(RESEARCH ARTICLE)

Artificial Intelligence interventions to combat neglected tropical diseases in Middle East and African communities: Scope and challenges

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Abstract

The Neglected Tropical Diseases have attained a global presence, spanning 149 countries, thereby inflicting morbidity upon more than 1.7 million individuals globally and impacting in excess of 500 million children. They are the leading causes of premature death worldwide, causing 500,000 deaths annually. 40% of the affected population resides in marginalized communities situated in the Middle East and Africa, where resources, healthcare amenities, education, medical infrastructure, sanitation, and other essential services are constrained. Overcrowding, population displacement, climate fluctuations, uncontrolled vectors, diagnostic inaccuracies, under-reporting, and insufficient funding collectively contribute to the failure of the control programs of these diseases. Within this context, gender disparities and social inequities among healthcare workers have emerged, with 52.7% of the youth expressing social stigma towards female patients. The World Health Organization has mandated countries to ensure equitable access to high-quality healthcare services for these diseases by 2030. This research assesses the scope and challenges associated with innovative technological interventions in healthcare within the Middle East and Africa. Real-world Artificial Intelligence applications, boasting an algorithmic accuracy of 91%, enhance various health sectors, including diagnosis, management, drug selection, cost-effectiveness, and risk mapping. The study finds that cross-sectoral partnership to implement innovative and sustainable solutions in healthcare system is imperative to eradicate these diseases in conflict zones and socio-economically marginalized communities. This research underscores the Neglected Tropical Diseases to the attention of policy makers and healthcare professionals, bridges the existing digital knowledge gap, and enhances research opportunities in health and information technology in these communities.

Keywords: Artificial Intelligence; Neglected Tropical Diseases; Healthcare Interventions; Middle East; Africa

1. Introduction

Neglected Tropical Diseases (NTD) are a group of more than twenty infectious diseases mostly affecting the population in tropical countries leading to at least 74 million Disability-Adjusted Life Years (DALY) and 1.4 million deaths in 2019. These are considered neglected because they are mostly endemic in certain nations with low socio-economic status, water scarcity, poor hygiene, illiteracy, and regional conflicts. As per World Health Organization (WHO), inadequate access to safe Water, Sanitation and Hygiene (WASH) service poses a significant, yet preventable health risk for spread of NTD in the low-income communities of Middle East (ME) and Africa. This scenario is reflected in multi-sectors of the community, ranging from school absenteeism, malnutrition, illiteracy, poor health education and awareness, and poverty resulting in poor societal outcomes and health indicators of these nations. Consequently, the high morbidity rates of NTD hinder the United Nations (UN) Sustainable Development Goals (SDG) #3.3 focusing on Health for All and SDG #3.8 Universal Health Coverage (UHC) which poses the urgent need to adapt sustainable solutions to eradicate the NTD. In the 73rd World Health Assembly held in November 2020, the WHO introduced the 2nd road map for NTD 2021-2030, setting specific goals to eradicate NTD by accelerating the existing control programs, attainable through sustainable digital interventions in healthcare sector. Among the five WHO-recommended global NTD interventions

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namely, innovative disease management, safe WASH, preventive chemotherapy through Mass Drug Administration (MDA), vector management, and veterinary public health services, the current study focuses on the innovative disease management of NTD.

Objectives of the study

The WHO required the countries to sustain equitable and high-quality healthcare services against NTD by 2030 through a cross-disease and cross-sectoral approach. In this context, the current study aims to review the opportunities and challenges of Artificial Intelligence (AI) interventions in healthcare in the ME and Africa to combat the NTD and thereby bridge the digital divide in the healthcare settings of these marginalized communities. The study provides an overview of the NTD epidemiology, factors influencing NTD control programs, some real-world AI health interventions and benefits of implementing AI interventions in NTD context. The study also provides recommendations to overcome the potential challenges.

2. Methods

A systematic review of literature was conducted by basic approach methodology using the elements such as databases, keyword search, and additional selection criteria such as timeframe, geographical scope and appropriateness of topic. 286 scholarly articles were identified using the keywords Artificial Intelligence, Neglected Tropical Diseases, WASH, Healthcare Interventions, Middle East, Africa, and Universal Health Coverage from the search engine Google Scholar database. Among these, 178 studies were excluded due to duplication. Out of the 108 records screened, 33 were excluded due to lack of currency and 75 studies selected for assessment which were published in the time period of 2020 to 2023. Among these, 62 were not accurate to the topic of study and 13 studies were included. This study reviews literatures focused only on certain ME and African countries which are epidemiologically relevant to NTD. Figure.1 shows the PRISMA flow diagram of identification of studies via databases.
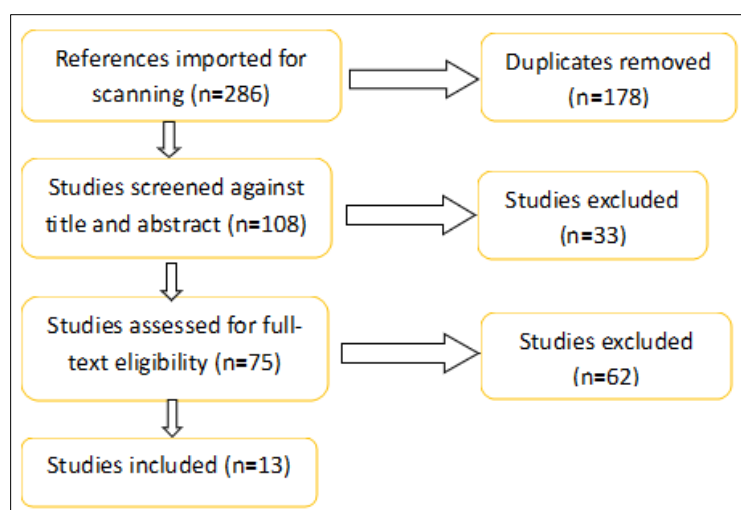
Figure 1 PRISMA flowchart of methods of study

3. Results

The WHO identified 20 NTD, spread globally in 149 countries accounting for 500,000 yearly deaths and imparting morbidity to more than 1.7 million people globally, the morbidity rate which is second to AIDS [1, 2]. They are among the top ten causes of premature death and DALY affecting more than 500 million children worldwide [1]. 40% of the NTD-affected population is seen in African vulnerable communities [2]. Nigeria carries the highest burden of NTD in sub-Saharan Africa [1]. NTD affect those communities where primary resources, healthcare facilities, education, medical infrastructure, and safe WASH are limited [3]. In Ethiopia, 75 million people are at risk of at least one NTD [2]. War and conflict zones of the ME countries are also endemic areas for various NTD. About 65 million people are affected in Lebanon [3]. In the last decade, 991 million people got treatment for at least one NTD [4].

Equitable, error-free, and high-quality healthcare services necessitates the implementing AI interventions [5]. (Sunarti et al., 2021) studied that AI healthcare interventions in rural areas improved service outcomes, assisted rural healthcare faculties, and promoted equitable healthcare delivery [6].

3.1. Factors influencing Neglected Tropical Diseases

Various factors such as insufficient WASH, over-crowding, population displacement, climate changes, uncontrolled vectors, diagnostic errors, and under-reporting influence the prevention and control programs of NTD [1].

3.1.1. Water, Sanitation and Hygiene

NTD predominantly occur due to inadequate WASH, affecting 24% of the population globally (1.5 million), mainly infecting school children and pregnant women [1,7]. The rural population resorts to farming and animal husbandry as their basic livelihood that leads to further contamination of the limited sources of freshwater with fertilizers and animal fecal matter, facilitating the spread of NTD [3]. Consumption of unclean raw vegetables for want of clean water also worsens the situation. In Ethiopia, improvement in WASH reduced NTD infection rate by 54% which signifies the role of WASH in the spread of NTD [2].

3.1.2. Climate change and vectors

Climate change, the upcoming global burden, has an invariable role in NTD outbreaks. The ME and African tropical areas are prone to unpredictable climate changes which favor vector replication and subsequent vector-borne NTD [4], which constitute eight diseases among the 20 WHO-identified NTD. Mitigation and prediction of climate changes [8], and effective vector surveillance are inevitable in low-resource settings [4]. Such interventions are lagging in some developed countries like Qatar. (Schaffner et al., 2021) found that vector control programs concerned with public health were not established in Qatar, where the distribution of certain vectors depends on climatic changes [9,10].

3.1.3. Wars and conflicts

Anthropogenic disasters like wars result in socio-economic deflation and also increase the risk of disease outbreaks. The ripple effects of conflicts are population displacement, migration, overcrowding, refuge camping, etc. which aggravate cross-border vector transmission. The Syrian civil war led to the displacement of nearly 6.5 million civilians resulting in a cross-border spread of highly endemic NTD into Lebanon, Turkey, and Iraq [3]. The civil and military conflicts in Afghanistan resulted in poor economic development and increased the risk of these infectious diseases [7].

3.2. Factors hindering NTD control programs

Ignorance by PHW, misdiagnosis, under-reporting, inadequate WASH, lack of medical infrastructure and inefficient Health Information System (HIS) are critical challenges in the success of NTD elimination programs in ME and African communities.

3.2.1. Inefficient existing control measures

Supportive monitoring of existing NTD control programs and error-free reporting are essential for developing AI-driven solutions that enhance risk-mapping, diagnosis, and cost-effectiveness in the management of NTD based on previously shared data. A study in Ethiopia found that NTD medicines were less accessible due to the low purchasing capacity for existing drugs. Limited availability of medicines, diagnostic tools, and rehabilitation services also adversely affected NTD control programs [2]. NTD eradication programs and MDA programs were unsuccessful due to other factors like social stigma, health unawareness, lack of leadership, insufficient basic amenities like footwear, shortage of drugs, and failure of follow-ups in Amhara, Ethiopia.

3.2.2. Fragile Health Information System

The lack of effective diagnosis and case reporting by the Primary Healthcare Workers (PHW) are prime factors in the failure of the NTD programs in several ME and African communities. The functional efficiency of HIS depends on the efficiency of PHW as they are the immediate point of detection, identification, and reporting of disease in any community. NTD were under-reported and misdiagnosed in ME countries like Lebanon and Afghanistan. The HIS of Afghanistan including the epidemiological surveillance was fragile and dependent on humanitarian aid due to insecurity of civilians including medical staff during conflicts [7]. Similar results were reported from Lebanon, where the PHW were unaware of certain non-endemic NTD as WHO clinical guidance does not exist in this country [3]. Furthermore, the under-reported NTD cases pose severe threat to marginalized communities since social disparities, conflicts, and unpredicted climate fluctuations exist in these tropical regions.

A survey conducted in Nigeria showed that only 57.2% of PHW had considerable knowledge about NTD [1]. Feedback system from PHW revealed about some mis-concepts about these diseases. The study also revealed that the PHW were ignorant about the case reporting procedure, and they lacked proper training and access to diagnostic tools. A study by (Semahegn et al., 2023) suggested the requirement for a national surveillance system and effective data monitoring for the NTD mitigation program [2].

3.2.3. Gender and social disparities

It is noticeable that gender disparities hinder women's healthcare needs. The study finds that gender disparities can be mitigated and healthcare services can be equally accessible to women by the introduction of digital health services or tools [1]. In African countries like Ethiopia, 52.7% of youths have a social stigma towards female patients with certain NTD [2]. There exist gender disparities and social inequities in Nigerian health workers regarding NTD knowledge. Urban and male PHW workers had more knowledge of NTD and access to health information in communities of Southwest Nigeria and Cameroon [1].

3.2.4. Underfunding

NTD programs received low external funding, particularly in low-resource settings. A study in Nigeria found that NTD receive only 0.6% of health funding from Official Development Assistance (ODA) annually [1,5]. Another study in Ethiopia also found that underfunding decelerated NTD eradication programs [2].

3.3. Real-world AI healthcare Applications

The review of the literature showed the successful implementation of AI-based applications in health care sector in various countries, the strategies which can be considered for re-modeling healthcare sectors aiming to control and prevent NTD, improve the efficiency of healthcare delivery and contribute to cross-sectoral community development through awareness, climate prediction, improved WASH, vector control, disease mapping, diagnosis and treatment in marginalized communities [7].

3.3.1. Early detection and management of diseases

It has been studied that the hospitals in developed nations have adopted AI-assisted disease prevention programs [11]. In low-resource settings, where the PHW are ignorant about disease identification and reporting, a cross-sectoral intervention is urgent to prevent the spread of NTD, which can be possible by implementing digital applications like Mobile Health and Chatbots-assisted telemedicine consultations [8]. Ifakara Health Institute in Tanzania applied mid-infrared spectroscopy coupled with a supervised Machine Learning model for vector control and assessment using supervised learning models in diagnosis utilizing patient symptoms and demographic features. This model is physically robust, low-cost, with minimum maintenance, and has a potential for rapid data collection during disease screening [12]. AI tools enhance risk mapping by analyzing infection trends through geospatial surveillance [5]. Studies showed that Machine Learning-based AI tools can predict disease outbreaks using current data in low-resource settings [12].

3.3.2. Diagnostic assistance

Accurate diagnosis and data recording of NTD by PHW are inevitable for disease prevention and efficient healthcare delivery [1]. The pandemic COVID-19 marked the digitalization of the health sector and its dependence on AI applications and tools that have proven efficiency in healthcare globally [8,12]. It is estimated that nearly 80,000 deaths occur in United States (US) hospitals due to diagnostic errors which comprise 60% of all medical errors due to human judgement [11].

AI interventions are replacing human-aided diagnostics at a fast pace because of the high accuracy rate (91%) AI algorithm, where a trained human accuracy rate is 69% [11]. AI-based solution assimilated collected data from patients, interpret the data, and provide the correct referral decisions. The first and the most widely used real-world AI health application, is International Business Machines Corporation's Watson for Oncology which assists doctors by suggesting accurate treatment solutions [11]. AI-assisted electronic systems integrate and digitalize medical records to reduce the work load of nursing staffs. AI would enhance decision-making and patient satisfaction using scientific evidence and comprehensive treatment solutions respectively [11]. They save healthcare service time, improve healthcare quality, assist doctors in diagnosis, prioritize patient needs, and may be adapted to rural communities.

(Fournier-Tombs, 2023) studied that Chatbots, with their cost-effectiveness and operational ease, facilitate healthcare services in illiterate and vulnerable communities with remote access to healthcare services [13]. (Lee and Yoon, 2021) found that AI-supported robots augment error-free data extraction and have up to 95% diagnostic accuracy [11].

3.3.3. Health supply-chain management

AI-assisted supply chain management would highly benefit MDA and immunization of NTD. A study conducted by (Sukums et al., 2023) explored that more than 60% of Tanzanian stakeholders agreed to implement AI solutions in the healthcare supply-chain with the support from investors and the government of Tanzania, as they have invested in integrated electronic data storage systems like Tanzania Immunization Registry, District HIS, Vaccine Information Management System, and the electronic Logistic Management Information System to registering health data [12].

3.3.4. Community awareness

Community awareness is a very relevant mode of educating the public about communicable diseases including NTD and is vital for sustained interventions [5]. Despite the digital transformation of healthcare sector in modern communities, there exists a digital and socio-economic divide in the marginalized communities of the ME and Africa due to which digital technologies are lagging [13]. According to (Semahegn et al., 2023), the Knowledge, Attitudes and Practices (KAP) of the communities should be learned for sustainable interventions of the NTD control programs [5]. Patients in rural communities who are unaware of digital technologies might refuse the new approaches. Appropriate interpretation of the benefits of the AI interventions by healthcare professionals is required to overcome the digital divide in healthcare sector [11]. AI-related technological and digital learning should be mandatory for medical school curricula and PHW [11]. To foster AI system utilization, technical training should be provided for patients, PHW, and various stakeholders. Simultaneously, the cross-sectoral stakeholders and donors should provide basic digital infrastructure and education to the public.

AI-driven chatbots and virtual assistants can disseminate sustainable community awareness, and minimize social and cultural stigma towards NTD. These AI devices prove to be efficient communication tools for hospitalized patients too [11]. These studies highly support the feasibility of AI-assisted interventions for community awareness in NTD-affected communities where social stigma plays a vital role.

3.4. Opportunities of AI healthcare interventions

Besides the clinical advancement in healthcare, (Sunarti et al., 2021) studied the various administrative and communicative opportunities of AI-assisted telemedicine which can remodel hospital administration and contributes to a sustainable and equitable system of healthcare, especially in low-resource settings, promoting these health sectors towards UHC [6]. Personalized treatment, diagnostics, new drug discovery, risk assessment, epidemiological surveillance, climate prediction, supply-chain management, community engagement, and efficient HIS are other promising benefits of AI interventions in NTD programs.

Fewer referrals and cost reduction are beneficial outcome of AI implementation in low-resource settings [6]. It is estimated that AI applications in the US health sector saved up to $52 billion in 2021 and are forecasted to save $150 billion annually by 2026 [11]. AI-assisted tools in hospitals reduced diagnostic errors, improved operational efficiency, identified high-risk patients, and enhanced admission procedures thereby reducing medical costs. Private hospitals in the US could reduce readmission rate to 31% thereby saving $4 million within two years through AI-enabled detection of high-risk patients [11]. Multiple projects like the African Observatory on Responsible Artificial Intelligence, the AI Africa Consortium, and the Africa-Canada AI and Data Innovation Consortium promote AI development in African countries [13].

The policymakers should utilize the Transplantation-Adaptation-Creation framework of the AI lifecycle to analyze the context of the NTD-affected communities for the feasibility of AI projects for public health [13]. The Creation phase of AI models (where the models are developed in the target countries) improves learning and recruitment opportunities and enhances the capabilities and skills of the younger generation who can easily adapt to rapidly growing technologies [12, 6]. (Fournier-Tombs, 2023) studied that the capacity building for adopting the creation phase of AI is possible by learning the culture and traditions of local communities [13].

3.5. Sustainability challenges of AI healthcare interventions

There exist numerous challenges in the transformation of the healthcare sector into a digital one, especially in low-resource and conflict zones where the socio-economic inequality is crucial. Poor literacy rates, language barriers, and gender disparities in these communities lead to social stigma hindering the development and digitalization of healthcare sectors. Cybersecurity risks, patient privacy policies, data sharing, medical errors, cultural stigma, and lack of regulatory frameworks for digital policies are major challenges in the implementation of AI-driven solutions in a local ecosystem. Social stigma is invariably seen in educational, health, and technical awareness practices in such communities. Sustainable awareness creation has a vital role to minimize the social stigma [2].

Wars and conflicts are ongoing challenges in ME countries which hinder the socio-economic and technical development of these communities and nations. African countries like Nigeria, Uganda, Ethiopia, and Kenya are also burdened with political riots and institutional corruption leading to the underdevelopment and lag in the digitalization of marginalized communities.

As AI-driven interventions in healthcare are an ongoing process in ME and African countries, researches done on its ethical and policy guidelines are relatively less [11,12]. (Kooli, 2023) found that patient privacy protection, data use ethics, and regulatory framework maintenance for digital technologies are the challenges in digital interventions [8]. Other cybersecurity challenges are medical errors and lack of trust in algorithms. The existence of fragmented data systems, data integrity issues, missing data, imbalance of datasets, inaccurate and inconsistent data, absence of deep learning-ready datasets, and data sharing between various health organizations are also challenges in this context [11]. Inaccurate and under-representative training data sets for AI models can cause bias, adverse events, misleading predictions, and even large-scale discrimination [6]. For the AI system to be implemented and sustained in the health sector of ME and African communities, stable and long-term external funding is also essential [13]. Figure 2. summarizes the opportunities, challenges and benefits of AI-assisted healthcare interventions.
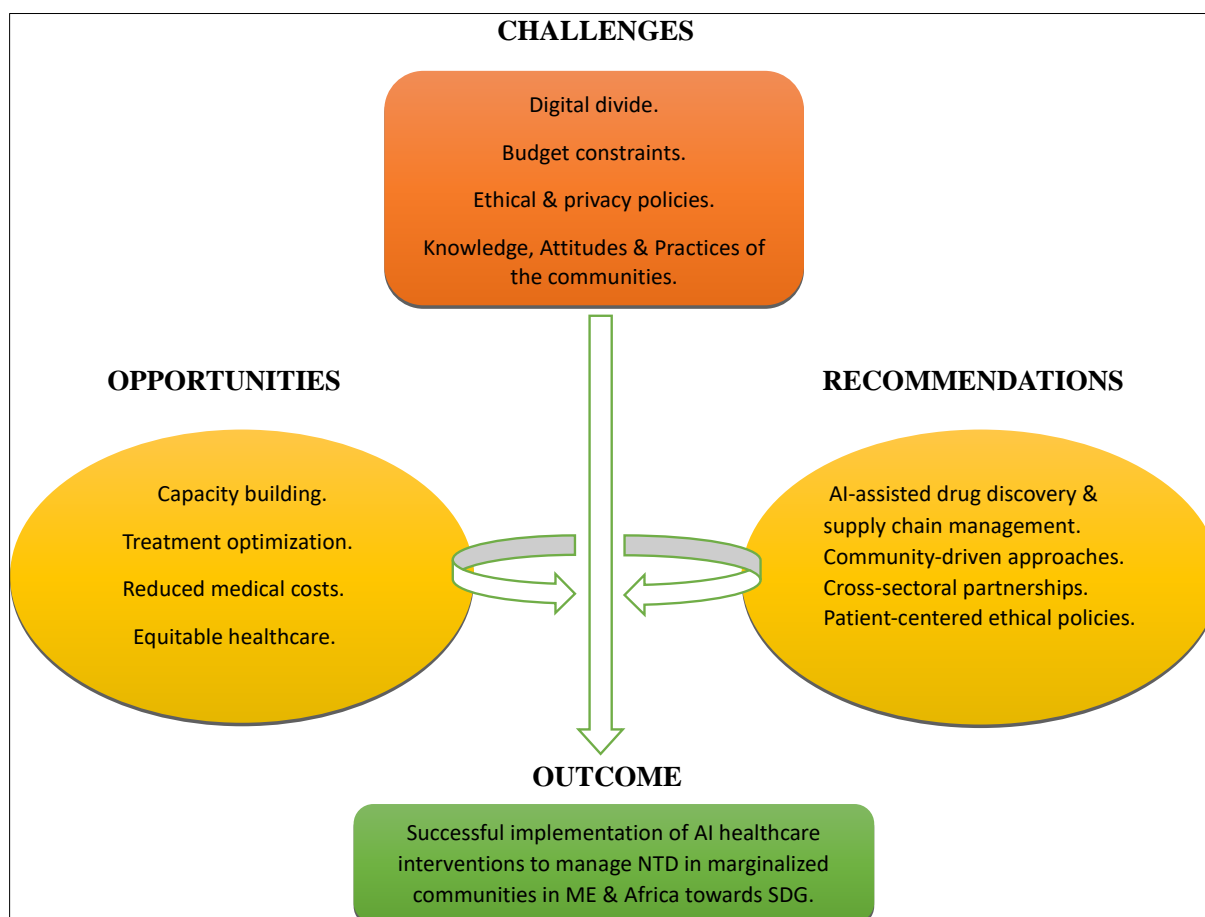
Figure 2 Opportunities, challenges and recommendations for AI interventions in healthcare sector of marginalized communities

4. Discussion

The study found that NTD and their control programs are influenced by several interconnected socio-economic and geographical factors such as unsafe WASH, population displacement, migration, climate changes and regional conflicts particular to the ME and Africa. Lack of clinical infrastructure, ignorance of PHW, erroneous diagnosis, inaccurate data, and under-reporting made their healthcare system inefficient, necessitating the digital awareness among community and healthcare faculties.

The systematic hierarchy of healthcare approaches such as error-free diagnosis, patient data collection, treatment, follow-ups and feedback, prevention protocols, vaccination, MDA, and community awareness should go parallel under a sustainable healthcare strategy of digitalized HIS. The progress in these components of the healthcare system is still lagging behind the WHO roadmap towards 2030, demanding sustainable solutions to accelerate the control programs. Therefore, the study suggests the need for AI implementation in the healthcare sector in the ME and African communities to control NTD and thereby achieve the UN's SDG #3 by 2030.

NTD can be mitigated if context-specific AI interventions are introduced in various sectors such as WASH, MDA, diagnostics, climate prediction, vector surveillance, and HIS. Centralized AI-health registers are beneficial models for NTD case registration in communities where PHW are ignorant of case recording. NTD control programs could be enhanced if AI health interventions are implemented for early detection and management of diseases, diagnostic assistance, health supply-chain management, community awareness, disease mapping, vector control, and drug discovery. AI interventions such as Tele-medicine and Mobile Health in disease identification, treatment, follow-ups, and awareness will ensure equitable healthcare access among these communities.

Social policies should be reformed according to the growing technological and healthcare needs of the communities. Governments and policymakers should upgrade the infrastructure of marginalized communities and make strategic decisions for responsible AI interventions aligned with social norms. AI system developers and stakeholders should ensure that the AI systems developed are disease-specific, context-specific, meet the healthcare needs of the community, and overcome the various challenges. Ethical policies should address patient autonomy, data protection, data consent, and cybersecurity to maintain sensitive health information and the sustainability of the interventions.

It is highly desirable that AI health interventions bring new job opportunities to the communities and strictly adhere to the WHO guidance on the ethics of AI for health [11]. AI localization is a new concern that has to be extensively researched in the context of NTD. AI model localization, which involves the creation of context-specific AI healthcare tools in the local communities by creating public awareness and enhancing digital capacity building is highly advantageous for NTD eradication programs. Cross-sectoral and cross-boundary partnerships of health professionals, AI developers, decision-makers, stakeholders, and various donor agencies are urgent for the AI model localization and adoption of AI tools in the healthcare sector of marginalized communities.

The current study suggests the need for investment in Research and Development of AI-driven solutions for NTD. AI-assisted real-time healthcare innovations should be extensively funded. Researchers should focus on AI-driven solutions in diagnostics and drug discovery, safe WASH provision, climate prediction, vector surveillance and various preventive and control protocols of NTD.

5. Conclusion

WHO's Global Strategy on Digital Health 2020–2025 emphasized the benefit of digital interventions including AI in healthcare for ensuring UHC for one billion people. The study shows that the existing control measures of NTD are not sufficient to bring remarkable progress towards the WHO roadmap of NTD programs towards UN SDG #3. This research assesses the possibilities and challenges associated with AI interventions in the prevention and control measures of NTD in ME and the African communities, thereby bridge the knowledge gap and digital divide in the healthcare settings of these marginalized communities. The current study brings to the attention of policymakers, healthcare professionals, and other stakeholders, the need for mainstreaming NTD to UHC, which is possible by bringing AI-driven solutions to foster the programs towards eradicating NTD in the disadvantaged communities of ME and Africa, which are endemic to NTD.

The governments of ME and African countries are working towards advanced digital transformations of their National Health Systems. Strategic policies such as the UAE Innovates, Qatar National Vision 2030, Saudi Arabia's Vision 2030, Country Cooperation Strategy for WHO and Oman 2021-2025, Health Vision 2050 of Sultanate of Oman, and Africa Centers for Disease Control and Prevention promote disruptive innovations and value creation across health sectors to accelerate toward UN SDG #3.3 and #3.8. In this context, priorities should be given to the least considered health issues such as NTD, which are endemic in tropical and hard-to-reach communities of ME and Africa. Due to their alarming healthcare costs, morbidity rates, and DALY, despite various control programs implemented, the NTD lead to several social imbalance concerning education, literacy rate, health, nutrition, and economy which hinder the development of these communities.

Community-driven approaches for sharing information about NTD and digitalization of healthcare sector to the public and healthcare workers are imperative. Simultaneously, technical capacity building, infrastructure development,

sustainable external funding, and informed adoption of AI solutions should be established. This research suggests the urgency of informed adoption, and sustainable and responsible AI solutions in the healthcare sector of ME conflict zones and African communities, adhering to WHO ethical guidelines such as equitability, accountability, responsibility, and transparency of AI policies.

The current research bridges the gap between existing knowledge about the multisectoral feasibility of AI implementation in healthcare sector in ME and African vulnerable communities. Capacity building and bridging the digital divide in the healthcare sector in these communities are also potential outcome of this research. This study will facilitate valuable information to multisector personnel like healthcare professionals, curricula developers, educators, researchers, AI application and tool developers, policymakers, non-government organizations, donors, and data analysts regarding the feasibility of AI interventions in healthcare sector in the NTD context. By digitalizing the healthcare sector, the community can benefit from innovative digital tools or applications during crises and conflicts when human interventions are hard to reach. This would considerably accelerate the nations towards achieving UN SDG #3, Health for All.

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