Integration of Machine Learning and Blockchain Technology in the Healthcare Field: A Literature Review and Implications for Cancer Care

Andy S. K. Cheng¹, Qiongyao Guan², Yan Su², Ping Zhou³, Yingchun Zeng¹

¹Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hong Kong, ²Department of Nursing, Yunnan Cancer Hospital, Kunming, ³Department of Oncology, Affiliated Hospital of Southwest Medical University, Luzhou, China

Corresponding author: Andy S. K. Cheng, PhD and Yingchun Zeng, PhD, Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hong Kong, China. E-mail: andy.cheng@polyu.edu.hk and chloezengyc@hotmail.co.uk

Received: May 14, 2021; Accepted: August 04, 2021; Published: October 04, 2021

ABSTRACT

This brief report aimed to describe a narrative review about the application of machine learning (ML) methods and Blockchain technology (BCT) in the healthcare field, and to illustrate the integration of these two technologies in cancer survivorship care. A total of six eligible papers were included in the narrative review. ML and BCT are two data-driven technologies, and there is rapidly growing interest in integrating them for clinical data management and analysis in healthcare. The findings of this report indicate that both technologies can integrate feasibly and effectively. In conclusion, this brief report provided the state-of-art evidence about the integration of the most promising technologies of ML and BCT in health field, and gave an example of how to apply these two most disruptive technologies in cancer survivorship care.

Key words: Artificial intelligence, Blockchain, Cancer care, Machine learning

Introduction

Globally, there was an estimated 19.3 million new cancer cases and approximately 10.0 million cancer deaths in 2020.[¹] With the advanced development of cancer therapies, the overall 5-year relative survival rate for all cancers increased steadily and was over 50%.²,³ In Asia-Pacific region, some countries such as in Australia the latest average 5-year relative survival of cancer patients is as high as 72%.[⁴] Although new cancer therapies improve the overall survival rate, the burden of cancer is a global phenomenon.[⁵]

Continuous advancement in technology such as the applications of artificial intelligence (AI) into clinical oncology and research offers potential solutions in reducing the burden of cancer.[⁶] AI is the term of using computers to model intelligent behavior with minimal human intervention either by physical or virtual approach,[⁶] and this report applied AI by the virtual approach such as through machine learning (ML). However, a major challenge in cancer management is
classifying patients into appropriate risk groups for better
treatment and follow-up.[7] To address this major challenge
in cancer management, the application of ML may offer
the possible solution.

ML is a suitable method for classifying patients into
high- or low-risk groups, as ML methods utilize various
statistical, probabilistic, and optimization techniques,
which train computers to learn and detect patterns
from large and complex cancer datasets.[7] For example,
some ML methods, including support vector machine,
semi-supervised learning, and decision tree, have been
applied to cancer prediction and prognosis.[8‑10] Compared
with traditional statistical methods for prediction, ML has
its own strengths in handling large volumes of multi-omics
data with noisy or missing data.[7,10] Access to a complete
history of cancer patients’ data is restricted due to high
patient mobility across multiple hospitals or clinics,[11]
however, using ML techniques for cancer disease status and
prognosis prediction can empower personalized medicine
and enhance the quality of cancer care.[11,12]

However, the key barrier of achieving personalized
medicine or nursing is isolated data islands owned from
different medical institutions. As widely and timely sharing
of healthcare data is essential in providing prompt cancer
treatment, and monitoring posttreatment effects to optimize
the care delivered,[11] Blockchain technology (BCT) has been
suggested as a promising tool to store healthcare-related
data for sharing, exchanging, and analysis purposes among
different providers.[13] The benefits of Blockchain for cancer
applications include decentralization, improved data
security and privacy, medical data owned by patients, data
verifiability, transparency, and trust.[14] Several attempts
have applied BCT to generate comprehensive profiles
of cancer patients,[11,15,16] as BCT is a new type of digital
architecture, treated as a distributed ledger to ensure the
resilience, traceability, and management of healthcare
data.[17]

BCT can also act as a digital backbone for interfacing
with other AI technologies, including ML.[15,17] Thus, BCT
is expansive and modular and has the flexibility to be adopted
for a variety of applications in cancer care.[17] The
advantages of integrating both ML and BCT are increasing
data security and transparency, so that clinicians or
oncology researchers can better open up isolated data
islands based on the BCT’s strong data storage capabilities
in an encrypted, distributed ledger format, and be informed
decisions based on the ML’s predictive capabilities.[10,18]
Therefore, this brief report aimed to explore the application
of ML and BCT in the healthcare field and to illustrate the
integration of these two data-focused innovations in cancer
survivorship care.

Methods

This brief report included two stages. Stage one is a
narrative review, which conducted literature search among
the following databases: PubMed, IEEE Xplore, and Google
Scholar. Initially, the search terms consisted of (“machine
learning” OR “deep learning”), AND (“block chain” OR
“blockchain” OR “distributed ledger”), AND (“health” OR
“healthcare”). This review included peer-reviewed journal
articles or conference proceedings until the end of February
2021. Stage two is a brief study protocol to illustrate how
to apply these two cutting-edge technologies in cancer
survivorship care.

Results

For stage one, it included six studies involving the
integration of ML methods and BCT. As shown in Table 1,
the main contribution of these selected studies proposes
integrating BCT and ML in a sequential order from disease
surveillance, disease prevention, and disease treatment to
health maintenance. For example, disease surveillance,[19,20]
disease prevention by early prediction of disease or its
symptoms,[21,22] disease treatment such as in the field of
drug discovery and development,[15] and health maintenance
such as privacy-preserving health care to obtain health
patterns.[22,23] Kuo and Ohno-Machado[22] proposed the
ModelChain framework, which utilizes a permissioned
Blockchain coupled with an ML model to increase the
security of distributed preserving healthcare and accurately
gain predictive patterns.

Guided by the ModelChain framework,[22] the second
stage of this report illustrated how to integrate ML and
BCT into cancer survivorship care [Figure 1]. As the
application of BCT can open up isolated data islands
among different medical institutions to achieve data
sharing of cancer diagnosis and treatment information,
then integrating the method of ML to automatically predict
the high risk of cancer recurrence or prognosis prediction
by extracting different medical databases across different
medical institutions to establish a classification index. In
combination with locating cancer survivors’ environmental
data and regional healthcare service, this BCT and ML
system can apply a rule-based expert system (the simplest
form of AI uses prescribed knowledge-based rules from a
human expert and convert this into a number of hardcoded
rules to solve a problem),[24] to automatically matching
cancer survivors’ individual healthcare needs with
personalized survivorship care service.

Discussion

This report aimed to explore the possibility of integrating
the ML and BCT in the healthcare field and to draw
implications for cancer care, as the application of BCT in the healthcare field is still in its infancy, and there is scant literature regarding the convergence of ML and BCT in health care. Of the six included papers, only one study mentioned the possible implications for cancer care,[15] but other papers may also have potential implications for cancer care.[19-23]

As the optimization of cancer care should deeply integrate ML and BCT, the successful integration and implementation of these two promising technologies in cancer care delivery could open new research avenues for the advancement of cancer research.[11,12,25] In 2018, a Medicalchain in the United Kingdom was created by using BCT to record patients’ medical information.[26] This Medicalchain platform incorporating other AI technologies, including ML, to monitor and analyze cancer risk for moving the cancer prevention and control forward, which significantly improves the capability of cancer prevention and reduces the burden of cancer.[26]

BCT is still in early-stage development and application in cancer care, so regulations and data-sharing standards should be established and updated, based on technology requirements, along with sustainability, technological, and information management perspectives.[27] As BCT is a relatively new technology, there is also a need to evaluate the long-term issues associated with this technology.[28]

Further, we still need to develop an understanding of BCT and its integration with ML and how this could be the best fit for different aspects of cancer care-related challenges.[29]

While this report provided a good overview of BCT-ML fusion in the healthcare field, it does not capture a complete picture, as there is an increasing number of promising developments in this cutting-edge area. Future research on this area of technology integration should consider the addition of more BCT technical details. Although this report provided an example of integrating of ML and BCT in cancer survivorship care, future research should explore further integration of other AI solutions with BCT in various real-world applications as other AI domains and BCT become increasingly powerful and robust,[30] thus moving these technology fusions forward in this area.[31]
Conclusions
ML and BCT are two data-driven technologies, and there is rapidly growing interest in integrating them for clinical data management and analysis in healthcare. This report provided relevant literature under this topic in the health domain and describes the implications for cancer care. Guided by the findings of the first stage, the second stage of this report gave an example of how to apply these two technologies in cancer survivorship care. Thus, this brief report indicated that both technologies can be integrated feasibly and effectively. Future research should explore wider and deeper integration of these most notable technologies in cancer care.

Acknowledgments
The authors sincerely thank Professor Winnie So’s valuable comments and advice for this brief report.

Financial support and sponsorship
This study was funded by the National Natural Science Foundation of China (Grant No. 72004039).

Conflicts of interest
There are no conflicts of interest.

References
1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin 2021;71:209-49.
2. Ferlay J, Ervik M, Lam F, Colombet M, Mery L, Piñeros M, et al. Global Cancer Observatory: Cancer Today. Lyon: International Agency for Research on Cancer; 2020. Available from: https://gco.iarc.fr/today. [Last accessed on 2021 Feb 21].
3. Cancer Research UK. Cancer Survival Statistics for...
All Cancers Combined. Available from: https://www.cancerresearchuk.org/health-professional/cancer-statistics/survival/all-cancers-combined. [Last accessed on 2021 May 02].

4. Tran N, Dunn N, Moore J, Guan T, Philpot S. Cancer in Queensland: Statistical Overview 1982-2021. Available from: https://cancerresearchqueensland.health.qld.gov.au/media/1441/cancerinqueenslandannualupdate2014.pdf. [Last accessed on 2021 May 02].

5. Dlamini Z, Francies FZ, Hull R, Marima R. Artificial intelligence (AI) and big data in cancer and precision oncology. Comput Struct Biotechnol J 2020;18:2300-11.

6. Hamet P, Tremblay J. Artificial intelligence in medicine. Metabolism 2017;69S:S36-40.

7. Hemphill GM. A Review of Current Machine Learning Methods Used for Cancer Recurrence Modeling and Prediction. United States: Los Alamos National Laboratory; 2016.

8. Kourou K, Exarchos TP, Exarchos KP, Karamouzis MV, Fotiadis DI. Machine learning applications in cancer prognosis and prediction. Comput Struct Biotechnol J 2015;13:8-17.

9. van IJzendoorn DG, Szuhai K, Briaire-de Bruijn IH, Kostine M, Kuijjer ML, Bovée JV. Machine learning analysis of gene expression data reveals novel diagnostic and prognostic biomarkers and identifies therapeutic targets for soft tissue sarcomas. PLoS Comput Biol 2019;15:e1006826.

10. Zhu W, Xie L, Han J, Guo X. The application of deep learning in cancer prognosis prediction. Cancers (Basel) 2020;12:E603.

11. Dubovitskaya A, Novotny P, Xu Z, Wang F. Applications of blockchain technology for data-sharing in oncology: Results from a systematic literature review. Oncology 2020;98:403-11.

12. Rajkomar A, Oren E, Chen K, Dai AM, Hajaj N, Hardt M, et al. Scalable and accurate deep learning with electronic health records. NPJ Digit Med 2018;1:18.

13. Kuo TT, Kim HE, Ohno-Machado L. Blockchain distributed ledger technologies for biomedical and health care applications. J Am Med Inform Assoc 2017;24:1211-20.

14. Agbo CC, Mahmoud QH, Ekund JM. Blockchain technology in healthcare: A systematic review. Healthcare (Basel) 2019;7:E56.

15. Mamoshina P, Ojomoko L, Yanovich Y, Ostrovski A, Botezatu A, Prikhodko P, et al. Converging blockchain and next-generation artificial intelligence technologies to decentralize and accelerate biomedical research and healthcare. Oncotarget 2018;9:5665-90.

16. Glicksberg BS, Burns S, Currie R, Griffin A, Wang ZJ, Haussler D, et al. Blockchain-authorized sharing of genomic and clinical outcomes data of patients with cancer: A prospective cohort study. J Med Internet Res 2020;22:e16810.

17. Mackey TK, Kuo TT, Gummadri B, Clauson KA, Church G, Grishin D, et al. ‘Fit-for-purpose?’-challenges and opportunities for applications of blockchain technology in the future of healthcare. BMC Med 2019;17:68.

18. Nicora G, Vitali F, Dagliati A, Geifman N, Bellazzi R. Integrated multi-omics analyses in oncology: A review of machine learning methods and tools. Front Oncol 2020;10:1030.

19. Chattu VK, Nanda A, Chattu SK, Kadri SM, Knight AW. The emerging role of blockchain technology applications in routine disease surveillance systems to strengthen global health security. Big Data Cognit Comput 2019;3:25.

20. Juneja A, Marefat M. Leveraging Blockchain for Retraining Deep Learning Architecture in Patient-Specific Arrhythmia Classification. In 2018 IEEE EMBS International Conference on Biomedical Health Informatics (BHI); 2018. p. 393-7.

21. Hathaliya J, Sharma P, Tanwar SS, Gupta R. Blockchain-Based Remote Patient Monitoring in Healthcare 4.0, 2019 IEEE 9th International Conference on Advanced Computing (IACC), Tiruchirappalli, India; 2019. p. 87-91. [doi: 10.1109/IACC48062.2019.8971593].

22. Kuo TT, Ohno-Machado L. ModelChain: Decentralized Privacy-Preserving Healthcare Predictive Modeling Framework on Private Blockchain Networks; arXiv: 1802.01746. https://arxiv.org/abs/1802.01746. [Last accessed on 2021 May 2].

23. Shae Z, Tsai J. Transform Blockchain into Distributed Parallel Computing Architecture for Precision Medicine, 2018 IEEE 38th International Conference on Distributed Computing Systems (ICDCS), Vienna, Austria; 2018. p. 1290-9. [doi: 10.1109/ICDCS.2018.00129].

24. Grosan C, Abraham A. Rule-based expert systems. In: Intelligent Systems. Intelligent Systems Reference Library. Vol. 17. Berlin, Heidelberg: Springer; 2011.

25. Siyal AA, Junejo AZ, Zawish M, Ahmed K, Khalil A, Soursou G. Applications of blockchain technology in medicine and healthcare: Challenges and future perspectives. Cryptography 2019;3:3.

26. Medicalchain: A Smart Medical Ecosystem. Available from: https://medicalchain.com/en/. [Last accessed on 2021 May 02].

27. Ali O, Jaradat A, Kulakli A, Abuhalimeh A. A comparative study: Blockchain technology utilization benefits, challenges and functionalities. IEEE Access 2021;9:12730-49.

28. Agbo CC, Mahmoud QH. Blockchain in healthcare: Opportunities, challenges, and possible solutions. Int J Healthc Inf Syst Inform 2020;15:82-97.

29. Khaatoon A. A blockchain-based smart contract system for healthcare management. Electronics 2020;9:94.

30. Khezr S, Moniruzzaman M, Yassine A, Benlamri R. Blockchain technology in healthcare: A comprehensive review and directions for future research. Appl Sci 2019;9:1736.

31. Boulos MN, Wilson JT, Clauson KA. Geospatial blockchain: Promises, challenges, and scenarios in health and healthcare. Int J Health Geogr 2018;17:25.