Approaches to Monkeypox Outbreak Control：A Focus on Technology and Innovation

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Abstract. The global outbreak of the monkeypox virus (MPXV) has necessitated the urgent identification of effective strategies for outbreak control. This essay focuses on the role of technology and innovation in addressing monkeypox outbreaks, aiming to evaluate the potential and practical benefits of these emerging approaches. The discussion begins with an overview of the epidemiological characteristics of monkeypox outbreaks and the associated public health risks. It subsequently examines the application of advanced technologies in patient treatment, disruption of transmission routes, and outbreak surveillance. Additionally, the challenges inherent to these technologies and innovations are explored. The essay highlights the effectiveness of these approaches in controlling outbreaks and offers recommendations for future research and policy development. Findings from this work are intended to enhance preparedness for future outbreaks.

Keywords: Monkeypox Epidemic; Technology And Innovation; Epidemic Monitoring And Early Warning; Vaccine Development; Treatment Methods.

1. 1 Introduction:

1.1. Background to the Monkeypox Epidemic:

Monkeypox is a zoonotic viral disease caused by Monkeypox virus (MPXV), primarily transmitted from animals to humans, but it can also spread through human-to-human contact. MPXV belongs to the genus Orthopoxvirus within the family Poxviridae and is characterized as a large, enveloped, double-stranded DNA virus. It shares genetic similarities with other notable viruses in the same group, such as the smallpox virus (Variola virus) and the vaccinia virus (Vaccinia virus), which is used in the smallpox vaccine.(Wang et al., 2023)

Monkeypox virus was first identified in monkeys in 1958. The first human case of monkeypox was recorded in 1970 when a 9-year-old boy from the Democratic Republic of the Congo (DRC) became infected. Since then, human cases of monkeypox have been reported in several countries in Africa. In 2003, the first case of monkeypox outside of Africa was reported in the United States, resulting from an outbreak linked to imported pet prairie dogs that had been housed with infected Gambian giant rats and dormice from Ghana. This incident underscored the potential for international spread of the disease through the wildlife trade.(Zahmatyar et al., 2023)

Transmission occurs predominantly through direct contact with the lesions or mucous membranes of infected individuals, which constitutes the most common route of transmission. Additional modes include respiratory droplets, contaminated materials, and vertical transmission.(Kaler et al., 2022) Infected individuals typically present with symptoms such as fever, headache, muscle aches, back pain, and malaise, followed by the development of a rash that progresses through various stages, beginning on the face and spreading to other areas, including the palms and soles. The incubation period for monkeypox usually ranges from 6 to 16 days and may be as long as 21 days.(Petersen et al., 2019) Recently, monkeypox outbreaks have demonstrated a concerning global spread, particularly in Latin America and the Caribbean, where countries such as Brazil and Peru have reported significant cases during the 2022 outbreak.(Quispe & Castagnetto, 2023) The international community is actively taking various measures to deal with the outbreak.

1.2. Technology and Innovation in Epidemic Prevention and Control

Current therapeutic options for monkeypox predominantly include antivirals originally developed for smallpox, such as tecovirimat, brincidofovir, and cidofovir, although their anti-monkeypox efficacy has yet to be validated through rigorous clinical trials. Yuhui Liao's team at Southern Medical University has proposed a promising treatment strategy involving bionic nanomedicine.(Li et al., 2024) Recent advancements have also introduced recombinant protein and mRNA vaccines as candidates for epidemic prevention.(H. Wang et al., 2024) Additionally, the monkeypox virus nucleic acid detection kit developed by BGI has played a crucial role in case identification. With the further development of these studies, the prevention and control of monkeypox epidemic will be more scientific and effective in the future.

Since the global monkeypox outbreak in 2022, public health systems have faced unprecedented challenges. This essay aims to systematically summarize and disseminate novel technologies and innovative methods that have been employed in epidemic response and control, thereby providing essential scientific insights and practical guidance for global public health practitioners and policymakers.

1.3. Purpose and significance of the paper

Science, technology and innovation play a pivotal role in epidemic prevention and control, which can not only improve the efficiency of prevention and control, but also contribute to the wisdom and strength of global public health security. The purpose of this paper is to analyse in detail the specific application of technology and innovation in the prevention and control of the Monkeypox epidemic and its effects, with a view to providing new ideas and methods for related prevention and control work.

2. Technological Innovations in Monkeypox Control

2.1. Artificial Intelligence in Monkeypox Control

AI technology plays a crucial role in public health surveillance and early warning. Leveraging big data analysis and machine learning, AI enables real-time tracking of epidemic dynamics and predictive modeling of monkeypox spread. In terms of medical diagnosis and treatment, AI is revolutionizing precision medicine by integrating vast data from multiomics analyses and enhancing deep-learning strategies. AI has made significant strides in detecting, screening, diagnosing, and classifying diseases, including characterizing virus genomes and assessing biomarkers for prognostic and predictive purposes.(Patel et al., 2023)

2.2. Applications of Mobile Health Applications in Monkeypox Response

Mobile Health Applications (mHealth Apps) make contributions to the development of public health by providing real-time monitoring, health education, convenient medical services. Sahin et al. proposed a smartphone-based skin disease-detection method utilizing MobileNetV2 and presented an android mobile application, using a smartphone camera to detect and classify the monkey-pox.(Sahin et al., 2022) As technology continues to evolve, the potential impact of mHealth Apps in public health is expected to expand further.

2.3. Novel Vaccines and Diagnostic Tools in Monkeypox Control

The application of mRNA technology has brought a revolutionary breakthrough for vaccine research and development. At present, research institutions have used mRNA technology to carry out research and development of monkeypox vaccine. Notably, Wang Han et al.(H. Wang et al., 2024), introduced the DAM vaccine, a "2-in-1" recombinant protein vaccine that exhibits a neutralization capacity 28 times greater than traditional attenuated live vaccines.

PCR is a commonly used method to detect pathogens in molecular biology.Several companies, such as BGI and Daan Gene, have developed monkeypox virus nucleic acid detection kits (fluorescent PCR method), which have high sensitivity and specificity, and can quickly identify monkeypox virus in a short time. Additionally, Fei Zhao et al., have developed a CRISPR/Cas12a based monkeypox virus detection system. (Zhao et al., 2023) The system combines isothermal amplification technology to achieve extremely high sensitivity, enabling rapid, sensitive and accurate detection of monkeypox virus.

2.4. Biosimilars and Generic Drugs in Monkeypox Control

At present, research on the treatment of monkeypox is rapidly advancing, with efforts focusing on both existing antiviral drugs and the discovery of new therapeutic agents. Hugh Adler et al.(Adler et al., 2022) reported responses to monkeypox from two antiviral drugs used to treat smallpox, suggesting that tecovirimat may have the potential to shorten symptoms and reduce the duration of infection in patients. The researchers are screening potential small molecule inhibitors of monkeypox virus thymidylate kinase from traditional Chinese medicine databases in search of new drugs to treat monkeypox.

3. Discussion:

With the global spread of monkeypox, the urgent need for effective control and management of the disease has become increasingly apparent. This article reviews the multifaceted applications of Artificial Intelligence (AI), Mobile Health Applications (mHealth Apps), novel vaccines and diagnostic tools, as well as biosimilars and generic drugs in controlling monkeypox. Studies indicate that AI and big data technologies can monitor and predict epidemic developments in real time, while mobile health applications provide convenient health education and services. Emerging mRNA vaccines and improved virus detection tools offer new hope in combating viral transmission, and the repurposing of traditional antiviral drugs presents practical treatment options.

The current studies showcase the significant potential of AI technology in public health surveillance and early warning. Through machine learning and data analysis, AI can quickly collect and analyze infection data, thus supporting public health decision-making (Liu et al., 2022). For instance, the smartphone-based skin disease detection method developed by Sahin et al. demonstrates the effectiveness of mobile health technology in enabling early detection and intervention, which is crucial in epidemic responses.

In terms of vaccine development, the introduction of mRNA technology, such as the DAM vaccine developed by Wang Han et al. (2023), not only enhances immunogenicity but also provides a flexible research and development model for addressing emerging epidemics. Moreover, the application of CRISPR/Cas12a technology significantly improves pathogen detection sensitivity (Fei Zhao et al., 2023), marking an important advancement in the ability to respond rapidly to outbreaks. The integrated application of these technologies offers new possibilities for global public health systems.

However, despite the encouraging results from current research, certain limitations must be acknowledged. For instance, the effectiveness of AI technology largely depends on the quality and availability of data, which may pose challenges in resource-limited settings. Additionally, while progress has been made in vaccine development, the safety and efficacy of these new vaccines still require further validation.

In summary, the control measures for monkeypox are continually evolving, supported by interdisciplinary research findings that provide new insights and solutions. However, current research also has limitations, such as insufficient sample sizes and the influence of external factors, which might restrict the generalizability of the conclusions. Future research should focus on the long-term efficacy and safety of these technologies to ensure their appropriate application in epidemic control. Furthermore, it is recommended to strengthen interdisciplinary collaboration by integrating expertise

from public health, computer science, and biomedicine to enhance the overall response capabilities to emerging infectious diseases like monkeypox.

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