Portuguese Journal of Public Health

Editorial

Port J Public Health 2024;42:1–5
DOI: 10.1159/000538141

Received: February 28, 2024
Accepted: February 29, 2024
Published online: March 28, 2024

Artificial Intelligence and Precision Public Health: A Balancing Act of Scientific Accuracy, Social Responsibility, and Community Engagement

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In Kazuo Ishiguro's novel "Klara and Sun" [1], Mr. Capaldi, a techno-optimist scientist, is hired by Josie's mother to create a robotic duplicate of her ill daughter, capable of harboring artificial consciousness and perpetuate her existence when she eventually dies. After reflecting on the complexities of human-AI (artificial intelligence) relationships, Mr. Capaldi talks to Klara, Josie's artificial friend, and observes: "*They accept that your decisions, your recommendations, are sound and dependable, almost always correct. But they do not like not knowing how you arrive at them. That's where it comes from, this backlash, this prejudice.*"

The subject of the human relationship with technology is anything but new, and the intersection between art, science, technology, and ethics is ancient, vast, and intricate. In fact, various "what ifs" or imaginative scenarios have found their way from paintings, sculptures, novels, and movies into real life through scientific and technological progress. Public health is no stranger to this phenomenon. More recently, the discussion surrounding AI and genomics (especially in conjunction with other data modalities) within public health constitutes a good example of the delicate balance between scientific advancement based on well-guided optimism, unfounded hype, and occasionally catastrophism that inspires fiction and impacts real life.

Technological progress has driven the most significant public health advancements, including vaccine development, antibiotic discovery, the implementation of innovative sanitation and hygiene methods, the development of medical imaging and diagnostic tools, and more recently, different applications of information and communication technologies. In particular, the convergence between AI and genomics has seen rapid expansion, a trend that is estimated to continue over the next decade. For example, AI can assist in the identification of variants of interest in DNA sequencing, help decipher chromosomal abnormalities, and improve the prediction of protein structure and function for drug development and disease characterization and staging, while helping correlate genotypes with phenotypes and thereby assist in the identification of genetic testing candidates and downstream stratification of health interventions [2, 3]. Therefore, AI can facilitate the role of genomics in transitioning towards patient-specific rather than symptom-specific patient outcomes in the context of chronic, acute, infectious, and rare diseases, enabling an era of precision medicine [4, 5].

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A parallel transition is underway in public health field, with AI helping shape an era of precision public health, a concept with different definitions but broadly characterized by "delivering the right intervention at the right time, every time to the right population" [6–10]. Specifically, the intersection of AI and genomics impacts different public health activities, including the identification of disease risk factors, conducting disease surveillance, modelling, and forecasting, and developing data-driven public health policy [11]. Other prominent applications of AI and genomics in the public health area include detecting and understanding emerging public health threats (including healthcare-associated infections and foodborne illness), identifying novel virus variants, and enhancing the resolution of epidemiological investigation and surveillance for bacterial antimicrobial resistance [11, 12]. Furthermore, AI can drive applications related to health promotion, behavioral changes, and the adoption of healthier lifestyles [2, 13]. Additional broader-scope AI applications include investigating the scientific literature or electronic health records (EHR) for trend and pattern identification and even assisting in amplifying access to genomics education [14, 15]. Overall, public health AI applications, including those intersecting with genomics, promise to reduce costs and save time while minimizing human errors, possibly reducing occupational burnout, and aiding in reinforcing trust in healthcare systems and professionals [16, 17]. Finally, and perhaps most importantly, we are now entering an age of multimodal AI applications, which integrate different types of data (such as different omics, clinical data, environmental data, imaging, text, economic, and social determinants-related) originating from different sources, including EHR, health surveys, clinical research, public health sources, wearables, biosensors, mHealth apps, web-based and social networks, among others [18, 19]. Therefore, this integrated approach exponentiates the transformative potential of this technology for public health by facilitating tailored, timely, and more precise public health interventions.

In parallel, the broader adoption of AI in public health is accompanied by significant technical, ethical, legal, and social challenges [2, 20, 21]. Many of these challenges are related to the data used to train algorithms [17]. Exponential data growth demands corresponding improvements in data interpretation and democratization. In particular, developing and agreeing on open-access databases and policies that promote data sharing and equitable data governance frameworks can ensure that essential data is available to researchers, health professionals, and even the general public [12]. Certainly, ethical principles and the protection of fundamental rights require that proportional conditions and safeguards be implemented, including those related to privacy and data protection [22]. Furthermore, for data to be useful, it must be understood. Therefore, efforts toward transparency, explainability, and interpretability are key, which calls for the development of educational resources and tools for data interpretation that can be applied in a professional context. Moreover, participatory public health depends on individuals making informed decisions based on accurate and reliable information extracted by tested and robust scientific processes and evidence, not on unfounded extrapolation. This aspect of data democratization highlights the importance of ensuring that AI applications in public health promote individual access and participation. In the specific case of AI and genomics, public health can benefit from the development of appropriate genomic data standards and better integration with EHRs [15].

Clearly, since data reflects human biases, care must be exercised so that these biases are not exacerbated by AI's processes. Different examples of bias at the intersection of technology, healthcare, and public health exist. These include the underassessment of pain in individuals according to racial beliefs (leading to reduced pain care in these patients), the design of spirometers and the misassessment of lung capacity (leading to different occupational health standards and liability), and, more recently, the pulse oximeter, which was developed based on data collected from white skin and therefore overestimated blood oxygen saturation in people with darker skin (leading to delayed oxygen support measures during the COVID-19 public health crisis) [23]. To responsibly harness the significant capabilities of AI adoption in public health, it is critical to correct biases rather than maintain or, worse, amplify them. Furthermore, efforts toward data democratization must address the fact that AI systems may be trained with data overrepresenting certain regions of the world to the detriment of others, which might be experiencing severe public health emergencies or needs. Ultimately, this emphasizes the importance of ensuring AI applications in public health contribute to a rigorous, nuanced, and comprehensive understanding of our diverse world [13].

In response to the significant challenges raised by AI adoption, there has been progress in regulating AI in recent years. In the USA, building on a 2016 report on algorithmic systems and big data that identified high-risk applications and the importance of promoting fairness and transparency, a 2022 executive order laid out a blueprint for an AI Bill of Rights[1]. This document

[1]See: https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/2016_0504_data_discrimination.pdf and https://www.whitehouse.gov/ostp/ai-bill-of-rights/(last accessed on 23/02/2024).

focused on safety, privacy, non-discrimination, and explainability. More recently, an executive order specifically set standards for safe, secure, and trustworthy AI, including in the public health and healthcare contexts[2]. In the European Union, ethical guidelines for trustworthy AI were introduced in 2019, emphasizing interconnected principles and the need for continuous evaluation of AI applications[3]. The EU is now in the final stages of approving an AI act, a legal document that stratifies risks and categorizes certain AI practices as unacceptable, including cognitive behavioral manipulation, social scoring, real-time biometric identification, and facial recognition, while recognizing the value of AI innovation for public health, including disease prevention, control, and treatment[4]. In the UK, a House of Commons Committee report on the governance of AI addressed issues such as bias, privacy, misrepresentation, access to data, and the existential challenge of our relationship with machines in light of the key societal benefits of AI adoption, including in the context of medicine and healthcare[5]. Finally, China has also set rules for generative AI and defined risk-stratification guidelines [24]. Overall, global, regional, and national AI regulatory principles and policies have been under development worldwide intending to maximize the potential of AI while reducing its more significant risks [25].

AI applications that support precision public health efforts can be examined through different ethical values and frameworks [26, 27]. It could be argued that the adoption of AI should be directed toward maximizing the well-being of populations, which is the hallmark of public health consequentialism. This might serve as a rationale for policies of AI adoption in contexts of resource allocation, lifestyle inferences, and more autonomy-restricting policies, such as imposing quarantines or adopting surveillance measures. Conversely, the consideration of professional duties (towards others and ourselves), which is characteristic of public health deontology, might lead to the rejection of AI adoption policies that violate autonomy, even if those policies maximize the well-being of the population. Furthermore, as health is considered a fundamental dimension of well-being, social justice considerations in public health demand that AI adoption prioritizes access to health care for everyone and that special attention is given to the most disadvantaged members of society. This relates to the human right to health and other human rights connected to determinants of health, such as personal security, food, clothing, housing, and education. In particular, the right to health encompasses elements such as the availability of functioning public health and healthcare facilities, goods, services, and programs. It also includes accessibility (physical, economic, and informational) without discrimination, the adoption of respectful and culturally appropriate health practices and policies, and the quality of health facilities, goods, and services, which includes updated scientific curricula and skilled professionals [28]. Adopting pluralistic views that factor in all these dimensions of public health law and ethics has advantages but requires weighing and balancing conflicting norms, principles, and values. Therefore, responsibly adopting AI to promote precision public health policies and practices is a continuous and evolving challenge.

Overall, there are compelling reasons to believe that AI can drive significant progress toward precision public health. Therefore, it would be irresponsible to risk not fully harnessing the potential of this technology, whether by being too naïve to believe that all risks of AI will manage themselves or by being too complacent to do the necessary individual and collective work required to mitigate the risks that do require attention. Hence, contrary to Mr. Capaldi's observation in "Klara and the Sun," the main risk may not be human ignorance about the infallibility of algorithms; it may be one of human negligence and diminished agency due to unscrutinized overreliance.

Interestingly, in "Klara and the Sun," it was Klara, Josie's Artificial Friend, who had a more enlightened conclusion about the whole human experience: *"Mr. Capaldi believed there was nothing special inside Josie that couldn't be continued. He told the Mother, he'd searched and searched and found nothing like that. But I believe now, he was searching in the wrong place. There was something very special, but it wasn't inside Josie. It was inside those who loved her"* [1].

When responsibly considering the role of AI in shaping the future of public health, we should bear in mind that it is our human connection, our individual and collective stories, amplified and made possible by social and political contexts, that drive scientific and

[2] See: https://www.whitehouse.gov/briefing-room/presidential-actions/2023/10/30/executive-order-on-the-safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence/(last accessed on 23/02/2024).

[3] See: https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai (last accessed on 23/02/2024).

[4] See: https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai (last accessed on 23/02/2024).

[5] See: https://committees.parliament.uk/work/6986/governance-of-artificial-intelligence-ai/publications/(last accessed on 23/02/2024).

technological progress. Furthermore, our past stories, present experiences, and future aspirations influence outcomes in the healthcare and public health contexts. However, not every aspect of these (think values like care, compassion, and conscience, for example) can be easily captured in data that can then be responsibly and effectively used to train an algorithm [29]. Therefore, a sustained effort to capture and value the full range of our human experience, together with our lifestyles and behaviors, living and working conditions, social and community networks, as well as socioeconomic, political, and environmental contexts, while building stronger alliances and relationships among all public health agents, is fundamental to responsible and effectively shape the future of AI in this field [30]. This effort should be based on education, communication, and improved expectation alignment between clinicians, scientists, researchers, industry and academia members, policymakers, health managers, ethicists, legal scholars, regulators, public health practitioners, patients and their associations, and the general public.

In conclusion, the contribution of AI to precision public health requires a balance between scientific accuracy, social responsibility, and community engagement. Within this required collective effort lie fascinating scientific questions waiting to be asked, the answers to which deserve a broad readership. At the Portuguese Journal of Public Health, we cannot wait to discover and publish them in the future.

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