Use of Virtual Reality in Managing Emerging Infectious Diseases

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The recent coronavirus (COVID-19) pandemic brought with it unprecedented health challenges and widespread economic disruption. However, it was also at the forefront of pushing innovative technologies and reshaping the way societies and industries operate. For instance, when students could not reach school, virtual classes brought education to them in their homes; remote work brought offices to workers; and telemedicine and teleconsultation offered crucial healthcare services for the sick and ailing. The pandemic also gave rise to innovations, such as COVID-19 tracking apps and drone deliveries, showcasing the adaptability of technology to current needs. Furthermore, it was seen as an opportunity to put to actual test and usage many prototype technologies. One such technology that saw advancement and usage during this difficult period was virtual reality (VR). Beyond its known application for entertainment and gaming, VR demonstrated its potential in contributing to the improvement of health and wellness. As per Bloomberg, the augmented reality (AR)/VR market is projected to achieve a staggering US$ 455 billion by the year 2030, marking a significant contrast to the 2020 statistics where the market valuation stood at a mere US$ 15 billion.[1]

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This commentary provides an overview of what VR entails. It explores how VR was employed during the COVID-19 pandemic. There is also a plethora of literature on the post-outbreak applications of VR, such as medical consultation, entertainment, research and analysis. However, less focus has been placed on preparedness and response in case of public health emergency scenarios. In recent times, disease outbreaks have become a recurring phenomenon and it is uncertain as to when a small-scale disease outbreak will become a global-level pandemic. The commentary discusses some aspects of preparedness and response via the use of VR to handle disease outbreaks.

Virtual Reality: A Primer

Virtual reality is an evolving field that has gained a lot of traction in recent times. In particular, the recent advances in the information and communication technology sector have brought about a substantial revolution in the realm of VR. The term 'virtual reality' is defined as 'a computer generated, interactive, three-dimensional environment in which a person is immersed'.[2] In a general sense, VR is an artificial environment generated through the utilisation of information technology tools, encompassing both hardware and software. This environment is presented to the user in a manner that closely resembles a real setting, providing a convincing and immersive experience.[3]

It is crucial to emphasise here that the virtual world is interactive, compelling the users to fully engage with an artificial environment distinct from their actual surroundings. To partake in the VR experience, individuals rely on two of their five senses, namely, sight and sound. To perceive predominantly three-dimensional images, various devices, including frequency modulators, mouse, joysticks, earphones, special gloves, head-mounted displays and goggles, are employed. These devices operate based on inputs received from a computer system. It is important to acknowledge that achieving an exact replica of the real world has proven challenging. There will inevitably exist some degree of disparity between the real and virtual realms.

Currently, VR applications are being employed across a spectrum of disciplines, ranging from computer science and mechanical engineering to biomedical engineering, medicine and architecture. Over the past few decades, immersion, interaction and imagination or 3I's of VR have steered its evolution from gaming towards diverse applications, with one of the most promising being the management of disease outbreaks. Virtual reality provides users with a visuospatial perspective, allowing them to grasp the intricacies of any kind of outbreak within a high-fidelity environment. This capability facilitates effective

communication of information about diseases to the public, presenting it in a manner closely resembling real-world conditions. As a result, VR not only improves public understanding of diseases but also enhances awareness of related risks of any form of outbreak.

Use of VR During the Covid-19 Pandemic

During the COVID-19 pandemic, VR was seen as a blessing in disguise as it provided multifaceted application. Medical professionals used it for research—for instance, to visualise COVID-19 molecular structures—telemedicine and assistance in palliative care of COVID-19 patients.[4] It also offered a valuable tool for continuous monitoring of health concerns in vulnerable populations, including older adults. Furthermore, VR technologies had the potential to enhance mental well-being by enabling connections with families and friends during quarantine.

From the perspective of entertainment and excursions, VR has been employed for visits to museums or panoramic tourist sites. Such activities are already taking place in various locations. such as The Louvre in France has an impressive and precise VR simulation of the Mona Lisa; the National Museum of Finland has a VR simulation that is a 3D version of the painting The Opening of the Diet 1863 by Alexander II among others.[5]

A recent study revealed that amid the pandemic, a significant number of participants leveraged VR across various domains.[6] Predominantly, individuals utilised VR for gaming, movie viewing and professional tasks. Additionally, respondents highlighted its applicability in tourism, education and social interactions, emphasising its positive impact on mental and physical well-being. There were also noteworthy cases of VR being used for facilitating virtual seminars and conferences, providing immersive experiences and networking prospects. Notably, businesses and organisations embraced VR for remote collaboration, allowing employees to engage in virtual meetings, workshops and training sessions securely from their homes. This widespread adoption of VR showcased its multifaceted utility, ranging from entertainment and education to fostering connectivity in professional and personal spheres during challenging times.

Use of VR for Response and Preparedness

Technologies like artificial intelligence (AI) have enhanced the predictability of outbreaks, as evidenced by the early prediction of COVID outbreak

by a Toronto-based AI start-up, BlueDot, even before the World Health Organization (WHO) released an official statement.[7] However, it remains challenging to foresee and monitor comprehensively the scale and spread of such outbreaks. It is, therefore, crucial to prioritise education, preparedness and response training to mitigate the potential impact and save lives.

Many such endeavours are already taking place in the realm of natural disasters. Especially after the massive tsunami in 2004, governments across the world have continued to stress on preparedness and response training that involves local communities as disasters are hard to prevent but lives can still be saved. Taking a leaf from that book, this commentary proposes leveraging VR as an innovative approach to enhance training, improve response strategies and ultimately, contribute towards saving lives in the face of an unforeseeable health emergency.

Conventional training for health emergency preparedness typically involves resources, like books, online platforms, classroom instruction and on-campus lectures.[8] Additionally, the effectiveness of public health emergency preparedness is often enhanced through emergency drills. A systematic review indicates that these drills are primarily designed for public health professionals, gradually extending to non-public health professionals, including medical students, dentists and dental health workers, with specialised functions serving the community.

However, conducting emergency drills for emerging infectious diseases demands substantial manpower and material resources. The reality is that the general public may find it challenging to participate in such drills due to limited opportunities, presenting a hurdle to effective implementation.

Virtual reality training for emerging infectious diseases is an innovative method designed to educate both individuals and organisations on how to effectively respond to health crises. In fact, VR's real-world simulations enhance preparedness by addressing human behaviours, disaster consequences and experiences in infectious outbreaks or disaster situations. This technology immerses users in simulated scenarios related to emerging infectious diseases, enabling them to experience and respond to the aftermath of such outbreaks.

These scenarios can encompass a range of infectious diseases, adapting the VR simulations to the specific type of disease and the required level of training. As an illustration, Nakasone et al. presented the 'Open Bio-Safety Lab', a virtual world-based biosafety training app for medical students.[9] In a preliminary test study involving 24 students, the system demonstrated a high level of usability. Additionally, this technology offers an innovative approach

to examining healthcare providers' behaviour in a controlled virtual setting, facilitating infection prevention training.[10]

Virtual reality training for managing emerging infectious diseases offers distinct advantages over traditional methods. First, it provides a secure learning environment, allowing individuals to acquire and practice response techniques without exposure to real-life risks. This feature enables learners to understand the consequences of infectious diseases and learn response strategies without physically being present in a hazardous situation. Second, VR training can be cost effective as it eliminates the need for resources, like manpower, equipment and transportation. This cost efficiency ensures accessibility for a wider audience, including individuals and organisations with budgetary constraints.

Furthermore, VR training for emerging infectious diseases delivers an immersive and engaging learning experience, aiding individuals in retaining information more effectively compared to conventional methods. Through simulating scenarios of infectious disease outbreaks, learners can experience the stress and pressure of responding to health crises, thereby enhancing their ability to react in real-life situations. Additionally, the flexibility of VR allows customisation to simulate various infectious disease scenarios, enabling learners to practice responses tailored to specific types of health emergencies.

India as a Case in Point

Even before the COVID-19 outbreak, India has successfully dealt with virus outbreaks, an example being Nipah, which was effectively contained before it became a global outbreak. Indeed, India has faced around six Nipah outbreaks since 2001 and each time the country has successfully curbed it. There are several lessons that can be used and implemented from the Nipah cases. Government authorities at both state and national level initiated a coordinated response to curb the outbreak. This involved implementing an array of measures, such as heightened surveillance; thorough contact tracing; laboratory testing for suspected cases and high-risk contacts; ensuring hospitals were prepared for effective case management; emphasising infection prevention and control (IPC); and actively engaging in risk communication and community outreach.[11]

India's strength lies in its human resources and community resilience, with local communities often taking the lead in response efforts—whether it is dealing with avalanches in the north or cyclones in the south. Recognising this, the Indian government launched a scheme, called Aapda Mitra, for disaster management wherein communities are trained to respond during

stressful times. Akin to the Aapda Mitra scheme, there could be a model for preparedness and response for emerging infectious diseases which uses VR to train and fortify communities to control the rapid spread of infection. This approach aims to broaden the scope of community-based efforts, supporting communities in identifying and implementing local risk-reduction measures.

Virtual reality facilitates immersive simulations for healthcare professionals, first responders and public health workers, allowing them to practice and refine their responses to disease outbreaks in a virtual environment. By localising these efforts, traditional best practices and indigenous knowledge can be leveraged effectively, ensuring a comprehensive and culturally sensitive approach to disease control and community resilience. It can also be used to simulate inter-agency coordination exercises, helping various organisations practice and refine their collaborative efforts in the face of a disease outbreak.

Conclusion

Although VR has been making rapid progress, the simultaneous adoption rate of VR has not seen an equivalent rise. There is a visible gap in this respect. One should not wait for another disaster and outbreak to drive the adoption of technology; rather, VR technologies should be gradually and seamlessly integrated into day-to-day lives. By doing so, a continuous state of preparedness can be fostered, ensuring that communities are well-equipped and knowledgeable, not just in times of crisis but as an inherent part of their routine. This proactive integration would empower individuals to navigate unforeseen challenges with familiarity and ease, creating a resilient society that can respond effectively to emerging threats.

Additionally, it is important to note that individuals often misconstrue that specialised VR headsets are required to get the immersive feel, but it can also be experienced in any handheld device like smartphones, although the immersive effect may vary.[12] The adaptability of VR technology allows for immersive and realistic simulations, offering a unique platform to educate and prepare communities for potential health crises. By harnessing the power of VR, one can empower individuals and communities to effectively respond to emerging infectious diseases, whether they be endemic or pandemic, fostering a culture of preparedness that transcends the aftermath of pandemics. The versatility of VR not only enhances training strategies but also contributes to building resilient communities capable of swiftly and decisively addressing health challenges, thereby laying a foundation for a proactive approach to global health security.

The COVID-19 pandemic stands as a testament for weak preparation, inadequate awareness or knowledge and a lack of active collaboration in efforts to prevent and control the pandemic. Leveraging VR provides countries as well as societies an opportunity to close the gap and enhance readiness for emergencies and equip individuals with practical skills to prepare for potential emergency situations.

Notes

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