johb.info



Review Article

One Health Bulletin

Human mpox (monkeypox): Epidemiologic, pathogenetic and clinical characteristics, and prevention

Husheng Xiong, Jinlin Tan, Dingmei Zhang✉

[1]*Department of Epidemiology, School of Public Health, Sun Yat-sen University, Guangzhou 510080, China*

ABSTRACT

Mpox (monkeypox) is a zoonotic disease caused by monkeypox virus, which belongs to the orthopoxvirus genus. Concern has recently been expressed over the appearance of the human monkeypox virus and its severe clinical presentation that resembles smallpox. Currently, due to the decrescence of immunity among smallpox-vaccinated residents, and the accumulation of unvaccinated cohorts, people are generally susceptible to mpox. A cumulative number of 79 411 laboratory-confirmed cases of mpox and 50 fatalities have been reported to the World Health Organization from 110 countries between 1 January and 13 November 2022. This paper provides an overview of the epidemiology and clinical features of mpox, and control and prevention approaches for mpox to fully understand and prevent human infections.

KEYWORDS: Mpox; Epidemiology; Pathogeny; Characteristic; Prevention

1. Introduction

Since the first human cases of mpox (monkeypox) were discovered in the Congo in 1970, human cases of mpox have mostly been found in 11 African countries: Benin, Cameroon, the Central African Republic, the Democratic Republic of the Congo, Gabon, Cote d'Ivoire, Liberia, Nigeria, the Republic of the Congo, Sierra Leone, and South Sudan, with the Congo being the most severely impacted nation[1, 2]. After the eradication of smallpox, monkeypox virus infection in humans is the most significant infectious orthopoxvirus-related disease in the world today. In the past, there have been numerous instances of mpox outbreaks on a global scale[1, 3–7]. In 2003, the first outbreak of mpox outside of Africa occurred in the United States. There were 71 cases with patients aged from 1 to 51 years and a median age of 28 years[1, 3]. Thirty-nine years after the final case of mpox was recorded in Nigeria, verified cases of mpox were once more reported there in 2017. The mpox outbreak in Nigeria at the time was the largest outbreak of the evolutionary branch in West Africa[5]. Since then, new disseminated cases of mpox have also been reported in Nigeria, with a total of 869 suspected cases and 359 confirmed cases recorded between 2017 and 2022, with a preponderance of male patients[4–7].

The multinational outbreak of mpox in 2022 was the first widespread transmission of mpox outside of Central and West Africa. This study aimed to comprehensively describe the epidemiological and disease characteristics of mpox and to provide a basis for the development of preventive and control measures for the mpox epidemic.

2. Mpox outbreak in 2022

On 7 May 2022, the UK reported to the World Health Organization (WHO) a confirmed case of mpox, who had recently returned

✉To whom correspondence may be addressed. E-mail: zhdingm@mail.sysu.edu.cn

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

©2023 *One Health Bulletin* Produced by Wolters Kluwer- Medknow.

How to cite this article: Xiong HS, Tan JL, Zhang DM. Human monkeypox: Epidemiologic, pathogenetic and clinical characteristics, and prevention. One Health Bull 2023; 3; 3.
https://www.doi.org/10.4103/2773-0344.369071

Article history: Received 11 October 2022 Revision 27 November 2022
Accepted 1 December 2022 Available online 9 February 2023

from Nigeria. Subsequently, confirmed cases of mpox emerged in countries where the disease was not previously endemic, and the WHO issued a news release on May 21 confirming the emergence of monkeypox outbreaks in several countries[8]. Since then, the number of mpox cases from non-mpox endemic countries or regions has been on the rise. On 21 July 2022, the Director-General of WHO identified the outbreak of mpox in 72 countries as a public health emergency of international concern[9].

Within the period 1 January 2022 to 13 November 2022, a total of 79411 laboratory-confirmed cases were reported to WHO from 110 countries and regions[10]. The largest number of cases were reported from countries in Europe and the Americas, and mpox cases were predominantly found in men, with the majority occurring in men who have sex with men (MSM)[9, 11]. In a study that included 528 confirmed cases of mpox, 98% of those infected were gay or bisexual; 75% were white, and the median age was 38 years[11]. The WHO reported that mathematical models estimate that the basic reproduction number (R_0) for monkeypox was above 1 in the MSM group and below 1 in other groups[9].

3. Pathogenetic characteristics

The monkeypox virus can infect both humans and animals. It is a double-stranded DNA virus that belongs to the same virus genus as the smallpox virus, which causes smallpox. And the smallpox is a disease that only affects humans and cannot be transmitted between animals. The monkeypox virus was first discovered in 1958 by the Copenhagen laboratory in crab-eating macaques, hence named the monkeypox virus. Monkeypox virus is a brick-shaped virus with a size of 200-250 nm[12]. The virus has two evolutionary branches, one in West Africa and one in Central Africa, which have different levels of virulence, with the Central African evolutionary branch being more virulent. Previous epidemiological studies have found a higher mortality rate among patients infected with the Central African evolutionary branch compared to the West African evolutionary branch[1]. A study that compared the virulence of the two branches of the monkeypox virus in crab-eating monkeys found that the Central African branch caused greater morbidity and mortality, indicating that the Central African evolutionary branch is more virulent[13]. The West African evolutionary branch was responsible for the outbreak of mpox in countries around the world in 2022.

4. Clinical features

In 1970, the first human case of mpox was discovered in the Congo[14]. The average incubation period of mpox is 8.3 days (5-13 days)[15], with most patients presenting with fever, headache, and weakness, followed by a highly characteristic pustular rash. Usually, the rash first appears on the face and then rapidly appears on the body in a centrifugal distribution. The rash may cover the entire body, including the palms of the hands and soles of the feet, but unlike smallpox, many patients with mpox also develop enlarged lymph nodes in the upper jaw, neck, and groin[16–18].

Mpox is a self-limiting disease, with symptoms usually resolving within 2-4 weeks. However, severe cases of mpox can also lead to death, with a mortality rate of around 3%-6%[2]. Some people, particularly youngsters, pregnant women, or those with weakened immune systems as a result of other medical conditions, may be more severely affected by mpox infections, including death[8]. Furthermore, the monkeypox virus can infect both the mother and the fetus during pregnancy, which can result in undesirable pregnancy outcomes such as spontaneous abortion, preterm delivery, or stillbirth[5, 19].

5. Epidemiological characteristics of mpox

The main source of mpox infection is animals infected with the monkeypox virus, such as woodchuck[20, 21], Gambian giant rat[22], etc. Patients infected with mpox can also become the source of infection[5].

Contact transmission of the monkeypox virus from animals to people is the most common method, such as contact with sick animals' bodily fluids or exudates, or bites and scratches from infected animals. Using data from the 2003 mpox outbreak, researchers in the United States discovered that patients who had "complex contact" with mpox-infected animals, such as bites or scratches, were more likely to develop systemic clinical manifestations or end up in the hospital than those who had only "non-invasive contact" with the animals, such as touching or cleaning the cages where the animals lived[23]. Mpox can also be spread from person to person, mainly through contact transmission and droplet transmission[2, 5, 22, 24]. Moreover, the monkeypox virus can be transmitted from the mother to the fetus through the placenta[19]. Several studies have shown limited human-to-human transmission of mpox[5, 21, 25], but as many as six consecutive human-to-human transmission occurred in the 2003 mpox outbreak

in Congo[26]. A healthcare worker in the United Kingdom was diagnosed with mpox in 2018 after being exposed to a confirmed mpox patient, presumably through contact with infected bed linens. This is the first confirmed human-to-human transmission of mpox outside Africa[24, 27].

In this multi-country mpox outbreak in 2022, 95 % of clinically diagnosed patients were suspected of human-to-human transmission through close contact[11]. And there was evidence that sexual intercourse can spread the mpox[28]. A study has isolated monkeypox virus DNA in a semen sample of a monkeypox patient[29].

Due to the decrescence of immunity among smallpox-vaccinated residents, and the accumulation of unvaccinated cohorts, people are generally susceptible to mpox[30]. Among them, people who have had contact with suspected or confirmed cases, as well as those who have been to Central or West Africa, are at an increased risk of contracting mpox.

6. Preventive controls

Currently, there is no specific vaccine for mpox, and previous study has shown that vaccination against smallpox can prevent orthopoxviral infection, including monkeypox virus[17]. The Congo officially stopped vaccinating against smallpox in 1980, and an active mpox surveillance program in Congo from 1981 to 1986 found that the smallpox vaccine could protect the population from mpox with an efficacy rate of about 85%[31]. The incidence of mpox in Congo increased nearly 20-fold between 2005 and 2007, one of the main reasons being that the cessation of smallpox vaccination resulted in a marked decline in population immunity to poxviruses. With the development of vaccines and changes in mpox epidemic trends, in recent years, several companies have been developing a new generation of poxvirus vaccines, which has an effective rate of 85%. It has been approved by the United States, Canada, etc. for the prevention of mpox or smallpox infection in high-risk groups, but has not been widely used in the whole population[2, 32–34].

Since most cases of mpox in humans are infected from animals, in order to prevent mpox infection, it is necessary to avoid contact with wild animals, especially sick or dead wild animals, including animal excrement. Additionally, all foods containing animal parts must be cooked thoroughly before consumption. In order to reduce the risk of the virus being introduced through animals, the trade of rodents or primates from Africa can be restricted, the quarantine standards for animals can be strictly enforced, and any animals that may have come into contact with animals infected with mpox should be isolation[2]. After the outbreak of mpox in the United States in 2003, the US Centers for Disease Control and Prevention and the US Food and Drug Administration jointly banned the import of all rodents from Africa[21].

Contact transmission is the main route of spreading mpox among individuals, such as contact with the patient's body fluids, secretions from ulcers, or contaminated clothing. During mpox outbreaks, health care workers and household members of mpox patients are at higher risk of infection. Therefore, standard precautions need to be taken when caring for mpox patients or collecting samples. During the transport of the samples, they also need to be packaged according to the standards for infectious substances.

Health education is an integral part of mpox prevention measures. Community manager and elected officials could hold some public lectures to raise awareness about monkeypox virus transmission, actions to reduce the risk of onward transmission to others and clinical presentation in communities, including limiting skin to skin contact or other forms of close contact with others while symptomatic, promoting the reduction of the number of sexual partners and so on. What's more, non-governmental organizations, civil society, and behavioral scientists are supposed to provide guidance on methods and tactics to prevent stigmatizing any individuals or population groups in the implementation of appropriate interventions, to encourage timely testing, access to preventive measures, and clinical care, and to stop the spread of the monkeypox virus without being noticed[9].

7. Conclusions

With increasingly close international communication, infectious diseases have become a global challenge. Mpox is a zoonotic disease that can be transmitted to humans through wild animals. Because of the severity and transmissibility of this virus, stringent controls are required even in nations where mpox is not widespread now. In the One Health perspective, the government and the related departments should collaborate with researchers to facilitate research with mpox, developing diagnostic assays and antiviral compounds for detecting and treating mpox and draw the clinical experiences to help guide future decisions.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Funding

The study received no extramural funding.

Authors' contributions

Zhang DM designed the study and secured the project. Xiong HS and Tan JL collected, screened, and analyzed the theses and data. Xiong HS and Tan JL drafted the manuscript and finalized it together. Zhang DM reviewed and approved the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

References

[1] Bunge EM, Hoet B, Chen L, Lienert F, Weidenthaler H, Baer LR, et al. The changing epidemiology of human monkeypox-A potential threat? A systematic review. *PLoS Negl Trop Dis* 2022; **16**(2): e0010141.

[2] World Health Organization. *Monkeypox*. [Online] Available from: https://www.who.int/news-room/fact-sheets/detail/monkeypox. [Accessed on 13 August 2022].

[3] Centers for Disease Control and Prevention. Update: Multistate outbreak of monkeypox--Illinois, Indiana, Kansas, Missouri, Ohio, and Wisconsin, 2003. *Morb Mortal Wkly Rep* 2003; **52**(27): 642-646.

[4] United Nations Office for the Coordination of Humanitarian Affairs. *Update on Monkeypox (MPX) in Nigeria (Epi–week 29)*. [Online] Available from: http://hub.ccouc.cuhk.edu.hk/news-and-info/update-monkeypox-mpx-nigeria-epi-week-29-july-24-2022. [Accessed on 8 July 2022].

[5] Yinka-Ogunleye A, Aruna O, Dalhat M, Ogoina D, McCollum A, Disu Y, et al. Outbreak of human monkeypox in Nigeria in 2017–18: A clinical and epidemiological report. *Lancet Infect Dis* 2019; **19**(8): 872-879.

[6] Yinka-Ogunleye A, Aruna O, Ogoina D, Aworabhi N, Eteng W, Badaru S, et al. Reemergence of human monkeypox in Nigeria, 2017. *Emerg Infect Dis* 2018; **24**(6): 1149-1151.

[7] World Health Organization. *Monkeypox–Nigeria (Disease outbreak news)*. [Online] Available from: https://web.archive.org/web/20181008195024/http://www.who.int/csr/don/05-october-2018-monkeypox-nigeria/en/. [Accessed on 25 July 2022].

[8] World Health Organization. *Multi–country monkeypox outbreak in non–endemic countries*. [Online] Available from: https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON385. [Accessed on 31 July 2022].

[9] World Health Organization. *Second meeting of the International Health Regulations (2005) (IHR) Emergency Committee regarding the multi–country outbreak of monkeypox*. [Online] Available from: https://www.who.int/news/item/23-07-2022-second-meeting-of-the-international-health-regulations-(2005)-(ihr)-emergency-committee-regarding-the-multi-country-outbreak-of-monkeypox. [Accessed on 23 July 2022].

[10]World Health Organization. *Multi–country outbreak of monkeypox, External situation report #10–16 November 2022*. [Online] Available from: https://www.who.int/publications/m/item/multi-country-outbreak-of-monkeypox--external-situation-report--10---16-november-2022. [Accessed on 23 November 2022].

[11]Thornhill JP, Barkati S, Walmsley S, Rockstroh J, Antinori A, Harrison LB, et al. Monkeypox virus infection in humans across 16 Countries-April-June 2022]. *N Engl J Med* 2022; **387**(8): 679-691.

[12]Swiss Institute of Bioinformatics. *Orthopoxvirus*. [Online] Available from: https://viralzone.expasy.org/149?outline=all_by_species. [Accessed on 25 August 2022].

[13]Chen NH, Li GY, Kathryn Liszewski M, Atkinson JP, Jahrling PB, Feng zh,, et al. Virulence differences between monkeypox virus isolates from West Africa and the Congo basin. *Virology* 2005; **340**(1): 46-63.

[14]Marennikova S S, Selunina EM, Mal'ceva NN, Cimiskjan KL, Macevic GR. Isolation and properties of the causal agent of a new variola-like disease (monkeypox) in man. *Bull World Health Organ* 1972; **46**(5): 599-611.

[15]Nolen LD, Osadebe L, Katomba J, Likofata J, Mukadi D, Monroe B, et al. Extended human-to-human transmission during a monkeypox outbreak in the democratic republic of the Congo. *Emerg Infect Dis* 2016; **22**(6): 1014-1021.

[16]Reynolds MG, Damon IK. Outbreaks of human monkeypox after cessation of smallpox vaccination. *Trends Microbiol* 2012; **20**(2): 80-87.

[17]McCollum AM, Damon IK. Human monkeypox. *Clin Infect Dis* 2014; **58**(2): 260-267.

[18]Kantele A, Chickering K, Vapalahti O, Rimoin AW. Emerging diseases-the monkeypox epidemic in the Democratic Republic of the Congo. Clin *Microbiol Infect* 2016; **22**(8): 658-659.

[19]Mbala PK, Huggins JW, Riu-Rovira T, Ahuka SM, Mulembakani P, Rimoin AW, et al. Maternal and fetal outcomes among pregnant women with human monkeypox infection in the Democratic Republic of Congo. *J Infect Dis* 2017; **216**(7): 824-828.

[20]Guarner J, Johnson BJ, Paddock CD, Shieh WJ, Goldsmith CS, Reynolds MG, et al. Monkeypox transmission and pathogenesis in prairie dogs. *Emerg Infect Dis* 2004; **10**(3): 426-431.

[21]Reed KD, Melski JW, Graham MB, Regnery RL, Sotir MJ, Wegner MV, et al. The detection of monkeypox in humans in the Western Hemisphere. *N Engl J Med* 2004; **350**(4): 342-350.

[22]Giulio DBD, Eckburg PB. Human monkeypox: An emerging zoonosis. *Lancet Infect Dis* 2004; **4**(1): 15-25.

[23]Reynolds MG, Yorita KL, Kuehnert MJ, Davidson WB, Huhn GD, Holman RC, et al. Clinical manifestations of human monkeypox influenced by route of infection. *J Infect Dis* 2006; **194**(6): 773-780.

[24]Vaughan A, Aarons E, Astbury J, Brooks T, Chand M, Flegg P, et al. Human-to-human transmission of monkeypox vrus, United Kingdom, October 2018. *Emerg Infect Dis* 2020; **26**(4): 782-785.

[25]Jezek Z, Grab B, Dixon H. Stochastic model for interhuman spread of monkeypox. *Am J Epidemiol* 1987; **126**(6): 1082-1092.

[26]Learned LA, Reynolds MG, Wassa DW, Li Y, Olson VA, Karem K, et al. Extended interhuman transmission of monkeypox in a hospital community in the Republic of the Congo, 2003. *Am J Trop Med Hyg* 2005; **73**(2): 428-434.

[27]Mauldin MR, McCollum AM, Nakazawa YJ, Mandra A, Whitehouse ER, Davidson W, et al. Exportation of monkeypox virus from the African continent. *J Infect Dis* 2022; **225**(8): 1367-1376.

[28]Heskin J, Belfield A, Milne C, Brown N, Walters Y, Scott C, et al. Transmission of monkeypox virus through sexual contact-A novel route of infection. *J Infect* 2022; **85**(3): 334-363.

[29]Lapa D, Carletti F, Mazzotta V, Matusali G, Pinnetti C, Meschi S, et al. Monkeypox virus isolation from a semen sample collected in the early phase of infection in a patient with prolonged seminal viral shedding. *Lancet Infec Dis* 2022; **22**(9): 1267-1269.

[30]Nguyen PY, Ajisegiri WS, Costantino V, Chughtai AA, Maclntyre CR. Reemergence of human monkeypox and declining population immunity in the context of urbanization, Nigeria, 2017-2020. *Emerg Infect Dis* 2021; **27**(4): 1007-1014.

[31]Fine PE, Jezek Z, Grab B, Dixon H. The transmission potential of monkeypox virus in human populations. *Int J Epidemiol* 1988; **17**(3): 643-650.

[32]Kennedy JS, Greenberg RN. IMVAMUNE: Modified vaccinia Ankara strain as an attenuated smallpox vaccine. *Expert Rev Vaccines* 2009; **8**(1): 13-24.

[33]U.S. Food & Drug Administration. *FDA approves first live, non–replicating vaccine to prevent smallpox and monkeypox*. [Online] Available from: https://www.fda.gov/news-events/press-announcements/fda-approves-first-live-non-replicating-vaccine-prevent-smallpox-and-monkeypox. [Accessed on July 25 2022].

[34]UK Health Security Agency. *Recommendations for the use of pre and post exposure vaccination during a monkeypox incident*. [Online] Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1083791/Recommendations-for-pre-and-post-exposure-vaccination-during-a-monkeypox-incident-17-june-2022.pdf. [Accessed on 17 June 2022].

Publisher' s note

The Publisher of the *Journal* remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.