Saied *et al.*
The Egyptian Journal of Internal Medicine (2023) 35:46
https://doi.org/10.1186/s43162-023-00233-0

The Egyptian Journal of Internal Medicine

REVIEW

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Mpox and healthcare workers — a minireview of our present knowledge

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Abstract

Introduction Workers in the healthcare industry form the backbone of health systems everywhere. In the face of global health crises like the current monkeypox (mpox) outbreak, healthcare workers like doctors, dentists, pharmacists, nurses, midwives, paramedics, administrators, support staff, laboratory technicians, and community health workers all play crucial roles in providing care and containing the spread of the disease.

Aim Therefore, in the wake of concerns about mpox recurrence, we seek to shed light on the occupational transmission of mpox infection and the possible risk to healthcare personnel.

Results Contamination of the environment of the household of cases of mpox and environment of the patient care units with the viral DNA has been reported besides asymptomatic cases and detection of viral DNA in air samples; therefore, more research on non-lesion-based testing for human mpox infection for screening asymptomatic people, particularly among populations at high risk of infection, in the event of asymptomatic transmission and potential transmission via aerosols is necessary. Monitoring efforts can be aided by incorporating mpox testing into locations where people are more likely to contract illnesses and seek medical attention. We must take a precautionary infection control approach to control the spread of the virus while completing urgent research to understand better the human-to-human mpox transmission process.

Conclusions In this minireview, we discuss the potential routes of mpox transmission to healthcare and preventative strategies and measures that should be taken and considered.

Keywords Mpox, Healthcare, Risk, Personal protective equipment, Contact tracing, Transmission

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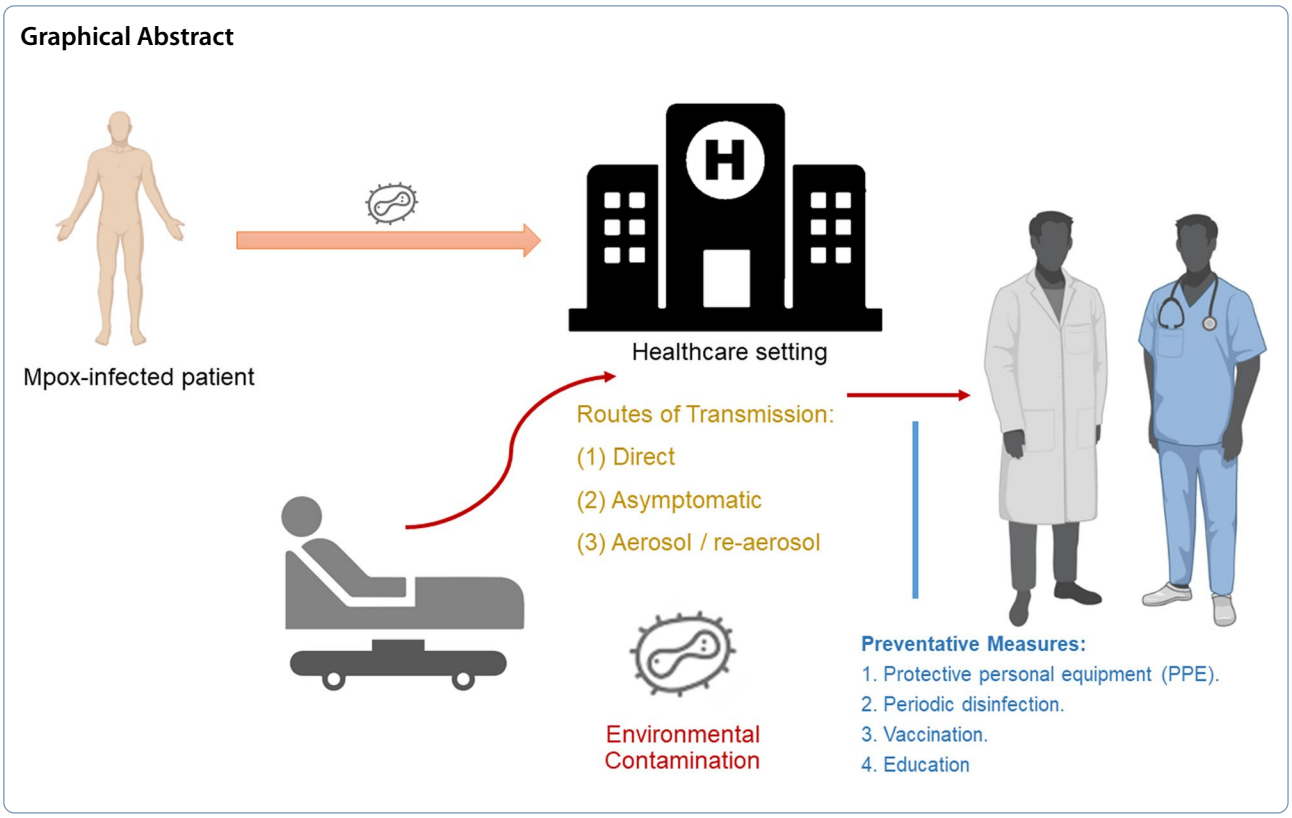

Introduction

Mpox (formerly known as monkeypox) is a zoonotic disease that has emerged in West and Central Africa, transmitting from animals to humans through contact with animal reservoirs, such as rope squirrels [1, 2]. In the same family as the smallpox virus, mpox is an *Orthopoxvirus* infection of the skin and mucous membranes. Infection mostly impacts the skin, although it can also involve different degrees of the eyes, lungs, brain, gastrointestinal tract, and other organs. Since the 1970s, there has been a continuous rise in the number of mpox cases in humans, especially in the Democratic Republic of Congo (DRC). The case fatality rate (CFR) due to the disease (overall) is 8.7%. The CFR with the Central African clade (Clade I) is greater than that with the West African clade (Clade II) [2]. The transmission of the mpox virus mostly occurs through direct contact with infected lesions or bodily fluids. Mpox spread related to travel and import are responsible for outbreaks occasionally outside Africa since 2003. Interactions with people or animals that have the mpox virus are risk behaviors that increase the risk of contracting the disease. However, sustained human-to-human transmission was reported in the mpox outbreak in Nigeria in 2017 [3, 4] and becomes more obvious in the 2022 mpox outbreak in non-endemic areas, such as Europe and the USA.

Mpox outbreak was declared as a Public Health Emergency of International Concern (PHEIC) by the World Health Organization (WHO) on July 23, 2022, and to lessen the related stigma, the WHO suggested using the Mpox as a new name for the illness on November 28, 2022. The relevance of the disease globally is evident from the history of outbreaks beyond the territory of Africa. The abrupt and unexpected emergence of the mpox virus in numerous non-endemic places suggests that there has been some undetected transmission in the past, followed by recent amplifier events [5]. Variations in the mpox course can result from different exposure pathways to course [6]. It is advised to frequently review the available guidelines because the clinical presentation of Mpox is always altering [7].

Toll-like receptors 2 and 4 (TLR2 and TLR4) play a considerable role in the host defense against microorganisms [8] and elicit major contributions to the pathogenesis of MPOXV, as the latter inhibits TLRs-dependent innate responses [9]. To combat monkeypox infections, CD4 + T cells are complex and priming CD8 + T cells to differentiate into effector and memory T cells to promote B-cell-dependent antibody responses [10]. CD11a is to normal lymphocyte development [11]. Some studies confirm that NK cells infected with MPXV are often associated with a Th1 response, NK-cell activation, IFN-γ production,

and T-cell activation [12]. TGF-β1 suppresses the functions of Th1 and Th2, NK cells, and CD4 + effector cells and promotes the generation of Treg cells. While promoting immune responses, TGF-β1 induces the generation of Th1 cells in combination with IL-6 [13]. IL-10 is an immune-regulatory cytokine that has an anti-tumor effect [14] and is observed in patients with serious MPV disease [15].

Mpox and atypical transmission

Although the epidemiological investigations do not link the aerosol transmission among people and the current and previous mpox outbreaks [16], infection via aerosolized mpox virus has been reported in nonhuman primates [17–20]. Characterization of an inhalation exposure system for delivering mpox virus was done wherein the development of an inhalation mpox model in nonhuman primate (NHP), viz., *cynomolgus macaques*, was developed. The mass median aerodynamic diameter (MMAD), which varies from 1.08 to 1.15 μm [17], of the aerosol particles utilized in the study demonstrated that they were small enough to enter the alveoli. Individual animals were exposed utilizing the flow-through design of the Battelle large animal exposure system, with the animal's head placed inside an exposure chamber. Out of the six animals used in the study, only two animals survived as they received the lowest exposure doses. The rest four animals either died or were euthanized as they were at the point of death. The pathogenesis of aerosol mpox virus infection is comparable to that of smallpox because the infection starts in the respiratory mucosa and spreads to nearby lymph nodes before the primary viremia [16].

The Mpox virus can live in aerosols for up to 90 h and is stable in the environment [21]. Human-to-dog transmission was documented in the ongoing mpox outbreak. A case of human-to-animal transmission is also reported [22]. Mpox virus has been thought to have spread to a male Italian greyhound dog accompanying two gay men, one Latin and human immunodeficiency virus (HIV) positive and the other a white man (HIV negative) who are partners (non-exclusive) living in a common household [23]. Mucocutaneous lesions are observed in the dog, such as pustules at the abdomen and ulceration (thin) in the anal region. By applying PCR, the dog has tested positive for mpox. Notably, samples from the Latin man and the dog have revealed the presence of viruses of the same clade (clade IIb) and lineage (B1) that spreads in non-endemic nations. A total of 100% sequence homology has been detected among the virus infecting the HIV-positive Latin man and the dog [23]; in addition, dog-to-human transmission was reported in the 2003 US outbreak with suspicion of aerosol transmission is one of the expected routes for mpox transmission from prairie dogs to humans [6, 16, 24] without reported human-to-human transmission [25]. Strikingly, mpox infection in various animals is asymptomatic [26, 27].

Mpox in healthcare settings/patient care environments

In the face of global health crises like the current mpox outbreak, healthcare workers like doctors, dentists, pharmacists, nurses, midwives, paramedics, administrators, support staff, laboratory technicians, and community health workers all play crucial roles in providing care and containing the spread of the disease. In both the previous mpox outbreaks and the ongoing mpox outbreak, cases of human mpox linked to healthcare have been documented [28, 29]. Mpox virus DNA contamination of patient care environments [30] and domestic environments [31] has been documented. Healthcare workers and young children (neonatal mpox virus infection) [32] are at risk for severe disease. Although rare, some nosocomial cases have been reported [33, 34]. In the Central African Republic, nosocomial transmission of mpox has previously been documented [35]. In 2003, there may have been an asymptomatic illness in a hospital environment in the USA. This outbreak in the USA was linked to contact with infected prairie dogs. In this instance, the potential of transmission from one person to another was a concern. A minimum of one encounter with a pox-infected patient in an unprotected manner, such as using gloves, a gown, and either a surgical mask or an N95 respirator, had been reported in more than three-quarters of the healthcare workers (HCWs) exposed. One of the HCWs showed evidence of infection by *Orthopoxvirus* recently, as found in laboratory findings. This kind of infection with the *Orthopoxvirus* may be attributed to infection recently or immunization against smallpox [35]. Because anti-vaccinia virus serologies resulting from smallpox vaccination and anti-monkeypox virus serologies are cross-reactive, known smallpox vaccination histories can aid in interpreting the anti-*Orthopoxvirus* serology results. The single-positive IgM result might not be caused by a recent vaccine or infection, and it is unknown how long IgM persistence typically lasts following smallpox vaccination [35]. In the UK in 2018, a healthcare worker contracted mpox, and the cause was thought to have been exposed to the virus while changing bedding [33]. There were additional reports of occupational infection in a healthcare worker who treated a patient with confirmed mpox [36].

In the ongoing global mpox outbreak in 2022, asymptomatic infections are probably going to happen (suspected in previous mpox outbreaks) [27, 37]. Multiple PCR-positive samples have been reported in asymptomatic individuals [38]. In Belgium, De Baetselier and colleagues [39] reported that the mpox virus is able to transmit

from asymptomatic patients to close contacts, indicating silent spread with undetected cases and subsequently lost transmission routes. In France [40], the mpox virus was detected in anorectal samples using PCR in three asymptomatic men with no cutaneous lesions. Asymptomatic or paucisymptomatic people may spread the mpox virus [41]. Further epidemiological research is necessary to assess the potential relevance of the respiratory mode of infection in the mpox virus outbreak in 2022 in light of the discovery of mpox virus DNA in droplets and aerosols with bearing in mind cases of asymptomatic infection [37]. Healthcare workers should emphasize the significance of effective immunization campaigns and be knowledgeable about various mpox transmission modes, including a potential asymptomatic spread [42]. More research on non-lesion-based testing for human mpox infection to screen asymptomatic people, particularly among populations at high risk of infection, in the event of asymptomatic transmission and potential transmission via aerosols, is necessary.

Contamination of the environment of the household of cases of mpox and of the patient care units with viral DNA has been reported. After 3 days of admission to the hospital, the virus (replication competent) has been detected in a patient household. The virus has also been detected in the air vents and other non-touch surfaces at a distance greater than 1.5 m from the patient bed. It has led to the proposal that the mpox viral DNA in the dust, aerosols, or skin flakes can remain in suspension in the air through either droplets (respiratory) or from activities like the change of bedding. It requires a special mention here that as the environment of patient care is associated with surface contamination in a widespread manner, systemic approaches must be standardized to ensure proper cleaning of the surface of the hospital rooms and patients' households. Moreover, personal protective equipment (PPE) should be appropriately used and removed by health workers during patient care since viral DNA has been detected on PPEs as well. Further surgical masks should be worn by staff while changing the bedding material as there may be an association between the changing bedding and the suspension of viral particles [28].

Mpox in the surrounding patient's air

Recent two studies [43, 44] revealed the presence of mpox virus DNA in their collected air samples and patients' exhaled droplets. The two studies are related to symptomatic mpox in the UK and Spain (two countries in Europe) [43, 44]. Hernaez and colleagues [44] found the mpox virus DNA in aerosols, one of which was found to contain high concentrations of the mpox DNA virus. Strikingly, high quantities of mpox virus DNA were found in air samples, although patients were wearing an FFP2 mask, indicating that much higher levels may be exhaled when masks are not donned. Mpox virus was detected as viruses breathing aerosols or in fomites re-aerosolize aerosols [44]. Adding to the atypical presentation of the 2022 mpox outbreak, the statement of potential airborne transmission of the mpox virus should be cautiously treated [16]. Researchers have postulated that the presence of the mpox virus in respiratory droplets and aerosols could be linked to the current mpox transmission [16, 44]. As suggested by Hernaez and colleagues [44], the recent evidence for the identification of the mpox virus in the air raises the possibility that the mpox virus is also present in aerosols that travel longer distances (over 1.5 m). Hernaez and colleagues have reported that about 94% of mpox virus DNA detected inside exhaled droplet-containing masks from patients with mpox was a noninfectious virus. Moreover, all mpox virus DNA in aerosols collected from the medical consultation room were noninfectious viruses [44].

Mpox risk in intensive care unit

Patients with an emerging infectious illness (EID) might need an urgent procedure or intensive care unit (ICU) admission while purportedly contagious. The ICU environment would get contaminated by airborne pathogenic microorganisms from patients and equipment [45]. Therefore, any elective surgery in mpox-infected patients should be delayed until the lesions on the skin have healed. It is important to note that patients infected with the mpox virus may develop skin lesions like paronychia or abscess in the mucosa, which necessitates the urgency of surgical procedures. It is highly crucial that elective surgery in patients infected with the virus must be delayed until the patients recover from the skin lesions, meaning that the patients are not contagious anymore [46]. The essential component of ICU management strategies is monitoring airborne microorganisms to reduce hospital-acquired infections. With the use of biosensors and robotics, we can better comprehend the dynamics of airborne microorganisms and develop future infection prevention strategies [46, 47].

Mpox risk and challenges during healthcare practice

There are a number of additional risk factors that put healthcare professionals at risk of contracting viruses. Healthcare personnel who predominantly serve high-risk populations, e.g., men who have sex with men (MSM), the immunocompromised, and their household and workplace contacts, bear the brunt of mpox management when they fail to take appropriate measures at work due to patient mistrust and stigma. Furthermore, preventative measures, such as contact tracing and sufficient

follow-up of suspected cases, lack effective implementation in many countries. Simultaneously, there is a lack of access to medicines and vaccinations across the healthcare industry, affecting everyone from the front desk staff to doctors and nurses and from lab techs to aides to discharge planners. It was reported that patients are able to spread the mpox virus to a healthcare worker through a needlestick injury in Brazil [48], in France [49], and South Korea [50]; additionally, the fomite transmission route of mpox in healthcare workers was reported [51]. In California, USA, a case of non-needle stick MPXV transmission to an HCW was reported [52]. Mpox transmission may occur through direct inoculation from getting pierced and tattooed [53, 54]. New transmission networks for mpox could emerge along with changes in the disease's epidemiology, such as most patients in the tattoo parlor being female [53]. It exhorts people to pay closer attention to activities, involving close touch, like going to a tattoo parlor.

Workers in the medical field have a crucial role in the investigation, diagnosis, and direct care of patients with possible or proven mpox infections. Many medical professionals, though, acknowledged that they had concerns about their capacity to identify and treat patients accurately. It is exacerbated by the fact that the suspect may exhibit symptoms, such as a rash, similar to those of measles, chickenpox, or an STD. Testing fluid from a swab taken from a rash or eruption is presently the gold standard for diagnosing mumps. However, the ability to diagnose the disease necessitates advanced laboratory infrastructure and specialized equipment like polymerase chain reaction (PCR) assays, nucleic acid amplification tests, and GeneXpert assays, which may be challenging to carry out in limited-resource settings, thereby impeding the disease diagnosis and possibly exposing healthcare workers. Another risk concern for healthcare workers is that many countries still need vaccination despite the vaccination advice for healthcare professionals, who are regarded to be at high risk of exposure/infection.

Recommendations

Protection measures for healthcare providers must be put into place. As part of a larger strategic response to halt the mpox outbreak and strengthen the capacity of health systems to address this concern without sacrificing other pressing public health concerns, it is strongly advocated that countries develop and enforce necessary precautions and measures to protect healthcare workers.

(1) Sustaining the provision of sufficient PPE such as disposable isolation gowns, gloves, fluid-repellent surgical facemasks (FRSM), eye protection, and FFP3 respirators for personnel in areas with a high risk of mpox transmission is strongly advised. This is consistent with the global strategy of developing human resources for health towards Universal Health Coverage (UHC) and the Sustainable Development Goals (SDGs), which seeks to protect the rights of all healthcare employees and guarantee their safety while on the job.
(2) In addition, it is important to encourage preventive action in the event of a suspected case of mpox among healthcare professionals, such as through adherence to protective measures and infection control safety measures. This will greatly reduce the risk of infection spreading to more vulnerable groups, such as pregnant staff, elderly staff, and those with compromised immune systems.
(3) Vaccination of healthcare workers is needed in high-exposure areas.
(4) Negative pressure or airborne precaution rooms are unnecessary unless an aerosolizing procedure is performed.
(5) Using wet methods of cleaning; avoid things like dry dusting, sweeping, and vacuuming.
(6) A local procedure should be established focusing on each perioperative step to adapt to the environment and lower the risk of transmission for mpox-infected patients who might require urgent surgery.
(7) Increasing education on Mpox among HCWs, particularly regarding the virus's transmission dynamics and vaccines.
(8) Activities such as frequent hand disinfection and appropriate surface cleaning are widely recommended.

The cryptic spread of mpox requires us to define the animal reservoir of mpox and bolster diagnostic capacity in Africa [55]. Over 2018/2019–2022, the mutation rate was between 6 and 12 times higher than anticipated, and around 50 single-nucleotide polymorphisms (SNPs) separated the 2022 strain from the 2018/2019 strain [56]. Inadequate diagnostic capacity in Africa may have led to missing many aspects of diagnostic modalities and transmission routes of mpox [57]. We should not forget that according to our current knowledge, mpox clades are Clades I and II (IIa, IIb). Our recent evidence and literature are related to Clade IIb (which has low case fatality rate than Clade I). Understanding the nature of the current outbreak is crucial for effective use of the resources at hand. Cases can be identified. The scope of the outbreak is defined by implementing screening technologies in healthcare settings and maintaining a high degree of suspicion using evolving clinical case definitions. It will be vital to restrict new infections and interrupt transmission chains by isolating suspected and confirmed patients as soon as possible and then closely

monitoring and vaccinating their close contacts and healthcare personnel with high-risk exposures as needed [58, 59]. Community healthcare workers can help promote access to healthcare systems and aid in psychosocial support in developing nations like India, where 70% of the population lives in rural areas with minimal healthcare access. It is recommended that healthcare providers receive enough training to reduce the spread of mpox [60, 61]. Remembering the role that HCWs played during COVID-19 is crucial. As such, they played a significant role in facilitating contact tracking and the distribution of health facilities to conserved communities and outlying settlements. Patients may easily approach healthcare professionals if they have any health issues because of the great regard that the general people have for healthcare professionals. Patients are at risk because uncertified healthcare workers play a key role despite their lack of formal training. The increase of mpox infections in rural regions might be stopped, and the disease might be contained for longer if healthcare personnel was introduced and educated early on [62, 63]. Allocating appropriate resources to determine the disease's transmission pattern, zoonotic hosts, reservoirs, and vectors are always a good idea. In addition, we suggest allocating sufficient finances to offer incentives to healthcare personnel to inspire them to improve their performance.

Conclusion

Amid suspicion of mpox resurgence and rapid spread [64], monitoring efforts can be aided by incorporating mpox testing into locations where people who are more likely to contract illnesses seek medical attention. Mpox surveillance in wastewater will help in detecting mpox transmission, which will help curb its further spread [65]. We must take a precautionary infection control approach to control the spread of the virus while completing urgent research to understand better the human-to-human mpox transmission process. It is especially crucial to safeguard the MSM and other at-risk communities. Every healthcare professional who may have been exposed to the virus should get tested. They should also receive guidance on self-monitoring, isolating themselves, and reporting symptoms as soon as they appear, all of which will vary according on their risk level. Medical staff should be prepared to deal with any infectious disease outbreaks and educated on the potential dangers posed by the mpox virus. Among the healthcare personnels in the frontline, there is always opportunity for improvement of training as well as awareness. Awareness campaigns are most essential in primary care settings and settings associated with urgent care. The use of PPE should be encouraged especially among clinical staff members including nurses. Moreover, classification of exposure risk is also essential.

Abbreviations

CFR	Case fatality rate
DNA	Deoxyribonucleic acid
DRC	Democratic Republic of Congo
EID	Emerging infectious illness
FFP	Filtering face piece
FRSM	Fluid-repellent surgical face masks
HCWs	Healthcare workers
HIV	Human immunodeficiency virus
ICU	Intensive care unit
MMAD	Mass median aerodynamic diameter
MSM	Men who have sex with men
NHP	Nonhuman primate
PCR	Polymerase chain reaction
PPE	Personal protective equipment
SDGs	Sustainable Development Goals
SNPs	Single-nucleotide polymorphisms
STDs	Sexually transmitted diseases
UHC	Universal health coverage

Authors' contributions

All named authors have seen and agreed to the submitted version of the paper, and that the material is original, unpublished, and has not been submitted elsewhere.

Funding

None.

Availability of data and materials

Non-applicable.

Declarations

Ethics approval and consent to participate

Non-applicable.

Consent for publication

Non-applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 3 April 2023 Accepted: 14 June 2023
Published online: 26 June 2023

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