Short Report

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

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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.[5] 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

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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

Table 1: Summary of characteristics of included studies

Authors (year)	Aims	Study design	Key system design components	Main findings
Chattu *et al*. (2019)	To present the role of blockchain and ML techniques in disease surveillance and global health security agenda	Proof-of-concept/ case-study	Permissioned blockchain plus ML techniques	Blockchain technologies with ML strengthen the capacity of the countries with simplified early warning surveillance for diseases of epidemic potential by reducing the mortality, morbidity and economic costs for reducing public health threats to global health security
Hathaliya *et al*. (2019)	To propose a blockchain-based remote patient monitoring using ML techniques	Proof-of-Concept	Permissioned blockchain plus trained ML models to improve the disease diagnosis	Blockchain technologies with ML algorithms can use for early prediction of symptoms or disease prediction and can impact the healthcare industry
Juneja and Marefat (2018)	To propose blockchain with deep learning for strengthening the detection of normal heart beats	Proof-of-concept/ case-study	Permissioned blockchain for retraining deep learning in arrhythmia classification	This integrated novel system indicated an increased accuracy for ventricular and supraventricular ectopic beats, higher than previous published deep learning models
Kuo and Ohno-Machado (2018)	To propose a ModelChain framework by applying privacy-preserving online ML algorithms on blockchains	Proof-of-Concept	Permissioned blockchain to enable multiple institutions to contribute health data to train a ML model for improving care without disclosing their health records	Such a framework increases the security and robustness of the distributed privacy-preserving health care predictive modeling across multiple institutions
Mamoshina *et al*. (2018)	To converge blockchain and deep learning in accelerating the biomedical research	Proof-of-concept	Integrating blockchain and deep learning technologies to resolve the challenges faced by the regulators and return the control over medical records back to the individuals	This study introduced a roadmap for a blockchain-enabled decentralized personal health data ecosystem to enable deep learning for drug discovery, biomarker development, and preventative healthcare
Shae and Tsai (2018)	To integrate transforming blockchain smart contract with AI such as ML to build large scale medical data sets for big data analytics	Proof-of-concept	Transforming blockchain smart contract with deep learning to build a large size of data sets	This work applied blockchain and ML as a new architecture to build a real-world evidence of clinical trial toward personal and precision medicine

AI: Artificial intelligence, ML: Machine learning

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]

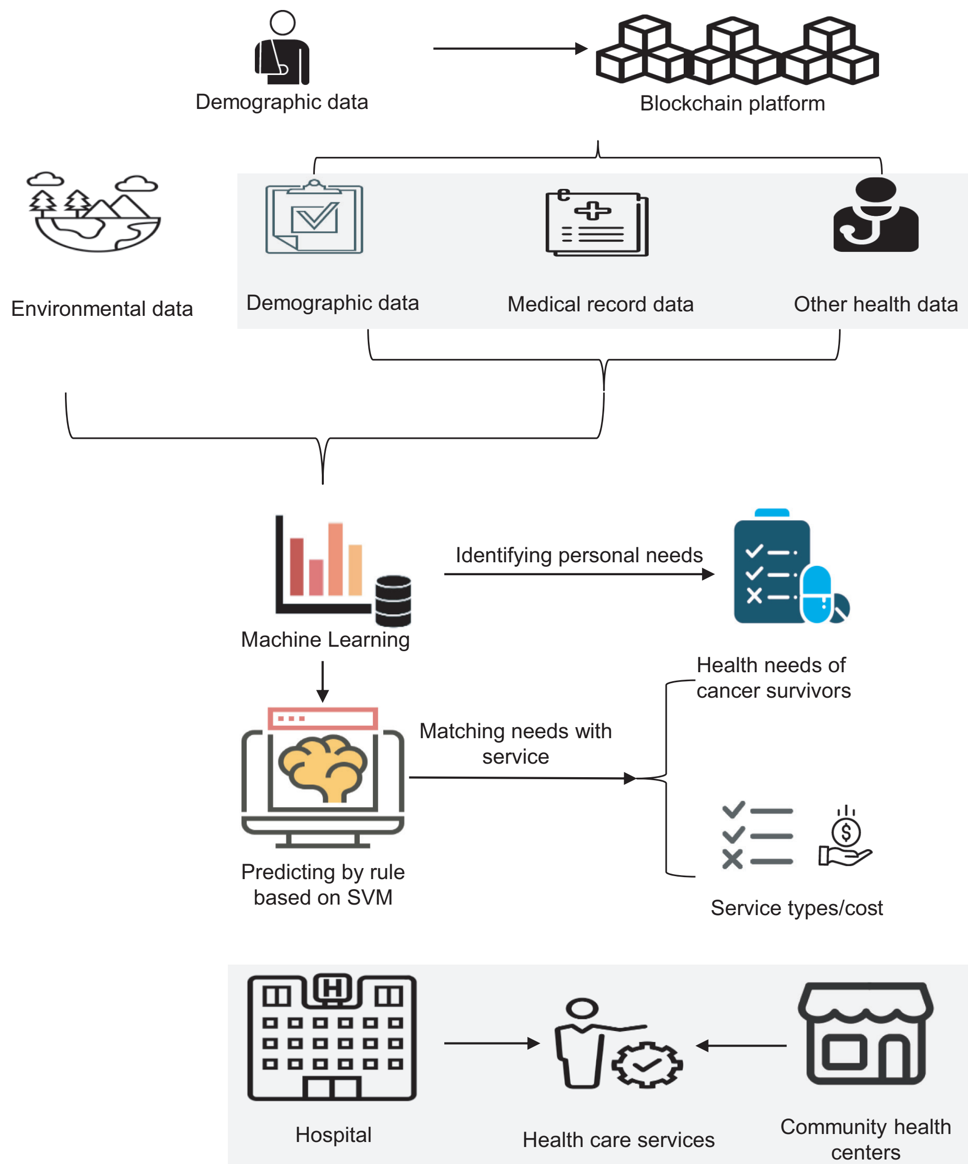

Figure 1: Proposed study framework of integrating machine learning and blockchain technology in cancer survivorship care

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.

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Conflicts of interest

There are no conflicts of interest.

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