Introduction

Applied artificial intelligence in healthcare: Listening to the winds of change in a post-COVID-19 world

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Abstract

This editorial article aims to highlight advances in artificial intelligence (AI) technologies in five areas: Collaborative AI, Multimodal AI, Human-Centered AI, Equitable AI, and Ethical and Value-based AI in order to cope with future complex socioeconomic and public health issues.

Keywords: Health AI, artificial intelligence, machine learning, AI governance, multimodal AI, human-centered AI, ethical AI, COVID-19

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Introduction

The COVID-19 pandemic impacted almost every sector of our modern world and created unprecedented change and disruption in the way we live, work, communicate, commute, socialize, learn, entertain ourselves, and do business. From the onset of the COVID-19 pandemic, artificial intelligence (AI) tools and technologies have been used to improve disease surveillance, screening, diagnostics, case detection, prediction, risk stratification, drug and vaccine development, resource allocation, and socioeconomic interventions. Despite their great potential, these AI tools have had little, if any, impact on the response to this devastating pandemic. Many of published prediction models were inadequately reported and most of them had low accuracy, weak predicitve power, high risk of bias,1 and methodological flaws with limited potential for medical and clinical use.2 Part of the problem might have originated from the lack of access to high-quality COVID-19 data sets,3 insufficient historical data, and inaccurate training data, which may cause researchers to rely on heterogeneous and noisy data collected at low temporal and geographic resolutions. Furthermore, critical issues stem from the frequent suboptimal implementation and use of AI technologies including the ways they are shared, evaluated, governed, and regulated.4,5

The road ahead

Regardless of the above-mentioned challenges, the experiences gained from the COVID-19 pandemic can accelerate innovations in AI technology to better prepare societies to respond to future crises. According to the World Bank,6 to accelerate AI development at the country level, policymakers are advised to focus on AI research, talent development, supporting entrepreneurship, ethical or trustworthy AI, increasing access to quality data, adoption of AI for public service, strategic sectoral targeting of AI, and strengthening AI governance. Furthermore, to cope with complex socioeconomic and public health issues, we anticipate AI technologies to advance in the following five areas:

1. Collaborative AI: During the emergencies imposed by the pandemic, researchers tried to create their own solutions, which often led to many isolated, standalone, and redundant models with similar limitations and biases. Future AI must foster opportunities to promote collaboration (cooperation, competition, or coordination)7 from multiple stakeholders (human and machines) to maximize a common goal while balancing each entity’s individual interests.

2. Multimodal AI: Multimodal technologies8 enable users to access, integrate, and process ever-increasing
multimodal and complex medical data sets and interact with a system in different modalities at the same time. Multimodal AI particularly attempts to process, manage, and understand these multimodal data through making multimodal inferences to analyze complex associations and relationships between various biological processes, health indicators, risk factors, and health outcomes, and developing exploratory and explanatory models.

3. **Human-centered AI:** With the intention to create AI models that “amplify and augment rather than displace human abilities. It seeks to preserve human control in a way that ensures AI meets human needs while also operating transparently, delivering equitable outcomes, and respecting privacy,” human-centered AI focuses on including the human in the loop. In this way, it provides substantial gains in transparency, fairness, accountability, reliability, and explainability of AI systems. The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems recently announced a few principles to advance discussion on the alignment between AI models and human rights and interests.

4. **Equitable AI:** The Covid-19 pandemic once again exposed social, economic, and racial inequalities among under-represented and marginalized communities across the globe. Precision equity should be an integral part of precision health and health AI. According to the World Economic Forum’s call for more inclusive AI infrastructure, AI scientists and designers “should identify and partner with representatives of these impacted stakeholders on data collection methods, especially when identifying new or non-traditional resources for gathering data.” Algorithmic equity is also an important area that needs special attention to ensure that decisions and policies made based on AI algorithms are nondiscriminatory.

5. **Ethical and value-based AI:** Future AI solutions should consider ethical issues and incorporate human values, in their design and use. An important step here is listening to and understanding individuals’ concerns and respecting their personal autonomy and right to informed consent, and dissent.

**Thematic issue on the future of AI**

This thematic issue on the future of AI includes various contributions presenting results on theory, methods, systems, and applications of AI in medicine and healthcare. Boursalie et al. studied the challenges of evaluating deep learning–based imputation models by conducting a comparative analysis between root mean square error (RMSE), a predictive accuracy metric, and evaluation metrics used in statistical literature, including qualitative, predictive accuracy, statistical distance, and descriptive statistics metrics. Using two tabular data sets from the healthcare and financial sectors, they design an aggregated metric to evaluate deep learning–based imputation models called reconstruction loss (RL). Tanwar et al. proposed an unsupervised method that leverages external clinical knowledge and contextualized word embeddings by ClinicalBERT for numerical reasoning in different phenotypic contexts. Jana et al. presented methods for predicting intensive care unit (ICU) length of stay as well as need for critical interventions for patients based on vital signs, laboratory measurements, and nursing notes prepared within the first 24 h of ICU stay. Their approach has been built and cross-validated over publicly available Medical Information Mart for Intensive Care (MIMIC-III v1.4) data set.

Xia et al. summarized publicly available data sets annotated by respiratory experts and reviewed the latest machine learning methods used for respiratory screening during the Covid-19 pandemic. Scaboro et al. compared some of the current systems for detecting adverse drug events using social media data and proposed strategies to increase the robustness of these systems. Using unstructured clinical notes, Karisani et al. created pipeline to infer the existence of alternative biological pathways from clinical phenotypes. Mohammadi et al. applied an existing weakly supervised learning algorithm to a real-world data set in histopathology, with over 90% validation accuracy. Then they extended this method to handle multicase slide-level labels and presented an end-to-end saliency-mapping algorithm to segment regions of interest at the pixel level based only on slide-level labels.

**AUTHORS’ CONTRIBUTIONS**

A.S.N., M.M., S.B. conceptualized, drafted, reviewed, and edited the manuscript. J.S.B., D.L.B., R.L.D. reviewed and edited the manuscript.

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**REFERENCES**

1. Wynants L, Van Calster B, Collins GS, Riley RD, Heinze G, Schuit E, Bonten MMJ, Dahly DL, Damen JAA, Debray TPA, de Jong VMT, De Vos M, Dhiman P, Haller MC, Harhay MO, Henckaerts L, Heus P, Kammer M, Kreuzberger N, Lohmann A, Luijken K, Ma J, Martin GP, McLernon DJ, Andaur Navarro CR, Reitsma JB, Sergeant JC, Shi C, Skoetz N, Smits LJ, Snell KIE, Sperrin M, Spijker R, Stereyer EW, Takada T, Tzoulaki I, van Kuijk SMJ, van Bussel B, van der Horst ICC, van Royen FS, Verhakel JY, Wallisch C, Wilkinson J, Wolff R, Hooft L, Moons KGM, van Smeden M. Prediction models for diagnosis and prognosis of covid-19: systematic review and critical appraisal. BMJ 2020;369:m1328. Update in: BMJ 2021;372:n236. Erratum in: BMJ 2020;369:m22X04.

2. Roberts M, Driggs D, Thorpe M, Gilbey J, Yeung M, Ursprung S, Aviles-Rivero AI, Etmann C, McCague C, Beer L, Weir-McCall JR, Teng Z, Krcmar-Klotsas E, AIX-COVNET, Rudd JHF, Sala E, Schönlieb C-B. Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans. Nat Mach Intell 2021;3:199–217.
3. Brakefield WS, Ammar N, Olusanya OA, Shaban-Nejad A. An urban population health observational system to support COVID-19 pandemic preparedness, response, and management: design and development study. JMIR Public Health Surveill 2021;7:e28269.

4. World Health Organization (WHO). Ethics and governance of artificial intelligence for health. Geneva: WHO, 2021.

5. Krass M, Henderson P, Mello MM, Studdert DM, Ho DE. How US law will evaluate artificial intelligence for covid-19. BMJ 2021;372:n234.

6. World Bank. Harnessing artificial intelligence for development on the post-COVID-19 era: a review of national AI strategies and policies. Analytical insights. Washington, DC: World Bank, 2021. https://openknowledge.worldbank.org/handle/10986/35619.

7. IBM Research. Collaborative AI. https://researcher.watson.ibm.com/researcher/view_group.php?id=7806 (accessed 30 October 2022).

8. Shaban-Nejad A, Michalowski M, Bianco S. Multimodal artificial intelligence: next wave of innovation in healthcare and medicine. In: Shaban-Nejad A, Michalowski M, Bianco S (eds) Multimodal AI in healthcare: a paradigm shift in health intelligence (Studies in Computational Intelligence Series, Vol. 1060). Cham: Springer, 2022, pp. 1–9.

9. Geyer W, Weisz J, Pinhanez CS, Daly E. What is human-centered AI? IBM Research Blog, 31 March 2022. https://research.ibm.com/blog/what-is-human-centered-ai (accessed 30 October 2022).

10. Shaban-Nejad A, Michalowski M, Brownstein JS, Buckeridge DL. Seven pillars of precision digital health and medicine. In: Shaban-Nejad A, Michalowski M, Buckeridge DL (eds) Explainable AI in healthcare and medicine (Studies in Computational Intelligence, Vol. 914). Cham: Springer Nature, 2020.

11. Shaban-Nejad A, Michalowski M, Buckeridge DL. Explainability and interpretability: keys to deep medicine. In: Shaban-Nejad A, Michalowski M, Buckeridge DL (eds) Explainable AI in healthcare and medicine (Studies in Computational Intelligence, Vol. 914). Cham: Springer, 2021, pp.1–10.

12. The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems. Ethically aligned design: a vision for prioritizing human well-being with autonomous systems, Version 2. New York: IEEE, 2017. http://standards.ieee.org/develop/indcom/ec/autonomous_systems.html (accessed 30 October 2022).

13. Brakefield WS, Olusanya OA, White B, Shaban-Nejad A. Social determinants and indicators of COVID-19 among marginalized communities: a scientific review and call to action for pandemic response and recovery. Disaster Med Public Health Prep. Epub ahead of print 2 May 2022. DOI: 10.1017/dmp.2022.104.

14. McCarthy G, Shore S, Ozdenerol E, Stewart A, Shaban-Nejad A, Schwartz DL. History repeating—how pandemics collide with health disparities in the United States. J Racial Ethn Health Disparities. Epub ahead of print 20 May 2022. DOI: 10.1007/s40615-022-01331-5.

15. Shaban-Nejad A, Michalowski M, Peek N, Brownstein JS, Buckeridge DL. Seven pillars of precision digital health and medicine. Artif Intell Med 2020;103:101793.

16. Shaban-Nejad A, Michalowski M (eds). Precision health and medicine: a digital revolution in healthcare (Studies in Computational Intelligence Series, Vol. 843). Cham: Springer Nature, 2020.

17. The World Economic Forum. A blueprint for equity and inclusion in artificial intelligence. White Paper, June 2022. https://www.weforum.org/whitepapers/a-blueprint-for-equity-and-inclusion-in-artificial-intelligence/ (accessed 30 October 2022).

18. Osoba OS, Boudreaux B, Saunders JJ, Irwin L, Mueller PA, Cherney S. Algorithmic equity: a framework for social applications. Santa Monica, CA: RAND Corporation, 2019.

19. van de Poel I. Embedding values in artificial intelligence (AI) systems. Mind Mach 2020;30:385–409.

20. Boursalie O, Samavi R, Doyle TE. Evaluation methodology for deep learning imputation models. Exp Biol Med. Epub ahead of print 21 September 2022. DOI: 10.1177/15353702221112160.

21. Tanwar A, Zhang J, Ive J, Gupta V, Guo Y. Phenotyping in clinical text with unsupervised numerical reasoning for patient stratification. Exp Biol Med. Epub ahead of print 11 October 2022. DOI: 10.1177/153537022221118092.

22. Jana S, Dasgupta T, Dey L. Predicting medical events and ICU requirements using a multimodal multiobjective transformer network. Exp Biol Med. Epub ahead of print 16 October 2022. DOI: 10.1177/153537022221126559.

23. Xia T, Han J, Mascolo C. Exploring machine learning for audio-based respiratory condition screening: a concise review of databases, methods, and open issues. Exp Biol Med. Epub ahead of print 16 August 2022. DOI: 10.1177/15353702221115428.

24. Scabaro S, Portelli B, Chersoni E, Santus E, Serra G. Increasing ADE extraction robustness on social media: a case study on negation and speculation. Exp Biol Med. Epub ahead of print 31 October 2022. DOI: 10.1177/15353702221128577.

25. Karisani N, Platt DE, Basu S, Parida L. Topology and redescriptions detect multiple alternative biological pathways from clinical phenotypes. Exp Biol Med 2022. in press.

26. Mohammadi M, Cooper J, Arandjelovic O, Fell C, Morrison D, Syed S, Konanahalli P, Bell S, Bryson G, Harrison DJ, Harris-Birtill D. Weakly supervised learning and interpretability for endometrial whole slide image diagnosis. Exp Biol Med. Epub ahead of print 25 October 2022. DOI: 10.1177/15353702221126560.