Advances in Infectious Diseases, 2025, 15(1), 110-127
https://www.scirp.org/journal/aid
ISSN Online: 2164-2656
ISSN Print: 2164-2648

Prevention Treatment and Management Strategies for Monkeypox Virus Infection in Pregnant and Breastfeeding Women: A Systematic Review

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How to cite this paper: Eva, M.A., Ovi, M.A.R., Akhter, M.S., Tanjin, R., Akter, R., Samapti, M.M.S., Masuma, R. and Rahman, M.A. (2025) Prevention Treatment and Management Strategies for Monkeypox Virus Infection in Pregnant and Breastfeeding Women: A Systematic Review. *Advances in Infectious Diseases*, **15**, 110-127.
https://doi.org/10.4236/aid.2025.151009

Received: December 30, 2024
Accepted: February 21, 2025
Published: February 24, 2025

Abstract

Background: Monkeypox (Mpox) is an infectious disease caused by the virus, which has become a global concern in recent years. As a result of its outbreak, the World Health Organization (WHO) has twice declared monkeypox a global emergency, in June 2022 and on 14 August 2024. In cases of such diseases, pregnant and breastfeeding women are typically considered a sensitive or high-risk group; however, very few studies have been published on that group. **Objective:** This review aims to evaluate the risks of monkeypox virus infection in pregnant and breastfeeding women, assessing prevention strategies, safety measures, treatment options, and management protocols. **Methods:** we systematically searched for desired data in PubMed, ScienceDirect, Wiley Online, Scilit, and Google Scholar from 2009 to 2024. After removing duplicates, the search yielded 2031 results, of which 49 full-text papers were assessed for eligibility. From these, 32 studies were included in the final analysis. **Results:** It has been established that Mpox infection contributes to adverse maternal outcomes and complications such as miscarriage, fetal death, congenital Mpox, etc. This review noted that although there are some accessible guidelines for the treatment of Mpox in general, there is a severe lack of comprehensive protocols for pregnant and breastfeeding mothers. This article covers precautions such as vaccination and isolation, available therapies like

tecovirimat, and guidelines on fetal monitoring. **Conclusion:** Finally, this paper proposes an integrated defense and treatment system for monkeypox prevention in pregnant and breastfeeding women, potentially aiding in determining prevalence and contributing to the third number goal of the Sustainable Development Goal (SDG).

Keywords

Prevention, Treatment, Management, Monkeypox Infection, Pregnant Women, Breastfeeding Women

1. Introduction

The remarkable rate at which new disorders are affecting both the human and animal populations is a major source of concern for the veterinary and public health professions. A zoonotic disease known as Mpox was primarily discovered in monkeys in Denmark in 1958. The monkeypox virus (MPXV) is responsible for the outbreak of Mpox disease. This virus belongs to the *Poxviridae* family and is an enveloped double-stranded DNA virus from the genus *Orthopoxvirus* [1] [2]. The virus has two unique classes: class I, which includes subclass Ia and Ib, and class II, consisting of subclass IIa and IIb [3] [4]. The early symptoms of monkeypox are different from those of smallpox in that they comprise fever, headache, myalgia, fatigue, and lymphadenopathy which may persist for a duration of 2 to 4 weeks [5] [6]. Mucosal blisters appear in the mouth area after a period of one to two days, and then skin lesions appear mainly on the skin of the face and other parts of the body [5] [7].

In the country of the Democratic Republic of the Congo, the first instance of Mpox in humans was documented in 1970 [1] [8] [9]. As of 2022, 89 nations, domains, and regions—six WHO regions—have reported instances of Mpox. As of August 7, 2022, the ten nations with the largest number of events revealed around the world are the United States (n = 7510), Spain (n = 4577), Germany (n = 2887), United Kingdom (n = 2759), France (n = 2239), Brazil (n = 1721), the Netherlands (n = 959), Canada (n = 957), Portugal (n = 710), and Italy (n = 505).

These nations account for 89% of all cases recorded globally to date [10]. The overall number of cases documented those dramatically the previous year, and as of now, this year's total—more than 14,000 illnesses and 524 deaths—has surpassed that of the previous year. Mpox was classified as a public health emergency of international concern (PHEIC) by the WHO on August 14, 2024.

Expectant mothers exhibit comparable clinical features to non-pregnant mothers, but they may experience more severe changes over time, making them a higher risk category. Concerns regarding fetal viability, the potential for vertical transfer, and the birth outcome exist along with the clinical implications for the mother. It has been established that infection with MPXV can cause miscarriages and fetal mortality during pregnancy [11]. The main consequences for mothers

were early labor, miscarriage, need for hospitalization or critical care, as well as death. Congenital features include microcephaly, preterm, underweight for gestational age, underweight at delivery, micro-maturity, and congenital abnormalities [12].

Breastfeeding mothers with monkeypox face several risks. Direct contact during breastfeeding, especially if there are lesions on or around the breast, can spread the virus (Centers for Disease Control and Prevention [13]. Although the virus's presence in human breast milk is unknown, research on related viruses in other animals points to possible transmission hazards [14]. Preventing transmission during nursing is crucial because infants who have monkeypox are more likely to experience serious consequences. To protect their infants from these hazards, the Centers for Disease Control and Prevention (CDC) advises moms who have monkeypox to temporarily stop nursing until they are completely recovered [13].

Earlier monkeypox guidelines emphasized containment in endemic areas, principally by isolation and smallpox-based vaccines, which carried greater risks of side effects, particularly in immunocompromised individuals like pregnant & breastfeeding women [14]. The effectiveness of medicines and diagnostics was reduced in locations with minimal resources. Furthermore, care was inconsistent since previous guidelines lacked explicit recommendations for vulnerable groups, such as pregnant people. These limitations underlined the need for globally adaptable and inclusive techniques, which are currently addressed in modern recommendations that prioritize fair access and individualized interventions.

Although there are numerous studies on Mpox in general, there is a considerable lack of information regarding the effect of this disease on pregnant and breastfeeding women as a special group and the integrated immune system to deal with it. As a result, there are general guidelines regarding prevention treatment & management to deal with this disease, but it is not specified how these will be in the case of pregnant & breastfeeding women. In some research papers, considering pregnant & breastfeeding women as a special group, the information related to prevention, treatment & management has been presented separately, but the necessary information on these issues has not been presented together as part of an integrated defense system. Therefore, this systemic review has been tried to present crucial information regarding the prevention, treatment, and management of monkeypox virus infection in pregnant & breastfeeding women as part of an integrated defense system. Moreover, this review will partially contribute to achieving the third goal of the SDG (Good Health and Well-Being: Ensuring Healthy Lives and Promoting the Well-being for All at All Ages) by presenting significant information and strategies concerning protecting mothers and children from infection with Mpox through a consolidated safeguarding network.

2. Methods

2.1. Study Searching and Selection Strategy

To find relevant papers on the management, prevention, and treatment of mon-

keypox virus (Mpox) infection in pregnant and lactating women, a thorough literature search was carried out. Studies released from January 2009 to September 2024 were included in the search. PubMed, ScienceDirect, Wiley Online, Scilit, and Google Scholar were the electronic databases that were searched. In addition to Along with the Boolean operators (AND), the following targeted keywords were used for search in a given combination: "Prevention and Treatment of Monkeypox in Pregnant Women", "Treatment of Mpox in Pregnant Women", "Management of Mpox in Pregnant and Breastfeeding Women", "Treatment of Mpox in Breastfeeding Women", "Prevention of Mpox in Breastfeeding Women" "Monkeypox and Pregnancy".

Additionally, we examined the list of references of the selected papers to identify pertinent studies. Then, the two distinct researchers conducted the initial and secondary screenings to evaluate the eligibility of the publications following the recommendations of the preferred reporting items for systematic reviews and meta-analyses (PRISMA).

2.2. Inclusion and Exclusion Criteria

The following criteria were used to determine which studies were included or eliminated to guarantee quality and relevance.

2.2.1. Inclusion Criteria

We contained the studies that met the requirements, including original English-language papers with adequate relevant information, published between the timelines with full-text availability, offering prevention, treatment, and management guidelines for pregnant and breastfeeding women.

2.2.2. Exclusion Criteria

We eliminated the papers that met the following criteria: duplicate publications, review papers, abstracts from conferences, editorials and letters, papers written in languages other than English, research that is not specifically focused on the target group, offering guidance on prevention and treatment processes to the general population and the papers highlighting the details of a global outbreak or that is not directly relevant to this study.

2.3. Data Collection and Screening

To eliminate duplicates, the 2031 results from the search were inserted into a reference system for scrutinization. A two-step screening procedure was used for the inclusion and quality assessment of the studies.

1) Title and Abstract Screening: Articles were scrutinized to make sure they addressed the topic of the study.

2) Full-Text Review: The inclusion and exclusion criteria were used to determine which research studies were suitable for inclusion.

Following the review, a title and abstract screening process, eligibility was determined for 49 full-text papers. Among these 32 studies were included in this

study for final qualitative and quantitative synthesis. Seventeen papers were disqualified because they were irrelevant to the main goal of the study, could not be accessed in full, or were not in English (Figure 1). The results were combined to give a thorough grasp of the effects of MPXV on expectant and nursing mothers, paying special emphasis to clinical results, possible hazards, and practical treatment techniques. To assess the formal quality and reduce the risk of biased analysis of the included studies, the data extraction form was reviewed by two independent researchers. The selection procedure and results were recorded using a PRISMA flow diagram.

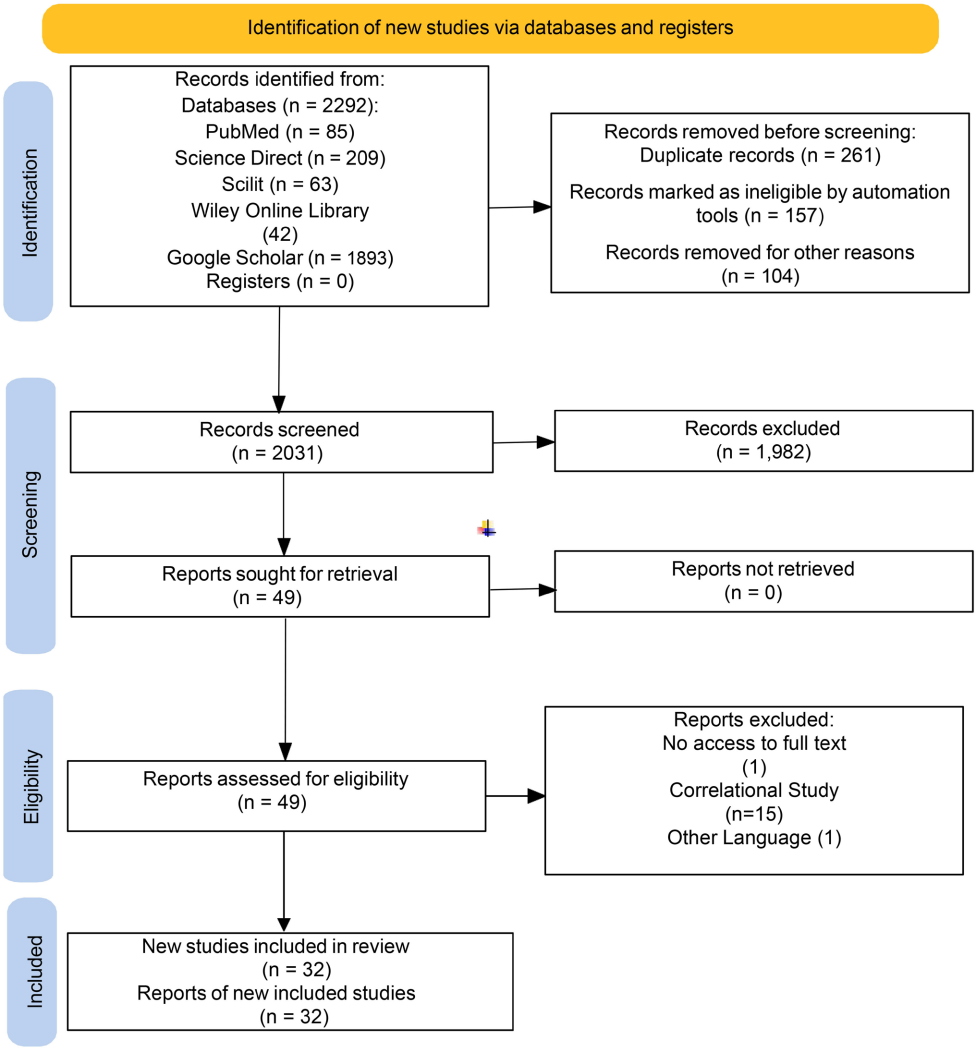

Figure 1. PRISMA flow diagram outlining the steps involved in data searching and collection.

3. Fundamentals about the Mpox Virus

Among the *Poxviridae* family, the *orthopoxvirus* is one of the most well-known genera [15]. One of the members of the *orthopoxvirus* species, which also includes the viruses responsible for cowpox, smallpox as well as vaccinia, is the MPXV, causing human Mpox [16] [17]. It's a big double-stranded genome virus that's

brick-shaped and encased. The affected cells' cytoplasm is where it duplicates, just as other poxviruses, as opposed to the nucleus [18]. The wide variety of species that host the stereotype of MPXV, from rope squirrels to sooty mangabeys, sets it apart from different poxviruses and might have contributed to the virus's protracted zoonotic transmission in the wild [19]. The MPXV genome is approximately 197.2 kb and contains 181 proteins. The straight genome contains a covalently attached helical end, with no free 3' or 5' ends. The 10 kb inverting termination repeats (ITR) are situated at the two ends of the genomic [20]. An A+T-rich helical loop is found in a conserved area of less than 100 base pairs inside poxvirus genomes' ITRs. This hairpin lapse, marked by imperfect base pairing, serves a critical function in the viral genome's survival [21]. In this instance, the housekeeping chromosomes are found in the middle area and are therefore extremely common among *orthopoxviruses*, whereas the genes producing host-interactive proteins are found further closer to the termini areas and have a lesser structural identity. The previously mentioned gene codes are referred to be virulence indicators because, although their absence reduces in vivo pathogenesis, the majority appear to be necessary for in vitro multiplication in cell culture (**Figure 2**) [22].

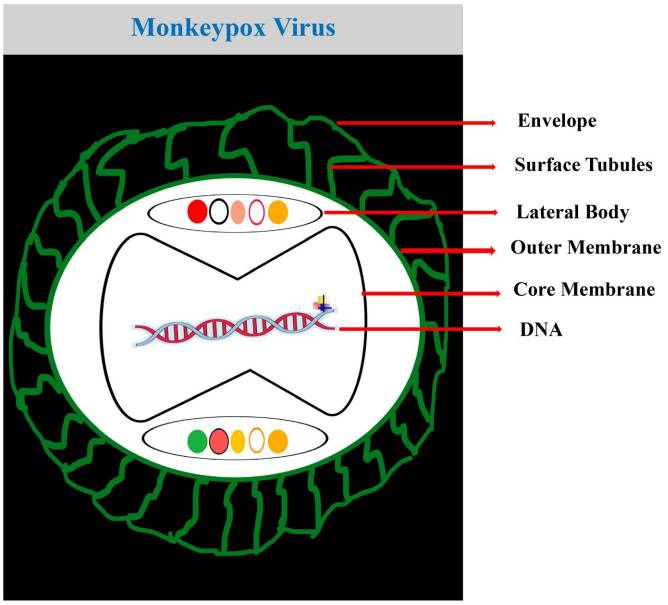

Figure 2. The monkeypox virus.

Historically, two separate clades of monkeypox have been detected in various parts of Africa, exhibiting a genomic sequence variation of around 0.5%. Clade 1 is typically responsible for disease in central Africa and the Congo Basin, with case-fatality rates ranging from 1% to 12%. On the other hand, clade 2, which is less virulent and has case-fatality rates of less than 0.1%, is found in West Africa. The variations in clinical severity between clade 1 and 2 viruses are likely due to genomic alterations that take place in areas that encode crucial virulence genes [22].

4. Mode of Transmission of Mpox Virus

The virus causing monkeypox, in contrast to smallpox, affects animals. Most of the affected species appear to be tiny mammals and monkeys. Numerous animals, such as rat species, squirrels, prairie dogs, and monkeys were found to either possess antibodies to the monkey virus or to be infected with the disease [23]. The MPXV can spread through two different routes: transmission from human to human and animal-to-human (zoonotic) transfer [24].

The two most common ways that animals can spread the disease to humans are through bites or scratches from animals that are infected, however non-invasive exposures such as maintenance, contracting, and killing or preparing the animal's flesh are less likely to result in human infection (Mitja *et al.*, 2023) [22]. Additionally, coming into contact with tainted food may result in infection. Furthermore, behaviors that increase exposure to animals, such as camping outdoors and on ground level, may also contribute to the illnesses [15]. The respiratory system, damaged skin, and mucous membranes including those in the nose, throat, and eyes are all possible entry points for the virus into the body (**Figure 3**) [21].

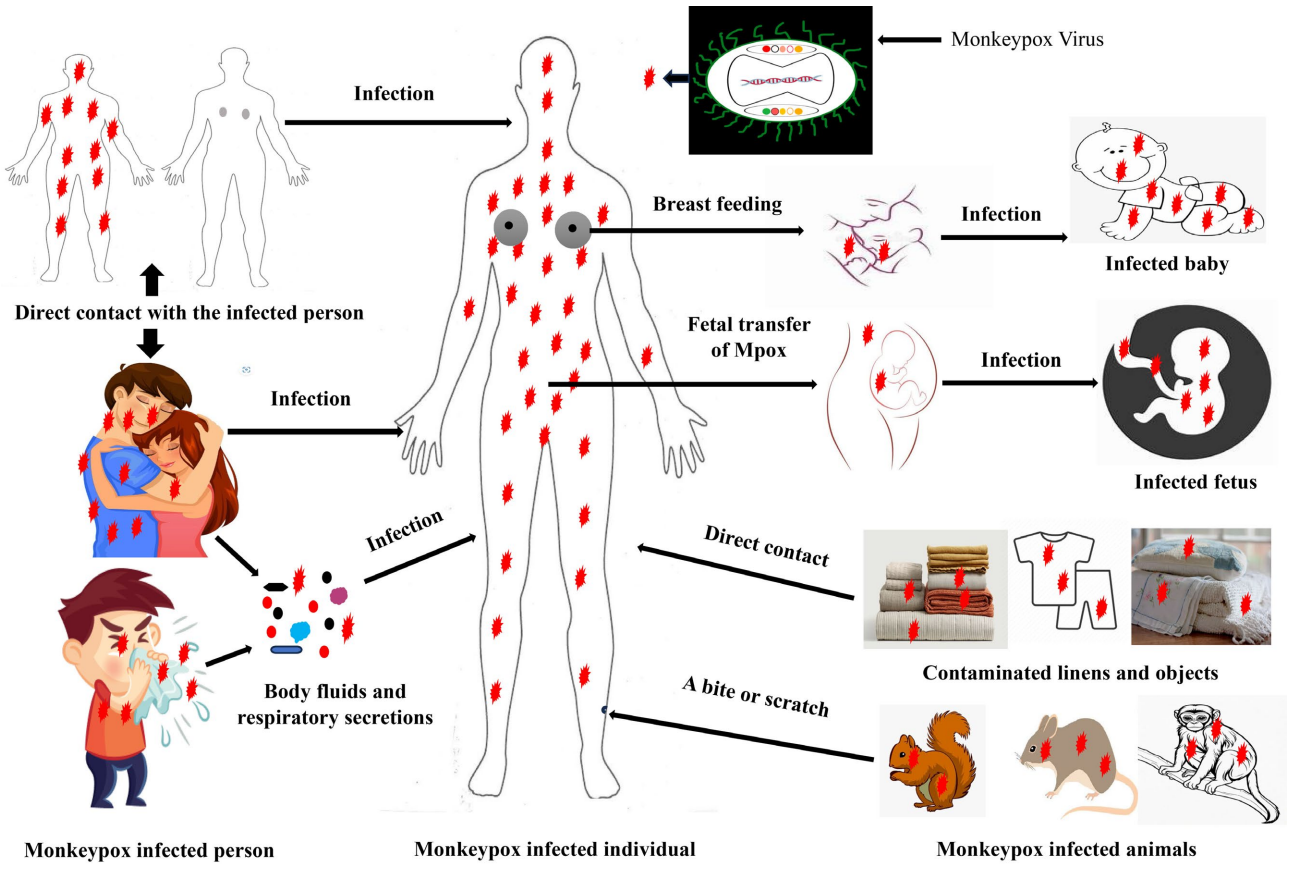

Figure 3. Mode of transmission of Monkeypox virus.

The transmission of Mpox from one person to another is believed to occur through intimate and close interaction with infectious lesions, scabs, or bodily fluids [25]. It is believed that proximity (directly, skin-to-skin, mouth-to-mouth,

or mouth-to-skin contact) involving massive droplets from respiration, bodily fluids, affected surfaces, lesion ingredients, or more things like clothing or linens is the most common cause for subsequent proximate person-to-person the purpose of transmission [26]-[28]. According to current research, the outbreak mostly affects young men below the age limit of 40 and shows a considerable bias in the geographical distribution of infections. Over 95% of the events that have been documented involve these men. The virus is known to spread among guys who have intercourse with other men. But it's also important to take into account the sexual activity of heterosexuals as a possible mechanism of transmission [29]. Additionally, intimate contact between a pregnant woman and her fetus throughout pregnancy or following delivery might spread the disease (**Figure 3**) [6].

5. Pathogenesis

MPXV may affect the mucous membrane of the oral as well as respiratory tracts by entering the host through these pathways. The principal sites of MPXV infection are the upper, intermediate, and bottom airway epithelium [30] [31]. The virus creates a cytopathic along with effective infection in the skin by infecting keratinocytes, the fibroblasts as well as cells of the endothelial system [22]. Little blood clots are created as a result of these cells' migration to lymph nodes and subsequent infection of nearby endothelial cells. Consequently, the virus travels throughout the circulatory system to different tissues and organs, resulting in a variety of health problems [23] [31]. Two primary contagious variants of MPXV are known to be available: the fully developed virion (MV, also known as internal mature virions, or IMV) along with the encapsulated virion (EV, also known as extrinsic encased virions, or EEVs) along with cell-associated enclosed virions (CEVs) [15]. The mechanism of infection commences with the external encapsulated virus (EEV) virions interacting and entering inside the host cell via the connection between MPXV protein surfaces and main binding sites (glycosaminoglycans) on the exterior of the host cell's inner membrane [6] [20]. The method of the virus attaching itself to the host cell is aided by an overall of four protein molecules within the virus. To enter the cytoplasm and begin replication, MV first uncoats. Upon the deactivation of the cell's defense systems, the initial genes begin to express themselves. Already wrapped viral proteins and metabolic components work together to produce this deactivation. This is followed by a virus-specific DNA-dependent RNA polymerase synthesizing initial messenger RNA (mRNA). The early mRNA that has been translated promotes the production of intermediary transcription elements, DNA replication, as well as an additional uncoating process. Intermediate mRNAs are translated and transcriptionally mediated to encourage later mRNA production. Late mRNAs translate structural and non-structural enzymes. DNA concatemers are grouped with translated proteins, creating immature virions (IMVs) and mature virions (MVs). Microtubules help them enter the inner cell membrane, merging into cell-associated virions (CEVs). These virions initiate filament growth and actin polymerization (**Figure 4**) [15].

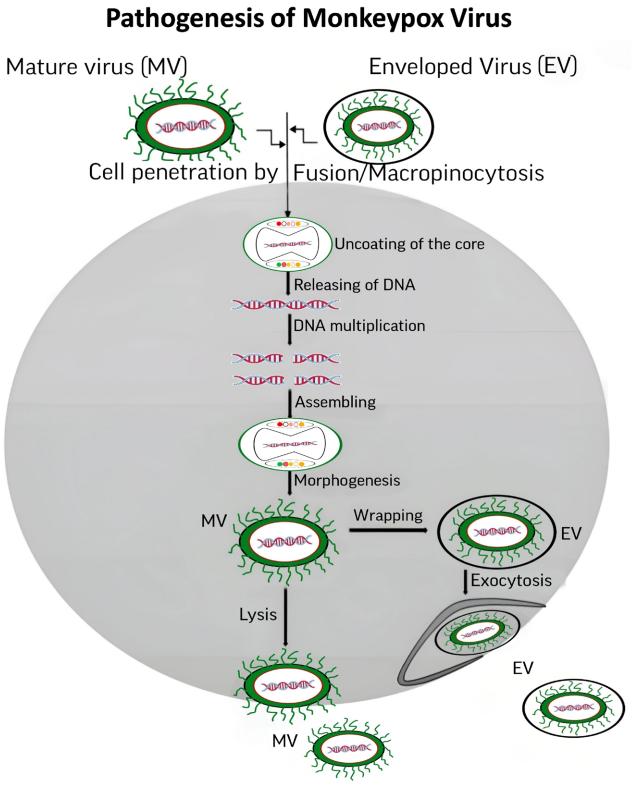

Figure 4. Pathogenesis of Mpox virus.

6. Results and Discussions

6.1. Monkeypox Virus Infection during Pregnancy and Its Complications

It is recognized that the virus enters the fetus through the placenta. Therefore, it raises the chance of miscarriage, fetal death, preterm, and other fetal problems [11] [32]. From March 2007 to July 2011, a study was conducted in the Sankuru Province of the Democratic Republic of the Congo to examine the inherent history of Mpox in an endemic location. In this cohort, four women were found to have had Mpox confirmed by PCR testing during pregnancy, of whom three (75%) had a fetal death [9] [33]. Three of these pregnancies ended in fetal loss—two of them were natural abortions in the first trimester, and another one was a stillbirth. Upon examination, the fetal remains revealed lesions on the skin and different parts of the body including palms, head, and trunk. By Using Polymerase chain reaction analysis, the presence of the monkeypox virus was confirmed in fetal tissues and the placenta. High viral loads were found in multiple fetal tissues [9] [34].

In a different Zairean story, a mother who was suspected of having monkeypox gave birth to a preterm baby at 24 weeks of pregnancy. After six weeks, the baby died from malnourishment and had a widespread skin rash resembling MPXV [35]. About all of the cases in the 2022 Mpox prevalence were in men; while there have also been cases among women, newborns, and pregnant people. By February 14, 2023, fifty-six pregnant people were known to have contracted Mpox during

the global pandemic in 2022 [36].

Pregnant women are more susceptible to monkeypox due to immunological system alterations during pregnancy. MPXV can be perpendicularly transferred from mother to fetus or after birth to the baby through close contact [35] [37].

6.2. Prevention Strategies for Monkeypox Infection in Pregnant Women

The primary strategies for preventing the Mpox virus are avoiding intimate contact and sexual relations with infected individuals, remaining apart from other people, and vaccinating after exposure [38]. When the Mpox is present, decisions about reproduction should be reevaluated. Pregnancy planning can wait until the danger of infection is negligible, even though the evidence regarding the infection's effects on the fetus is still being investigated [39]. Wearing masks is also recommended, particularly in areas where people may be affected by the virus [11]. There is strong cross-protection between smallpox vaccinations and MPXV infection. Pregnant women's mortality rate decreased by 26%, while that of males and non-pregnant women declined by 1% - 2% due to smallpox immunization [5]. The third-generation smallpox vaccine MVA-BN was just approved in the United States, Canada, and European Union. The vaccinated virus has very little capacity to multiply due to its high level of attenuation, and neither the pregnant mother nor her fetus should be at risk. Under the brand name JYNNEOS; MVA-BN is FDA approved. The JYNNEOS vaccination has an 85% success rate in preventing Mpox [25] [40]. Due to the live virus (vaccinia virus) in the ACAM2000 vaccine and the recorded incidences of fetal vaccinia following maternal vaccination, it is not recommended to be administered during pregnancy [40] [41].

6.3. Treatment for Monkeypox Infection of Pregnant Women

Pregnant women are thought to be more susceptible to MPXV infection than the general population due to the general virulence of smallpox, particularly in the third trimester when there is a higher risk of perinatal transmission from birth canal passages. It is advised not to use Cidofovir as a first line of treatment, but rather only in cases where the expectant mother is unwell [42].

Several recommendations about the treatment of pregnant women suspected of having Mpox have been released recently. Patients should be closely watched to spot any early indicators of the disease's severity progression after PCR tests confirm the infection's diagnosis [43]. It is advised that pregnant and nursing women with Mpox receive treatment with Tecovirimat [28]. There are no human studies on this medication, however, research on animal studies has shown that it is neither teratogenic nor embryotoxic and that it is eliminated through breast milk. It is not advised for pregnant or nursing women to take Cidofovir or Brincidofovir due to their known teratogenic effects. Additionally, VIG (Vaccinia immunoglobulin) has not been studied in women who are pregnant or nursing. It is necessary to evaluate the advantages and disadvantages of VIG on an individual basis [44] [45].

6.4. Management Strategies for Monkeypox Virus Infection in Pregnant Women and Newborns

These infections have already been demonstrated to have a major impact on the disruption of the mother-child bond through the development of a negative clinical state in the fetus or placental damage resulting from maternal sickness, which ultimately affects the pregnancy's physiology. If the Mpox viral infection is verified, hospitalization and seclusion in a facility equipped with negative pressure chambers are recommended [39]. The pregnant Mpox-positive women ought to be kept apart for 21 days. The women need to have their blood pressure, thermal regulation, and rashes checked [46]. Fetal screenings should be performed every four weeks for the remainder of the pregnancy, even though the danger to the infant is probably minimal once the mother's infection has cleared up. Consequently, newborn infections may result during childbirth as well as vaginal delivery in a woman who has genital sores. It is advisable to prescribe a cesarean birth if vaginal infections are detected, as infants seem to be the most susceptible to serious infections caused by Mpox. After discussing the (now unquantifiable) risk of newborn contamination, a cesarean delivery must be recommended to a woman with proven or probable contracted Mpox, although genital symptoms are not visible [47].

Following delivery, healthcare professionals should closely monitor the newborn for any indications of skin lesions like wounds, or irritation and use PCR techniques to identify the mpox virus genetic material in specimens of the mother's reproductive fluid, the umbilical cord blood, eruptions, scabs, and a nasal swab. The newborn should be taken to an isolating room for medical surveillance by caregivers shortly after delivery to prevent transmission from mother to child [48].

6.5. Prevention Strategies for Monkeypox Virus Infection in Breastfeeding Women

It is well known that close contact with the skin, breastfeeding, and mother-infant chambers are beneficial to the progress and development of babies [48]. However, if the mother has a current infection, interaction with the neonate should be discouraged to avoid a fatal infection even if the infant tests negative [49]. When the mother and infant both have positive test findings then the mother and her infant can share her room with some precautions.

- Maintain the right amount of moisture and temperature in the space, keep visitors to a minimum, open the curtains and windows frequently, clean the baby's things, and clean the floor and equipment with a solution of 75% ethanol and chlorinated disinfectant water [11].
- In extreme temperatures disinfection is recommended for heat-resistant containers and teats and prompts replacement of infected garments, bed linens, wrapping attire, and baby diapers [11].
- The mother and the infant shouldn't come into proximity with one another. If

contact is necessary, the mother ought to always put on gloves and clean clothes, cover any flesh showing below the neck area, cover any sores on the infant's skin, stay neat and dry to avoid spreading infection, and replace her clothes right away [11].

- Throughout seclusion, lactation should be delayed while providing special care to enable continued breastfeeding [11].
- The facilities of the local hospital for Mpox management and avoidance policy should be followed by maternity and newborn nursing personnel. They should also become proficient in the usage and handling of PPE and ensure that they are kept clean and safe [48].

Before permitting the mother and child to be reunited, two negative PCR analyses (skin and throat swabs) must be acquired. There's no need to separate mother and kid if the newborn is afflicted [49].

When considering pre-exposure or after-exposure immunization in pregnancy or when nursing, non-replicating (MVA-BN) or slightly duplicating (LC16) vaccinations are recommended. Vaccination against infection with the Mpox virus is expected to be effective if administered within 4 days of infection. Vaccination given 4 - 14 days after exposure is likely to lessen signs but might not stop the disease from developing [34] [50]. It has been determined that the MVA-BN is safe to use when nursing. The dangers of transmission of MPXV for both the mother and baby should therefore be taken into consideration before vaccinating any nursing woman who has had significant contact with the virus [11].

6.6. Treatment for Monkeypox Virus Infection in Breastfeeding Women

When treating individuals who are pregnant or nursing and have already been infected by the Mpox virus, tecovirimat ought to be the initial course of treatment administered to them. Nonetheless, it is unknown if mother's milk contains Tecovirimat and limited information is available regarding this matter. Taken together, Cidofovir and Brincidofovir must be avoided since this medication may cause teratogenic effects. It is unknown whether Cidofovir and Brincidofovir may disseminate in breastmilk or not. However, because this drug may cause major undesirable effects, nursing is not advised [51] [52].

6.7. Management Strategies for Monkeypox Virus Infection of Breastfeeding Women

As for nursing, the American Academy of Pediatrics recommends that infants should be isolated from relatives and kept in an isolated space to minimize the risk of infection. As a result, feeding should be postponed and breast milk collected and disposed of throughout the separation period [42]. Until the isolation requirements are satisfied, safeguards should be kept in place [11]. The infant needs to be closely observed for any indications of infection or impairment [47].

Several crucial measures must be taken to develop an integrated defensive mechanism against monkeypox. For early detection, surveillance must be improved

through the use of mobile technologies and community-based systems. High-risk groups should be given priority in vaccination efforts, and accessibility should be guaranteed. Global distribution of antiviral medications such as Tecovirimat is necessary, along with appropriate training for medical personnel. Protocols for isolation should be modified to fit local conditions while providing patients with sufficient assistance. Campaigns to raise public awareness are essential for prevention. Particular recommendations are required for vulnerable populations, including children and pregnant women. It is necessary to increase research on the diagnosis, treatment, and transmission of monkeypox. Addressing constraints in low-resource environments requires international cooperation and resource sharing.

7. Limitations and Future Directions

Although these populations are very susceptible to contracting Mpox, surprisingly, few case studies and empirical studies have been conducted on the disease. Consequently, for a better understanding of the prevention, treatment, and management of these groups, more research is needed on whether a virus is more likely to be transmitted to the fetus during delivery than at any other gestational period. In addition, the presence of advised medication in breast milk and the mode of transmission of Mpox from mother to fetus are not well documented. We were unable to incorporate enough information on these features in our study because of scant research that has been done. The pathophysiological processes of Mpox affecting pregnant women, as well as its effects on fetal growth, placental transfer, and childbirth outcomes, should be the subject of future research. Assessing the viability, immunogenicity, and effectiveness of mpox vaccinations is essential. Treatment regimens for expectant and nursing mothers should be developed, taking into account possible hazards and antiviral medications. The clinical importance of Mpox transmission through breast milk should be studied in further research. It ought to look at the possible dangers of viral transmission in breast milk for young children. Subsequent studies are advised to concentrate on long-term implications for moms and babies, encompassing immunity effects and developmental impairments. Regulations and particular clinical instructions should be created for managing Mpox in pregnant or nursing women.

8. Conclusion

Mpox is emerging as a very infectious virus that threatens public health globally. The risk is higher for pregnant and breastfeeding women than for the general population. The medical condition of Mpox is too serious to ignore any longer, particularly if it appears during pregnancy and breastfeeding time. Considering pregnant & breastfeeding women as a special group, they need to adopt integrated defense measures to deal with the risk of infection. Urgently, it is important to have a global registry of pregnant and breastfeeding women with Mpox infection. Besides, it is necessary to take immediate action by identifying the current prevalence

of these diseases through empirical research.

Acknowledgments

The authors are indebted to the respected faculty members of the Department of Pharmacy, Jahangirnagar University, and Mawlana Bhashani Science and Technology University, Bangladesh for their cordial cooperation, insightful directions, and suggestions for preparing and enriching this review paper.

Authors' Contributions

Mahafuza Akter Eva: Conceptualization, Data curation, Investigation, Methodology, Writing—original draft, Visualization, Writing—review & editing. **Md. Arafat Rahman Ovi**: Data curation, Formal analysis, Methodology, Software, Writing—original draft, Writing—review & editing. **Mst. Sanjida Akhter**: Conceptualization, Methodology, Software, Writing—review & editing, Validation, Supervision, Project administration. **Rehnuma Tanjin:** Data curation, Formal analysis, Methodology, Writing—review & editing. **Rupa Akter:** Conceptualization, Data curation, Validation, Writing—review & editing. **Mst. Mabiya Sultana Samapti:** Conceptualization, Data curation, Methodology, Formal analysis, Writing—review & editing. **Runa Masuma:** Conceptualization, Formal analysis, Validation, Writing—review & editing. **Md. Ataur Rahman:** Conceptualization, Data curation, Methodology, Formal analysis, Software, Validation, Writing—original draft, Writing—review & editing, Project administration, Supervision.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Levitt, C.V., Tran, Q.K., Hraky, H., Mazer-Amirshahi, M. and Pourmand, A. (2023) Emergency Department Approach to Monkeypox. *World Journal of Emergency Medicine*, **14**, Article 341. https://doi.org/10.5847/wjem.j.1920-8642.2023.098

[2] Bragazzi, N.L., Woldegerima, W.A., Wu, J., Converti, M., Szarpak, L., Crapanzano, A., *et al.* (2024) Epidemiological and Clinical Characteristics of Mpox in Cisgender and Trans. Women and Non-Binary Individuals Assigned to the Female Sex at Birth: A Comprehensive, Critical Global Perspective. *Viruses*, **16**, Article 325. https://doi.org/10.3390/v16030325

[3] WHO (2024) WHO Director-General's Opening Remarks at the Media Briefing Following the IHR Emergency Committee Meeting on the Upsurge of Mpox. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-following-the-ihr-emergency-committee-meeting-on-the-upsurge-of-mpox-2024---14-august-2024

[4] World Health Organization (2024, August 26) Mpox. https://www.who.int/news-room/fact-sheets/detail/mpox

[5] Abu-Azzam, O., Abu-Jeyyab, M., Daradkeh, M., Eldeen, S.Z., Zuaiter, S., Al-Mseadeen, M., *et al.* (2024) Monkeypox Infection and Pregnancy in Lower and Middle-Income Countries: Precautions & Recommendations. *Revista Brasileira de Ginecologia e*

Obstetrícia, **46**, e-rbgo54. https://doi.org/10.61622/rbgo/2024rbgo54

[6] Hatmal, M.M., Al-Hatamleh, M.A.I., Olaimat, A.N., Ahmad, S., Hasan, H., Suhaimi, N.A.A., *et al.* (2022) Comprehensive Literature Review of Monkeypox. *Emerging Microbes & Infections*, **11**, 2600-2631. https://doi.org/10.1080/22221751.2022.2132882

[7] Altindis, M., Puca, E. and Shapo, L. (2022) Diagnosis of Monkeypox Virus—An Overview. *Travel Medicine and Infectious Disease*, **50**, Article 102459. https://doi.org/10.1016/j.tmaid.2022.102459

[8] Cabanillas, B., Murdaca, G., Guemari, A., Torres, M.J., Azkur, A.K., Aksoy, E., *et al.* (2023) A Compilation Answering 50 Questions on Monkeypox Virus and the Current Monkeypox Outbreak. *Allergy*, **78**, 639-662. https://doi.org/10.1111/all.15633

[9] Schwartz, D.A. (2024) High Rates of Miscarriage and Stillbirth among Pregnant Women with Clade I Mpox (Monkeypox) Are Confirmed during 2023-2024 DR Congo Outbreak in South Kivu Province. *Viruses*, **16**, Article 1123. https://doi.org/10.3390/v16071123

[10] Kim, S.B., Jung, J. and Peck, K.R. (2022) Monkeypox: The Resurgence of Forgotten Things. *Epidemiology and Health*, **44**, e2022082. https://doi.org/10.4178/epih.e2022082

[11] Mattar, R., Neto, A.R.B., Luz, A.G., Hatanaka, A., Zaconeta, A., Guazzelli, C.A.F., *et al.* (2022) Expert Recommendations on Monkeypox (MPX) in Pregnancy, Postpartum and Lactating Women. *Revista Brasileira Ginecologia e Obstetrícia*, **44**, 1122-1125. https://doi.org/10.1055/s-0042-1759635

[12] Clemente, N.S., Coles, C., Paixao, E.S., Brickley, E.B., Whittaker, E., Alfven, T., *et al.* (2024) Paediatric, Maternal, and Congenital Mpox: A Systematic Review and Meta-analysis. *The Lancet Global Health*, **12**, e572-e588. https://doi.org/10.1016/S2214-109X(23)00607-1

[13] Centers for Disease Control and Prevention (2022) Monkeypox and Pregnancy: Clinical Considerations. https://www.cdc.gov/mpox/hcp/clinical-care/pregnancy.html

[14] Adler, H., Gould, S., Hine, P., Snell, L.B., Wong, W., Houlihan, C.F., *et al.* (2022) Clinical Features and Management of Human Monkeypox: A Retrospective Observational Study in the UK. *The Lancet Infectious Diseases*, **22**, 1153-1162. https://doi.org/10.1016/S1473-3099(22)00228-6

[15] Rampogu, S., Kim, Y., Kim, S.W. and Lee, K.W. (2023) An Overview on Monkeypox Virus: Pathogenesis, Transmission, Host Interaction and Therapeutics. *Frontiers in Cellular and Infection Microbiology*, **13**, Article 1076251. https://doi.org/10.3389/fcimb.2023.1076251

[16] Ogoina, D., Damon, I. and Nakoune, E. (2023) Clinical Review of HUMAN Mpox. *Clinical Microbiology and Infection*, **29**, 1493-1501. https://doi.org/10.1016/j.cmi.2023.09.004

[17] Sukhdeo, S., Mishra, S. and Walmsley, S. (2022) Human Monkeypox: A Comparison of the Characteristics of the New Epidemic to the Endemic Disease. *BMC Infectious Diseases*, **22**, Article No. 928 https://doi.org/10.1186/s12879-022-07900-7

[18] Eid, R.E., Allaw, F., Haddad, S.F., Kanj, S.S. (2022) Human Monkeypox: A Review of the Literature. *PLOS Pathogens*, **18**, e1010768. https://doi.org/10.1371/journal.ppat.1010768

[19] Harapan, H., Ophinni, Y., Megawati, D., Frediansyah, A., Mamada, S.S., Salampe, M., *et al.* (2022) Monkeypox: A Comprehensive Review. *Viruses*, **14**, Article 2155. https://doi.org/10.3390/v14102155

[20] Karagoz, A., Tombuloglu, H., Alsaeed, M., Tombuloglu, G., AlRubaish, A.A., Mahmoud,

A., *et al.* (2023) Monkeypox (Mpox) Vius: Classification, Origin, Transmission, Genome Organization, Antiviral Drugs, and Molecular Diagnosis. *Journal of Infection and Public Health*, **16**, 531-541. https://doi.org/10.1016/j.jiph.2023.02.003

[21] Krishna, S., Kurrey, C., Yadav, M., Mahilkar, S., Sonkar, S.C., Vishvakarma, N.K., *et al.* (2024) Insights into the Emergence and Evolution of Monkeypox Virus: Historical Perspective, Epidemiology, Genetic Diversity, Transmission, and Preventative Measures. *Infectious Medicine*, **3**, Article 100105. https://doi.org/10.1016/j.imj.2024.100105

[22] Mitjà, O., Ogoina, D., Titanji, B.K., Galvan, C., Muyembe, J.J., Marks, M., *et al.* (2022) Monkeypox. *The Lancet*, **401**, 60-74. https://doi.org/10.1016/S0140-6736(22)02075-X

[23] Patel, V.M., Patel, S.V. (2023) Epidemiological Review on Monkeypox. *Cureus*, **15**, e34653. https://doi.org/10.7759/cureus.34653

[24] Cheema, A.Y., Ogedegbe, O.J., Munir, M., Alugba, G. and Ojo, T.K. (2022) Monkeypox: A Review of Clinical Features, Diagnosis, and Treatment. *Cureus*, **14**, e26756. https://doi.org/10.7759/cureus.26756

[25] Tiecco, G., Antoni, M.D., Storti, S., Tomasoni, L.R., Castelli, F. and Quiros-Roldan, E. (2022) Monkeypox, a Literature Review: What Is New and Where Does This Concerning Virus Come from? *Viruses*, **14**, Article 1894. https://doi.org/10.3390/v14091894

[26] Nyame, J., Punniyakotti, S., Khera, K., Pal, R.S., Varadarajan, N. and Sharma, P. (2023) Challenges in the Treatment and Prevention of Monkeypox Infection; A Comprehensive Review. *Acta Tropica*, **245**, Article 106960. https://doi.org/10.1016/j.actatropica.2023.106960

[27] Spirito, F., Guida, A., Caponio, V.C.A. and Lo Muzio L. (2023) Monkeypox: A New Challenge for Global Health System? *Life*, **13**, Article 1250. https://doi.org/10.3390/life13061250

[28] Patel, M., Adnan, M., Aldarhami, A., Bazaid, A., Saeedi, N., Alkayyal, A., *et al.* (2023) Current Insights into Diagnosis, Prevention Strategies, Treatment, Therapeutic Targets, and Challenges of Monkeypox (Mpox) Infections in Human Populations. *Life*, **13**, Article 249. https://doi.org/10.3390/life13010249

[29] Anwar, F., Haider, F., Khan, S., Ahmad, I., Ahmed, N., Imran, M., *et al.* (2023) Clinical Manifestation, Transmission, Pathogenesis, and Diagnosis of Monkeypox Virus: A Comprehensive Review. *Life*, **13**, Article 522. https://doi.org/10.3390/life13020522

[30] Alakunle, E., Kolawole, D., Diaz-Cánova, D., Alele, F., Adegboye, O., Moens, U., *et al.* (2024) A Comprehensive Review of Monkeypox Virus and Mpox Characteristics. *Frontiers in Cellular and Infection Microbiology*, **14**, Article 1360586. https://doi.org/10.3389/fcimb.2024.1360586

[31] Letafati, A. and Sakhavarz, T. (2023) Monkeypox Virus: A Review. *Microbial Pathogenesis*, **176**, Article 106027. https://doi.org/10.1016/j.micpath.2023.106027

[32] Huang, Y.A., Howard-Jones, A.R., Durrani, S., Wang, Z. and Williams, P.C. (2022) Monkeypox: A Clinical Update for Paediatricians. *Journal of Paediatrics and Child Health*, **58**, 1532-1538. https://doi.org/10.1111/jpc.16171

[33] Schwartz, D.A. and Pittman, P.R. (2023) Mpox (Monkeypox) in Pregnancy: Viral Clade Differences and Their Associations with Varying Obstetrical and Fetal Outcomes. *Viruses*, **15**, Article 1649. https://doi.org/10.3390/v15081649

[34] Daneji, S.M., Aminu, A., Borodo, A.M., Dayyab, F.M. (2022) Monkeypox in Human Pregnancy: An Overview. *AJOG Global Reports*, **2**, Article 100130. https://doi.org/10.1016/j.xagr.2022.100130

[35] Najimudeen, M., Chen, H.W.J., Jamaluddin, N.A., Myint, M.H. and Marzo, R.R. (2022) Monkeypox in Pregnancy: Susceptibility, Maternal and Fetal Outcomes, and One Health Concept. *International Journal of Maternal and Child Health and AIDS*, **11**, 1-7. https://doi.org/10.21106/ijma.594

[36] Schwartz, D.A., Ha, S., Dashraath, P., Baud, D., Pittman, P.R., Waldorf, K.M.A. (2023) Mpox Virus in Pregnancy, the Placenta, and Newborn. *Archives of Pathology & Laboratory Medicine*, **14**, 746-757. https://doi.org/10.5858/arpa.2022-0520-SA

[37] Kisalu, N.K. and Mokili, J.L. (2017) Toward Understanding the Outcomes of Monkeypox Infection in Human Pregnancy. *The Journal of Infectious Diseases*, **216**, 795-797. https://doi.org/10.1093/infdis/jix342

[38] Meaney-Delman, D.M., Galang, R.R., Petersen, B.W. and Jamieson, D.J. (2022) A Primer on Monkeypox Virus for Obstetrician-Gynecologists. *Obstetrics and Gynecology*, **140**, 391-397. https://doi.org/10.1097/AOG.0000000000004909

[39] Velázquez-Cervantes, M.A., Ulloa-Aguilar, J.M. and León-Juárez, M. (2022) Mpox, and Preg Nancy: A Neglected Disease and its Impact on Perinatal Health. *Revista Clínica Española (English Edition)*, **223**, 32-39. https://doi.org/10.1016/j.rceng.2022.09.002

[40] Carvajal, A. and Gracia, P.V.D. (2022) Monkeypox and Preg Nancy. *American Journal of Obstetrics & Gynecology MFM*, **4**, Article 100746. https://doi.org/10.1016/j.ajogmf.2022.100746

[41] Dashraath, P., Nielsen-Saines, K., Rimoin, A., Mattar, C.N.Z., Panchaud, A. and Baud, D. (2022) Monkeypox in Pregnancy: Virology, Clinical Presentation, and Obstetric Management. *American Journal of Obstetrics and Gynecology*, **227**, 849-861.e7. https://doi.org/10.1016/j.ajog.2022.08.017

[42] Gaeta, F., De Caro, F., Franci, G., Pagliano, P., Vajro, P. and Mandato, C. (2022) Monkeypox Infection 2022: An Updated Narrative Review Focusing on the Neonatal and Pediatric Population. *Children*, **9**, Article 1832. https://doi.org/10.3390/children9121832

[43] D'Antonio, F., Pagani, G., Buca, D. and Khalil, A. (2023) Monkeypox Infection in Pregnancy: A Systematic Review and Metaanalysis. *American Journal of Obstetrics & Gynecology MFM*, **5**, Article 100747. https://doi.org/10.1016/j.ajogmf.2022.100747

[44] Mohamed, N.A., Zupin, L., Mazi, S.I., Al-Khatib, H.A. and Crovella, S. (2023) Nanomedicine as a Potential Tool Against Monkeypox. *Vaccines*, **11**, Article 428. https://doi.org/10.3390/vaccines11020428

[45] Zimmermann, P.M. and Curtis, N. (2022) Monkeypox—What Pediatricians Need to Know. *The Pediatric Infectious Disease Journal*, **41**, 1020-1031. https://doi.org/10.1097/INF.0000000000003720

[46] Morris, S., Joshi, P., Soni, P., Jakhmola, V., Sahiba, N., Kalita, K., *et al.* (2023) A Systematic Review on Human Monkeypox Virus Disease and Infection in Pregnancy. *Journal of Pure and Applied Microbiology*, **17**, 650-659. https://doi.org/10.22207/JPAM.17.2.52

[47] Khalil, A., Samara, A., O'Brien, P., Morris, E., Draycott, T., Lees, C., *et al.* (2022) Monkeypox and Pregnancy: What Do Obstetricians Need to Know? *Ultrasound in Obstetrics and Gynecology*, **60**, 22-27. https://doi.org/10.1002/uog.24968

[48] Yan, K., Tang, L.K., Xiao, F.F., Zhang, P., Lu, C.M., Hu, L.Y., *et al.* (2022) Monkeypox

and the Perinatal Period: What Does Maternal-Fetal Medicine Need to Know? *World Journal of Pediatrics*, **19**, 213-223. https://doi.org/10.1007/s12519-022-00630-5

[49] Cuérel, A., Favre, G., Vouga, M. and Pomar, L. (2022) Monkeypox and Pregnancy: Latest Updates. *Viruses*, **14**, Article 2520. https://doi.org/10.3390/v14112520

[50] Abdelaal, A., Reda, A., Lashin, B.I., Katamesh, B.E., Brakat, A.M., Al-Manaseer, B.M., *et al.* (2022) Preventing the Next Pandemic: Is Live Vaccine Efficacious against Monkeypox, or Is There a Need for Killed Virus and mRNA Vaccines? *Vaccines*, **10**, Article 1419. https://doi.org/10.3390/vaccines10091419

[51] Goyal, L., Ajmera, K., Pandit, R. and Pandit, T. (2022) Prevention and Treatment of Monkeypox: A Step-by-Step Guide for Healthcare Professionals and General Population. *Cureus*, **14**, e28230. https://doi.org/10.7759/cureus.28230

[52] Elsayed, S., Bondy, L. and Hanage, W.P. (2022) Monkeypox Virus Infections in Humans. *Clinical Microbiology Reviews*, **35**, e00092-22. https://doi.org/10.1128/cmr.00092-22

List of Abbreviations

CEVs = Cell-Associated Enclosed Virions, EEV = External Encapsulated Virus, EV = Enveloped virions, FDA = Food and Drug Administration, IMVs = Immature Virions, ITR = Inverting Termination Repeats, MBA-BN = Modified Vaccinia Ankara–Bavarian Nordic vaccine, Mpox = Monkeypox, MPXV = Monkeypox virus, MV = Mature Virions or Internal Mature Virions, PCR = Polymerase Chain Reaction, PHEIC = Public Health Emergency of International Concern, PPE = Personal Protective Equipment, PRISMA = Preferred Reporting Items for Systematic reviews and Meta-Analyses, SDG = Sustainable Development Goal, VIG = Vaccinia immunoglobulin, WHO = World Health Organization.