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Healthcare worker protection against mpox contamination:

Position paper of the French Society for Hospital Hygiene

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Abstract (n=237)

Aim. In the context of the recent re-emergence of mpox (MPXV, formerly monkeypox virus) worldwide, the French Society for Hospital Hygiene (SF2H) performed a literature review of the transmission paths and proposed specific recommendations for healthcare workers (HCWs) caring for patients with suspected or confirmed MPXV. **Findings** In developed countries, the risk of contamination among HCWs in healthcare facilities seemed to be very low, limited to contamination through needle stick injuries. Two additional contamination cases were reported and not fully explained. Beyond healthcare settings, the analysis of the literature highlighted (i) a main contamination route during sexual intercourse, mainly among men who have sex with men, and (ii) a very low secondary attack rate in other contexts, such as schools or jails. Numerous studies have reported molecular or virus identification on surfaces or in the air surrounding patients, without any association with the low secondary case incidence; moreover, the minimum infectious dose through air or mucosal exposure is still unknown.

Conclusions and recommendations. Owing to the lack of evidence of MPXV respiratory transmission in the healthcare setting, the SF2H recommends the implementation of standard and contact precautions combined with medical/surgical mask use. Owing to the lack of evidence of transcutaneous contamination, the SF2H recommends the use of gloves only if contact with cutaneous lesions or mucous membranes occurs. Regarding the risk of contamination from the environment in healthcare facilities, additional studies must be conducted to investigate this.

Keywords:

Mpox; transmission; healthcare facility; healthcare worker; prevention; guidelines

Introduction: Context

The past year has seen the re-emergence of mpox (MPXV, formerly monkeypox virus) infections in humans [1,2]. Compared to previous outbreaks, the 2022 wave reached countries outside Africa and mainly affected men who have sex with men (MSM) and involved the virus subclade IIb (mainly the B.1 lineage) [1,2,3].

Facing a new emerging infectious phenomenon and before understanding how MPXV was transmitted, the recommendations for the prevention of contamination among healthcare workers (HCWs) during patient care were highly protective. On May 19, 2022, the French Ministry of Health recommended in its first warning message to follow the guidelines of the national operational Coordination Mission for Epidemic and Biological Risk (COREB, Coordination Opérationnelle Risque Épidémique et Biologique), that is, a combination of airborne and contact precautions [4,5]. Thus, HCWs had to wear a fit check-adjusted respiratory protective device/respirator (such as a filtering face piece 2 (FFP2)), single-use gowns, safety goggles and gloves if they came into contact with cutaneous lesions or mucosa. In the case of close contact (e.g., assisting the patient with personal hygiene), HCWs had to wear an apron or preferably a dry coat. Waste and effluents had to be disposed of through the infectious medical waste procedure. Surfaces had to be decontaminated with 0.5% bleach. Patients had to wear a surgical mask, and cutaneous lesions had to be covered. If a patient was hospitalized, a single room was needed, and hand hygiene had to be performed as often as necessary. Subsequent updates from the French High Council for Public Health national working groups expanded the list of recommended disinfectants to those meeting the EN14476 standard and underlined the need to deal cautiously with contaminated laundry and to remove it in a double bag (Table 1) [6,7]. These measures were globally concordant with the European Centre for Disease Prevention and Control (ECDC) and CDC guidelines (Table 1) [8,9]. The ECDC supported the use of single-use gloves and gowns without limiting lesion or mucosa contact [8,9]. The CDC recommended the use of a National Institute for Occupational Safety and Health (NIOSH)-approved particulate

respirator equipped with N95 filters or higher [9]. Dedicated footwear that could be decontaminated could be used [8]. While French guidelines supported the use of a single room, including a negative pressure room if available, the ECDC only recommended a well-ventilated single room, and the CDC underlined that special air handling was not needed, but the door should be kept closed and a dedicated bathroom had to be available [9].

From the French, European and North American guidelines, an assessment of contamination risk was provided, leading to recommendations for postexposure prophylaxis [6,7,8,9].

A higher risk was considered when:

- unprotected contact with broken skin or mucosa with skin lesions/contaminated bodily fluids/soiled materials from an infected patient (i.e., without respiratory protection, gloves or gown) occurred.
- an HCW was inside the patient's room or within 6 feet of a patient exposed to a procedure that generated aerosols or activities that may suspend dried exudates without wearing a respirator or eye protection.

An intermediate risk of contamination was considered when:

- an HCW was within a 6-foot distance for 3 hours or more of an unmasked patient without wearing at least a face mask;
- unprotected contact of intact skin or clothing with skin lesions/contaminated bodily fluids/soiled materials from an infected patient (i.e., without wearing gloves or gown) occurred.

Other situations of exposure were considered to have a lower or no risk of contamination.

Beyond the time and money dedicated to the implementation of these guidelines, HCWs who do not exhaustively follow these recommendations are considered exposed staff. They should undergo active clinical surveillance for 21 days following exposure; moreover, they should not care for

patients at high risk for severe MPXV infection, including immunocompromised patients, pregnant women or neonates [8]. They could be considered for postexposure vaccination. The recommended vaccine is a live attenuated formulation for which the risk-benefit ratio must be individually analysed.

An analysis of the literature was performed up to April 2023, including a targeting review using the following key words “Mpox or monkeypox, healthcare or health and worker, air, surface, transmission”. The databases used were PubMed, Embase and Web of Science Collection databases. Articles related to endemic transmission were excluded. No limit on language was imposed.

One year into the MPXV outbreak, how can we define the risk for occupational contamination for HCWs?

Update on cases of HCW contamination

Although healthcare-associated infections were reported from African episodes, we focused on occupational cases occurring in high-income countries [10]. Because of the availability of personal protective equipment and up-to-date preventive recommendations, the conditions of professional practice in healthcare establishments could be considered optimal: the occurrence of infections among HCWs could be fully described, and each part of the prevention strategy could be analysed.

Before the 2022 outbreak, HCW contamination was reported in an imported case in the UK [11]. A healthcare assistant developed an MPXV infection two weeks after occupational contact with a confirmed imported case. Although vaccinated against smallpox 5 days after exposure to the patient, this HCW developed cutaneous and general symptoms leading to the confirmation of an MPXV infection. He attended to the index patient wearing a disposable apron and gloves; neither a mask nor a respirator was worn. No information was provided about hand hygiene compliance. The hypothesis was contamination during the changing of bed linen of the patient who presented with

multiple skin lesions. The presence of viable virus in the air during a bedding change was then proven [12]. Nevertheless, the route of transmission (cutaneous contact with unrecognized skin lesions, mucosal or respiratory) was not clearly established.

Since the beginning of the 2022 outbreak, several cases of occupational contamination among HCWs have been reported. First, five cases of occupational contamination through needle stick injuries were reported and summarized by Choi et al. [13]. The HCWs wore gloves and sustained needle stick injuries while collecting samples from cutaneous lesions. Nodules or vesicles appeared quickly 3 to 10 days after injury. One case of unexplained MPXV transmission was reported by Alarcon et al.: during her exposure period, that is during the 21 days before the onset of the symptoms, an HCW cared for two patients with confirmed MPXV but always wore a surgical mask and gloves and her PPE armamentarium (i.e., N95 respirator, gown and eye protection) once MPXV was suspected [14]. Unfortunately, no genomic comparison of the different strains was performed to confirm the reservoir of the virus: the transmission pathway hypothesis was her inadvertent contamination from a contaminated surface or during glove doffing.

The Colorado Department of Public Health and Environment retrospectively evaluated MPXV in HCWs after their exposure to infected patients [15]. The study included an evaluation of the risk level of contamination, the wearing of recommended PPE according to CDC guidelines and the contribution of postexposure immunization if required and accepted. During the 3-month study period, 313 HCWs were exposed, 72 (23%) of whom wore all the recommended PPE and 88 (28%) of whom were considered at intermediate or high risk. Among this last category of exposed HCWs, 42 (48%) received the vaccine: this rate corresponded to 12% of all 313 exposed HCWs. No HCW developed MPXV infection during the 21-day post-exposure period. The riskiest situations were exposure to an aerosol-generating procedure without a respirator (n=4), direct contact with the patient's skin or lesions without wearing gloves (n= 30), and handling linens without wearing gloves

(n=23). Only 118 out of 313 (38%) exposed HCWs wore a respirator, and 97 out of 313 (31%) used eye protection.

Furthermore, an occupational infection was reported in two nurses collecting samples from an infected patient during a visit at his home [16]. These HCWs wore respirator masks, safety glasses and gowns at the entry of the patient's home and during the entire visit. Gloves were worn from the collection of biological samples to the end of the visit; they sanitized their hands with 70% ethanol. The contamination pathway could have been contact with contaminated surfaces or fomites in an environment that might have been heavily contaminated: this setting cannot be compared to a healthcare environment where daily disinfection is performed.

Surface contamination around patients in healthcare facilities

Several studies have addressed surface and air contamination inside rooms occupied by patients infected with MPXV [12,17,18]. As is often the case with such studies, the results varied according to numerous parameters: date of sampling after hospitalization, characteristics of the patients, lesions, technical considerations, types of surfaces sampled, etc. Sometimes the contamination of surfaces was identified through PCR detection and quantification. The higher load of DNA was associated with positive viral culture on cells, which corresponds to replicable virus. The threshold is debated, depends on technical parameters and is not standardized: nevertheless a minimum DNA load corresponding of at least 10^6 viral copies or a cycle threshold (Ct) value below 30 was proposed [12; 18]. The virus was identified from personal protective equipment from HCWs caring for the patients (mainly gloves) [12,18]. Viral DNA was identified from surfaces that were not touched, such as the top of the door or the cupboard in the room of an infected patient, suggesting airborne contamination of these surfaces; nevertheless, viral quantification estimated through the CT value was low, and its viability was not evaluated [17]. Another study had 162 environmental samples in ambulatory settings after clinical visits of 27 patients infected with MPXV who consulted 30 days on average after the onset of their symptoms [19]. Information on the number of cutaneous lesions was

available for 75% of patients: 11 patients presented 1-9 lesions, five patients had 10-24 lesions, and the remaining four patients presented more than 25 lesions. Before cleaning, MPXV was detected by PCR on 32% of surfaces sampled after 18 visits, among which 46% were patient high-touch surfaces (in contact with patients' skin), 50% were shared hand high-touch surfaces and 4% were untouched surfaces, suggesting that MPXV may be disseminated through the environment by contact and fomites. When positive, samples presented low concentrations of MPXV, including on surfaces sampled before the cleaning procedure [19].

Air contamination around patients in healthcare facilities

In addition to surface contamination, the presence of the virus in the air could be an additional risk for contamination. In infected patients, the oropharynx is the second most important reservoir of MPXV after skin lesions: the median viral load is 4.6 log₁₀ copies per mL (interquartile range 2.9-5.8), below the threshold value that is associated with replication-competent viruses (> 6.5 log₁₀ copies per mL) [20]. Therefore, air contamination could occur by a simple cough or sneeze. The study by Gould et al. provided relevant data from a well-controlled frame: the air change (at least ten per hour), the negative pressure exerted inside the room (8 Pa), the cleaning protocol and frequency (two times per day using 5000 ppm chlorine sodium hypochlorite), and the collection procedures (position of air sampling at 1 m high/1 m from the bed and 2 m high />1.5 m from the bed) [12]. The characteristics of the patients who may have spread the virus in the environment were obviously difficult to standardize (timing of disease evolution, number and location of skin Lesions, etc.). Of the 20 air samples, five were PCR positive: Ct values were above the threshold value of 30 for the presence of viable virus (32.7 to 36.5). Additional air sampling in one room during bedding changes revealed lower Ct values (17.5 and 27.6), leading to a positive viral culture. This study highlighted the presence of viable virus in the air, especially during bedding changes, as previously suggested by Vaughan in 2020 [11]. The contribution of these findings to the knowledge about infection risk for

HCWs is debated because of the lack of data about the infectivity of the virus, the infectious dose, the protective effect of a surgical mask, etc. Another study assessed air contamination around a patient in an isolation room [21]. Although the collection time was extended (2-3 hours), the Ct of the positive samples was high (30 and 29), and no infectious virus was recovered in cellular culture. Notably, the patient wore an FFP2 mask during the experiments.

Air, surface and human contamination outside the healthcare setting

The new wave of MPXV outbreaks in 2022 outside of Africa was associated in its overwhelming majority with sexual relationships; the classification of MPXV as a sexually transmitted infection is still debated [22]. Beyond transmission during sexual intercourse, the risk of contamination seems to be low. For example, the investigation of putative secondary cases linked to a symptomatic jail resident did not identify any contamination [23]. However, 57 co-detainees were housed with this patient during a median period of 5 nights. The conditions were conducive to contamination: poor mask usage, shared living, dining and bathroom spaces, poor aeration and other risk factors. In another study, no secondary case was observed among 340 students and 100 staff members exposed in four different settings to adult staff members with cutaneous symptoms [24]. Despite the prolonged intermediate risk of contamination, high-quality follow-up and a poor postexposure vaccination rate among exposed children (21 out of 186), no contamination was identified.

Recently, Beeson et al. reviewed MPXV respiratory transmission [25]. The presence of viable virus (and even more so of viral DNA) in the air was not associated with aerosol transmission between humans. First, at the cellular level, no dedicated receptor has been identified in the human respiratory tract: MPXV cannot be considered a respiratory virus, such as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or influenza virus. Although animal models highlighted possible air transmission, at least for clade I MPXV, several arguments against this were reported by the authors: (1) during the 2003 US human outbreak due to clade II MPXV, no animal-to-human contamination was reported among people who came within 6 feet of contact with an infected

animal for > 3 hours, and (2) no case of transmission was reported during travel (international travel by plane, car or train) among people exposed to symptomatic travellers [25]. In addition to the percutaneous pathway, the authors underlined the dual role of mucosal and respiratory transmission that could be confused when no mask is worn.

In contrast the transcutaneous contamination has been clearly established; this transmission pathway was supported by the identification of secondary cases identified in tattoo establishments [26,27]. Regarding environmental studies that could be considered indirect surrogates for contamination risk, the question of the minimal infectious dose is still debated, i.e., the level of contamination required during contact with mucosa or damaged skin. During the investigation of a case of MPXV in a young woman without any risk factors, the authors suspected that her contamination occurred through contact of her face with a circular pillow covered by a linen or a towel on a table she was lying on during a massage [28]. A history of acne was reported, but details about the presence of skin lesions promoting transmission were not provided.

Discussion

By April 2023, more than 87 000 cases of MPXV had been reported in 110 countries, including among 1224 HCWs [29]. The proportion of these infections due to occupational exposure seems to be low, but further investigation is ongoing for some. Of note, in a large epidemiological study from the GeoSentinel Network, 8 out of the 168 patients were HCWs, all of whom were MSM, and no nosocomial transmission was identified [30]. Half of them reported having sexual relationships during mass gathering events, which are known to be transmission Boosters. Nevertheless, the contamination rate could be substantially blurred by the use of postexposure treatment, including smallpox vaccination, which has shown a partially protective effect. Almost all the reported cases of HCW contamination in a healthcare context (i.e., during home care) were due to transcutaneous exposition.

The famous first case of HCW contamination during the bedding change of an infected patient was typically ambiguous about the type of transmission and, consequently, the type of PPE that could have prevented it (i.e., surgical mask vs. respirator) [11] . . Mucosal protection by wearing a medical/surgical mask seems to be an acceptable protection measure, consistent with the presence of the virus in the oropharynx in an important percentage of infected patients.

In addition to the use of PPE and strict adherence to hand hygiene, the decrease in the viral burden through regular (at least daily) cleaning of contaminated surfaces using an effective disinfectant is an important factor in controlling the risk of HCW contamination. This could not be the case for the in-house contamination of the patient environment: the persistence of the virus for days/weeks after the departure of the patients could be explained by its survivability on inanimate surfaces and a lack of cleaning [31,32,33,34]. This cumulative burden of the virus could be a threat for both HCWs and visitors [16]. Regarding airborne transmission, environmental studies confirmed the presence of viral DNA in the air in some cases, but its replicative capacity was rarely ascertained. For numerous viruses, the correlation between the viral load detected by PCR and the presence of infectious viral particles is debated, and even if it is proven, the threshold varies greatly between studies [20, 35]. Moreover, some critical parameters, such as the infectious dose, remain unknown to date; the failure of surgical masks to prevent this contamination pathway has never been reported. Finally, the hypothesis of the air transmission pathway for MPXV transmission would have led to a higher contamination rate among exposed households. In the room of an infected patient, daily cleaning of different surfaces contained the spread of the virus at a tolerable level that did not require additional control measures, such as headwear or overshoe protection. Regarding the systematic use of gloves, no report of contamination through intact skin was reported. Gloves must be worn as a component of standard precautions, especially when a cutting device contaminated by the bodily fluids of an infected patient is manipulated. On the other hand, the negative contribution of glove overuse to hand hygiene is well established.

Since the initial recommendations of scientific societies, several articles have debated the contribution of the different MPXV contamination pathways among HCWs and the associated protection measures [36,37]. Although the incidence of the disease has declined in the past few months, persistent low-level viral circulation is possible, associated with one-off outbreaks in some particularly favourable circumstances. Recently, a cluster of symptomatic mpox infections was reported from persons who were mostly vaccinated [38]. Additional risks, such as reinfection or the emergence of a new variant escaping acquired immunity, could reinforce the need for updated recommendations for mpox management [39].

The 2023 SF2H recommendations for the prevention of MPXV among HCWs.

According to the items previously discussed, the SF2H supports the implementation of standard and contact precautions combined with wearing a medical/surgical mask when HCWs have to care for a patient with suspected or confirmed MPXV (Table 1). To date, regarding the 2022 outbreak, no HCW contamination has been clearly established in the healthcare environment, except through needle stick injuries. Gloves are recommended only if there is a risk of contact with broken skin or body fluids; in other cases, such as contact with intact skin or with the surrounding patient environment, hand hygiene through alcohol-based solutions is recommended. The case of the unmasked healthcare assistant reported in 2018 in which the inhalation of viable viral particles resuspended during the changing of the patient's bedding was hypothesized as the transmission pathway but did not support the systematic use of respirators for patient management [11]. This finding underlined the mucosal exposure when an infectious agent is suspended in the air during bedding changes, as previously reported for *Staphylococcus aureus* twenty years ago [40]. Mucosa must be protected by wearing face shields or goggles in addition to the medical/surgical mask when changing sheets, as is the case for some other infectious diseases. Moreover, the increasing evidence of asymptomatic, presymptomatic and postsymptomatic risk of transmission supports the need for universal infection and transmission control efforts [41,42,43,44]. The promotion of extensive precaution measures can

result in an increase in exposed HCWs who do not carry all the required PPE, leading to unnecessary stress or exposure to postexposure treatment. Furthermore, as reported by Dhar et al., compliance with contact isolation precautions decreases as the proportion of patients in contact isolation increases [45]. Excessive infectious waste production and dedicated laundry procedures have financial and ecological consequences without any proof of their contribution to preventing contamination.

Regarding aerosol-generating procedures, we do not support a dedicated approach for MPXV: a broader reflection must be implemented regarding the associated risk of these procedures and the corresponding precautions required from HCWs.

We agreed with all the different recommendations that support the maintenance of precautions until all lesions have crusted, those crusts have separated, and a fresh layer of healthy skin has formed.

Deimplementing some infection control interventions is a difficult and sensitive issue: the motivation must not be the lack of protective equipment but the prioritization of the most efficient measures [46]. The emergence of a new virus or variant obviously requires the implementation of the most precautionary prevention measures. After storm time is over, the time comes to analyze the epidemiologic and scientific data supporting each intervention. Regarding SARS-CoV-2 pandemic, the situation was completely different from the mpox outbreak: several real-life reports of suspected airborne transmission were soon published [47,48]. The scientific and medical community now pointed-out the need of considering the air-born transmission pathway to prevent SARS-CoV-2 transmission, especially in some overcrowded setting [49]. Furthermore, some colleagues claim for the reconsidering routine use of contact precautions [50]. Our recommendations about mpox transmission are limited to the healthcare settings and will be updated if new relevant data appears. Furthermore, immediate enlarging of the prevention interventions must be implemented if a new mutant or variant emerges associated to modified transmission pathways.

Conclusion

In infection control, perfect is sometimes the enemy of good. As reported by the ECDC, the probability of exposure to MPXV for HCWs wearing appropriate PPE is very low, although the actual contamination rate could have been blurred in a considerable number of cases by the use of postexposure treatment, including smallpox vaccination. The SF2H recommends the standard plus contact precautions for the protection of HCWs, combined with the wearing of a surgical mask. A systematic register to collect and analyse each new HCW occupational contamination must be implemented. Regarding the risk of contamination from the environment in healthcare facilities, additional studies must be conducted to specify the role of air. In the meantime, the risk–benefit ratio of additional control measures beyond our proposal seems to be unfavourable. Finally, clinicians and infection control practitioners must be aware of the risk of viral evolution that could lead to changes in transmission routes.

Conflict of interest statement

The authors declare that they have no competing interests.

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