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RESEARCH ARTICLE

AI for Population Health Management: Predicting Health Trends and Improving Community Health

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ARTICLE INFO	ABSTRACT
	An application of the new technological advance is the use of artificial intelligence in population health management where population-level data sources can be used in anticipating health risks, recognizing rising susceptibilities or proactively designing preventive measures. Machine learning and predictive analysis techniques are becoming more prevalent to analyse various health information including, clinical health records, environmental and social health indicators. This paper aims to discuss the importance of AI in improving data analysis, forecast the existing health concerns and develop intervention measures that addresses community needs. The utility of AI is also important for identifying and redressing health inequalities, enhancing the delivery of primary care and generating policies supported by strong evidence. Nonetheless, AI introduced problems in the application to population health management such as privacy, fairness, and accessibility questions. This is especially important in public health as AI is often applied in decision making processes. Finally, the paper examines potential recommendations for future uses of AI in enhancing the health of the public and minimizing the gaps prevalent in health.
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I. INTRODUCTION

PHM is defined as the coordinated process of increasing the healthy years of life and decreasing the burden of disease within a specific population or geographic area, with the aim of optimizing the use of available data in healthcare service provision. In the past, the approach to population health has relied on measures including epidemiology, health questionnaires, and recorded data [1]. The above approaches have been useful in establishing trends on health with added benefits of appreciating needs of health among given population. However, they are frequently cross-sectional; in other words, they incorporate restricted, quantitative data collected at one point in time and rely intensely on archival research methodologies.

As the world continues to shift to the fourth industrial revolution led by AI the management of population health is also transforming rapidly [2]. The effective use of a wide range of algorithms and the ability to handle vast amounts of sophisticated data makes AI an unparalleled tool for healthcare practitioners, policy makers and researchers understanding the states and trends of the population's health. Currently, with the help of highly developed ML and NLP, there is no a larger amount of EHRs, or social factors of health, for more effective investigation than now. These datasets are large and of a high dimensionality, thus it is challenging to find trends that can inform decision making by using the typical statistical tools [3].

Thus, AI presents distinct advantages when it comes to sorting through large amounts of data and finding relationships within the data which would benefit population health. The brink of AI into the management of population health holds the promise of improving both on the appropriateness and accuracy of interventions in health care. Real-time data makes it possible for AI to anticipate levels of health and determine new risks that are likely to arise as well as design measures for certain groups of people [4]. This ability to forecast future health challenges is useful because it allows for the shift from a reactive model to a preventive model. Unlike waiting for a disease to develop or worsen, AI systems can alert possible common health risks out before they arise. It may range from a very basic phenomenon, such as when there will be the flu season, to a highly developed and detailed prognosis as to the time and circumstance when it will be expected that there would be an increase in conditions such as diabetes and hypertension. Such predictive functions can offer interventions at the right time and to the right extent so that prevailing diseases can be averted before they spread [5]. Further, conversely, AI increases the effectiveness of the care delivered because it offers material for healthcare personnel to create individualized treatments.

Thus, using AI tools, it is possible to ensure that different health interventions correspond to a particular patient's characteristics better and can be based on his or her demographic, behavioural, and even genetic profile. Such personal approaches can be especially effective in handling chronic illnesses because of the effectiveness of individual treatment plans. In this context, artificial intelligence strengthens patient characterizations and makes treatments more efficient and cost-effective than they are when they are offered to any patient [6]. AI is also being used in a critical way to identify health disparities in populations. Inequality in health care can be related to some general indicators for example, income, health literacy and access to doctors which result in a worse health in communities in need of them. By looking into health data together with socio-economic indicators, AI tool can establish these gaps to help in determining which communities are most vulnerable [6]. For this reason, it empowers healthcare providers and policymakers to come up with effective strategies that will bridge these disparities and close the gaps in specific areas to make affirmative changes in social determinants by enhancing the citizens' access to care and make right investments in the right areas within the country. AI can also be used to track the success of such interventions in the future making it easier to modify such methods as one deems fit.

Paradoxically, the application of AI in the population health management system is not without limitations. AI-based applications depend on big high-quality data, however, protecting the information is critical. Since health information is considered as sensitive information, any AI systems used in the management of health care information must respect the ethical and legal requirement for information protection [7]. Moreover, AI models are only powerful as their training data proves to be. This means the AI algorithms might help to worsen the existing heath inequalities contingent upon the population data on which they were developed from being insufficient or skewed. Hence, it is important to consider how AI delivers compelling, accurate and most importantly fair heath reports [8]. However, these AI use cases in public health can only happen through the participation of health care workers. Although the introduced AI systems help in finding solutions to various problems, their purpose is not to act as an expert. Healthcare providers then have to read AI derived analytics and make clinical decisions based on the provider's discretion. Hence, there is a need to train healthcare professionals to embrace, use, and collaborate with AI tools to enhance application of those technologies in population health [9].

In this paper, the author aims at discussing how the approaches in artificial intelligence are revolutionising the way the population health is being handled especially in large databases, in the forecast

of the adverse trends, or while adopting the measures to prevent development of the undesirable outcomes. In particular, its focus on AI applications in community healthcare settings explores the: value of AI intervention in identifying disparities, enhancing health equity, and underpinning policy-based healthcare innovations. It also speaks about such issues as data protection, use of AI, and fairness and openness explanations as the drawbacks of integrating AI to population health managing. In conclusion, this paper presents a systematic analysis of AI as an instrument for changing the future of population health and the management of healthcare systems and provides solutions for more effective, innovative and individual approaches to medical care.

I.   Research Findings

A. The Role of AI in Analysing Population Health Data

Big Data in healthcare is one of the most critical advancements in medicine today, and it will only become even more important in the future. Big data healthcare can be defined as the interacting and complex, large amount of structured, unstructured, semi-structured data colouring through means of EHRs, patient monitoring systems, genomic data, wearable devices, social determinants of health, and others. In the past, the amount and density of this data have usually made it an almost impossible feat to organize and harness for efficient use by the healthcare systems of the world. However, AI brings the required amounts of computational resources and algorithms to process this data in unthinkable earlier terms [10].

i.   Big Data and AI Integration

AI helps healthcare providers analyse a large volume of health information in a relatively short amount of time compared to when it is done by hand. In this way, AI systems can filter through the detailed information of various patients and patient populations by utilizing ML and DL algorithms in order to discover patterns which guide interventions. For instance, AI can also use population statistics, like the rate of certain diseases in specific locations, historical statistics and determine overall health trends. With the help of stationing learning algorithms, it is possible to make prediction about how probable the occurrence of some diseases is, efficacy of interventions, or even about the threat of viral pandemics, which in turn will allow the authorities in the sphere of public health to take appropriate actions [11].

ii.   Machine Learning Algorithms in Health Data Analysis

Artificial intelligence in general and more specifically Machine Learning are used when it comes to the analysis of health data. In other words, it does not empower programmers to program every single detail but to teach computers to learn patterns in data on their own. Generally, these algorithms work based on past data, and since these are AI based, they become more and more accurate as they continue to function. The primary benefit of using ML in healthcare is in its capacity to pick out features that might be non-transparent to human analysts. The methods commonly used in machine health data learning include; the supervised learning, the unsupervised learning, and learning through reinforcement. Supervised learning algorithms for instance are trained on tagged data, in this case a clinical database and will therefore be useful in future predicting possible patients' status. For instance, supervised learning can always be used for risk

assessment of one developing a given disease given their medical histories, lifestyle, and other factors [12].

iii. Natural Language Processing (NLP) for Health Data

It's Important to note that Natural Language Processing (NLP) is a subfield of AI that focuses on the interaction between computers and humans. In healthcare, NLP is applied to identification of significant facts from inevitably structured data like clinical notes and patient records, and from other resources available in forms of articles, journals, and even online postings. Most of the health care information is narrative making it complex to analyse using conventional tools & method. Nonetheless, NLP can be employed to extract and analyse this data, make it orderly and integrate able into the population health management initiative. NLP aids the review and selection of valuable data, including the symptoms, diseases, treatments and patient histories as extracted from medical notes without the need for keying in [12]. For instance, NLP can identify data from the notes written by physicians in the EHRs and integrate these with formal data streams such as laboratory work to help offer an improved picture of the health condition of a patient. Once this process is IT is integrated, healthcare providers can receive, filter and apply the latest information to formulate their decisions faster. From the perspective of the number of people, big data and NLP can be used to search for medical texts and health articles to track new diseases or threats to find out the new threat at the first moment. Besides, NLP is in a position to increase the level of engagement with the patients since it can detect the patients feedbacks and sentiment, thus assist in constructing more impactful public health messages and campaigns [13].

B. AI in Predicting Health Trends

The healthcare industry has a strong social impact on the well-being of individuals, communities, and societies. Social responsibility in this industry includes fair labour practices, community outreach, patient care, diversity, and health equity. As closely related to human life, healthcare organizations are uniquely positioned to lead in addressing social challenges while fostering trust and stronger relationships with stakeholders.

i. Predictive Analytics for Disease Forecasting

The ability to forecast future health behaviours is one of the most valuable kinds of AI in public health. Predictive analytics therefore refers to the crafting of health results by applying predictive models as well as past data. It can involve predicting the incidence of diseases, the increase in chronic diseases including diabetes, or simply the effects of health interventions. Machine learning models can forecast disease incidences using health, and other parameters, environmental, social, and behaviour aspects. For instance, there are models built on machine learning algorithms that sought to predict the cases of flu, based on some factors such as seasonality, peoples' vaccination rates and the climatic factors. Intelligent higher AI systems can also utilize real-time data, like social media interaction or movements, in regard to the COVID-19 like virus outbreaks and advise the health authorities beforehand [14].

ii. Real-Time Data and Trend Identification

Up-to-date information is critical to monitor and address the tendencies of overall human health in real-life conditions. As a result of the increased demand for digital health technologies, wearables, and connected medical devices, the healthcare has a continuous inflow of data about the status of patients. Data recoded have to include aspects like the level of physical activity, increase in mental

health problems or infectious diseases and all this have to be analysed by the AI. But with the help of AI, processing of the corresponding real-time data leads to the identification of new health threats in their development stages [15]. For instance, AI systems are used in monitoring the rate of influenza and tell where the next one is most likely to happen. This ability to forecast means that healthcare practitioners and department of public health have the chance to act before a disease spreads any further and more lives are lost.

iii.   Addressing Public Health Crises with Predictive AI

Business innovation and operational optimization have always been the primary advantages in the usage of Predictive AI but what has stood out most in the modern world is their capability to manage public health emergences including the pandemics, natural disasters, and environmental health. AI can detect what may be an early sign of a health crisis like increase in disease cases, changes in people's behaviour or the environment that may cause spread of diseases. For instance, in the current COVID-19 outbreak, AI models were applied to forecast the extension of the virus; monitor infection events on a real-time basis; and determine a probable number of cases within some locations. These predictions assisted policy makers to make reasonable decisions concerning lock down, social distance and other issues concerning resources. One particular problem in managing public health crises is that of AI functioning as an improved tool for the analysis of threats and the coordination of the response to them [16].

C. AI-Driven Preventive Interventions

Another important benefit of AI in Population health management is the creation of individual health interventions. Specifically, the concept of providing a suit of personal health services for further application to an entire population has been a developing concept in the field of healthcare and artificial intelligence rises to the next level to support this cause by analysing lots of data in order to provide an appropriate health treatment regimen required for every single person in the population. When analysing the demographic data, medical history and behaviour, artificial intelligence may suggest specific treatments or interventions that would be useful in dealing with certain health peril or disease [17]. For instance, AI can be employed in developing fitness regimes for a specific client or prescribe a diet plan for people with cardiac, diabetes, or hypertensive problems among others. Incorporation of genetic susceptibilities, lifestyle choices and medical history factors, makes it easier for AI systems in the management of such diseases, to develop specific and effective intervention models from which patients can benefit.

i.   AI in Health Education and Behaviour Change

Happen also education and health behaviour changes through artificial intelligence. With the help of analysing the health data and understanding the type of behaviour, AI can create special health education programs that will inspire people most of all. Health advising, reminding, and encouragement may also be delivered through AI applications to ensure that patient behaviours that promote good health, more physical activity, better diets, or even better medication compliance are encouraged [18]. AI can also help in behaviour change by giving feedback during the task. For instance, wearable devices with AI related platforms can track number of steps taken in a day or the number of hours spent exercising, and respond promptly to the users by urging them to meet the required number of steps or exercise hours based on the prescribed regimes or treatment regimens. In particular, the fact that this feedback is received simultaneously enhances user interaction and encourages the right behaviour alteration.

ii. Targeted Public Health Campaigns

The deployment of AI in designing effective population-level health communication campaigns is relevant to enhancing the effectiveness of various public health campaigns. AI can use the demographic data, SDOH, and health trends to estimate the populations and areas most at risk of receiving incorrect information and use that data to target populations for campaigns that contain the accurate messages that populations need to stay healthy. Thus, AI offers the possibility to address high-risk populations directly and offers the potential to reach more people while making it more likely that the specific needs of people in these communities are being addressed. For example, AI can be applied to create smoking cessation Global Health promotional campaigns specifically for groups with high smoking prevalence [19]. AI can extract the needed information about smoking behaviour, population characteristics together with the social network analysis to understand what types of messages would be more helpful to stop smoking and on which channels they might be delivered: digital, community or healthcare. This kind of targeting makes the probability of getting through all the critical masses a much more attainable feat.

D. AI in Detecting and Addressing Health Disparities

Inequalities in health is one of the toughest barriers to public health in the society. Health inequalities in both application, treatment, as well as the outcome based on the care received by the minority groups predominantly target the vulnerable groups of people. AI can also help overcome such primary injustices by accessing data across sectors like SDOH, race, ethnicity, and SES. AI driven engagement can therefore be used to detect areas with the highest health disparities and provide more and better health services to those in need. AI can also find out latent health inequalities not easily comprehensible after a manual study has been conducted. For instance, AI models can predict vulnerable groups of people to problems such as asthma or diabetes even if these cases may not be seen by doctors [20].

i. Targeting Interventions for Vulnerable Populations

It also enables healthcare system to identify multiple parameters for at-risk populations and come up with relevant preventive measures for a specific prey. Using big data, for example, AI will be able to detect factors like education level, transport, and healthy diets and case them against the health outcomes of the population of interest. Once these factors are identified, AI can assist in designing interventions that target the values of the communities where they are located with an aim of identifying the causes for these problems and work on solving them with better and healthier solutions than before [21]. For instance, AI may be applied to develop interventions for nutrition, and physical activities for populations residing in food pandas or aces where access to healthcare services is hard to come by. Likewise, it can be applied to inform plans on how to address the hindrances to obtain care including transport or language that hampers health enhancement procedures hence enhancing the functionality of public health interventions.

a. Improving Healthcare Access through AI:

AI has the potential to expand healthcare access by advancing remote care delivery and telemedicine solutions. For patients who have no chance to receive professional medical help, AI technologies can grant an opportunity to receive higher-level treatment. AI in telemedicine can present virtual consultations and diagnosis, advice on treatment, diagnostic kinds, and prevent facing an individual with the challenge of reaching a doctor or paying for services. AI can also

enhance access to care as a way of identifying the patients that fall through the system. For example, AI can help to determine from the EHRs patients that were due for periodic screening or follow-up appointments, and then, send them gentle reminders to visit their medical providers. It can help to prevent neglect in some patients and also would decrease potential gap in health care for some groups of people [22].

ii.   AI in Enhancing Healthcare Resource Allocation

a. *Emerging Metrics for ESG Performance:*

AI proves to be a very effective tool in directing utilization of health care resources since it can estimate regions with high demand. For instance, there are techniques which enable the AI systems identify emerging patterns of diseases, healthcare facilities, and patient outcomes then make predictions on where grants should be channelled. Predictive analytics applied to disease history helps to determine the most appropriate funding allocation throughout hospitals, clinics, and public health programs that will supply adequate funding to address community requirements. This optimization forges a way of avoiding scarcity of resources and enhances the fairness of health care provision [23].

b. Predicting Healthcare Workforce Needs:

The same way, AI based predictive models may also be used to predict potential future healthcare workforce requirements based on health status and utilization trends of a given population. For instance, AI can determine where density of health care employees will be higher, that is areas with a growing population of elderly people or people with chronic diseases. This enables health systems to have long term schedules so as to meet the demands made by the population by ensuring that doctors, nurses and mental health professionals are posted to the endemic areas. Using AI for workforce forecast enables healthcare systems to remain balanced and efficient because of its accuracy [25].

c. *Reducing Healthcare Costs through Efficient Allocation:*

AI has the ability to analyse result of treatment and make recommendations about economic changes. AI has the ability of analysing data from different departments in the healthcare System, and it can discover what is wasteful, for example, duplicated imaging and doctors' pathways, and poor resource utilization. AI thus highlights all these gaps, and by eliminating them, it helps healthcare providers reduce cost of service, hence increasing accessibility for the community [26].

II.   Conclusion

Population health management through AI has numerous possibilities that might lead to better people's health, timely recognition of the upcoming tendencies, and equal opportunities in providing all people with necessary healthcare. With vast amounts of data, it is possible by using big data, machine learning, and natural language processing and other tools AI can provide hither to impossible information that may be used to provide personalized therapies, early identification of diseases, more effective public health interventions, and social marketing. Nevertheless, as the AI technologies advance, some questions arise as data privacy and protection, algorithm's bias and AI accessibility for all as the benefit for all population. It is only if these challenges are to be addressed AI can cause the phenomenal change in the health sector and the over-all health of the global population.

III.   References

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