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GLOBAL RESPONSE TO MONKEYPOX: PREVENTION, VACCINATION, AND CHALLENGES IN DISEASE CONTROL

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Abstract

Monkeypox, a zoonotic viral disease caused by the monkeypox virus (MPXV), was historically confined to Central and West Africa but has now emerged as a significant global public health concern. Transmission occurs through direct contact with bodily fluids, lesions, or respiratory droplets, as well as via animal-to-human exposure. Individuals with weakened immune systems are at higher risk of severe disease. The 2022 international outbreak, driven by global travel, human–animal interactions, and waning smallpox immunity, marked the virus's spread beyond endemic regions and posed particular challenges for healthcare systems and professionals.

Preventive measures such as personal hygiene, patient isolation, and the use of protective equipment remain critical. In clinical management, antivirals such as Tecovirimat and smallpox-based vaccines (JYNNEOS and ACAM2000) are valuable tools. Public health strategies—including contact tracing, quarantine, and early diagnosis—are essential for containment. However, prevention and control efforts are hindered by barriers such as limited healthcare infrastructure, misinformation, stigma, and resource constraints.

Addressing these challenges requires strengthened surveillance systems, targeted vaccination strategies, and coordinated international collaboration. Enhancing these measures will be vital to mitigating the global impact of monkeypox outbreaks.

INTRODUCTION

The Monkeypox virus (MPXV), a member of the Orthopoxvirus genus, which also contains the smallpox and cowpox viruses, is the cause of monkeypox, a zoonotic viral disease. Even though monkeypox was originally only found in parts of central and West Africa, new outbreaks have elevated the disease to the top of the global health agenda. The first human case was recorded in the Democratic Republic of the Congo (DRC) in 1970 after the disease was initially discovered in non-human primates in 1958. Flu-like symptoms such as fever, headache, back pain, muscular aches, and enlarged lymph nodes are common signs of monkeypox. These are usually followed by a characteristic rash that usually begins on the face and spreads to other parts of the body. From flat lesions (macules) to raised bumps (papules), blisters filled with fluid (vesicles), pus-filled lesions (pustules), and

ultimately scabs, the rash develops in phases. Together with a high fever and exhaustion, these clinical symptoms set monkeypox apart from other viral illnesses such as measles or chickenpox (Meyer et al., 2022). Although the illness usually resolves on its own in two to four weeks, severe cases can happen, especially in infants, people with weakened immune systems, or people with underlying medical disorders. These cases might result in complications such as respiratory distress or secondary infections (Bunge et al., 2022). Although the death rate from monkeypox varies, it has historically varied between 1% and 10%, especially in areas with poor access to healthcare and immunizations. The monkeypox virus can spread from person to person as well as from animal to animal. Direct contact with the bodily fluids, lesions, or blood of infected animals such as rodents, monkeys, or other wildlife species is usually the method of animal-to-human transmission. These animals are thought to be the main virus reservoirs (Parker et al., 2022). Hunting, eating bushmeat, or coming into contact with diseased animals can all expose individuals to monkeypox in endemic areas. Conversely, close contact with an infected person's lesions, bodily fluids, or respiratory droplets facilitates human-to-human transmission. The virus can spread through contaminated surfaces or objects, a mechanism known as fomite transmission, even though direct skin-to-skin contact is the main way it is transferred (McCollum & Damon, 2019). Although it is feasible, respiratory transmission is less frequent and usually necessitates intimate, sustained contact (Ježek et al., 2018). Even while people are most contagious when they have rashes, asymptomatic people can also spread the disease, especially when it shows only minor symptoms (Kraemer et al., 2022). Recent monkeypox outbreaks have caused serious alarm throughout the world. Because it was the first time the disease had expanded outside of the customary endemic regions of central and west Africa, the 2022 worldwide outbreak was especially concerning because it affected nations in Europe, the Americas, and portions of Asia. More than 20,000 cases had been documented in more than 70 countries by July 2022, which was a significant rise above earlier epidemics. International travel, an increase in human-animal contact, and the lack of universal immunity after smallpox was eradicated worldwide have all been blamed for this increase in instances.

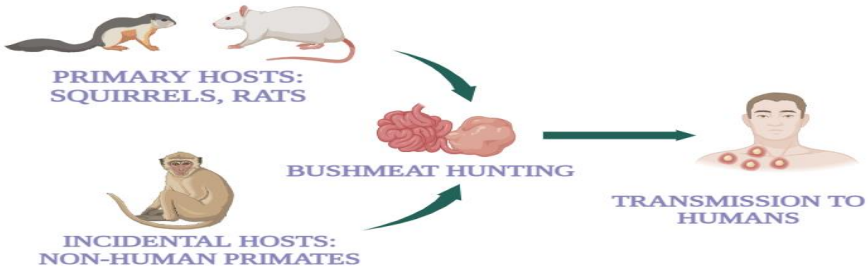

Fig.2. Monkeypox transmission cycle

With a significant concentration of cases among men who have sex with men (MSM), metropolitan centers saw the highest outbreaks in non-endemic areas, underscoring the importance of intimate contact in viral transmission during this outbreak (Adler et al., 2022). Although MSM is not the only group affected by the virus, the rise in cases in this group highlights the necessity of focused public health initiatives and education. Additionally, in geographical locations where outbreaks regularly occur, healthcare personnel are at higher stake due to chronic exposure to infected patients, especially in areas where personal protective equipment (PPE) is not a major concern (Afolabi et al., 2022). Due to the reduced immune systems of children and those living with HIV, they are more vulnerable to severe illness particularly in endemic areas (Reynolds et al., 2022).

In order to control the virus's outbreak, these milestones encourage the need of strong public informative programs, such as immunization, contact tracking, and efficient infection control methods. The current monkeypox spread has demonstrated a loophole in international health response, especially about prompt response and surveillance systems. The

population's sensitivity to monkeypox has been compounded by the reduction of guarded immunity against orthopoxviruses as a result of smallpox vaccination campaigns ending after the disease was eradicated (Dawson et al., 2022).

In this context, health authorities including the Centres for Disease Control and Prevention (CDC) and the World Health Organisation (WHO), have pushed for accelerated diagnosis, public awareness campaigns, and the preparation of efficient vaccination protocols. In response to the recent outbreak, new vaccines like JYNNEOS and ACAM2000 have been created and used (Huang et al., 2022).

Given the recent outbreaks around the world, monkeypox is still a serious zoonotic illness that can have a big influence on public health. Channeling effective safety protocols needed comprehension of the virus's transmission dynamics, risk factors, and the groups most at risk. It would be highly productive to reduce its spread and lessen its effects on world health through robust immunization initiatives, educational campaigns, and ongoing surveillance.

Preventive Measures for Monkeypox

A. Personal Preventive Measures

In controlling the spread of monkeypox public attitude and dedication is important to advise preventive measures and hygienic procedures that include sanitation and hand hygiene, which lower the risk of infection. One of the swift and efficient methods to stop the outbreak of viruses like monkeypox is to thoroughly wash your hands with soap and water for at least 20 seconds (Goh et al., 2022). The efficient way to dormant the viruses and lower the risk of contamination is by using alcohol-based hand sanitizers with at least 60% alcohol and through surface contact when soap and water are not available (Tanner et al., 2023).For those people who are handling potentially contaminated surfaces, including handles on public transport or shared medical equipment, hand hygiene is especially crucial because it may contain virus particles from infected people (Afolabi et al., 2022).

Along with that, avoiding contact with infected people is another crucial safety measure. It would be necessary to isolate people who exhibit monkeypox symptoms, such as fever, enlarged lymph nodes, and a characteristic rash, to stop the virus from spreading by direct contact with wounds or bodily fluids (Bunge et al., 2022). People who are in close contact with infected people should also be watched for symptoms and isolation if time demands (McCollum & Damon, 2018). Furthermore, in affected regions social distance is advised, avoiding mob and maintaining a safe physical distance from persons who are exhibiting symptoms can help lower the risk of respiratory or contact-based transmission. It is typically important in sensitive settings like medical institutions or major public hotspots (Adler et al., 2022).

Wearing protective gear is the need of time to stop the outbreak of monkeypox, especially for medical experts and those who are giving care to affected people. It is crucial to use the proper Personal Protective Equipment (PPE), such as gloves, masks, and gowns for those who are in close contact with sick people or animals (Afolabi et al., 2022). It is always suggested to employ N95 respirators or comparable high-filtration masks for an accelerated level of protection against respiratory droplets that may contain the virus (Reynolds et al., 2022). Gloves must be declared mandatory in an outbreak to prevent direct contact with any skin lesions and items like gowns or aprons that always keep clothing from becoming contaminated.

Wearing disposable gloves and masks adds an extra layer of protection while interacting with symptomatic people in non-medical settings (such as homes), especially when tending to those who have open lesions or possible respiratory symptoms. It has been demonstrated that these straightforward but efficient steps greatly lower the probability of transmission, particularly in high-risk populations like carers and medical professionals (Huang et al., 2022).Frequent handwashing, avoiding contact with symptomatic people, and wearing protective garments are all essential personal preventative actions that work together to effectively stop the spread of monkeypox. To reduce the risk of infection in both endemic and non-endemic areas, public health programs that highlight these measures are

crucial, as are good personal cleanliness habits (Parker et al., 2022).

B. Reducing Animal-to-Human Transmission

One important way to slow the virus's spread is to stop monkeypox from spreading from animal to human, particularly in areas where the illness is endemic. Certain primates, rodents, and other wildlife species are the main animal reservoirs of the monkeypox virus. These animals can act as vectors for the virus, passing it on to people through direct contact with bodily fluids, lesions, or animal carcasses (Parker et al., 2022). Humans frequently come into contact with these reservoirs when hunting, trapping, or handling animals for food in regions where monkeypox is endemic. Consequently, limiting the danger of zoonotic transmission requires avoiding contact with possible animal reservoirs.

People who live in or visit endemic areas should be made aware of the dangers of contact with wild animals, especially if they exhibit strange behavior or symptoms of disease, as these could be evidence of infection (Adler et al., 2022). Since they can carry the virus without exhibiting obvious symptoms, rodents such as squirrels and prairie dogs are especially linked to the spread of monkeypox since it can be challenging to identify them as infection carriers (Gorib et al., 2022). Public health officials strongly advise against handling wild animals, particularly in regions where cases of human monkeypox have been documented.

Safe handling procedures must be followed in places where interaction with animals is inevitable, such as rural areas or places where hunting is the primary source of food. To reduce the chance of coming into direct contact with bodily fluids, tissues, or lesions from infected animals, these recommendations include donning the proper protective equipment (PPE), such as gloves, face masks, and gowns (Goh et al., 2022). The use of N95 respirators, disposable gloves, and goggles is advised for healthcare personnel or anyone else handling animals suspected of carrying the virus, particularly when working with potentially infected animals or carrying out operations like skinning, necropsy, or euthanasia (Reynolds et al., 2022).The risk of contamination is significantly decreased by practicing good hygiene after working with animals, which includes thoroughly cleaning clothing and equipment. To prevent unintentional exposure to the virus, public health organizations also advise the cautious disposal of animal carcasses. Since physical contact is the main way that monkeypox is transmitted, it is crucial in high-risk areas for people to wear complete protective gear while dealing with domestic or exotic animals.

Lastly, one of the most important ways to lower the danger of animal-to-human transmission is through public education about zoonotic illnesses. Many people who reside in endemic areas may be unaware of the link between human illness transmission and animal health. The increased infraction information on the possible dangers of handling wildlife, the significance of avoiding contact with ill animals, and appropriate hygiene procedures can reduce the chances of infection. The main objective of public health campaigns should be to inform local people about the symptoms and indicators of monkeypox in animals. Most importantly, the best way to prevent transmission is to get medical help immediately if an animal bites or scratches a person. In parts of Central and West Africa community involvement is critical to spread awareness of the dangers of eating bushmeat, which has been ranked as a high-risk behavior (Bunge et al., 2022). These awareness programs are set to equip with knowledge of zoonotic diseases that can be caused by animals to people and their consequences for public health and wildlife preservation.

Effective risk communication, safety measures, and community involvement can considerably decrease the chances of a monkeypox outbreak from animals to people. Continuous awareness campaigns and human and animal population surveillance are crucial in order to hamper the disease from spreading in highly sensitive hotspots.

C. Quarantine and Isolation

The spread of monkeypox can be prevented by isolation and quarantine techniques. Isolating patients is one of the most important therapies, and direct contact with bodily fluids, lesions, or respiratory droplets from an infected person can cause the spread of monkeypox. For that matter,

early detection is essential to isolate people quickly and prevent the virus from spreading to other people. A rigorous study has shown that the likelihood of epidemics spreading was decreased when cases of monkeypox were promptly identified and isolated (Reynolds et al., 2022).

The World Health Organisation (WHO) and the Centres for Disease Control and Prevention (CDC) draw an outline that sufficient ventilation and full-fledged facilities must be streamlined in doubt or approved and placed in isolated rooms. The doctors must follow the treatment of these patients by using personal protective equipment (PPE) like gloves, gowns, N95 respirators, and face shields, which is one of the robust infection control procedures. During an urban monkeypox outbreak, the recruitment of strict isolation measures in hospitals considerably decreases the rate of virus transmission in medical settings (Patel et al., 2023).

Along with isolation contact tracing and surveillance prevent future transmission of those who have had intimate contact with infected individuals. Quarantine is the next step when a patient is exposed to the virus at high risk. For identifying secondary cases effective contact tracing is important, particularly for those who may be asymptomatic (Krause et al., 2023). Since 21 days is the extended incubation period, the CDC suggests that individuals exposed to the virus require full-time isolation. In this time frame caregivers like household members or healthcare staff need to watch patients for symptoms throughout this time, and they ensure their safety as well.

The 2022–2023 monkeypox outbreak in Europe dramatically decreased secondary transmission due to strict regulations demonstrating the pace of this intervention (Harris et al., 2023). Continuous surveillance of those who have been unfolded can also help assess new cases early, which is essential for effective safety protocols. Digital health solutions like using Mobile Health Technologies (MHT) can improve real-time tracking of symptoms by increasing the overall efficiency of contact tracing (Chan et al., 2023). A strong coordination between healthcare channels is made possible by these systems. Therefore, they can take part in the considerable preventive measures as soon as possible.

A more comprehensive outbreak management plan can be implemented in combination with more conventional surveillance techniques to provide a conducive service. The virus's spread can be considerably slowed by quickly identifying, isolating, and closely monitoring those who have been exposed. To effectively stop the virus's spread in both endemic and non-endemic areas, the international health community will continue to modify its tactics in response to the changing nature of monkeypox. Recent outbreaks will provide valuable insights into these techniques.

Vaccination and Medical Interventions

Because the smallpox vaccine causes immune responses that can neutralize the virus, people who have had the vaccination have a much lower chance of getting monkeypox (Aguas et al., 2023). However, many people today might have declining immunity because smallpox immunization was discontinued after smallpox was eradicated. As a result, additional specialized vaccinations against monkeypox have been created, including JYNNEOS (also called Imvamune or Imvanex) and ACAM2000. Third-generation live-virus vaccine JYNNEOS has shown a calculated amount of precision against the spread of monkeypox and smallpox. It has a safer profile than previous vaccines as well, especially for those with impaired immune systems.

Since JYNNEOS is a suggested choice against the spread, it produces robust immunity against both viruses with a high degree of safety and effectiveness (Fitzgerald et al., 2023). The live-attenuated vaccine ACAM2000 is formulated by Vaccinia virus, which is efficacious but has a higher chance of adverse effects, particularly in people with defective immune systems. It is considered that ACAM2000 is saved for people who are at high risk of exposure at the time of JYNNEOS inappropriateness (Holland et al., 2023). Antiviral therapies and vaccination are one of those measures, which can help us to reduce the intensity and duration of monkeypox infection.

In this context, Tecovirimat (TPOXX) has demonstrated reduced viral loads in infected individuals which hamper the replication of the virus. It is effective in the treatment of monkeypox where severe illness symptoms including fever and

skin sores are observed (Smith et al., 2023). In addition to that, Cidofovir has been shown to stop monkeypox proliferation in vitro despite the potential for nephrotoxicity and Brincidofovir. Brincidofovir may be one of the more effective treatment plans with a reduced risk of renal harm than Cidofovir (Mills et al., 2023).

The precision and effectiveness of latest vaccines like JYNNEOS and ACAM2000, and antiviral medications like Tecovirimat, helps in the early combat of monkeypox epidemics even though the smallpox vaccine still presents vital cross-protection. Worldwide management and safety procedures for monkeypox will continue to be shaped by upcoming research into more specialized vaccines and therapeutic approaches.

Public Health Policies and Surveillance

The outbreak of the virus heavily relies on public health rules and repeated examinations. The national and international health organizations including World Health Organisation (WHO) and the Centres for Disease Control and Prevention (CDC), are on the frontline for tracing and handling these spreads. The WHO has been collaborating closely with the affected nations to turn the containment plans into action, supply resources, and educate the local population for dealing with the virus. These coordinated efforts of governments, logistical support, and technical expertise during epidemics help to cater to the spread of the virus (Jones et al., 2023). To guarantee early and precise case identification the CDC plays a pivotal role in the US by streamlining examination data, guidelines for healthcare practitioners, and laboratory testing training (García et al., 2023). Managing monkeypox spread requires concerted international efforts that would greatly help to cater to the virus.in this context, the spread of Monkeypox can be hampered by community education, awareness campaigns, and directly targeted approaches from health organizations. In highly sensitive locations, It is mandatory to aware the population about the strategies of outbreak and self-defense protocols. The value of vaccination should be spread through media campaigns, educational initiatives, and medical facilities through guidelines on symptoms and safety. These Public awareness efforts that employ a variety of platforms, such as manual and virtual medical campaigns are successful in strengthening safety procedures and challenging the stigma associated with the illness (Liu et al., 2023).

For that matter it is important to foster local languages, culturally appropriate messaging, and reputable community leaders can considerably increase public participation and association with the health guidelines. These initiatives not only educate the public but also foster local authorities to actively engage in preventive measures for outbreaks (Khan et al., 2023). In clinical settings, early discovery, quick action, and diagnostic protocols are mandatory for the efficient eradication of monkeypox. Rapid molecular tests and other diagnostic technology developments have made it much simpler for medical experts to diagnose instances in a precise time.

The PCR testing in recent eras has considerably improved the procedures to detect monkeypox within a concentrated period of the onset of symptoms can result in smoothing readiness public health protocols (Patel et al., 2023). Improved surveillance systems that encapsulate data from international networks, local health authorities, and healthcare providers provide a more combined response and early warning system. The data reflected that improved surveillance and data exchange among nations during the 2022 monkeypox spread were fundamental in searching case clusters and stopping additional transmission (Wang et al., 2023). In short, effective monkeypox prevention and confinement rely greatly on strengthening examining procedures, surveillance, and a globally coordinated network of information.

Challenges and Barriers to Effective Prevention

The dichotomy in access to the healthcare system in different regions of the world has raised significant obstacles in the way of effective monkeypox prevention. In the background region budget is less allocated to a healthcare system that is hampering the medical treatment, vaccinations, and diagnostic equipment required to control the virus. The lack of standardized medical experts and decreased access to healthcare procedures, such as labs that can examine

monkeypox leads to the virus's transmission in health systems (Ali et al., 2023). These differences make it more difficult to respond quickly to spread and to be ready for future outbreaks in the long run. The lack of availability of vaccinations and treatments in rural populations like in Central and West Africa made the situation worse because control efforts are seriously hampered (Ndiaye et al., 2023).A large amount of the population is made worse by the disrupted availability of healthcare, which reduces the efficacy of preventive protocols like immunization campaigns.

One of the significant obstacles to successful prevention is the flow of false information and social stigma, which can jeopardize public health initiatives. Secondly, the debates related to monkeypox on social media have left a trust hazard in the population by discouraging them from consulting a doctor or taking part in safety protocols. This hesitancy to promote a conducive environment has been exacerbated by false propaganda regarding monkeypox ranging from its mechanisms of transmission to false beliefs about vaccines (Tulloch et al., 2023).

This outbreak of discrimination and resistance to testing or immunization is further worsening because many people link the illness to particular groups such as males who have sex with other men. It is obligatory for public health organizations, healthcare outlets, and local leaders, to combat disinformation by getting the attention of the local populace. In this context employing a variety of communication channels to address public concerns and distribute factual information is fundamental (Davies et al., 2023).

One of the major concerns in prevention efforts is the logistical challenge in vaccination distribution for underprivileged populations. Their effective and fair distribution continues to be a major obstacle even in the availability of vaccines such as **JYNNEOS** and **ACAM2000**. Cold chain requirements are necessary for vaccines, and provide logistical challenges that postpone vaccine delivery and administration in poor infrastructure (Sullivan et al., 2023). For example, JYNNEOS, need to be stored at sustainable temperatures, which is impossible for conflict-affected areas where resources may be inadequate.

It is required that we promote mobile vaccination units or collaborate with neighborhood organizations to leverage the availability of vaccines in far-flung areas or those encountering financial difficulties (Sharma et al., 2023). In addition to that, fair distribution among high-risk populations and geographical areas, as well as a huge amount of budget for vaccination is mandatory as well.

In today's modern world, there have been considerable advancements in the fight against monkeypox, and a series of challenges pose threats as well. Monkeypox outbreak containment and preventive measures remain complicated due to global inequalities in healthcare access, stigma and disinformation, and vaccine distribution channels. A combined strategy is required to tackle it, including enhancing public health communication, strengthening healthcare infrastructure, and ensuring fair access to medical care and vaccinations.

Recommendations

For reducing the harm of monkeypox it is important to take a series of preventive measures. Initially, it is mandatory to strengthen diagnosing systems for living organisms through early discovery and quick containment. For that matter, it is necessary to leverage public awareness programs that focus on the risks of zoonotic transmission that must be coupled by focusing on high-risk populations such as healthcare workers, men who have sex with men (MSM), and residents of confined areas. It is crucial to fortify the healthcare protocols, particularly in underdeveloped areas, to guarantee that medical professionals have high access to diagnostic tools, personal protective equipment, and thorough case handling practices.

To improve immunity and stop outbreaks, high-risk groups and frontline workers should be given priority when expanding vaccination campaigns, especially with JYNNEOS and ACAM2000. In this context, educating people on safe animal handling procedures and bushmeat consumption must be the main propaganda in the world to stop the spread of zoonotic diseases. In addition to that fair access to resources particularly in underdeveloped regions like vaccine delivery, and cold chain requirements, must be transitioned. Lastly, global containment efforts

depend on promoting international cooperation through coordinated surveillance, data exchange, and prompt epidemic response. The international community may play a critical role in the reduction of its impacts and spread of monkeypox by addressing these obstacles.

Conclusion

In today's world zoonotic transmission of monkeypox is an even greater threat to the global health sector and recent broad outbreaks have made it much more complicated. For its containment, a comprehensive approach is required that recruits stringent public health measures like quarantine and contact tracing. In addition to that antiviral medications like Tecovirimat, immunization with JYNNEOS and ACAM2000, and efficient surveillance are much more important for catering to the increasing number of monkeypox cases. In underserved regions if these concerted efforts have been successful other barriers like poor healthcare infrastructure, false information, stigma, and logistical obstacles in vaccine distribution hinder the reduction of the virus. It is mandatory to tackle these challenges to slow down the virus's transmission and stop future outbreaks through improved healthcare systems, international collaboration, and focused public health initiatives, especially in non-endemic areas.

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