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The Need for Robots in Global Health

Iroju Olaronke [a*], Gambo Ishaya [b], Ojerinde Oluwaseun [c], Ikono Rhoda [b] and Olaleke, Janet [a]

[a] Department of Computer Science, Adeyemi Federal University of Education, Ondo, Nigeria.
[b] Department of Computer Science and Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria.
[c] Department of Computer Science, Federal University of Technology, Minna, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author IO initiated and designed the study and wrote the first draft of the manuscript, Author GI wrote the protocol, Authors OO, IR and OJ managed the analyses of the study. All the authors managed the literature searches, read and approved the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The health of every individual in the world is greatly influenced by global health issues and threats which are usually caused by international trade and voyage. These threats which have exposed the inadequacies of healthcare systems across the globe include the rapid spread of non-communicable and infectious diseases, pandemics, hunger and starvation, natural disasters, shortage of healthcare personnel and climate change. These threats have led to economic and social disruption in almost all spheres of human lives such as agriculture and education.

Aim: Against this background, this study reviews global health challenges and the importance of robots in global health. This study also appraises the factors hindering the effective use of robotic technology to improve global health.

Methodology: A total of 41 literatures relevant to the subject matter were obtained from diverse scientific electronic databases including CiteseerX, Science Direct, Google Scholar, IEEE explore, indexCat, PubMed and National Library of Medicine.

Results: The study showed that robots can be used to improve global health by diagnosing and treating infectious diseases, reducing the dangers of human contact during pandemic and delivering food and medicines to infected individuals. The study also showed that robots can be used to reduce harmful gases released into the atmosphere and also limit the anxiety and fear of

**Corresponding author: E-mail: irojuolaronke@gmail.com;*

vaccination. The study also revealed that high cost, privacy-related issues, interoperability challenges and the fear of displacement of jobs by robots are some of the factors hindering the effective use of robotic technology to improve global health.
Conclusion: This paper suggests that adopting a common standard for robots of different brands and education strategies are some of the strategies that will facilitate the effective use of robotic systems to improve the health of individuals across the globe.

Keywords: Global health; global health threats; health; robots.

1. INTRODUCTION

The rapid and exponential rise in the frequency of international commerce, trans-border population flows, and the globalization of food supplies, feeds, and medicine have introduced diverse health risks that directly and indirectly affect the health of the world's population. As the world economy also becomes increasingly globalized due to various advances in technology, transportation, electronic communication modalities and common interests, global health is threatened by the emergence and re-emergence of infectious diseases and pandemics, climatic change, air pollution, food and energy crisis, natural disaster, social inequality and migration of healthcare personnel [1]. The effect of these global health threats includes an unstable economy, inadequate security, overuse of healthcare facilities, the rapid spread of infectious diseases, hunger and starvation, travel ban and decline in the number of tourists, rising cost of healthcare, closure of schools and educational facilities as well as environmental pollution [2,3]. Several governmental and non-governmental organizations such as the Center for Disease Control (CDC) and World Health Organization (WHO) are committed to providing tools and practices for reducing global health threats such as quality disease surveillance, a well-trained workforce, rapid and accurate public health and emergency response [4]. In spite of this, the world is still menaced by new and rising global health challenges annually. For instance, an average of 2000 people in the United States of America is diagnosed with malaria after international travel annually [5]. In addition, Hurricane Matthew claimed the lives of at least 546 Haitians in 2016 while the emergence of infectious diseases and pandemics such as influenza, Middle East Respiratory Syndrome Coronavirus (MERS-CoV), Ebola, ZIKA and Coronavirus Disease 19 (COVID-19) is becoming rampant in countries across the globe.

Robots have been used in recent times to address global health issues [6,7]. For instance, they have been used to reduce the spread of infectious diseases and pandemics by assisting healthcare workers in dispensing medicines, drawing blood as well as checking and monitoring infected patients' vital signs. In addition, robots have been used to address hunger and starvation by reducing farm waste, improving food quality and safety, fighting against pests, pathogens, and diseases, and engineering new and improved food products [8]. As a result of the benefits of robotic systems in containing global health threats, technologically advanced countries such as Japan and China have deployed a variety of robots for ameliorating global health challenges, while most economically emerging countries cannot afford these systems due to the high cost of procurement, maintenance, training and integration [9]. Also, usability issues, privacy-related issues, interoperability challenges, and the fear of displacement of workers from their jobs are some of the factors hindering the effective use of robotic technology to improve global health. Consequently, the adoption of robotic technology by different countries across the globe to curb global health threats is low. This ultimately leads to a high disease burden and an increase in mortality rate. Based on this background, this paper addresses the importance of robots in global health and the problems confronting the effective use of robots in resolving global health challenges. This is to promote and sustain the health of the world's population, which is in line with the requirements of the Sustainable Development Goal 3 (SDGs), which emphasizes that all countries should promote the well-being of all individuals at all ages and also ensure that their citizens are healthy.

This paper is organized into seven sections. Section two introduces the concept of global health, section three provides the study methodology while section four reviews the applications of robots in combating global health challenges. Section five presents the challenges confronting the effective use of robotic

technology in combating global health challenges, section six recommends the strategies for the effective deployment of robotic technologies in resolving global health threats, while section seven concludes the study.

2. METHODOLOGY

A total of 98 literatures relevant to the subject matter were obtained in diverse scientific electronic databases including CiteseerX, Science Direct, Google scholar, IEEE explore, indexCat, PubMed and National Library of Medicine. In addition, 20 additional documents and WebPages were obtained from the Google search engine. The keywords used in the search process include “global health”, “global health threats”, “robots used to combat global health threat” and “robots in healthcare systems” The qualities of these documents were assessed based on the following critical appraisal guidelines.

1. Are the aims and objectives of the studies related to the subject matter?
2. Are the aims and objectives clearly defined?
3. Do the documents contribute to the body of industrial and research knowledge?

The qualities of the documents were appraised based on the answers to each of the appraisal guidelines. The study adopted a 3-point Likert scale which include strongly agree, strongly disagree and undecided to score the papers. The scores allotted to each scale are shown in Table 1.

Table 1. The likert scale for scoring the literatures for the study

Score	Scale
1	Strongly disagree
2	disagree
3	undecided

The quality of each paper was determined by summing up the scores of the responses to the criteria guidelines on the Likert scale. The authors agreed that the qualities of the studies should be determined by considering papers with a 50% score in the Likert scale. At end of this process, 77 papers were excluded from the review process while 41 papers which were considered relevant for the review were selected for the study.

3. OVERVIEW OF GLOBAL HEALTH

There is no commonly agreed definition for the term global health despite the recent global crises currently ravaging every nation across the globe, such as the COVID-19 pandemic, climate change, and food and energy crises [10]. Generally speaking, global health can be viewed as the process of improving the health of the world’s population. It can also be defined as health issues that transcend national boundaries. Nevertheless, diverse authors have made different attempts to define global health in different ways concisely. Koplan et al. define global health as an area of study, research, and practice that emphasizes the importance of improving health and attaining equity in health for all individuals across the globe [11]. Beaglehole and Bonita view global health as a collaborative, trans-national research and action responsible for promoting all health [12]. Futhermore, Kickbush defines global health as health issues that transcend national boundaries and governments and call for actions on the global forces that determine people's health [13]. Macfarlane et al. view global health as the global improvement of health, reduction of health disparities, and protection against global threats that disregard national borders [14]. These definitions primarily focus on promoting the health of all individuals globally and a collaborative effort by all governments across the nations to provide equitable healthcare services for all individuals across the globe. These definitions ignore the causes of global health challenges as well as the agents and actors who provide diverse methods to provide solutions to global health threats [10]. Based on this gap, we define global health as multidisciplinary research that deals with the improvement of the health of every individual in the world through the collaborative efforts of governments, non-governmental organizations, and individuals who identify the causes of health threats that transcend national boundaries and recognize, respond to, and control known and unknown global health threats through the provision of population and individual-level clinical care and disease prevention actions, community education as well as large scale national or international interventions. From the definition above, it can be deduced that the field of global health is interdisciplinary in approach ranging from the field of medicine, public health, epidemiology, demography, psychology, sociology, and economics. The concept of global health is graphically depicted in Fig. 1.

The importance of global health cannot be underemphasized because it aims to improve the health of the world's population, maintain global security and provide equal access to healthcare services. However, global health is usually affected by public health threats and diverse events across the globe. Some of these threats, as identified by the World Health Organization [15], are discussed as follows:

3.1 Air Pollution

The World Health Organization [15] identified that about 90% of the world population inhale polluted air daily. The majority of these individuals are from low and medium income countries. Causes of air pollution include high volumes of emissions from vehicles and industries as well as the burning of fossil fuels. According to the United Nations Economic Commission for Europe (UNECE), air pollution causes about seven million premature deaths annually [16].

3.2 Climate Change

According to World Health Organization [2], one of the major contributions to climate change is air pollution caused by burning fossil fuels. The emissions from the burning of fossil fuels results in global warming. This in turn leads to non-communicable diseases such as heart diseases, cancer and respiratory diseases [16]. Other causes of climate change include deforestation and oil drilling.

3.3 Non-Communicable/Non-Infectious Diseases

According to Frumkin and Haines, non-communicable diseases contribute largely to the global burden of disease. Frumkin and Haines noted that about 70% of deaths across the globe could be linked to non-communicable diseases such as diabetes, cancer and heart diseases [17].

3.4 Infectious Diseases and Pandemic

According to the Center for Disaster Philanthropy, infectious diseases and pandemic are a sustained transmission of infectious diseases across international borders, countries, and continents [18]. The last two decades have experienced diverse pandemics due to international travel and trade, rapid urbanization, environmental degradation and limited access to healthcare. Typical examples of pandemics include the global influenza pandemic, Ebola, Zika and the ongoing COVID-19 currently threatening the lives of individuals across nations of the world.

3.5 Vaccine Hesitancy

This refers to the delay in the acceptance of vaccines or the outright refusal of individuals to take vaccines in spite of their availability [19]. Vaccines prevent about 2-3 million deaths annually. Factors affecting the acceptance of vaccines include lack of confidence, inconvenience in accessing vaccines and complacency. About 2% of people living in developing countries have only received at least one dose of the COVID-19 vaccine despite the availability of the vaccine in these countries [20]. This makes the individuals in these countries and the world at large vulnerable to the disease.

3.6 Inequality in Access to Healthcare Systems

Some countries especially advanced countries, have healthcare systems that are affordable and easily accessible by their citizens, while most developing countries are characterized by healthcare systems that are weak, less developed and not easily accessible. The lack of access to quality healthcare services contributes to millions of premature deaths across the globe annually. However, the 1978 Declaration of Alma-Ata emphasized that the gross inequality in the health statuses of both developed and developing countries is politically, socially, and economically unacceptable [21].

3.7 Shortage of Health Workers

Health workers are the people whose major responsibility is to enhance people's health. They include doctors, nurses and midwives, pharmacists, laboratory technicians, community health workers and radiologists. There is currently a shortage of over seven million health workers across the globe [22]. Unfortunately, this situation is worsening as the World Health Organization projects that there will be a shortage of about eighteen million health workers globally by 2030 [23]. The shortage of health workers has negative impacts on the healthcare system. These include a high rate of child and maternal mortality, outbreaks of diseases, and a high rate of medical errors.

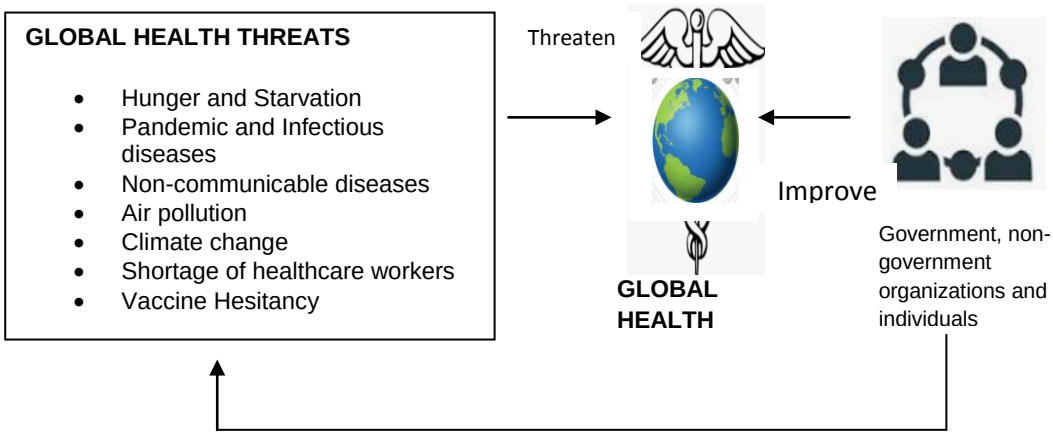

Fig. 1. Depiction of global health

3.8 Hunger and Starvation

Hunger is the anguish associated with lack of food, while starvation is the severe deficiency in caloric energy intake. Hunger is one of the leading threats of global health in developing countries, as more than 650 million people were estimated to have been malnourished in 2019 [24]. With the emergence of COVID-19, global hunger increased to about 720-811 million people in 2020 [25].

3.9 Dengue

This is a disease caused by a virus tagged dengue virus (DENV). It is however transmitted through the bite of an infected *Aedes aegypti* mosquito. It usually occurs in tropical and non-tropical regions, albeit the global incidence of dengue is estimated to be around 100-400 million infections, with almost half of the world's population at risk of the disease [2].

3.10 Weak Primary Healthcare

Primary healthcare is the first level of contact healthcare practitioners have with people in a community to improve their health. It is usually affordable, comprehensive and community based. However, most countries lack adequate primary healthcare services.

4. ROLES OF ROBOTS IN IMPROVING GLOBAL HEALTH

The World Health Organization and several non-governmental organizations, governmental agencies, and individuals have played diverse roles in combating global health threats. For instance, the World Health Organization provides leadership roles in global health matters. It also establishes, supervises, strengthens and implements global health policies and practices. It engages in research of diseases and health policies that can be implemented globally. It establishes evidenced-based science and ethical policies [26]. Despite the diverse roles of the World Health Organization, the world is struggling to tackle global health threats ranging from the outbreak of infectious diseases and pandemics, climate change, air pollution, and global warming. Consequently, the objective of this section is to address how robotic technology can deal with the problems created by global health threats. Hence, the applications of robots in global health are clearly highlighted below:

4.1 Reduction in the Spread of Infectious Diseases and Pandemics

With the upsurge in the number of infectious diseases and pandemic cases such as COVID-19 in recent times, there has been a remarkable demand for robots in the healthcare system [27]. The introduction of robots in the healthcare system protects frontline healthcare workers from getting exposed to infectious diseases and it also enhances self-isolation by reducing doctor-patient interaction. Robots such as the autonomous TUG robot have been used to deliver food and medicines to patients in infectious disease wards. Robots are also used to clean and disinfect objects such as door

handles and elevators, which are sources of transmitting infectious diseases. A typical example of a robot used in disinfecting objects is the UVD-bot. Another type of robot that reduces the spread of infectious diseases and the pandemic is the Wegree Robot which serves as a check-in staff for hospitals in order to reduce the physical interaction of healthcare workers with potentially infected patients [28]. The UVD-robot and the Sayabot help to maintain social distance between health workers and their patients by taking temperature readings using a non-contact thermometer connected to the robot. Sayabot also helps in dispensing sanitizer to visitors [27]. In Italy, Medical practitioners have also used mobile tele-presence robots with screens and touch screen interfaces to monitor COVID-19 patients without physically attending to them [29]. Fig. 2 shows some robots that can help to reduce the spread of infectious diseases.

4.2 Assistance of Inadequate Healthcare Workers

The healthcare system globally is plagued with shortage of healthcare personnel. This affects the efficiency and the quality of healthcare services delivered by health workers. This results in an increase in the incidence of diseases and thus devastating economic situations. However, robots can assist healthcare workers in performing diverse roles, including dispensing drugs, taking patients' vital signs, lifting patients, drawing blood from patients, and performing surgeries. This reduces the workload of healthcare personnel, increases their efficiency, and reduces medical errors that could be caused by fatigue from heavy workload. Fig. 3 shows a robot drawing blood from a patient. This robot developed by Veebot can adequately identify the most accessible vein with an accuracy of 83%, which is as good as an experienced phlebotomist [33]. Robots have also been used to assist healthcare workers in surgeries. The advantages of surgical robots include increased precision of surgical manipulation, improved vision due to magnification, a more controlled, comfortable and safer environment and better ergonometric for the operator [34]. A good example of a surgical robot is the Da Vinci surgical system which is used to assist surgeons to perform delicate and complicated operations. Robots have also been used to provide support and companion to patients during the healing process and after recovery. A typical example of this robot is Paro.

Fig. 2. Some robots that help to contain the spread of infectious diseases [30-32]

Fig. 3. Veebot robot drawing blood from a patient [33]

4.3 Reduction of Harmful Gases Released Into the Atmosphere

Humans, animals and plants feel the effect of climate change. Some of the numerous effects of climate change are extreme temperature, global warming and adverse weather conditions, respiratory health disorder, flood and drought. One of the ways that robots can help in climate change is by reducing the amount of harmful gases introduced into the atmosphere. For instance, robots can be used in place of heavy duty manually operated machines that use fossil fuels and introduce carbon emissions into the environment.

4.4 Food Security

Research has shown that 820 million people do not get enough food to eat daily despite governments' efforts to end hunger and starvation globally [35]. Robots can be used to end hunger and starvation as well as achieve food security across all nations of the world. For instance, Saga (Swarm Robotics for Agricultural Applications), a swarm of drones, monitors weed infestations in the farm and checks the status of crops [36]. The R2Weed2 robot designed by Nexus Robotics is also used to differentiate between weeds and crops before removing the weeds amongst the crop on the field. In addition, Vegebot shown in Fig. 4. is a robot developed by Cambridge University for harvesting crops with precision and accuracy. This robot reduces wastes that could have been caused by human errors such as harvesting of unripe fruits, tearing of leafy vegetables and bruising of fruits. Furthermore, Harvest Croo is a robot that is designed for harvesting crops that are prone to damages during the harvesting season, such as strawberries.

Fig. 4.Vegebot [37]

4.5 Reduction of Anxiety and Fear of Vaccination

The World Health Organization identified vaccine hesitancy as one of the greatest threats to global health [15]. The promotion of vaccination by health workers is usually weakened by weak counseling capacities, limited resources and lack of confidence in communication [38]. Nevertheless, robots are used to boost vaccination rate and reduce anxiety before vaccination. For instance, the humanoid robot Pepper, as shown in Fig. 5, is programmed to greet people waiting to be vaccinated and provide information about the vaccine [39].

Fig. 5. Pepper robot encouraging people to be vaccinated at Victoria University [39]

5. FACTORS AFFECTING THE EFFECTIVE USE OF ROBOTS IN COMBATING GLOBAL HEALTH THREATS

Robots have been deployed in diverse areas to help mitigate the effects of global health threats worldwide, such as reducing harmful gases released into the environment, assisting healthcare workers in performing diverse tasks and combating hunger and starvation. Despite these benefits, various factors affect the effective use of robotic technology in combating global health threats. These factors, which include high cost of procurement, installation and maintenance, continuous power supply, fear of loss of job, usability issues, are discussed below:

5.1 High Cost of Procurement, Installation and Maintenance

One of the challenges of using robots to mitigate the effects of global health threats is the rising cost of robots. This is because the cost of

procurement, installation, configuration and maintenance of robotic systems are quite on the high side.

5.2 Continuous Power Supply

Robots need continuous power sources to provide voltage signals that will make them function effectively. Such power sources include electrical, electromagnetic, thermoelectric, fuel cells, and super capacitors. The functions of robots become hampered if these power sources are inadequate or unavailable. These sources of power are also potentially damaging to the environment because they contribute to global warming and greenhouse gas emissions which contribute to global health challenges.

5.3 User Acceptance

User acceptance refers to the willingness of a group of users to employ technology for the task it is designed to support as well as to integrate it into an environment based on the users' interaction, experiences, perceived usefulness of the technology and perceived ease of use. Hence, the deployment of robots to combat global health threats depends on how a particular country perceives the usefulness of the technology. For instance, robotic systems are highly accepted in Japan and Scandinavian countries, while countries in the Middle East are against the use of iconic technologies such as robots. Consequently, the use of robotic technologies to enhance global health is hindered in some nations.

5.4 Fear of Displacement of Job

One of the major challenges affecting the deployment of robotic systems is the fear that people will be displaced from their jobs and replaced with robots. This is because robots can work faster and for longer hours than human beings and at a cheaper cost. They can perform repetitive tasks without getting weary. The job insecurity created by the fear of job displacement by robots results in poor mental health, which is often linked with heart diseases and high mortality rates.

5.5 Privacy Concerns

Privacy, according to Laurinda, is the right of individuals to prevent their information from being revealed to others; the claim of individuals to avoid surveillance or interference from other individuals, organizations, or the government [40]. Robots cause privacy concerns because they can move around in the real world, gather data/ information and process data. Some robots record and transmit these data in human-readable format. Privacy concerns are raised when the user of a robot is not aware of what kind of data is collected, to whom the data is shared, and for what purpose the data is disclosed. Besides information privacy, robots can also violate other kinds of privacy, including personal space, territoriality, and solitude. Privacy concerns may lead to lack of confidence, transparency and trust in robotic systems, thereby reducing their acceptance rate in society.

5.6 Interoperability Issues

In simple terms, interoperability can be defined as the ability of two or more independent systems or components to exchange meaningful information reliably and quickly without errors [41]. Hence interoperability facilitates communication between two or more systems. Interoperability still remains a major challenge for effective communication among robotic systems. This is because robots are proprietary in nature. They are developed by different companies with a variety of hardware and software components. However, this makes it difficult for robots to easily share information, resulting in interoperability problems easily. Consequently, the lack of seamless, effective and meaningful exchange of information among robots of different brands can result in a collision between robots, leading to serious accidents.

6. THE WAYS FORWARD

The achievement of a world devoid of global health threat is a demanding task characterized by several barriers despite the numerous efforts of individuals, government of different nations, and non-governmental organizations. However, the following solutions can be adapted to facilitate the effective use of robots for combating global health threats:

6.1 Adoption of a Common Standard for Robots of Different Brands

One significant way of ensuring interoperability amongst diverse systems is the use of standards. Standards are established by consensus and approved by a recognized body to provide rules, guidelines, or characteristics for activities [40]. The adoption of a common

standard for data exchange is essential for achieving complete interoperability amongst robotic systems.

6.2 Education Strategy

Government, non-governmental organizations and individuals should be taught the importance of robots in combating global health threats. Individuals should also be made to realize that using robots to perform their tasks is in their best interest in terms of time and professional convenience. People should also be educated that robots are designed to assist them and not to out rightly replace them in their jobs because they lack the human camaraderie required in workplaces.

6.3 Capacity Building

Individuals should be made to acquire the technical skills and knowledge needed to make full use of robotic systems to combat global health threats.

6.4 Adoption of Greener Sources of Energy

Greener sources of energy should be provided to power robots in order to reduce the effect of global warming and greenhouse emissions caused by other sources of energy such as electrical power sources, electromagnetic generators, thermoelectric generators, fuel cells and super capacitor.

6.5 Privacy and Security Policies

Robots should be designed to collect data from individuals in a lawful manner with the knowledge and consent of the owner of the data. In addition, the purpose for which the robot collects the data should also be communicated to the data owner. The data collected should be accurate and up-to-date and solely used for the purpose for which it is collected. The data must also be guarded against data loss, unauthorized access, destruction and modification.

7. CONCLUSION

Global health is an interdisciplinary research that deals with improving the health of all individuals of the world. It also deals with the identification of global health threats such as hunger and starvation, the spread of infectious diseases, climate change and air pollution, and how these threats are controlled by governmental and non-governmental organizations as well as individuals. Some of the ways individuals, governmental and non-governmental organizations control global health threats, include establishing global health policies and practices, evidence-based science, ethical policies, and research. Despite these efforts, the world is still struggling to deal with global health threats. Accordingly, this study explores how robots have been used to tackle the problems created by global health challenges such as reducing the spread of infectious diseases and pandemics, providing food security, reducing harmful gases released into the atmosphere, and reducing anxiety and fear of vaccination. The study also revealed some factors hindering the effective use of robotic technologies in combating global health threats. Such factors include privacy concerns, interoperability issues, fear of job displacement and high cost of procurement, installation and maintenance. The study suggests that adopting a common standard for robots of different brands, education strategy, capacity building and adopting greener sources of energy for robots are some ways to facilitate the effective use of robots for combating global health threats.

DISCLAIMER

The products used for this research are commonly and predominantly used products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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