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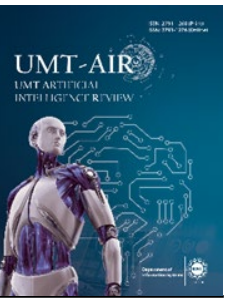

Title: **Role of Artificial Intelligence in different aspects of Public Health**

Author (s): Ifra Chaudhary[1], Hassan Anwar[2], Umar Latif[3], Ali Latif[4]

Affiliation (s):
[1]Faculty of Veterinary & Animal Sciences MNS-University of Agriculture, Multan, Pakistan
[2]Faculty of Agriculture & Environmental Science, MNS-University of Agriculture, Multan, Pakistan.
[3]Faculty of Computing & Information Technology, University of the Punjab, Lahore, Pakistan.
[4]COMSATS University Islamabad, Wah Campus, Wah Cantt, Pakistan

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Role of Artificial Intelligence in Different Aspects of Public Health

Ifra Chaudhary[1], Hassan Anwar[2*], Umar Latif[3] and Ali Latif[4]

[1]Department of Pathobiology, Faculty of Veterinary & Animal Sciences, MNS-University of Agriculture, Multan, Pakistan.
[2] Department of Food Science and Technology, Faculty of Agriculture & Environmental Science, MNS-University of Agriculture, Multan, Pakistan.
[3]Department of Computer Science, Faculty of Computing & Information Technology, University of the Punjab, Lahore, Pakistan.
[4]Department of Computer Science, COMSATS University Islamabad, Wah Campus, Wah Cantt, Pakistan

***Abstract*- In the next decade of disease surveillance research, innovative and novel techniques are required to utilise massive quantities of complex and multi-dimensional data, effectively. Public health is one of the most significant domains of public governance and artificial intelligence has emerged as an innovative problem-solving technique in this domain. Artificial intelligence is a requirement for the early identification of diseases and disasters in order to prevent high mortality rates and reduce economic burden by timely providing appropriate healthcare. This detection is made possible in this research by identifying patterns in the database. This review shows that the use and development of AI techniques has increased in the field of public health over the past few years and most of the existing studies show a positive impact of AI in the domain of public health. This study is divided into three portions. The first portion reviews the role and potential usage of artificial intelligence in epidemics, since it is very important to timely investigate them and AI has the potential to cope with them. The second part of the review provides a detailed discussion about serious game usage in public health. Serious games are used for the training and rehabilitation of the gamer. The third part deals with the management of public health emergencies including evacuation, causality response, and information processing.**

***Index Terms*- artificial intelligence, epidemics, health crises, public health**

I. Introduction

Public health is defined as the science and art of promoting health, increasing life expectancy, and preventing diseases through organized community effort. It is a multidisciplinary field comprising

* Corresponding Author: hassan.anwarft@gmail.com

epidemiology, management of health services, social sciences, and biostatistics, all of these come under the umbrella of public health. The core functions of public health are assessment, policy development, and assurance. The pillars of public health are prevention, protection, and promotion. Providing a suitable intervention to the target population at the appropriate time is fundamental to public health. It facilitates the entire community and ensures its protection from environmental hazards and infectious diseases. Consequently, it helps to achieve a quality life through nutritional diet, breastfeeding, personal hygiene, delivery of vaccination, and increasing healthcare accessibility [1].

Artificial Intelligence (AI) uses epidemiological data to predict population health through disease detection, elimination, and mitigation. AI does not confine itself to biologically observable methods because it is related to the use of computers to understand human intelligence. It is also used in public health policy and Moreover, it provides real-time data analytics, improves patient care, and allows continuous patient monitoring [2].

Nowadays, the Internet has become a primary source of health information and its popularity has grown dramatically among youngsters. AI serve as a tool to identify the population at risk and to promote healthy behavior. It also helps to understand and develop interventional strategies to improve people's health. The manual surveillance system is not very reliable in this regard. So, AI is used in the surveillance systems of both non-communicable and communicable diseases. It is used in designing treatment plans, medical record mining, forecasting health events, medication management, drug creation, assisting repetitive jobs, precision medicine, online consultations, and in healthier choices and decisions. Although AI has proven effective in other health-related fields, its use is still lagging in the public health domain [3].

II. Artificial Intelligence in Epidemics of Health Crises

In public health emergencies, public health problems and epidemic succession are chased with enormous customary internet data to procure early indications, monitor crises and anticipate epidemic inclinations in advance [4]. Huang et al. developed an analysis receptacle to assess the four measurements of information involving the epidemic itself and the response from the media, medical

community, general public, and the government [5]. The global health crisis was addressed through the use of AI in numerous departments of the healthcare system. AI techniques in the field of health and medicine attained fascinating improvements, corresponding with its growing use in the detection of disease [6].

AI is increasingly preferred over traditional healthcare systems in terms of forecasting, preventing, and monitoring newly developed contagious diseases. A surveillance system based on AI allows for a quick analysis of the hazards of the epidemic. AI plays a crucial role in identifying intricate relationships within a specified group and serves as a valuable tool for identifying the origin of the disease. It provides aid in automatically analyzing pertinent evidence from test results and medical examination findings, identifying clinical features, providing therapeutic strategies, and forecasting illness prediction and succession. AI tools are now accessible for identifying infection mechanisms and its early detection, monitoring disease transmission, resistance to treatment, and quarantined individuals, predicting infection rates, and enhancing vaccine compositions. Vaccine development and research can go more rapidly with higher integrity because of progressive computational inspection [7]. AI plays an important role in a smart surveillance system to diagnose and forecast the disease for future plans. Figure 1 shows the crucial elements and data usage via AI techniques to prevent transmission, enhancing control, and implementing decisions.

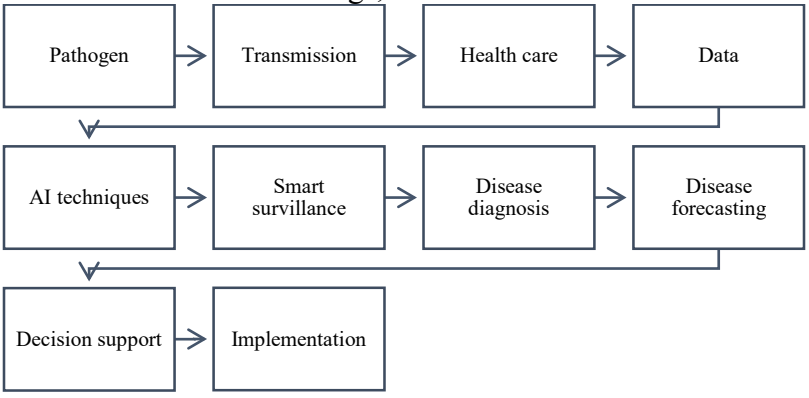

Fig. 1. The elements to prevent disease through AI based decision implementation

The COVID-19 pandemic was one of the most prevalent public health concerns. The current research indicates that around 20% of COVID-19 hospitalized cases and 6.4% of its victims required intensive sustenance due to drastic indications, which directs a 49% death rate and utilizes a lot of medical resources [8]. The role of AI applications and strategies in this health catastrophe was admirable. AI remains extremely significant in diagnosing, precluding, decision management, and treatment of COVID-19.

With the aid of AI techniques and big data, the professionals examined the computed tomography manifestations, clinical traits, efficacy, and treatment approaches in several types of victims based on the accumulated data [9]. The analysis rationalized the modification of treatment and diagnosis strategy for COVID-19 cases. For more practical risk assessment and related patient diagnosis and therapy, the AI prognosis criterion for COVID-19 disease succession was used to forecast the probability of significant ailment in COVID-19 sufferers after 5, 10, and 30 days. The COVID-19 prediction, diagnosis, and screening all have significantly improved as a result of the current development and research in the area of AI, making the outcomes more credible and valuable. Indeed, sometimes AI even outperforms human beings in specific healthcare chores [10]. Figure 2 demonstrates how AI is used in key therapeutic processes to increase accuracy, decrease complexity, and shorten treatment times.

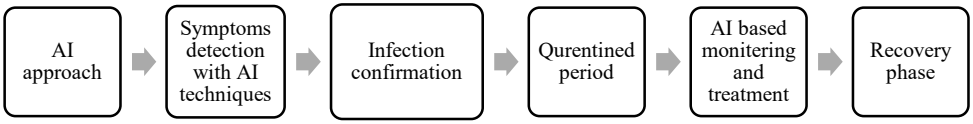

Fig. 2. Stage of communicable disease AI Techniques

The use of AI in epidemic control and prevention supports timely investigation, identification of sick individuals, epidemiological investigation, epidemic trend evaluation, isolation, and contact tracing [11]. AI proposed efficient services for the systematic action to

the nation, an overview of endeavor and production by ascertaining the largest cross-structural, cross-departmental, cross-regional and cross-industrial disseminated databases to furnish a prevalence rate for epidemic control and prevention [12]. Deep learning is among the most prominent AI-based techniques utilized to help radiologists in the early detection of COVID-19. Additionally, it decreases the burden of radiologists, strengthens diagnosis more effectively and precisely, and delivers prompt assistance and appropriate therapy for COVID-19 victims. To prevent the transmission of disease, a lot of techniques based on AI have been used to recognize, categorize, and diagnose medical images [13].

AI was considerably used to drastically slows the development of COVID-19. Along with its many benefits and useful findings, there are various restrictions and difficulties, such as the lack of standard data, symptoms similarities, pandemic data pattern variation, cross-validation, security, and privacy related to its application that need to be assessed and resolved.

III. Artificial Intelligence in Public Health: From a Decision-Making Perspective of Serious Game

Serious games are computer games used for applications unrelated to entertainment or traditional games, such as military operations, flight or driving training, surgery, education, and general healthcare. They are used to educate and communicate with people and raise their awareness about health. The privilege of using serious games as a teaching mode strengthens the acquisition of mental, emotional, and psychomotor abilities and knowledge. The idea of relating serious games to public health came from a project named ‘serious game’ [14].

The main aim of a serious game in public health is coaching, training, prediction, diagnostics, and rehabilitation. Decision-making, strategy, and movements are the three essential components of AI in games. Furthermore, game engagement factors are attention, pictorial, critical thinking, problem-solving, interpretive analysis, decision-making, cognitive challenge, reinforcement, effective learning, enthusiasm, achievement, motivation, and empathy [15]. The term decision-making and

movement are used for an individual, while the term strategy is used for a group. One of the most essential AI tasks adopted in serious games is decision-making. Based on the data gathered from the rational and logical decision-making mechanisms, several algorithms and techniques have been developed.

The term decision-making which means what to do next is used for an individual. Each individual has a spectrum of different behaviors they choose to perform, such as running, exploring, walking, patrolling, clenching, attacking, and swimming. Based on individual behavior, the decision-making system needs to work/The operations of the decision-making system should be based on individual behavior. By using animation technology and movement, Al selected behavior is executed. Commonly employed AI techniques in the domain of decision-making are fuzzy logic and decision tree [16].

A. Fuzzy Logic

Fuzzy logic systems deal with ambiguous, inaccurate, distorted, or incomplete (fuzzy) input and create a noticeable output. Fuzzy logic similitudes to human understanding. The fuzzification module, inference engine, defuzzification module, and knowledge base are the four major parts of a fuzzy logic system. In 2018, Twinkle et al. designed a smartphone game for autistic children by using fuzzy logic. The game consists of a house that has a bedroom, living room, kitchen, and bathroom. The game puts the children in different situations based on daily activities scenarios where they are forced to think extraordinarily in order to move forward and take the next step. This game improves the mental health of children by addressing two characteristics namely repetition and recognition, according to the number of clicks and time taken by the child [17].

Karimi et al. suggested an adaptive wrist rehabilitation receptacle based on fuzzy logic. The major constituents of this application were the web client, client interface, and rehabilitation engine. This system has emerged as encouraging assistive equipment for significant diagnosis and training [18].

B. Decision Tree

A decision tree is a particular kind of probabilistic tree that bring revelations on how the answer to the previous series of questions was given. Many studies in the field of public health used the decision tree technique. In a previous research, this technique was used for training,

learning, prediction, rehabilitation, and diagnostic purposes. Vidani and Chittaro recommended the designing of a serious game for teaching medical emergency procedures using a decision tree. Nurses comprised the game's intended audience. The objective of the game was to acquaint and teach nurses about certain medical emergency protocols as well as uncommon conditions. This game successfully educated the player about the correct way to perform emergency procedures [19].

Qin et al. also adopted the concept of serious game to develop an orthopedic blood administration game as a surgical procedure training support. The musculoskeletal system was treated with orthopedic surgery where bleeding was prevalent and potentially lethal. Through the use of predetermined game rules, surgeons learned surgery independently and were able to improve their abilities to control bleeding with help of the decision tree algorithm used in this game. The game incorporates time attack and task-oriented schemes, game levels, bonuses, and performance examination tools [20].

Hussaan et al. designed a game to help children with cognitive disabilities. This game was developed for diagnostic and learning purposes. It provided three types of knowledge: 1) domain knowledge, such as the concepts of mathematics, biology, and physics, 2) pedagogical resource for exams, and 3) serious game resources including tables, chairs, doors, and non-playing characters. This game helps children to behave like normal individuals and provides them with aid to recognize things easily and improve their cognitive abilities, such as attention, writing style, perception, oral language, memory, and logical reasoning [21].

Table I shows the studies pertaining to the public health concern and the serious game purpose used to deal with the concerns using fuzzy logic and decision tree.

Table I

Public Health Concern and AI Technique Used to Address Them

Public health Concern	Artificial Intelligence Technique	Purpose of game	Reference
Emergency Medical Procedures	Decision Tree	Training	[19]
Environmental Interaction	Fuzzy Logic	Learning	[22]

Public health Concern	Artificial Intelligence Technique	Purpose of game	Reference
The Project Cognitive and Linguistic Element Stimulation	Decision Tree	Diagnostic	[23]
Teamwork in emergencies	Fuzzy Logic	Teaching	[24]
Orthopedic Surgery	Decision Tree	Learning	[20]
Autism	Fuzzy Logic	Prediction	[17]
Cognitive stimulation	Decision Tree	Rehabilitation	[21]
Cognitive training	Fuzzy Logic	Training	[25]
The Cure	Decision Tree	Prediction	[26]
Nursing Education	Fuzzy Logic	Teaching	[27]
Supermarket Game	Decision Tree	Diagnostic	[28]
Wrist Training	Fuzzy Logic	Rehabilitation	[18]
Deficit Hyperactivity Disorder	Decision Tree	Diagnostic	[29]
Therapy for Post-Traumatic Stress Disorder	Fuzzy Logic	Supporting	[30]
Self-Adaptive Rehabilitation	Fuzzy Logic	Rehabilitation	[31]

C. Advantages and Disadvantages of the Game from a Public Health Perspective

It is widely accepted that video game can be utilized as a tool to encourage positive behavior and present a chance for interdisciplinary learning. Serious games are recognized in health education as simulated games, social and cooperative plays, virtual environments, simulations, and alternate reality games in health-related education. There are some advantages and disadvantages of games.

Advantages and disadvantages of a serious game in health education are as follows:

Advantages	Disadvantages
Offers a consistent learning environment [32]. Enables students to indirectly enhance their understanding [33]. Increases the acquisition of knowledge and has a favorable effect on evaluation [34]. Offers a chance for extracurricular learning [35]. Provides a viable teaching technique for	Some students find the competitive character of games to be threatening and scary [36], [45]. Risks of anxiety and shame for some students [36]. Poor performers' propensity for boredom causes demotivation, while the failure of the game results from the learners' lack of collaboration [41].

teaching adult students [33], [36].	Time commitment required by games [45].
Remains beyond the requirements of a core curriculum [37].	Cause physical inactivity and increase vulnerability for lifestyle diseases.
Strengthens learning goals [38], [39].	
A framework for remembering is provided [36].	
Develops social and emotional skills [40].	
Provides context action that is ruled and structured [39].	
Enhances decision-making, prioritization, and leadership [41].	
Offers a chance that is goal-oriented [42].	
Boosts the ability to manage stress [43]. Enhances the ability to solve problems [33], [37], [39].	
Leads to joyful feelings and stable moods [44].	

According to the above mentioned studies, the risk of body pain in video gamers is extremely high. The body position of the gamer during gameplay, as well as sitting stationary for a prolonged duration of time, endangers the players' neuromuscular functioning.

IV. Management of Public Health Emergencies through Artificial Intelligence

A "public health emergency," as defined by the World Health Organization (WHO), is an occurrence or event that endangers public health and presents a significant threat to it. Natural catastrophes, epidemics, and bioterrorism are examples of emergencies. To respond to these public health crises, quick decision-making and efficient information exchange among organizations, government agencies, and healthcare facilities are necessary. Crucial elements of reducing disaster risks are recognizing contextual threats, improving preparedness for effective responses, strengthening leadership, and investing in resilience-building measures [46].

The development of AI and Machine Learning (ML) has significantly increased the potential to predict disease spread, creating more effective precautionary measures and facilitating the allocation of resources to regions that need them. ML was biased as a result of learning, training, and re-learning frequency and strengthening such preconceptions within specific datasets. This is completely accurate for any

construction process that employs learning models [47]. Regretfully, many of the publications fail to address such biases, which must be recognized while assessing their validity and reliability. Kim et al. attempted to address the bias of the dataset. They relied entirely on a pre-defined criteria from everyday traffic incidents, rather than injuries from emergency circumstances [48].

When the range of symptoms is confined, the model proposed by Boltin et al. to identify active ingredients demonstrates promising results. ML algorithms can easily recognize the associated chemical agent based on nine symptoms. Moreover, as the variety of symptoms expands, the algorithm's reliability decreases correspondingly. This is because an increased number of parameters can overwhelm the algorithm, resulting in the least successful outcomes [49]. Due to the errors associated with a number of these techniques, they have not been widely employed in the area of public health. Hori demonstrated that the innovative use of artificial intelligence has increased every year and AI-based models have been constantly improved [50]. Table II briefly describes the available studies on public health emergencies, such as emergency evacuation, emergency management, information processing, and casualty response.

Table II
Studies of Different Public Health Emergencies.

Topic	Study
Emergency evacuation	Zaho et al. evaluated the variables that may affect the pre-evacuation judgment procedure through a random forest algorithm [51]. Horii observed the general behavior of an airlifting crowd with the help of deep learning [50]. Bagloee et al. [46] determined the best vehicular escape routes in a catastrophic situation given a "budget" of roadworks through supervised machine learning. Forcael et al. used ant colony optimization to figure out the best emergency exit in the event of a natural disaster [52]. Using ant colony optimization, Jiang determined the best escape routes in the scenario of fire [53].

Topic	Study
Emergency management	Wang et al. identified the best pathways for distributing relief materials in disaster-stricken regions [54]. Tang and Shen created plans for emergency response and indicated the best way to proceed in typhoon situations [55]. Lopez et al. proposed a system to allocate healthcare resources to improve the number of individuals allowed to treat an emergency [56]. Chaudhuri classified rescuers after earthquake debris to find out the needy for the allocation of emergency resources [47].
Information processing	Kaufhold et al. filtered tweets based on information that may be pertinent to first responders during an emergency [57]. Pekar et al. categorized appropriate text-based tweets as providing up-to-date information during a disaster [58]. Havas et al. assessed the damage by analyzing if satellite signals perform poorly in providing sharp pictures [59].
Casualty response	Kim et al. developed a classification model using AI that can precisely and quickly triage through wearable devices in the absence of medical personnel [48]. Train school teachers and administrators by simulating an active shooter event in a virtual setting [60]. Direct civilians to the closest and safest exit during indoor mass shootings [61]. Boltin et al. determined the offending chemical weapon based on the signs [49].

AI applications and techniques in the field of public health are not self-sufficient, currently. However, these techniques remain extremely adaptable and have the potential to be used broadly. As illustrated by the various algorithms of AI used in disaster response, different emergencies require different modes and tools for action. Several of these mechanisms have been adapted to resolve other types of public health emergencies, such as AI-powered satellite photos have

been used for the analysis of the catastrophic conditions resulting from natural calamities, during violent mass casualty events, and terrorist attacks.

V. Conclusion

Currently, AI topics are leading and dominating global discussion regarding the future of societal change, disease prevention, and monitoring disasters and epidemics. AI is an emerging and beneficial technique to identify health crises and early infection. With its advent, there has been a positive change in routine screening methods. AI has the potential to profoundly affect the future. It plays an important role in the domain of public health, particularly in health protection and prevention of disease. It has the potential to improve the efficiency and effectiveness of population health through social determinants and prevention. In serious games, AI serves as an innovative tool to improve public health through coaching, training, prediction, diagnostics, rehabilitation, and improving the cognitive function of the human body. The current authors believe that greater use of AI would result in the development of more effective surveillance systems that can quickly recognize diseases and other risk factors. Although, ethical issues in the use of AI have not been addressed significantly in the domain of public health and need future attention. In order to prevent public health practice from falling behind in emerging technologies or missing possibilities for health promotion, disease surveillance, and prevention in this rapidly changing environment, this study encourages the AI and public health communities to work together.

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