Understanding sexual transmission dynamics and transmission contexts of monkeypox virus: a mixed-methods study of the early outbreak in Belgium (May–June 2022)

Jef Vanhamel ,[1] Valeska Laisnez,[2,3] Laurens Liesenborghs,[4] Isabel Brosius,[4] Nicole Berens-Riha,[4] Thibaut Vanbaelen ,[4] Chris Kenyon ,[4] Koen Vercauteren,[4] Marie Laga,[1] Naïma Hammami,[5] Oriane Lambricht,[6] Romain Mahieu ,[7] Amaryl Lecompte,[2] Wim Vanden Berghe,[2] Bea Vuylsteke [1]

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/sextrans-2022-055601).

For numbered affiliations see end of article.

Correspondence to
Jef Vanhamel, Department of Public Health, Institute of Tropical Medicine, Antwerp, Belgium; jvanhamel@itg.be

JV and VL contributed equally.

JV and VL are joint first authors.

Received 11 August 2022
Accepted 31 October 2022
Published Online First 17 November 2022

To cite: Vanhamel J, Laisnez V, Liesenborghs L, *et al*. *Sex Transm Infect* 2023;**99**:330–336.

ABSTRACT

Objective The available epidemiological and clinical evidence from the currently ongoing monkeypox (MPX) outbreak in non-endemic areas suggests an important factor of sexual transmission. However, limited information on the behaviour and experiences of individuals with an MPX infection has to date been provided. We aimed to describe the initial phase of the MPX outbreak in Belgium, and to provide a more in-depth description of sexual behaviour and transmission contexts.

Methods We used routine national surveillance data of 139 confirmed MPX cases with date of symptom onset until 19 June 2022, complemented with 12 semistructured interviews conducted with a subsample of these cases.

Results Sexualised environments, including large festivals and cruising venues for gay men, were the suspected exposure setting for the majority of the cases in the early outbreak phase. In-depth narratives of sexual behaviour support the hypothesis of MPX transmission through close physical contact during sex. Despite awareness of the ongoing MPX outbreak, low self-perceived risk of MPX acquisition and confusing initial signs and symptoms for other STIs or skin conditions delayed early detection of an MPX infection. In addition, we describe relevant contextual factors beyond individual behaviour, related to sexual networks, interpersonal interactions and health systems. Some of these factors may complicate early MPX detection and control efforts.

Conclusion Our results highlight the role of sexual contact and networks in the transmission of MPX during the early phase of the outbreak in Belgium. Risk communication messages should consistently and transparently state the predominant sexual transmission potential of MPX virus, and prevention and control measures must be adapted to reflect multilevel factors contributing to MPX transmission risk.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Monkeypox virus is known to spread among humans mainly through close physical contact. Clinical and epidemiological information from the ongoing global outbreak suggests that sexual contact might be a particularly efficient form of monkeypox transmission, yet we lack a contextualised understanding of transmission dynamics.

WHAT THIS STUDY ADDS

⇒ Combining routine Belgian surveillance data with a unique insight into the narratives of people who acquired monkeypox, our study confirms the high sexual transmission potential of monkeypox virus and reveals important interpersonal, network-level and health system factors contributing to efficient transmission contexts for monkeypox.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study demonstrates the importance of risk communication and outbreak control measures that address the multilevel factors associated with monkeypox transmission.

BACKGROUND

In the first half of May 2022, the UK reported several cases of laboratory-confirmed monkeypox (MPX) virus infection.[1] Soon after, other countries in Europe, including Portugal, Italy and Belgium, reported similar cases, raising the alarm for potential widespread transmission of MPX.[2–4]

Not only the scale of this current outbreak is unprecedented, but also the geographical spread and the transmission mode. Historically, only few cases have occurred outside Central and Western Africa, mostly import related through infected animals or travellers and with limited secondary attack rates.[5–12] However, as of 20 October 2022, 75 345 confirmed cases of MPX have been reported from 109 countries globally.[13] People identifying as gay and bisexual men having sex with men (gbMSM) have been disproportionately affected.[14 15] This raises questions about the role of sexual behaviour in the transmission of MPX. Apart from zoonotic transmission, human-to-human transmission in endemic countries is thought to occur through

direct or indirect contact with skin lesions or bodily fluids, or via respiratory droplets during prolonged face-to-face contact.[16 17] Although transmission during sexual contact has been speculated, it was never confirmed in these settings.[18] In the current outbreak, however, patients predominantly presented with localised anogenital or oral lesions, suggesting transmission through local inoculation via close physical contact during sex.[15 19 20] There is a need to unravel sexual behaviour histories and relevant contextual factors contributing to transmission risks, to better understand MPX transmission dynamics.

The first MPX case in Belgium was notified on 19 May 2022. On 21 October 2022, Belgium had become one of the most affected countries globally, reporting 67.61 cases per 1 million inhabitants.[21] Cases clustered mainly in urban areas, especially in and around the city of Antwerp, with many initial cases reporting an epidemiological link to an international gay-oriented fetish festival that took place from 5 to 8 May 2022.[22] In Belgium, all suspected MPX cases are referred to designated facilities for clinical assessment and laboratory confirmation within specialised infectious disease units.

The objective of this study was to describe the initial phase of the outbreak in Belgium and to provide a more in-depth description of sexual behaviour and transmission contexts.

METHODS

Study design

We conducted a rapid cross-sectional, observational, mixed-methods study of laboratory-confirmed MPX cases with onset of symptoms between 10 May and 19 June 2022 in Belgium.

Data collection and analysis

This study was based on two distinct, yet inter-related, data sources: national routine surveillance data of confirmed MPX cases, and narrative data from semistructured interviews conducted with a subsample of these cases.

National routine surveillance

Probable and confirmed cases of MPX are mandatory notifiable to the three regional health authorities in Belgium. A confirmed case was defined as a person with an MPX virus-specific PCR assay positive result or an orthopoxvirus-specific PCR assay positive result, and symptom onset since 1 March 2022, as defined by the European Centre for Disease Prevention and Control.[6] All cases are interviewed by the regional public health authorities to collect information on the most probable source of infection and to initiate contact tracing. The Belgian Institute for Public Health (Sciensano) is responsible for epidemiological follow-up, risk assessment and development of guidelines for healthcare workers. As part of the outbreak management procedures, a linelist is constructed with the information collected by the regional health authorities on demographic characteristics, diagnosis, clinical symptoms and possible exposure settings and transmission routes during the 21 days before symptom onset (presumed incubation period). We extracted MPX cases with date of symptom onset until 19 June (N=139) from this linelist to use as a basis for the epidemiological description of the initial weeks of the outbreak. Statistical analyses were performed with R (V.4.0.5).

Semistructured interviews with MPX-confirmed cases

To gain a contextualised understanding of the perspective and behaviour of those affected, we additionally conducted semi-structured interviews with a subsample of the initial cases. Participants were all recruited between 24 May and 30 June 2022 at a large STI clinic in Antwerp, which reported the majority of cases. The attending physician asked patients' informed consent to be contacted by a researcher for an interview at the time of clinical MPX diagnosis. Out of 62 patients, 47 provided consent to be contacted. Of these, a sample of 19 were contacted by the first author (JV) with the invitation to participate. Of these, 12 agreed to participate in this study. Initially, we conducted interviews with all consenting individuals who were available for an interview (ie, convenience sampling). In a later stage, participants were more purposely selected, guided by emergent findings after preliminary analysis of the first interview data and as per the iterative nature of qualitative research. Notably, people with atypical clinical manifestations or symptoms (eg, skin lesions outside the anogenital area, a single isolated skin lesion with or without general symptoms) or particularly information-rich cases based on clinical judgement of the attending physician (eg, a clear epidemiological link, no self-reported history of sexual contact) were intentionally recruited to allow for maximum variation.

Interviews were held via telephone or online, using Zoom, and lasted between 30 and 60 min. All interviews were conducted by a social science researcher with a medical background and trained in qualitative research, guided by a questionnaire containing both open-ended and closed-ended questions (see online supplemental material 1). Questions related to sociodemographic background, social and sexual behaviour during the 3 weeks before symptom onset, epidemiological linkages related to MPX (eg, contact with known MPX cases), and health-seeking behaviour and risk perception related to MPX. Interviews were not recorded to foster a feeling of trust, yet answers were documented in the questionnaire and detailed notes were taken instead.

The first author (JV) analysed the interview data by creating a data matrix of questionnaire responses using a spreadsheet manager (MS Excel V.2108), supplemented with thematic coding of the researcher's notes and free-text data using the Framework Method.[23]

RESULTS

General description of the initial outbreak

The first case of confirmed MPX in Belgium developed symptoms on 10 May. Afterwards, numbers steadily increased, from 3 cases during the first week to 58 cases during the sixth week of the epidemic, as shown in the epidemic curve (see figure 1). This epidemic curve also shows the probable exposure settings. While 31 (61%) cases indicated a gay-oriented festival as being the probable source of infection in the first 4 weeks, this decreased and was only reported by 10 (11%) cases in weeks 5 and 6.

All cases (N=139) were men, with a median age of 38 years (youngest 20, oldest 62 years old). The majority self-identified as gay or bisexual men (95%) (see table 1).

Almost all cases reported skin lesions, the majority of which had anogenital lesions (78%). Eight cases (6%) were hospitalised: six to control pain, one because home isolation was not possible and one for unknown reasons.

Eight cases (aged between 29 and 62 years old) self-reported a history of smallpox vaccination. The HIV status was known for 124 patients, among whom 40 were HIV positive.

Travel history was available for 131 cases, 52 (40%) of whom reported travelling outside Belgium during the presumed incubation period, which was set at 21 days prior to symptom onset. Of all notified cases, 28 (20%) reported contact with a confirmed MPX case during the presumed incubation period.

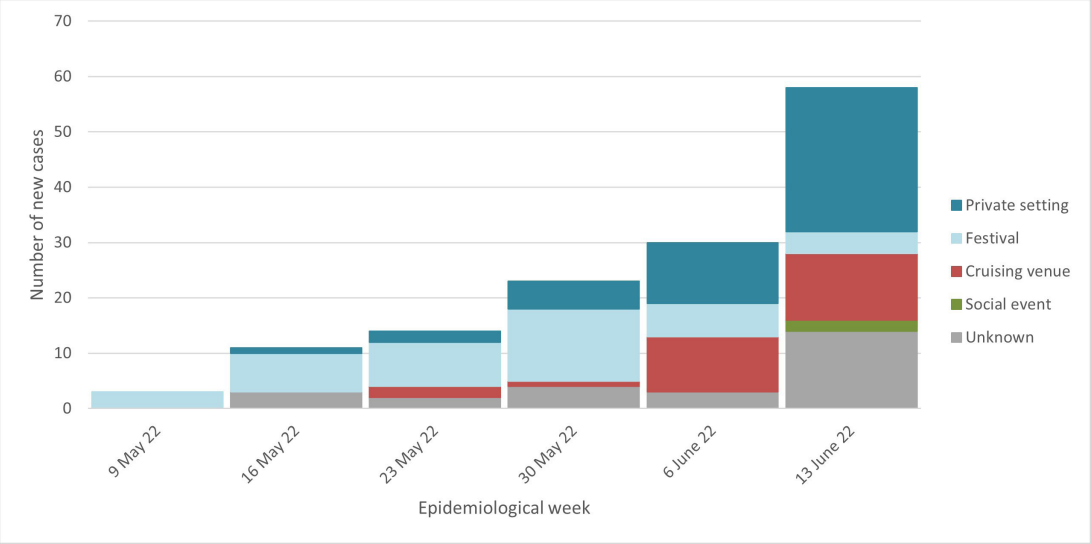

Figure 1 Epidemic curve monkeypox cases per week in Belgium, by date of symptom onset and by most probable exposure setting.

Exposure settings, interactions and conducive contexts for MPX transmission

Among the notified cases, 39 (28%) mentioned participation in a gay-oriented festival where they had sexual contact, and 2 persons (1%) reported participation in a gay-oriented festival without having had sexual contact on-site during the presumed incubation period. Mainly four different festivals were reported: a fetish festival for gbMSM in Belgium (attended by 18 cases), two Pride festivals in Spain (attended, respectively, by 12 and 4 cases) and one Pride festival in Belgium (attended by 11 cases). In addition to the routine surveillance data, we conducted semi-structured interviews with a subsample of 12 MPX cases (see table 2). The narratives of these interviews (summarised through quotation excerpts in table 3) supported the potential role of gay-oriented festivals in MPX transmission, with four participants having attended at least one of these events with anonymous sexual contacts on-site (see online supplemental material 2). In addition, four other interviewees demonstrated an indirect link to these events, through sexual contact with one or more partners who recently attended these events.

Other cruising venues for gbMSM (eg, saunas, gay bars) were reported as the most probable exposure setting by 25 (18%) notified cases. Qualitative data revealed how the anonymous nature of sexual contacts in these venues often complicated backward and forward contact tracing efforts.

Suspected modes of transmission

Sexual contact was self-reported as the most probable mode of transmission, among 83% of the notified cases (table 1). No distinction between different types of sexual contact could be made, as such more granular data were not collected through routine surveillance. Also, all but one interviewee self-perceived having acquired the infection from a sexual partner. However, only two interviewees were able to label a specific sexual encounter as the likely source of MPX acquisition. Both cases had observed a perianal pustular rash on the buttocks of a particular sex partner during penetrative anal sex. Partner notification was not possible for either as the partners were anonymous contacts. When inquiring about noticeable signs and symptoms of possible MPX infection among their sex partners, the other interviewees highlighted a number of impediments to the acquisition of this information, such as darkrooms and the cruising nature of sexual contacts (see table 3).

When comparing a more detailed history of behaviour of interviewees during the presumed incubation period with the manifestation of skin lesions, we generally observed a compatibility between reported sexual behaviour and possible inoculation sites (see online supplemental material 2). Often, multiple sex acts could be documented during the same encounter, combining penetrative oral and anal sex, interspersed with kissing contacts. In such cases, most participants reported anogenital lesions, often combined with skin lesions on other body parts where close physical contact occurred. In three cases, no anogenital lesions could be detected despite reportedly engaging in condomless anal and/or oral penetrative sex.

Four cases from the routine surveillance reported close physical contact other than during sex as the most likely transmission mode. We interviewed one of these cases, which revealed non-sexual transmission via close physical contact or fomites as a possible transmission route. This person did not report any history of sexual contact during the past few months. Yet, he reportedly hugged and kissed, and later shared bathing towels, with contacts identifying as gbMSM attending several cruising venues during a short stay at his place. One of these contacts later reported testing positive for MPX.

Health-seeking behaviour and risk perception

Routine surveillance data show a time interval between symptom onset and clinical diagnosis of up to 21 days (median of 6 days). Analysis of qualitative data provided additional insights into the reasons for diagnostic delay.

Many participants reported not recognising signs and symptoms as suspect of MPX when they first emerged, despite reportedly having heard of MPX circulating in gbMSM communities in Belgium and Europe through several media reports. Inadequate representation of the diversity of the extent and nature of skin lesions through media reports was mentioned as a reason. Skin lesions in the anogenital area were frequently linked to a possible STI, for which care was sought in primary care or specialist sexual health services. In two cases, treatment was first initiated for a presumed STI, such as a herpes simplex or secondary

Table 1 Sociodemographic, clinical and epidemiological characteristics of the initial 139 confirmed cases in the Belgian MPX outbreak based on routine surveillance data

Patient characteristics (N=139)		
Age (years)		
Median (IQR, range)	38 (32–43; 20–62)	
Time between symptom onset and clinical diagnosis (days)		
Median (IQR, range)	6 (4–8; 0–21)	
	n	**%**
Gender		
Male	139	100
Sexual identity		
Gay/bisexual	132	95
Heterosexual	4	3
Unknown	3	2
Reported symptoms*		
General symptoms (fever, general malaise, fatigue, headache, myalgia)	97	70
Skin lesions in anogenital area and other body parts	76	55
Skin lesions only outside the anogenital area	29	21
Skin lesions only in the anogenital area	26	19
Localised lymphadenopathy	40	29
Generalised lymphadenopathy	14	10
Respiratory symptoms (cough, sore throat)	3	2
Unknown	5	4
Hospitalisation due to MPX		
No	131	94
Yes	8	6
HIV status and PrEP use		
HIV negative and on PrEP	52	37
HIV positive	40	29
HIV negative and not on PrEP/PrEP status unknown	32	23
Unknown HIV status	15	11
Suspected setting of exposure†‡		
Private setting	45	32
Festival	41	30
Cruising venue	25	18
Social event	2	1
Unknown	26	19
Suspected route of transmission		
Sexual contact	115	83
Other person-to-person transmission	4	3
Unknown	20	14
Travel outside Belgium in the 21 days prior to symptom onset		
No	79	57
Yes	52	37
Unknown	8	6
Contact of other confirmed MPX case		
No	66	48
Yes	28	20
Unknown	45	32

*Several symptoms could be reported by each case.
†Several suspected settings of exposure could be reported by each case.
‡The categories we used for exposure setting are based on the categories used for reporting to ECDC. The category 'festival' includes large events that were attended by cases where they did or did not have sexual contacts. The category 'cruising venues' includes visits at nightclubs, party, sauna or similar settings with having sexual contacts. The category 'social event' includes visits at bar, restaurant or other small events where there was no sexual contact reported. Other exposure settings reported by the cases in our study fit under the category 'private setting'.
ECDC, European Centre for Disease Prevention and Control; MPX, monkeypox; PrEP, pre-exposure prophylaxis.

Table 2 Sociodemographic, clinical and behavioural characteristics of interview participants

Characteristic	N=12
Age group	
30–40	6
41–50	4
51–60	2
Clinical manifestation of skin lesions	
Anogenital and other body parts	8
Only in anogenital area	2
Only outside anogenital area	2
Type of recent* sexual exposures relevant to MPX transmission†	
Contact with a known confirmed MPX case	3
Sexual contact with a person suspect of MPX‡	2
Sexual contact at a festival publicly associated with MPX	4
Sexual contact with person who attended a festival publicly associated with MPX	4
Sexual contact at cruising venue (sauna, club or bar)	6
Sexual contact via dating apps	5
Other casual sexual contacts at persons' home	3
Suspected mode of transmission	
Close physical contact during sex	11
Close physical contact other than during sex	1

*Recent refers to the 21-day period before symptom onset.
†Multiple responses possible.
‡Refers to contacts being suspect of MPX based on either self-reported (ie, by sex partner) or observed (eg, by the index case) signs or symptoms associated with an MPX infection.
MPX, monkeypox.

syphilis infection, before either patient or provider considered a possible MPX infection.

A low self-perceived MPX risk was linked to notions of MPX being a rare disease in the general population, a low number of sexual partners and consistent condom use, which constituted a perception of safe sex in relation to MPX (see table 3). In three cases, the presence of atypical symptoms (eg, a single lesion or very discrete skin lesions) caused participants to confuse lesions for other possible skin conditions, such as insect bites or eczema. The gradual appearance of additional skin lesions, or the pattern of skin lesions with general symptoms after having had sexual contact with men, ultimately urged participants to seek care that led to a clinical MPX diagnosis.

DISCUSSION

Our findings support the role of sexual contact in the early spread of MPX during the current outbreak in Belgium. Yet, as suggested in previous reports, our surveillance data show a shift in the probable source of infection from (international) festivals and gatherings to smaller, yet also sexualised, events and cruising venues.[24]

This description of the initial cases in Belgium confirms other reports from European countries, indicating that MPX is predominantly spreading in sexual networks of gbMSM. Although our observations do not provide any conclusive evidence in terms of established sexual transmission routes, they support earlier raised hypotheses of MPX transmission through sexual contact. A more detailed inquiry into sexual activities through 12 semi-structured interviews revealed frequent and multiple skin-to-skin and skin-to-mucosa exposures over the 3 weeks before symptom onset. These exposures present different opportunities for MPX transmission, depending on the presence of active virus in skin lesions and bodily fluids of an MPX-infected sexual partner. Recent studies have detected high viral loads in samples from skin lesions, anal swabs, saliva or oropharyngeal swabs of infected patients, and MPX DNA as well as replication-competent virus has also been detected in semen[3 25–27] (own observations). Virus that is shed from these sites can be readily transmitted when it

Table 3 Overview of the main themes and subthemes identified in the narratives of semistructured interviews, supported by illustrative quotes

Theme	Subtheme	Quote
Self-perceived exposure settings and contexts	Gay-oriented festival	"For me, these events [referring to two gay festivals] are all about socialising. And yes, also having sex is part of that for me." (Participant #1)
	Cruising venue	"I travelled to Budapest and, you know, I am a single man… I've been visiting quite some different bars and [gay] saunas(…)I think [the infection] must have happened there." (Participant #11)
	Home	"I usually meet casual hook-ups from Grindr at my place, or his place, it depends." (Participant #9)
	Unknown (sexual)	"I don't know [where infection was acquired], but it must have been from a sexual contact. I have been preoccupied with work, and apart from sexual contacts I haven't been meeting people lately." (Participant #5)
	Unknown (non-sexual)	"I have been puzzled as to where I caught it [monkeypox]. I haven't had any sexual contact in months!" (Participant #12)
Sexual interactions	Anonymous encounters	"I don't spend a lot of time with them [sex partners], it's really just about casual hook-ups(…)When you've had some drinks and the lights are dimmed [in the dark room], you don't really notice much [physical symptoms]." (Participant #8)
	MPX-suspected symptoms among sex partners	"I noticed a rash on his buttocks, but I didn't really think much of it. I thought it must have been some pustules or acne or something." (Participant #4)
	Sexual networks of gbMSM	"Me and my partner met a man via Grindr for a sex date at our place. He told us he was from the U.S.A., visiting Belgium to attend (name of gay fetish festival in Antwerp, Belgium)." (Participant #2)
Health-seeking behaviour and risk perception related to MPX	Confusing MPX symptoms for other STIs	"It started with a pustule on my penis. Then I went to my GP because I recognised it as herpes, from previous times." (Participant #5)
	Confusing MPX symptoms for other skin conditions	"They [the media] always talked about 'pox', in plural, but I only had one lesion that looked like a mosquito bite. How the hell was I supposed to know that was going to be monkeypox?!" (Participant #3)
	Risk perception	"I did not think it [MPX] was something I would get … I have always been careful, using condoms, and I am not that adventurous when I go out." (Participant #5)
		"I had heard of it [monkeypox], but never thought I would really catch it.(…)I always thought of it as something not affecting me. They [media] call it a rare disease." (Participant #3)
	Provider-related diagnostic delay	"He [the GP] thought about Syphilis and did a blood test, but it came back negative. He wanted to test for Syphilis again… I had the feeling he was not really digging deep enough, so I went to an STI clinic instead." (Participant #10)

gbMSM, gay and bisexual men having sex with men; GP, general practitioner; MPX, monkeypox.

comes into contact with mucosal membranes, as during sexual contact. Previous outbreaks in Central and West Africa predominantly occurred after zoonotic spillover from the animal reservoir. Subsequent human-to-human transmission is known to occur through direct skin-to-skin contact or via the respiratory route, but transmission rates were generally found to be low with limited secondary spread.[7] Sexual contact, on the other hand, might be more efficient in transmitting MPX due to the intense contact with mucosal membranes. This enhanced mode of transmission in combination with spread through dense sexual networks, therefore, may allow for sustained transmission within the population.

Although our research strongly focuses on individual behaviour, its role in MPX transmission should be understood within facilitating contexts comprised of multilevel factors. In the context of the current outbreak, our interview data provide more insight into interpersonal and community-level factors. A first finding is the interconnectedness of sexual networks among gbMSM, with linkages to a specific event (ie, international gay-oriented fetish festival) that took place in Belgium early in the epidemic.[28] We described both direct (ie, sexual contact at the event) and indirect (ie, sexual contact with partners who attended the event) connections to this event. Dense sexual networks—across international boundaries—imply that the chance to encounter an MPX-infected sexual partner is higher in communities of gbMSM compared with the general population.[29] Communicating this message is relevant, as we found evidence of low self-perceived MPX risk being linked to notions of low prevalence of MPX in the general population, or a low number of sexual partners, masking the elevation in risk caused by network-level factors. These processes of sensemaking were shown to impact health-seeking behaviour and prevented early diagnosis of an MPX infection in some cases. In addition, we also described factors related to the settings and interactions among gbMSM. The cruising nature of exposure settings, for instance, may facilitate anonymous interaction, with a frequent absence of contact information for contact tracing and partner notification. Lastly, interactions with the health system also emerged from our qualitative data, with primary care providers confusing MPX symptoms for other STIs. Healthcare providers—especially those attending to gbMSM—should maintain a high index of suspicion for MPX, especially among male clients presenting with anogenital skin lesions with or without general symptoms.

Our findings have several implications for effective outbreak control. First, a transparent and consistent communication on the sexual transmission of MPX is warranted, as risk communication is key to enable affected communities to take informed decisions to protect their health.[30] Even though human-to-human MPX transmission could theoretically occur through any close physical contact, all epidemiological, clinical and behavioural reports indicate that non-sexual MPX transmission in the current outbreak is rare. Information campaigns should be broad, yet primarily appeal to communities of gbMSM, as they currently remain most affected by the MPX virus. The risk of stigmatisation should be carefully considered and messages should be prepared in collaboration with affected communities and all relevant stakeholders, including venue managers of locations with cruising opportunities.[31] Moreover, the narratives of interviewees stress the importance of media reports, which should be inclusive towards the broad range in representations of a possible MPX infection to allow early recognition of (atypical) MPX-associated symptoms. Lastly, our data highlight the challenges of contact tracing for anonymous encounters. Therefore, there is a need for a rapid expansion of pre-exposure vaccine accessibility globally and innovative approaches for anonymous partner notification, for instance, through functional additions to the messaging systems of online dating apps, which many users would be in favour of.[32]

There are several limitations to our study. Sensitive information on sexual behaviour might not always be reliably disclosed to public health agencies. We have countered this effect to some extent through conducting interviews with a subsample, by an experienced qualitative researcher skilled in creating a safe and non-judgemental environment. However, social desirability bias

cannot be fully excluded. Second, four persons reported only heterosexual contact during the 21-day period before symptom onset, yet no further information could be obtained from these persons to reliably assess the most probable mode of transmission. Lastly, hypotheses inspired by these qualitative data need confirmation through larger quantitative follow-up studies.

CONCLUSION

In-depth behavioural data from this study highlight the role of sexual contact and sexual networks in the transmission of MPX during the early phase of the outbreak in Belgium. Risk communication should consistently and transparently state the predominant sexual transmission potential of MPX. Prevention and control measures must be adapted to reflect the multilevel factors impacting on MPX transmission, including supporting anonymous partner notification and attention for atypical clinical presentations.

Author affiliations
[1]Department of Public Health, Institute of Tropical Medicine, Antwerp, Belgium
[2]Department of Epidemiology and Public Health, Sciensano, Brussels, Belgium
[3]ECDC Fellowship Programme, Field Epidemiology Path (EPIET), European Centre for Disease Prevention and Control, Solna, Sweden
[4]Department of Clinical Sciences, Institute of Tropical Medicine, Antwerp, Belgium
[5]Department of Infectious Disease Prevention and Control, Agency for Care and Health, Flemish Region, Brussels, Belgium
[6]Agence pour une Vie de Qualité (AVIQ), Walloon Region, Charleroi, Belgium
[7]Department of Infectious Disease Prevention, Brussels Capital Region, Brussels, Belgium

Handling editor Anna Maria Geretti

Twitter Jef Vanhamel @JefVanhamel, Valeska Laisnez @VLaisnez and Romain Mahieu @rommah

Acknowledgements We would like to thank all interviewed participants for their time, cooperation and efforts. IB and LL are members of the Institute of Tropical Medicine's Outbreak Research Team, which is financially supported by the Department of Economy, Science, and Innovation of the Flemish government. VL is a fellow of the European Centre for Disease Prevention and Control (ECDC) Fellowship Programme, supported financially by the ECDC.

Contributors JV, VL, LL, IB, KV, AL, WVB and BV contributed to the conceptualisation of the study. LL, IB, NB-R, TV, CK and KV were involved in clinical management of the cases. JV, ML and BV designed the interview questionnaire. JV conducted the 12 interviews. NH, OL and RM interviewed cases as part of regional public health authorities. VL, AL and WVB analysed the routine surveillance data. JV and VL prepared the first draft of the manuscript. All authors were involved in the interpretation of the data and in writing and reviewing the final version of the manuscript. All authors approved of the final version. BV is the guarantor for this manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Disclaimer The views and opinions expressed herein do not state or reflect those of the ECDC. The ECDC is not responsible for the data and information collation and analysis and cannot be held liable for conclusions or opinions drawn.

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The planning, conduct and reporting of this study were in line with the Declaration of Helsinki, as revised in 2013. Monkeypox is a notifiable disease in Belgium. The Belgian Institute for Health (Sciensano), in cooperation with the Belgian regional health authorities, has legal permission to process patient information for both routine and outbreak surveillance without patients' explicit consent. The conduct of semistructured interviews was done as part of the routine outbreak investigation activities of the Institute of Tropical Medicine (ITM) in Antwerp, Belgium, and approved by the Institutional Review Board of the ITM (ref. 1596/22). All interview participants provided verbal informed consent.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. All relevant data supporting our findings are included in this published article. The complete dataset of conducted interviews is not made publicly available because they might contain information that could identify other persons, yet additional anonymised data are available from the corresponding author on reasonable request.

ORCID iDs
Jef Vanhamel http://orcid.org/0000-0003-0020-1876
Thibaut Vanbaelen http://orcid.org/0000-0002-5541-6041
Chris Kenyon http://orcid.org/0000-0002-2557-8998
Romain Mahieu http://orcid.org/0000-0001-6789-684X
Bea Vuylsteke http://orcid.org/0000-0003-0514-4372

REFERENCES

1 Vivancos R, Anderson C, Blomquist P, *et al*. Community transmission of monkeypox in the United Kingdom, April to may 2022. *Euro Surveill* 2022;27:2200422.
2 Perez Duque M, Ribeiro S, Martins JV, *et al*. Ongoing monkeypox virus outbreak, Portugal, 29 April to 23 may 2022. *Euro Surveill* 2022;27:2200424.
3 Antinori A, Mazzotta V, Vita S, *et al*. Epidemiological, clinical and virological characteristics of four cases of monkeypox support transmission through sexual contact, Italy, may 2022. *Eurosurveillance* 2022;27:2200421.
4 Selhorst P, Rezende AM, de Block T, *et al*. Belgian case of Monkeypox virus linked to outbreak in Portugal. Virological, 2022. Available: https://virological.org/t/belgian-case-of-monkeypox- virus-linked-to-outbreak-in-portugal/801 [Accessed 24 Jul 2022].
5 Vaughan A, Aarons E, Astbury J, *et al*. Human-to-human transmission of monkeypox virus, United Kingdom, October 2018. *Emerg Infect Dis* 2020;26:782–5.
6 Hobson G, Adamson J, Adler H, *et al*. Family cluster of three cases of monkeypox imported from Nigeria to the United Kingdom, may 2021. *Eurosurveillance* 2021;26:2100745.
7 Bunge EM, Hoet B, Chen L, *et al*. The changing epidemiology of human monkeypox-A potential threat? A systematic review. *PLoS Negl Trop Dis* 2022;16:e0010141.
8 Reynolds MG, Yorita KL, Kuehnert MJ, *et al*. Clinical manifestations of human monkeypox influenced by route of infection. *J Infect Dis* 2006;194:773–80.
9 Vaughan A, Aarons E, Astbury J, *et al*. Two cases of monkeypox imported to the United Kingdom, September 2018. *Eurosurveillance*2018;23:1800509.
10 Erez N, Achdout H, Milrot E, *et al*. Diagnosis of imported monkeypox, Israel, 2018. *Emerg Infect Dis* 2019;25:980–3.
11 OT N, Lee V, Marimuthu K. A case of imported monkeypox in Singapore. *Lancet Infect Dis*;19:1166.
12 Adler H, Gould S, Hine P, *et al*. Clinical features and management of human monkeypox: a retrospective observational study in the UK. *Lancet Infect Dis* 2022;22:S1473309922002286
13 World Health Organization (WHO). Monkeypox Outbreak: Global Trends [Internet], 2022. Available: https://worldhealthorg.shinyapps.io/mpx_global/ [Accessed 24 Oct 2022].
14 World Health Organization (WHO). Multi-country monkeypox outbreak: situation update [Internet]. Available: https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON393 [Accessed 24 Jul 2022].
15 Angelo KM, Smith T, Camprubí-Ferrer D, *et al*. Epidemiological and clinical characteristics of patients with monkeypox in the GeoSentinel network: a cross-sectional study. *Lancet Infect Dis* 2022. doi:10.1016/S1473-3099(22)00651-X. [Epub ahead of print: 07 Oct 2022].
16 Learned LA, Reynolds MG, Wassa DW, *et al*. Extended interhuman transmission of monkeypox in a hospital community in the Republic of the Congo, 2003. *Am J Trop Med Hyg* 2005;73:428–34.
17 Yinka-Ogunleye A, Aruna O, Dalhat M, *et al*. Outbreak of human monkeypox in Nigeria in 2017-18: a clinical and epidemiological report. *Lancet Infect Dis* 2019;19:872–9.
18 Ogoina D, Izibewule JH, Ogunleye A, *et al*. The 2017 human monkeypox outbreak in Nigeria-report of outbreak experience and response in the niger delta university teaching hospital, Bayelsa state, Nigeria. *PLoS One* 2019;14:e0214229.
19 Girometti N, Byrne R, Bracchi M, *et al*. Demographic and clinical characteristics of confirmed human monkeypox virus cases in individuals attending a sexual health centre in London, UK: an observational analysis. *Lancet Infect Dis* 2022;22:1321–8.

20 Thornhill JP, Barkati S, Walmsley S, *et al*. Monkeypox Virus Infection in Humans across 16 Countries - April-June 2022. *N Engl J Med* 2022;387:679–91.
21 Mathieu E, Dattani S, Ritchie H, *et al*. Monkeypox. Our World in Data [Internet]. Available: https://ourworldindata.org/monkeypox [Accessed 24 Oct 2022].
22 European Centre for Disease Prevention and Control (ECDC). Epidemiological update: Monkeypox multi-country outbreak [Internet]. Available: https://www.ecdc.europa.eu/en/news-events/epidemiological-update-monkeypox-multi- country-outbreak-0 [Accessed 24 Jul 2022].
23 Gale NK, Heath G, Cameron E, *et al*. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med Res Methodol* 2013;13:1–8.
24 Selb R, Werber D, Falkenhorst G, *et al*. A shift from travel-associated cases to autochthonous transmission with Berlin as epicentre of the monkeypox outbreak in Germany, may to June 2022. *Euro Surveill* 2022;27:2200499.
25 Noe S, Zange S, Seilmaier M, *et al*. Clinical and virological features of first human monkeypox cases in Germany. *Infection* [Internet]. Available: https://doi.org/10.1007/s15010-022- 01874-z [Accessed 24 Jul 2022].
26 Peiró-Mestres A, Fuertes I, Camprubí-Ferrer D, *et al*. Frequent detection of monkeypox virus DNA in saliva, semen, and other clinical samples from 12 patients, Barcelona, Spain, may to June 2022. *Euro Surveill* 2022;27:2200503.
27 Lapa D, Carletti F, Mazzotta V, *et al*. Monkeypox virus isolation from a semen sample collected in the early phase of infection in a patient with prolonged seminal viral shedding. *Lancet Infect Dis* 2022;22:1267–9.
28 World Health Organization (WHO) and European Centre for Disease Prevention and Control (ECDC). Risk communication and community engagement approaches during the monkeypox outbreak in Europe, 2022. Stockholm: WHO and ECDC, 2022. Available: https://www.ecdc.europa.eu/sites/default/files/documents/ECDC-WHO-Risk-communication-community-engagement-monkeypox-outbreak-Europe.pdf [Accessed 24 Oct 2022].
29 Kenyon CR, Delva W. It's the network, stupid: a population's sexual network connectivity determines its STI prevalence. *F1000Res* 1880;2018:7.
30 World Health Organization (WHO) and European Centre for Disease Prevention and Control (ECDC). Interim advice on risk communication and community engagement during the monkeypox outbreak in Europe, 2022. Stockholm: WHO and ECDC, 2022. Available: https://www.who.int/europe/publications/m/item/interim-advice-on-risk-communication-and- community-engagement-during-the-monkeypox-outbreak-in-europe--2022-(2022 [Accessed 1 Aug 2022].
31 World Health Organization (WHO) and European Centre for Disease Prevention and Control (ECDC). Interim advice for public health authorities on summer events during the monkeypox outbreak in Europe, 2022. Stockholm: WHO and ECDC, 2022. Available: https://www.ecdc.europa.eu/en/publications-data/interim-advice-public-health-authorities-summer-events-during-monkeypox-outbreak [Accessed 1 Aug 2022].
32 Hecht J, Zlotorzynska M, Sanchez TH, *et al*. Gay dating APP users support and utilize sexual health features on Apps. *AIDS Behav* 2022;26:2081–90.