REVIEW ARTICLE

A New Window of Hope for Management and Prevention of Poisoning: The Use of Artificial Intelligence

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Abstract

Background: Poisoning is a significant public health concern, encompassing a broad range of sudden and severe health issues resulting from the ingestion, inhalation, or contact with toxic substances. The potential for injury or fatality necessitates urgent medical attention and care. With the ongoing advancements in artificial intelligence (AI) and its increasing integration into medical and pharmaceutical domains, there is a growing interest in exploring the role of AI in the context of poisonings. This study aims to investigate the potential applications of AI in the management and treatment of poisoning.
Materials and methods: This research is a review by searching the keywords ("Artificial intelligence") [TIAB] AND (poisoning [TIAB] OR toxicity [TIAB] OR intoxication [TIAB] OR Toxin[TIAB] OR poison[TIAB]) was searched in the internet databases PubMed, Scopus, and Google Scholar search engine in 2016-2024.
Conclusion: Enhancing system management and treatment approaches is crucial in preventing accidental and intentional poisoning. This can be achieved by incorporating cutting-edge medical equipment, such as those equipped with AI. AI technology can recognize complex patterns beyond predefined rules and process large amounts of data, exceeding human capabilities. In the future, more progress in AI will likely affect various areas of healthcare, including poison prevention and treatment, to improve patient outcomes and reduce the burden of poisoning on healthcare systems.

Keywords: Artificial Intelligence, Machine Learning, Poisoning, Toxicity.

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INTRODUCTION

Acute poisoning is considered one of the most important medical emergencies in the world as it accounts for 15-20% of emergency room visits. According to rough estimates, around 15-60 million cases of acute poisoning occur worldwide each year, leading to 300,000 to 640,000 deaths (average poisoning-related fatality rate: 0.5-4%) [1, 2, 3]. In the United States, approximately, 2 million human toxic exposures are documented every year, resulting in about 3,000 deaths (death rate: < 0.5%) [4]. National Poisons Information Service of the United Kingdom has recorded an annual number of 170,000 hospital admissions due to acute poisoning cases with over 4500 deaths (poisoning-related fatality rate: ~2.6%) [3].

In Iran, it is roughly estimated that 350,000-550,000 acute poisonings occur each year, causing 7000-9,000 fatalities (poisoning-related fatality rate: ~1.6-2%)[5, 6]. Most poisonings can be prevented, controlled, and treated. However, the possibility of serious harm and death caused by poisoning, as well as socioeconomic impacts and the adverse physical and mental health consequences cannot be ignored [7]. Since there are different types of poisoning with different epidemiologic patterns, and different treatments, the processing, use and analysis of relevant information is time-consuming and difficult. Today, with the advancement of information technology at different levels and the need to modernize medicine, the employment of artificial intelligence (AI) is needed more than ever. AI, can be useful in the paradigm shift of medicine to achieve a high success rate in the diagnosis and treatment of diseases [8]. AI refers to systems that can have behaviors and reactions similar to human intelligent behaviors, including simulating human thinking processes and reasoning methods, understanding complex conditions, responding successfully to them, learning and having the ability to acquire knowledge and logical approach to solve problems [9, 10].

The first-ever technology based on AI in medicine was MYCIN, a name derived from the suffix of antibiotics used in the 1970s at Princeton University to diagnose blood-borne infections. But, due to the high number and complexity of the algorithms and lack of acceptable success, it failed in practice. Today, with extensive evolution and increased power of computers in information processing, the applications of AI in medicine and related fields such as pharmaceuticals and genetics have been improved to a great extent [11].

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In medicine, AI has aided in the more proper and faster diagnosis of diseases, interpretation of medical imaging, the discovery of more effective molecules in the manufacturing of new targeted drugs, and the ability to detect genetic patterns leading to certain diseases, among others, with high accuracy in performance [12]. For the management of acute trauma victims, although some ideas for the use of AI have been proposed and are being evaluated, it is still preliminary, and many of the basic needs in the field of trauma management have yet to be planned and solved by AI-based technologies [13]. Training, validation and continuous learning are three basic pillars of the healthcare system. An important part of therapy is based on correct and quick diagnosis. AI can reduce errors and shorten the time required for diagnosis. Today, due to the expansion of the medical sciences and the increased complexity of decision-making, the use of information systems, particularly AI systems, has become crucial in supporting decision-making. As a result, various types of intelligent systems are growing in medicine [14]. In this article, we sought to review the potential applications of AI in poisoning management and prevention and to appraise recent exploratory investigations aiming at the use of AI in medical toxicology.

MATERIALS & METHODS

In this review, the keywords ("Artificial intelligence" [TIAB]) AND (poisoning [TIAB] OR toxicity [TIAB] OR intoxication[TIAB] OR TOXIN[TIAB] OR poison[TIAB]) were used to search relevant articles in databases, including Pubmed, SID, Scopus, Science Direct and Google Scholar through the years 2016-2024. The criteria for including an article in the final analysis were that the articles should be most related to the topic, i.e., the role and use of AI in poisoning management and prevention. Irrelevant and repetitive articles and articles whose full texts were unavailable were excluded. Among the 1683 retrieved articles, only 34 were selected to review the role of AI in poisonings.

RESULTS & DISCUSSION

Experts believe that the necessary knowledge about the pattern of poisoning is essential for health officials. Medicines or toxic agents available in the market, the prevalence of addiction, racial differences, the healthcare infrastructure, regional pre-hospital care, and the availability of antidotes have an impact on poisoning outcomes in each region. In addition, over time, the rate of poisoning-related deaths varies from region to region due to the emergence of new illegal drugs and toxic chemicals [10]. In this context, the use of AI in determining the geographical distribution of poisonings and medical needs, i.e., GeoAI applications in healthcare logistics, disease distribution, and epidemic surveillance, has been advocated [15, 16].

Human intelligence learns through adapting to various problems and challenges in its surrounding environment and changing behavior. Computers and machines equipped with AI technology also follow the same basis. AI-based systems help predict and solve possible problems, reduce human error, and speed up action using logical algorithms. The creation and implementation of such algorithms by experts have led to the formation of different branches of AI, which include the following [7, 17]:

Expert System: A system or software that imitates human knowledge and makes decisions.

Robotics: Robots are created to perform tasks more accurately and faster than humans.

Machine Learning: Machine learning enables knowledge to be gained from the surrounding environment and creates a comprehensive algorithm with decision-making capabilities.

Artificial Neural Network: Artificial neural networks can predict or label new samples by observing and separating different samples and learning to distinguish them.

Fuzzy Logic: The modification and representation of uncertain information by the fuzzy logic branch of AI is done in the face of uncertainty to provide a certain level of flexibility and reasoning.

Natural Language Processing: The branch of natural language processing as a vital interface, by using a binary coding system (zero and one system), provides the possibility of understanding human natural language for computers and machines.

Machine learning is the most important branch of AI, and

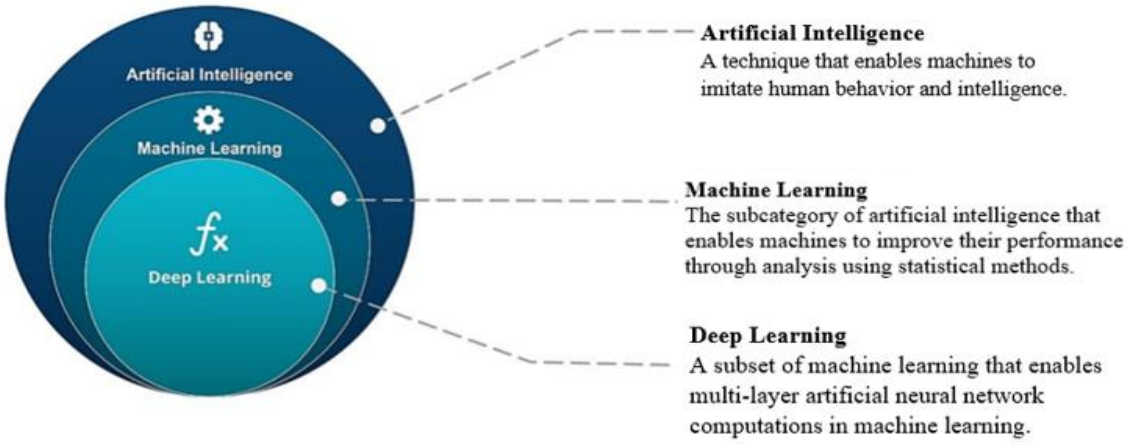

Figure 1. The position of deep learning and machine learning in artificial intelligence [11].

it includes various sub-branches, the most important of which is deep learning (Fig.1). The difference between machine learning and deep learning is the presence of more complex algorithms and more layers in deep learning [10]. In a study, an AI technology-based medical information processing and emergency first aid nursing management model can significantly improve triage efficiency, support emergency, nursing efficiency, and enhance the survival rate of emergency patients[18]. In another study, a neural network was used to diagnose and distinguish different types of eye strabismus. This web-based system (www.strabnet.com) revealed 100% accuracy[19]. In another study, AI was used to predict dose distributions and optimize treatment plans for intensity-modulated radiation therapy. The results showed that the optimized plans produced lower doses for organs at risk (OARs) compared to those generated by the deep learning model alone, while maintaining adequate planning target volume (PTV) doses and homogeneity [20].

AI is being used to improve diagnosis and treatment in fields such as clinical toxicology, intensive care medicine. For instance, ToxNet, a machine-learning based system, can predict poisons based on patient symptoms and metadata from the Poison Control Center database, outperforming medical doctors in some cases. In intensive care medicine, AI is being used to detect clinical deterioration, monitor patients, and predict disease progression [21, 22, 23].

A study used machine learning to predict the toxicity of small molecules. It was found that MolToxPred is a machine learning-based tool that predicts the toxicity of small molecules and metabolites. This tool uses a stacked model approach with different base classifiers and hyperparameter optimization. During evaluation, MolToxPred achieved an AUROC of 87.76% on the test set and 88.84% on an extemal validation set, outperforming its base classifiers and an existing tool. This tool can be valuable for drug discovery and regulatory pipelines in pharmaceutical and other industries for predicting the toxicity of small molecule candidates using in silico methods[24]. A study developed and evaluated machine learning algorithms to predict maintenance dose and duration of hospital stay in opioid poisoning. Using AI, researchers trained the XGBoost algorithm and achieved an accuracy rate of 91.04%, a prediction rate of 91.34%, and an area under the Curve (AUC) of 0.97 [25].

Poisoning is one of the most complicated diagnostic cases as, usually, the patient's history may not be reliable. Furthermore, the issue of "time" is a vital factor in the quick delivery of essential treatments for these patients [26]. Having extensive information about signs, symptoms, side effects, characteristics of toxic substances, and treatment methods, AI-based systems as skilled assistants and consultants can provide clinicians with effective and prompt suggestions on the diagnosis and management of poisoning. They could, thus, increase the cure rate while decreasing the death rate [17]. To prevent the potential risks and reduce potential errors, AI-based systems were first tested and used experimentally in veterinary medicine with promising results. Therefore, according to the positive feedback of this work, an application was created to function as an assistant for diagnosing common poisonings in animals. In this regard, Tabakova-Komsalova and colleagues developed an expert system for the diagnosis of livestock poisoning [27]. How to evaluate the severity of poisoning with low-risk medications and whether antidote for such should be administered or not are challenges of medical toxicologists and questions of emergency clinicians. Mehrpour et al. demonstrated that by the use of machine learning prognosis of Diphenhydramin poisoning can be predicted and the need for physostigmine treatment can be appraised [28].

In the same manner, machine learning techniques are proven to be accurate for prediction of poisoning prognosis with highly toxic agents, such as methanol, which enables early intervention and personalized treatment strategies [29]. Machine learning can, also, be used to distinguish chronic from acute drug poisonings [30], and to classify the opioid overdose events [31]. Deep neural networks has been shown to be useful in distinguishing the causative agent of acute drug poisonings with good accuracy [32]. Machine learning algorithms have been even shown to be precise enough to distinguish the exact subclass of antihyperglycemic agents as the causative agent of acute poisoning with such medicines [33]. AI can revolutionize poisoning prevention and toxicovigilance. By incorporating big data analytics and AI into poison control databases, toxicovigilance processes can be optimized, and hazard identification and risk assessment of toxicants can be modernized [34].

Machine learning models can help predict the changes in environmental CO_2 concentration and preventing CO_2 toxicities [35]. AI has also widely used for prevention of pediatric lead exposures [36, 37, 38], warranting its usefulness in ecotoxicology. In an ecotoxicological outlook, some scientists are trying to apply AI to spatiotemporally predict arsenic contamination of the environment [39, 40]. In a broader perspective, the future of toxoepidemiology, ecotoxicology and pharmacovigilance will be drastically changed through the integration of AI and its subsets. Thus, it can efficiently improve management and prevention of poisonings, outbreaks and epi/pandemics [41, 42, 43, 44].

CONCLUSION

The high mortality rates among young people due to poisoning highlight the urgent need for innovative solutions, particularly, the integration of AI. AI-based software from smart networks can play a significant role in preventing accidental and intentional poisoning by simulating decision-making processes, identifying patterns beyond defined rules, and analyzing extensive information. This can improve diagnostic technology and enhance treatment and rehabilitation methods for poisoning victims. Integrating AI in the field of poisoning shows significant promise for updating and improving treatment and rehabilitation methods, ultimately, speeding up the recovery of those affected by poisoning incidents.

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