percent of all private AI equity investments received in the European Union (OECD 2015, 2019).

While North America and Asia appear to have financial interest and leadership advantages at stake; Europe appears more trying to fill a niche in the alignment of AI with economic, social and environmental goals, such as outlined in the Sustainable Development Goals (SDGs).While medical data is more available in Europe to maintain national security in universal healthcare providing territories, the general data access and reaping benefits from individual consumer data appears more protected in Europe than any other continent. International companies that offer products to European citizens are subject to European legislative privacy protection.

The massive amount of information collected will keep challenging privacy. Governments are now updating their privacy legislation to respond to privacy concerns fueled by the public outcry against massive data breaches and the unfettered use of data by large companies. Consumers have become increasingly concerned with the potential misuse of their personal information. In 2015, the European Commission conducted a survey carried out in 28 member states of the European Union that demonstrated that roughly seven out of 10 people expressed concern about their information being used for a different purpose than the one for which it was collected. The EU and international regulators have taken an active interest in AI, not only recognizing its benefits but also being mindful of potential risks and unintended consequences. Based on human dignity of privacy, which The Lisbon Treaty traces back as a quasi-human right, the European Union incepted the General Data Protection Shield (GDPR) in April 2016 as a comprehensive set of rules designed to keep the personal data of all EU citizens collected by any organization safe from unauthorized access or use. Aimed at strengthening the rights of natural persons and to harmonize national laws on data protection, companies must now be clear and concise about their collection and use of personal data, and indicate why the data is being collected and whether it will be used to create profiles of people's actions and habits. In other words, organizations must be transparent about the type of information they collect about consumers and how this information will be used. Around the world, internet companies have to become attentive to GDPR, which establishes attention to data minimization, care of sensitive data, respect for the right to be forgotten, data portability and data protection by design. This regulation is regarded as the foundation for EU data protection rules and has direct impact on all issues related to big data in healthcare.

Critics contend that the implementation of data administration remains at the national level. So far, the GDPR is believed to have raised the regulatory costs of new technologies – a trend which is expected to rise in the near future. GDPR presents an obstacle to developers looking to design more complex and sophisticated algorithms. GDPR appears to hit small and medium sized companies harder than large companies that have higher data-retrieved other financial and legislative support to comply. Human privacy can be – as in North America – infringed upon in the state of emergency and for national security purposes. Future legislative advancements are expected to concern taxation of big data generated revenues (Madsbjerg, 2017).

Transparency and communication are key pillars of the European Union (Mantl 2015, 2016). Digitalization requires to stretch the expertise of the European Union in the legal, ethical and design of communication, big data and AI (Mantl, Ochs & Pacheco 2006; Mantl & Winkelhofer 2013). As for AI and robotics, the EU is on the forefront to have laid a concrete foundation of its AI policy since 2016, when the European Parliament adopted its first draft resolution on "Civil Law Rules for Robotics." That initiative called for attributing both "rights and duties" to smart autonomous robots (EGE 2018). In the pursuit of a digital single market strategy (Mantl 2016), the European Commission leads the communication and directive on AI. In April 2018, following a political agreement between 24 member states and Norway on

cooperation in AI, the European Commission Communication on "Artificial Intelligence for Europe" adopted a strategy for the EU to lead the way in developing and using AI for good and for all, building on its values and its strengths. Thereby the Commission made explicit reference to the GDPR as well as to Article 2 of the Treaty on EU, which mentions explicitly "human dignity, freedom, democracy, equality, the rule of law and respect for human rights, including the rights of persons belonging to minorities; and a "society in which pluralism, non-discrimination, tolerance, justice, solidarity and equality between women and men prevail." The Communication also announced the adoption of a series of initiatives on AI, including the creation of a High-Level Expert Group on AI (AI HLEG), as well as the launch of an AI Alliance, which quickly attracted many adherents – 2,656 participants had registered as of 4 February 2019. The AI HLEG, counting 52 experts, was tasked with the definition of ethical guidelines, a first draft of which was published in December 2018; as well as the formulation of policy and investment recommendations by mid-2019 (Renda, 2019b). This report stresses the importance of future ethical guidelines on AI alongside granting an analysis of the possible content of the policy and investment recommendations (Renda, 2019b).

The European Group on Ethics in Science and New Technologies, an independent advisory body of the President of the European Commission, produced a statement on Artificial Intelligence, Robotics and 'Autonomous Systems' (EGE 2018), which stressed the importance of human dignity, autonomy, responsibility, justice, equity and solidarity, democracy, rule of law and accountability, security, safety, and bodily and mental integrity, data protection and privacy as well as sustainability when it comes to civil law codifications on AI (Renda 2019a). Additional codification in this realm are the Asilomar AI Principles, the Montreal Declaration for Responsible AI, the General Principles of the Ethically Aligned Design, and the five principles for AI developed by the UK House of Lords (2018) and the Tenets of the Partnership on AI (2018). Together, these documents hold about 50 different principles (Renda 2018, 2019a, b).

Fundamental principles include the lawful conduct around AI and a non-maleficence principle the urgency to do no harm. Protection of human integrity and dignity, security and privacy are stressed. Responsible AI development is meant to ensure the complementarity with humans enabled through responsible governance of monitoring, control and feedback but also AI transparency and explainability. Lastly, sustainable AI endeavors target at good benevolence principles for the use of AI, such as harmony with SDGs and limited or zero carbon footprint, quality education and promotion of female empowerment for industry, innovation and infrastructure (Renda 2019b). As borderline cases for the application of AI with dignity are predictive policing, social credit scores, facial and body recognition, content filtering and conversational bots (Renda 2019b). Regulation is targeted at putting respective risk management tools in place. In the implementation, core values are accountability in data governance, accessibility and usability of technologies, human oversight, non-discrimination and respect for human autonomy, privacy and robustness in terms of security risks and safety (Renda 2019b).

Problematic appears that the UK credit score system uses phone data and rental payments to filter job applications and determine access to social services and targeted advertisements (Hall & McCann 2018; Williams 2018). The German universal credit rating system also tracks geolocation and health records to determine access to credit and health insurance (Schaer 2018). Internet appearances and social online media behavior (e.g. LinkedIn) becomes the basis to monitor tax compliance.

North America

The United States (US) have a corporate approach to AI grounded in R&D of tech giants and leading universities in the field. In May 2018, the White House announced its broad intention to maintain American leadership in AI via public R&D and removed barriers to innovation. Unlike the EU, US federal lawmakers have yet to establish regulations to govern the use of personal information in the AI world. Sensing the inevitability of data regulation, some large American companies are actively engaging in the introduction of regulation on AI, robotics and big data use in the United States. On January 18, 2019, Accenture released a report outlining a framework to assist US federal agencies to evaluate, deploy and monitor AI systems. More recently, the US government's Defense Advanced Research Projects Agency (DARPA) announced the so-called "AI Next" programme, a $2 billion investment plan aimed at addressing the perceived limitations of current AI technologies, including excessive data-dependency, lack of explainability and contextual reasoning. The US federal government as a whole does not seem likely to adopt a common strategy for responsible AI any time soon (Renda 2019a).

The American privacy and big data approach is more sector specific. Commercial privacy is often discussed through an economic lens. US rights to data are mainly regulated by the Federal Communications Commission (FCC) and the Federal Trade Commission (FTC) that concerns to eradicate unfair and deceptive market activities and sanction privacy infringements (https://www.lexology.com/library/detail.aspx?g=4284727f-3bec-43e5-b230-fad2742dd4fb). The FTC uses a wide variety of data security measures. The split delegation of FCC and FTC, however, appears to heighten bureaucratic and regulatory costs while lowering the potential of industry control mechanisms. In general, corporations are obliged to inform the FTC about data protection and data integrity means. The US Congress most recently concerned big data revenue gains (Madsbjerg 2017). Institutional stakeholders on AI, robotics and big data frequently meet at the National Academy of Sciences.

In Canada, the intended use of data has to be appropriately disclosed and compliant with legislation such as the *Personal Information Protection and Electronic Documents Act* ("PIPEDA") (https://www.lexology.com/library/detail.aspx?g=4284727f-3bec-43e5-b230-fad2742dd4fb). The Breach of Security Safeguards Regulations under PIPEDA set forth certain mandatory requirements for organizations applicable in the event of a data breach. PIPEDA defines a breach of security safeguards as "the loss of, unauthorized access to or unauthorized disclosure of personal information resulting from a breach of an organization's security safeguards." Organizations will need to not only evaluate their compliance in terms of privacy legislation, but also ensure that their data handling practices are sufficiently secure to prevent cybersecurity breaches.

Start-ups operating in the United States account for most AI start-up equity investments worldwide as the United States accounts for 70-80 percent of global venture capital investments across all technologies (Breschi, Lassébie & Menon, 2018; OECD, 2019). In 2019, the U.S. President announced a nearly $1 billion federal commitment towards AI research in seeking the competitive edge over AI (Castellanos, 2019). A White House plan calls for government agencies to develop ethical AI systems and shared public data sets for AI training to improve human-machine interactions among other initiatives.

International comparison

Overall, the EU has a competitive advantage over the US in the healthcare sector as for a historically-grown wealth of data on a homogenous population ennobled with an ethical

imperative focus. Due to a highly-skilled population, the European continent is a technological innovation leader and picks up technological advancements around the world quickly and efficiently. Europe has a post-war history of stressing ethical considerations in market-driven innovations that it bestows upon scientific advancements – for instance, more precautionary standards in releasing drugs. Europe has an extraordinarily homogeneous population and hosts a major part of pharmaceutical agencies that are relatively independent of market actors – as in the US, for instance, big data insights are regulated by the Federal Trade Commission (FTC) and the Federal Communications Commission (FCC), two agencies that are more market oriented. European citizens pay for free universal healthcare by automatic provision of data. In the age of information, in which big data has become the new untaxed wealth generation means, novel computational advancements can now retrieve medical insights from patient data that can be capitalized, especially for preventive medical care. Contrary to the US, within the EU healthcare is oriented towards preventive rather than emergency and reconstructive medicine and puts a human face on capitalism. The US medical market is more fractionated into public and private sector health and features a more market-focused approach, in which ethics often get sidetracked. Europe can therefore offer the world a big data-driven preventive medical care in the Western tradition with particular attention to ethics (Puaschunder 2020c).

Discussion

In deriving big data inferences in the medical sector, Europe could establish itself as leader on ethical big-data-driven innovation hub (Medianet 2020). An ethical mandate could be promoted of data insights to only be used for the benefit of people but not be turned against human beings. Europe is known for upholding the precautionary principle in many domains – such as climate change mitigation efforts – and especially in medical care and pharmaceutical interventions. Europe could therefore also push for AI and big data innovation under the guiding principle of attention to precautionary principles (Leisure 2020). A stakeholder survey conducted in November 2019 revealed that risks in the use of big data insights, AI and robotics in healthcare include: Data misuse and leakage leading to privacy infringements, as well as biases and errors. Big data insights open gates for health care pricing, stigmatization, social stratification, discrimination and manipulation (Puaschunder 2020a).

Big data in the healthcare sector should only be used with caution and targeted particular information release to avoid discrimination. For instance, only anonymized data slices should be made available to the public in order to avoid stigmatization, gentrification and discrimination based on predictable prevalence within population groups or certain districts (Leisure 2020). Most novel innovations may feature creative design solutions that represent targeted information without revealing a compromising grid of information that would enable to distinguish between sensitive groups (https://www.berndplank.com/). For instance, targeted healthcare information could be displayed without revealing a whole grid of information that reveals if certain racial groups or minorities are more likely and prevalent to exhibit certain diseases or psychological impairments.

Data protection through technological advancement, self-determined privacy attention through education as well as discrimination alleviation through taxation of data transfer values are recommended. Taxation of data transfer revenues will grant the fiscal space to offset losses and the social costs of market distortions caused by robots and algorithms taking over human tasks and entering the workforce in the medical marketplace (Puaschunder 2020b).

In order to enable a big data capitalization coupled with upholding highest ethical standards, the European Union should foster a fifth trade freedom of data to bundle AI and big data gains large scale (Horizont 2020a). While big data is primarily used in the US to offer more targeted consumerism, Europe should aim for building a data stock to retrieve information for preventive care leading the world with ethical imperatives in big data insight-driven medicine (Horizont 2020b). A fifth data freedom should focus on setting positive market incentives for sharing information within the European compound, but also provide the necessary tools for anti-discrimination and legal means against human rights violations stemming from big data and new technologies (Puaschunder 2020c). In the eye of the ongoing COVID-19 pandemic, big data insights and AI solutions appear as most innovative means to track global pandemic spread and thus to serve as early warning systems and long-term sustainable global healthcare solutions (Live-pr 2020).

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