BMC Infectious Diseases

RESEARCH Open Access

Epidemiological profile and transmission of mpox in the Kamituga health zone of South Kivu, Democratic Republic of Congo: a cross-sectional prospective study

Léandre Mutimbwa Mambo[1,5†], Gaylord Amani Ngaboyeka[1,2,6*†], Emmanuel Ongezi Lurhangire[1], Armand Mulume Bisimwa[1], Moise Musafiri Namegabe[1,6], Ghislain Bisimwa Balaluka[1,3], Michel P. Hermans[7] and Pacifique Mwene-Batu[1,4]

Abstract

Background Monkeypox (mpox) remains a major global public health problem due to its rapid transmission, clinical severity and high case-fatality rate, especially for the clade I virus. Since August 2024, the disease was declared an public health emergency of international concern, with the resurgence of the disease cases and morbidity and mortality. Few studies exist in low-income countries. The Kamituga health zone (HZ) in South Kivu is the epicenter of the epidemic in the Democratic Republic of Congo (DRC). The aim of this study is to describe the transmission dynamics, epidemiological and clinical characteristics of mpox in this region.

Methods This was a prospective cross-sectional study conducted over 9 months (October 2023 to June 2024) in the Kamituga HZ involving 160 confirmed patients. Data included seroprevalence, sociodemographic, epidemiological, clinical and behavioral characteristics. Variables were described by means, medians or proportions as appropriate; to compare proportions, Pearson's chi-square, Z and Fisher's exact tests were used. A margin of error of 5% was taken as threshold of statistical significance.

Results Seroprevalence of mpox in Kamituga was 0.3%, well above the provincial average of 0,01% ($p < 0{,}001$). Over 80% of villages reported at least one case. The average age of patients was 23.5 years, with 58.7% women. Female sex workers accounted for 36.2% of cases. Around 26.3% had been in contact with an animal, mainly primate. mpox affected 52.2% of women with an sexual infected partner and 25.7% of men ($p = 0.001$). Overall, 70% of patients had more than one sexual partner in the last six months with more men (81.8%) than women (61.7%) ($p = 0.003$). Clinically, 86.3% presented with fever, and 91.9% with extensive pustular eruptions, predominantly genital (90%). Lymphadenopathy affected 98.7% of cases. Only 5.6% of patients had recovered fully.

†Léandre Mutimbwa Mambo and Gaylord Amani Ngaboyeka contributed equally to this work.

*Correspondence:
Gaylord Amani Ngaboyeka
amaningaboyekagaylord@gmail.com

Full list of author information is available at the end of the article

Conclusion mpox in Kamituga is alarmingly prevalent, affecting young adults and female sex workers with severe symptoms such as rashes and lymphandenopathy. Risky sexual behavior and late recourse to healthcare contribute to the spread of the disease. Urgent measures such as raising awareness, vaccine research and strengthening health infrastructures are essential. Collaboration between authorities, researchers and communities is important.

Keywords Transmission dynamics, Monkey pox, Epidemic, Health emergency, DR congo

Background

Human mpox (formerly known as monkeypox) remains a major public health problem, due to its alarmingly rapid transmission and spread, and is an emerging zoonotic disease caused by the monkeypox virus (MPXV) [1]. This virus can infect humans and other animals. The first documented cases of mpox in humans were described in 1970 on six unvaccinated children in the Democratic Republic of Congo (DRC), Liberia and Sierra Leone [2].

Since 2016, numerous confirmed cases have been reported in Sierra Leone, Liberia, Central African Republic, Republic of Congo and Nigeria [3]. However, mpox does not only affect African countries. Several epidemics have been reported on the American and Asian continents. All these cases had an epidemiological link to the African region, with human-to-human transmission [4–6]. An important epidemic was declared in May 2022 [7], when the first case was confirmed in the United Kingdom in a man returning from Nigeria. Furthermore, on August 14, 2024, the World Health Organization declared mpox a Public Health Emergency of International Concern (PHEIC) [8, 9]. is caused by MPXV clade II, and is mainly transmitted through networks of people engaging in frequent unprotected sexual activity [7, 10]. There were an important international Lesbian, Gay, Bisexual and Transgender, other sexual orientations and gender identities (LGBT+) event in a Canary island and from this event there were transmission to several European countries [11].Although previous epidemics of mpox in regions with enzootic reservoirs of MPVX have suggested a potential for spread to more diverse populations and via different modes of transmission, this has been very limited in the current global epidemic.

The clinical manifestations associated with MPXV resemble those of smallpox, a disease eradicated worldwide in 1980. Infection in humans manifests as fever, swollen lymph nodes and fatigue, followed by a rash (genital, anorectal or oral), with macular lesions progressing to papules, vesicles, pustules and crusts, usually on the face, hands and feet, lasting two to five weeks [12, 13].

In the DRC, the number of people suspected of being infected with MPXV has increased since the start of 2023. A total of 12,569 suspected cases of mpox were reported up to November 12, 2023, the highest number of annual cases ever recorded in the country. The case-fatality rate (CFR) was estimated at 4.6% [4]. New cases have occurred in remote geographical areas of the country where the disease was not previously observed, including the province of South Kivu, which is far from where other cases were reported [12].

Recently, it has been shown that the epidemic in South Kivu is associated with a new sub-lineage of clade I viruses, now designated as clade Ib [14]. The majority of these cases appear to be transmitted by sexual contact, with some modes of person-to-person transmission within and outside households. The Kamituga health zone (ZS) is the only area in South Kivu continually reporting cases of mpox and is considered the epicenter of mpox since September 2023. The index case of the current mpox epidemic originated in Kamituga, and since the last 4 epidemiological weeks at the start of 2024, i.e. in February, the Kamituga HZ in South Kivu, along with 4 other HZs in 2 other provinces (Equateur and Sud-Ubangi), have alone recorded 1,152 cases, i.e. (76.6%) of all cases reported in DRC [15]. Kamituga residents depend directly or indirectly on artisanal and small-scale gold mining (ASGM) for their livelihood. Profiling mpox patients in this mining context in eastern DRC could help better understanding the clustering of cases arising in this geographical setting. The aim of our study was to determine the overall seroprevalence and transmission dynamics of mpox, and to describe the clinical and epidemiological profile of mpox patients in the Kamituga HZ of South Kivu, eastern DRC. It should be noted that the present study is one of the few pieces of research since the start of the mpox epidemic that has highlighted the specific dynamics of mpox transmission, particularly in the context of eastern DRC, to inform local disease management strategies through targeted interventions. In addition, it highlights at-risk groups and modes of transmission, which can facilitate awareness campaigns. As such, these data provide useful practical information that can be used to guide major public health programs in order to better direct preventative and mitigating interventions. And also, it adds to the existing literature on mpox, providing specific and novel information in relation to an ongoing major epidemic declared a public health emergency of international concern by the WHO in August 2024.

Methods

Scope and type of study

This was prospective cross-sectional study conducted in the Kamituga HZ, from October 2023 to June 2024, i.e. over a 9 months duration. Kamituga HZ encompasses the largest gold mining town in South Kivu Province (eastern DRC), and covers an area of 2,482 km^2. The town is home to over 260,000 residents (according to the 2019 Kamituga HZ report), of whom around 16,000 are employed in the mining industry (Nkuba et al., 2017). The remaining residents depend directly or indirectly on ASGM (artisanal and small-scale gold mining) for their livelihoods [12].

Due to impassable roads, access to healthcare is extremely challenging for Kamituga's residents. A mere 7.8% of all referred patients reach hospital, whereas 38.1% of the population have no access to clean drinking water; there is also a low coverage of hygienic latrines [16, 17]. As a result of such dire sanitary conditions and lack of access to clean drinking water, residents often resort to drinking water from bear by rivers, a potential source of diarrhoeal diseases such as cholera. Difficult access to the area and recent demographic growth are conducive to regular resurgence of epidemics [16, 18].

From an epidemiological perspective, the Kamituga HZ is densely populated, and remains prone to recurrent epidemics such as cholera, measles and, since September 2023, mpox. As a priority, the public health conditions reported in 2023 in terms of morbidity were malaria (46.1%), acute respiratory infections (13.9%), diarrhea (8.2%), sexually-transmitted infections (STIs; 4.3%) and geo-helminthiasis; similarly, high mortality was noted among malaria cases (27.3%), followed by anemia (5.5%).

From a socio-economic and food security perspective, the population is mainly involved in ASGM, mostly gold, cassiterite and coltan. A small proportion of the population is involved in subsistence farming (such as growing cassava), small livestock rearing, fish farming and petty trading, resulting in a shortage of food products on the local market. Nevertheless, there is a contrast between the artisanal exploitation of minerals and the abject poverty in which the population lives, unable even to afford for basic health care. The almost persistent advanced deterioration of National Road 2 (RN2) has a negative impact on the population's purchasing power, accentuating the precariousness of living conditions [16, 17].

Study population

The present study was carried out among patients with symptoms of mpox and/or suspected of MPXV infection investigated in the Kamituga HZ, with subsequent positive serology during the ongoing 2023–2024 DRC epidemic. We considered any patient presenting clinical signs suggestive of mpox infection, such as fevers and rashes (primary cases), who were investigated and whose serology became positive for mpox, but also any person living in the same household with the primary case (secondary contact case) and who was tested positive after the serology results, and, in both situations after approval to participate in the study. All suspected cases whose serology were negative were excluded, as were confirmed cases who did not consent to participate. A total of 782 cases were investigated for mpox (including probable and suspected), of which 752 tested positive. Among them, only 160 mpox -confirmed patients agreed to participate in our study (the sample size was determined by the number of confirmed patients who consented to take part).

We carried out exhaustive sampling, by interviewing all consenting individuals (suspected or probable cases under investigation) who either came to the Kamituga RGH for consultation, were referred from other integrated healthcare facilities, originated from the community, had followed another first-line therapeutic pathway, and/or had received symptomatic treatment for mpox at the RGH, between October 2023 and June 2024. Data collection was performed through a structured questionnaire.

A total of 371 hospitalized mpox cases were identified as confirmed, probable, or suspected during this period. Of these, 160 laboratory-confirmed patients who provided informed consent were included in the study.

Study variables and data collection

The variables of interest were:

(i) Mpox seroprevalence throughout the HZ from beginning of October 2023 to June 2024.
(ii) Patient socio-demographic characteristics: age, gender, marital status, occupation, level of education, sexual orientation, and relationship to the first case.
(iii) Clinical variables:

- Past history of HIV or STIs.
- Disease history and symptoms: time since onset of first symptoms before appearance of skin lesions, temperature (in °C), fever, sore throat, myalgia, vomiting, lymphadenopathy, and mucosal or skin lesions.
- Evolution and therapeutic itinerary: length of hospital stay (days), recovery (ill/recovered meaning the complete disappearance of skin lesions), whether or not the patient consulted a doctor, and location of initial care;
- Skin lesion characteristics: approximate number of lesions, number of body regions affected defined in 4 segments including head + neck, trunk, upper and lower limbs, then classified into 3 categories

(2, 3 or 4 segments corresponding to the whole body), nature of lesions (papular, vesicular, pustular), lesion location (genital, peri-anal, buccal ulcers, peri-oral), presence or absence of lymphadenopathy, lymphadenopathy location (cervical, inguinal, axillary), time to dry crust formation (5–7, 7–10, 10–15, more than 15 days).

- Behavioral factors of patients with mpox over the 21 days preceding illness: travel to mpox-endemic area, notion of contact, relationship with mpox case, direct contact with an animal, consumption of suspected sick or dead suspect animal with mpox over the last 3 weeks, species of sick animal, other sources of exposure, more than one sexual partner over the previous 6 months, sleeping in the same room as a case, sharing a bathroom with a case (nominal: Yes, No, Don't know), shared objects such as utensils with a case (nominal: Yes, No, Don't know), place of contact with the primary case (nominal: bedroom, bed, toilet).

Data collection was prospective and took place over 9 months. Data were collected using a questionnaire (which can be found in the appendix 1) on Kobo-collect, and blood samples were taken for serological analysis of mpox antibodies. The samples were taken at HGR Kamituga by the hospital's laboratory technician; at the start of the epidemic, the samples were sent to the INRB-Goma laboratory, where they were analyzed by the PCR method, and the results shared with all stakeholders. Three months later, Gene-Expert analyses were already being carried out in Kamituga.

Data analyses

The data encoded on Kobo-collect was extracted into an Excel file for initial cleaning. After cleaning, they were analyzed using Stata software version 17.0. Categorical variables were described in terms of numbers and proportions, while continuous quantitative variables were described as averages and standard deviations, or as medians with range as deemed appropriate, depending on whether the distribution was Gaussian or non-Gaussian. To compare differences in proportions of categorical variables broken down by gender, we used Pearson's chi-square of independence or Z proportions and Fisher's exact test when more than 25% of the table had an expected frequency of less than 5. The threshold of statistical significance was set at 0.05 ($p < 0.05$).

Table 1 Mpox seroprevalence in Kamituga HZ, September 2024 to June 2024

Key indicators	Kamituga HZ	South Kivu Province	*P* value
Laboratory results			
Investigated	782	3318	
Seropositive	752	983	
Total population****	241,642	8,955,539	
PR**	30		
Prevalence (p)	0.3*	0.01*	< 0.001***

Mpox prevalence: Laboratory positives/total population **PR = Prevalence Ratio (p Kamituga/Kivu Province) ***Z-test for proportions ****Source: DPS Sud-Kivu and BCZ Kamituga

Results

Seroprevalence of mpox in Kamituga (Table 1)

Since the start of the epidemic, from September 2023 to June 2024, 782 cases have been investigated for mpox (including probable and suspected), of which 752 cases have tested positive, representing a seroprevalence of 0.3% in habitants for Kamituga HZ. The latter (0.3%) is 30 times higher than South Kivu's provincial figure of 0.01% in habitants, from the start of the epidemic to June 2024.

Socio-demographic characteristics of the population (Table 2)

A total of 160 patients were included in our study. The study population was generally young, with a mean age of 23.5(± 7.5) years. The 18–35 age group was the most represented (80%). 13.7% of subjects were under 18 years of age. More than half of subjects were female. Single women accounted for 45.0% of subjects, whereas 36.2% among women were sex workers (all sex workers were female).

More than half of our subjects (57.5%) have received no more than elementary school education, including 32.5% without basic education. Almost all subject (99.4%) self-declared as heterosexual. As for the degree of kinship with the primary cases, almost half of subjects were single living their family (51.3%), Whereas 21.9% were spouses of the primary confirmed cases. within the household.

History of the disease: symptoms and care pathways (Table 3)

The mean number of days since onset of symptoms was 13 days. 86.3% presented with fever, with an average temperature of 38.6 °C. Skin rashes and genital lesions were found in almost all patients. Dysphagia was found in 83.8%. Headache was reported in 73.2% and lymphadenopathy in 68.7%. Other reported symptoms included low back pain, sweating, vomiting and nausea.

Almost all patients were admitted to hospital. The median length of hospital stay was 8 (1–56) days. A small proportion of these patients (5.6%) recovered, against 94,4% who were still sick at the end of study.

As for their care pathways, a large proportion of subjects went to hospital (91.8%). The remainder consulted traditional healers and religious leaders. STIs were reported in 6.3% of cases. Only two patients (1.3%) were HIV-positive.

Table 2 Socio-demographic characteristics of the population

Variables	*n* (%)	Mean (± SD)
Age in years		23,5(± 7,5)
<18	22(13,7)	
18–35	128(80,0)	
>35	10(6,3)	
Gender		
Female	94(58,7)	
Marital status		
Single	72(45,0)	
Married	78(48,8)	
Divorced	9(5,6)	
Widower	1(0,6)	
Occupancy		
Hospitality (bars/restaurants)	13(8,2)	
Office worker	8(5,0)	
Construction workers	32(20,0)	
Farmer	12(7,5)	
Hunters/Butchers	5(3,1)	
Sex workers	58(36,2)	
Unemployed	32(20,0)	
Education level		
No formal education	52(32,5)	
Primary	40(25,0)	
Secondary	60(37,5)	
Commercial	8(5,0)	
Sexual orientation		
Heterosexual	159(99,4)	
Unknown	1(0,6)	
Relationship to case		
Brother/Sister	15(9,4)	
Mother and Child	14(8,7)	
Friend	14(8,7)	
Husband/Wife	35(21,9)	
Single with family	82(51,3)	

SD: standard deviation)

Table 3 Distribution according to disease symptoms and care pathways

Variables	*N* (%)	Moy(± SD) or Med (Min-Max)
Duration of first symptoms (in days, *n* = 160)		12,9(± 10,5)
T° in °Celsius (*n* = 127)		38,6(± 0,6)
Symptoms (*n* = 160)		
Fever	138(86,3)	
Headache	117(73,2)	
Myalgia	118(73,7)	
Fatigue/exhaustion	132(82,5)	
Lymphadenopathy	110(68,7)	
Chills and sweats	109(68,1)	
Skin rashes	156(97,5)	
Oral lesions	78(48,8)	
Genital lesions	154(96,3)	
Other mucocutaneous lesions	14(8,7)	
Cough/respiratory symptoms	104(65,0)	
Sore throat	134(83,8)	
Coryza	56(35,0)	
Lumbago	118(73,8)	
Sweating	90(56,3)	
Vomiting	85(53,1)	
Nausea	99(61,8)	
Conjunctivitis	62(38,7)	
Other	2(1,3)	
Median length of hospital stayindays (*n* = 158)		8(1–56)
Recovery (*n* = 160)		
Still sick	151(94,4)	
Recovered	9(5,6)	
Consulted a doctor (yes, *n* = 160)	158(98,8)	
Place of consultation (*n* = 158)		
Health outpost	50(31,6)	
Health center	45(28,5)	
Hospital	145(91,8)	
Traditional healers	15(9,5)	
Religious healers	16(10,2)	
Other	2(1,3)	
Admission/Hospitalization (yes, *n* = 160)	158(98,7)	
HIV (yes, *n* = 160)	2(1,3)	
Other STIs (yes, *n* = 160)	10(6,3)	

STIs: Sexually transmitted infections

Clinical characteristics of patients (Table 4)

As for the number of lesions, 65.6% had more than 40. Lesions affected 4 regions or the whole body in 60% of patients. 91.9% had pustular lesions. In terms of lesion location, 90% were found on the genital areas, and a substantial proportion (8.8%) on the perioral areas. Lymphadenopathy was present in almost all patients (98.7%), and was more prevalent in the cervical (74.7%) and inguinal (24.7%) areas. Nearly half of subjects (48.7%) had dry crusts 5–7 days old, followed by those between 7 and 10 days.

Behavioral and social factors over the 21 days preceding disease onset (Tables 5 and 6)

A significant proportion of cases (18.7%) had traveled, lived or worked in a region where mpox activity was endemic or confirmed within the last 21 days. A large proportion of patients (87.5%) had been in contact with a probable, suspected or confirmed case of mpox. Most were spouses of the primary case (70.6%). A quarter of patients had eaten or handled bushmeat butchered from a diseased or already dead animal over the previous 3 weeks. The dead animal was a primate in a third of cases. Among other possible sources of exposure, nearly half of patients had a regular sexual partner having presented with mpox, while others had had sexual intercourse with prostitutes (34.4%). The majority (70%) had had more than one sexual partner over the last 6 months. 76.3%

Table 4 Typology of lesions ($n = 160$)

Variables	*n* (%)
Number of lesions	
>40	105(65,6)
3–39	52(32,5)
1–2	3(1,9)
Affected body segments	
2	16(10,0)
3	48(30,0)
4 (full body)	96(60,0)
Types of lesions	
Papular	10(6,3)
Vesicular	3(1,8)
Pustular	147(91,9)
Lesion location	
Genital	144(90,0)
Perianal	1(0,6)
Oral ulcer	1(0,6)
Perioral	14(8,8)
Lymphadenopathies	
Yes	158(98,7)
Location of Lymphadenopathies ($n = 158$)	
Cervical	118(74,7)
Inguinal	39(24,7)
Axillary	1(0,6)
Dry crust duration	
5–7	78(48,7)
7–10	58(36,3)
10–15	6(3,8)
>15	18(11,3)

Table 5 Behavioural and social factors over the last 21 days preceding disease onset

Variables ($N = 160$)	*n* (%)
Travel within the last 21 days (endemic zone)	30(18,7)
Contact	140(87,5)
Type of relationship with index mpox case	
Child	11(6,9)
Spouse	113(70,6)
Parent	12(7,5)
Other	24(15,0)
Direct contact with sick animals (yes)	42(26,3)
Already dead animal consumption in last 3 weeks	40(25,0)
Animal sick or dead ($n = 40$)	
Antelope	2(5,0)
Primate	14(35,0)
Fruit-eating bats	4(10,0)
Rodent	2(5,0)
Unknown	5(12,0)
Other	13(32,5)
Other sources of exposure	
Regular sexual partner infected with monkeypox	66(41,3)
Household contact with monkeypox	30(18,7)
Participation to a public social event	9(5,6)
Sexual intercourse with a sex worker	55(34,4)
Sexual partner (more than 1 in last 6 months)	112(70,0)
Number of rooms in household	
<2	20(12,5)
2–4	122(76,3)
≥5	18(11,3)
Slept in the same room as index case	138(86,3)
Separate bathroom/toilet with case	61(38,2)
Shared objects (tower, utensil, etc.)	87(54,4)
Type of physical contact with index case	
Shared room	2(1,3)
Sharing a bed	129(80,6)
Same lavatory	1(0,6)

lived in two- to four-bedroom houses. Most had slept in the same bed as mpox index cases prior to confirmation of mpox infection.

Comparing behavioral factors by gender, regarding sources of exposure, our results show that women had statistically significantly more regular sexual partners with monkeypox (52.2%) than men (25.7%). On the other hand, men had more female sex workers (51.5%) than women (22.3%), with a significant difference between the proportions. With regard to the number of sexual partners, overall, many had had more than one sexual partner in the last 6 months (70%), with a difference between men (81.8%) and women (61.7%), the difference being statistically significant ($p = 0.003$).

Discussion

The aim of this study was to describe the transmission dynamics of mpox, as well as the clinical and epidemiological profile of subjects with mpox in the Kamituga HZ, thought to be the epicenter of the epidemic currently raging in eastern DRC.

A total of 160 mpox-confirmed subjects were selected for analysis. Overall mpox seroprevalence in the Kamituga HZ over the study period was 0.3%, significantly higher than south Kivu's provincial average. The affected population was young and predominantly female. Female sex workers accounted for a third of cases. Some 26.3% had been in contact with an animal, and in a third of cases with a primate. Overall, 70% of patients had had more than one sexual partner over the previous six months. Fever and rashes, often pustules, were observed in almost all patients. Lesions were predominantly genital. Almost all patients had lymphadenopathy, with cervical predominance. Only 5.6% of patients had completely recovered from the onset of symptoms to the end of data collection.

Mpox seroprevalence in Kamituga HZ and at South Kivu's provincial level

In this study, we found a mpox seroprevalence in the Kamituga HZ of 0.3% from the start of the epidemic to 2024, which is far higher than the provincial

Table 6 Behavioral and social features of mpox-infected patients by gender

Variables	Entire group	Gender		*P* value
	n (%)	Female *n* (%)	Male *n* (%)	
Travel within the last 21 days (Yes, *n* = 160)	30(18,7)	19(20,2)	11(16,7)	
Direct_animal contact (Yes, *n* = 160)	42(26,3)	25(26,6)	17(25,7)	1,000**
Consumption of previously dead animal within 3 weeks (Yes, *n* = 160)	40(25,0)	25(26,6)	15(22,7)	
Animal sick or dead (*n* = 40)				0,278**
Antelope	2(5,0)	2(8,0)	0(0,0)	
Primate	14(35,0)	6(24,0)	8(53,3)	
Fruit-eating bats	4(10,0)	4(16,0)	0(0,0)	
Rodent	2(5,0)	1(4,0)	1(6,7)	
Unknown	5(12,0)	4(16,0)	1(6,7)	
Other	13(32,5)	8(32,0)	5(33,3)	
Other sources of exposure (*n* = 160)				**0,001***
Regular sexual partner infected with monkeypox	66(41,3)	49(52,2)	17(25,7)	
Household contact with monkeypox	30(18,7)	17(18,1)	13(19,7)	
Participation to a public social event	9(5,6)	7(7,4)	2(3,03)	
Sexual intercourse with a sex worker	55(34,4)	21(22,3)	34(51,5)	
Sexual partner (more than 1 in last 6 months) (Yes, *n* = 160)	112(70,0)	58(61,7)	54(81,8)	**0,003****
Slept in the same room (Yes, *n* = 160)	138(86,3)	80(85,1)	58(87,9)	
Type of contact with primary case (*n* = 160)				0,761*
Hugging/embracing/squeezing/hand-holding	17(10,6)	9(9,6)	8(12,3)	
Eaten/shared cup/glass/same lavatory	12(7,5)	8(8,5)	4(6,1)	
Shared room/bed	131(81,9)	77(81,9)	54(81,8)	

*Pearson's chi2 test **Fisher's exact test

seroprevalence of 0.01%, i.e. a 30-fold higher prevalence ratio compared to all health zones combined. This shows the concerning scale of the situation in Kamituga HZ, given that it was the epicenter of the first mpox case (index case) of the current epidemic, which shows very rapid transmission and spillover.

Another factor to consider is that Kamituga ZS has more serological diagnostic facilities than other HZs of South Kivu. Nevertheless, the eradication plan has so far not been very effective, as intervention in terms of epidemiological surveillance was not implemented at the onset of the current epidemic, despite the efforts allocated at zonal level to reduce the spread of the virus. There was no initial support within this HZ, until 3 months later, once interventions from WHO, CDC, and other research institutions such as the INRB were initiated. Furthermore, the lack of a prior well-structured contingency plan at the onset of the current epidemic does not rule out the possibility that contact, suspected or probable cases may have escaped surveillance, and could represent a hidden reservoir for large-scale transmission of mpox in the HZ. Furthermore, another hypothesis that could be considered is poor hygiene, water and sanitation conditions, such as those that promote the emergence of cholera, suggesting that mpox is likely to be easily spread given similar sanitary conditions, on top of close contact, including sexual transmission [16, 18].

Another likely contributor to the current epidemic is the large conurbation of Kamituga city, with close proximity of households and artisanal gold mining operations, which attracts numerous sex workers, making it a major transmission hotbed for the disease. This HZ, along with 4 other HZ in the country (in two other provinces), accounts for more than 76% of RDC's cases, according to a WHO report with the DRC Ministry of Health [15].

The seroprevalence in this study was slightly lower than that reported in Japan by Mizushima D et al. [19], who found a prevalence of 0.37%. In their study, which was conducted among men who have sex with men (MSM), the seroprevalence was higher compared to that usually reported in heterosexual populations [Mizushima et al., year]. Other studies have also confirmed that seroprevalence tends to be higher among homosexual men than among heterosexuals [19–21]. The seroprevalence found in this study shows how mpox cases are clearly on the increase in DR Congo compared with the early years following the disease's discovery, but also that it spread rapidly to other countries [22].

General characteristics of the study population

The average age was 23.5, with a predominance of the 18 to 35 age group. Our study shows that young people are more affected. This can be partly ascribed to the fact that they are sexually active. Another factor is the age of the

workers in the mines, who are a priori mostly young men, given the physical demands of extraction work.

It should be noted that the predominance of females is explained by the fact that many cases originate from the Mero Health Area, which is home to many sex workers. Other studies have found that young people are more affected, such as Bunge EM et al., in a systematic review conducted in 2022, who found that the weighted average median age of mpox infection in Africa rose from 4 to 5 years in the 1970s and 1980s to 10 and 21 years in the years 2000 and 2010 [21]. In contrast, a study carried out in May 2022 in France on clinical features during an outbreak of mpox, reported that men aged 18 to 50 were predominantly affected with 25% aged under 29 and 25% aged 43 to 81 [23].

A global epidemic was declared on July 23, 2022 by the Director General of the World Health Organization [24]. As of February 25, 2023, 86,127 cases had been recorded, the majority of whom were men in the 18 to 44 age bracket, accounting for 79.2% of cases. For the few female cases whose sexual orientation was reported, the majority were heterosexual (934 out of 978, or 96%) [25]. More or less contradictory results were found in the study by J.G. Bramen et al. conducted on 47 cases of mpox, where male children were most affected, with an average age of 8 years (ranging from 7 months to 35 years), with 83% of subjects under 10 years of age [26]. The Kamituga population being predominantly young, the subjects who self-declared as either unemployed or construction workers, representing almost half the cases, were actually artisanal miners or mineral diggers. The considerable proportion of female sex workers would justify the presence of many more females than males in our study population.

The dynamics of disease transmission

It has been documented that transmission of mpox can occur through direct contact with blood, body fluids or skin or mucous membrane lesions of infected animals, which may be squirrels, rats, dormice or primate; the precise natural reservoir(s) is (are) still not yet identified [27]. The disease is contracted by eating infected meat that has not been properly cooked [28]. According to a study carried out in Africa, person-to-person transmission of the virus follows close contact, either directly or indirectly, with the biological secretions of an infected person [29]. Other studies have also suggested possible maternal-fetal transmission as a cause of congenital mpox [30], alongside sexual transmission [31]. In our study, we found that a large proportion of patients (87.5%) had been in contact with either a probable, suspected or confirmed case of mpox, mainly either their co-spouse or a dead primate. In the present study, mpox is considered a zoonotic disease. Indeed, contact with primates is frequent in the Kamituga SZ because of its proximity to the forest. With the hypothesis that primates are reservoirs of MPXV, the latter would be considered more as a source of contamination in this area where the population also feeds on bushmeat.

Potential sexual exposure was frequent, with almost half (41.3%) reporting having had a regular sexual partner with mpox, and others having had sex with prostitutes (34.4%). This finding is in line with what Hantz S et al. who found during the 2022–2023 global epidemic, particularly in France, that out of all settings in which cases were likely to have been exposed, the most frequent was partying with sexual contact, accounting for 3,720 cases out of 5,476 (67.9%) of combined exposure events [25, 32].

Sex-stratified analysis of behavioral exposure factors showed that women were more likely than men to report having a regular sexual partner with mpox. Men were more likely to report sexual contact with sex workers and to have multiple sexual partners in the previous six months. These differences were statistically significant ($p < 0.05$) This assessment may lead to the conclusion that men who have regular sexual partners (their wives) may become infected through sexual contact with sex workers (or vice versa), and subsequently transmit the disease to their wives. This would explain the high proportion of female subjects in the study, but also the importance of sexual transmission of the disease.

Clinical manifestations or symptoms of the disease

The overall clinical presentation in our subjects was heterogeneous. An influenza-like syndrome (fever, coryza, headache, cough, myalgia) was predominantly present, with fever (86.3%) represented by a mean temperature of 38.6(0.6)°C. Skin rashes (mainly pustular lesions) and genital lesions were found in almost all patients, 97.5% and 96.3% respectively, with 65.6% of subjects having more than 40 lesions affecting all 4 body regions. Almost all patients (98.7%) presented with lymphadenopathy, mostly cervical and inguinal. Other symptoms such as sweating, nausea, vomiting, and dysphagia were reported. The average length of hospitalization was 8 days, with some cases extending up to 56 days.

These observations overlap with with those of Breman et al. in France, who found that mpox in humans was mainly characterized by cutaneous lesions. These appeared more or less simultaneously, evolving at the same speed through stages (papules, vesicles and pustules), before depressing, drying out and desquamating. Most cutaneous lesions were 0.5 to 1 cm in diameter, localized on the mucous membranes, tongue and genitalia, with occasional adenopathy, especially axillary and cervical [26]. Variations in clinical presentations have emerged following the mpox outbreak reported since May 13, 2022. According to Mitjà et al., during the 2022

outbreak, the incubation period ranged from 7 to 10 days, and most patients presented with a systemic illness that included fever and myalgia, along with a characteristic rash featuring papules that progressed to vesicles, pustules, and crusts in the genital, anal, or oral regions, often affecting the mucosa [11].

In a retrospective observational study conducted by Adler H. et al. on the clinical characteristics and management of mpox in seven patients diagnosed in the United Kingdom (United Kingdom) between 2018 and 2021, findings included skin rashes with pleomorphic lesions, inguino-scrotal lesions, and lymphadenopathy. However, mood disorders, particularly depressive moods related to isolation, were also noted [33].

The Center for Desease Control and Prevention (CDC) described a clinical presentation of skin rashes that were less severe during past outbreaks in the United States [34]. In the description of mpox cases by Vaughan et al. in the UK in 2018, lymphadenopathy was observed, along with pruritic maculopapular rashes [35], and human-to-human transmission was low, though already observed in some contact cases [36].

Several studies, including an epidemiological review in light of the global outbreaks of 2022 and 2023, have shown that symptoms include fever, muscle pain, headaches, swollen lymph nodes, and a characteristic painful rash progressing through multiple stages, such as macules, papules, blisters, pustules, crusts, and desquamation of crusts involving the genital and anal regions [37, 38].

The tanapoxvirus, yatapoxvirus, described in Kenya in 1957, transmitted by mosquito bite after contact with an infected monkey, cause gave clinical manifestations similar to those of mpox, with general signs (fever, headache) and skin lesions generally unique and predominantly on the lower limbs, with the presence of adenopathies [39]. Hantz S et al. state that during the mpox epidemic of 2022, the rash most often began in the ano-genital and/or buccal area, most often as a single lesion that could be associated with satellite adenopathies; general signs were not systematic [40, 41].

Study limitations

The cross-sectional nature of the present study, and the lack of a control group, did not allow for establishing a causal relationship between the identified risk factors and the occurrence of mpox infection. The data were collected in a specific mining area, which may introduce a selection bias limiting the representativeness of the results to other non-mining areas. Given the recent nature of the ongoing epidemic, we were unable to compare between HZ or provinces in the DRC, due to lack of updated metrics; we were also unable to highlight factors associated with lethality, yet these would guide public health programs and clinicians as to which variable should be prioritized for monitoring patients. Despite these limitations, we included a diverse range of participants within the mining area to capture local specificities, aligning with our primary objective of identifying risk factors associated with Mpox in this specific context. Future studies are needed to overcome other limitations.

Conclusion

The seroprevalence among mpox cases is very high in Kamituga HZ, and is far higher than the provincial seroprevalence, with mpox disproportionately affecting young adults. Many patients were sex workers in close vicinity with mine workers. Patients presented with a varied clinical picture, with fever and numerous symptoms, mostly marked by skin rashes and lymphadenopathies, which could affect the whole body. Physical contact with infected mpox case was by far the major likely mode of transmission, with particular emphasis on sexual behavior, especially among men, which has been described as an important contributor to the dynamics of disease spread among artisanal mine workers, with likely spillover within household.

Recommendations

Based on our findings, we recommend that joint emergency measures be implemented, including the strengthening of health infrastructures and local capacities for improved detection and treatment of mpox, as well as awareness-raising campaigns. This underlines the need for studies on risk factors and new vaccines. Collaboration between health and non-health officials, researchers and local communities is essential for effective prevention, and non-governmental donors are needed to support these initiatives. The community must be actively involved in raising awareness and reducing risky behavior.

Abbreviations

ASGM	Artisanal and small-scale gold mining
BCZ	Central Office of the Health Zone
CDC	Center for Disease Control and Prevention of United States of America
LGBT+	Lesbian, Gay, Bisexual and Transgender, other sexual orientations and gender identities
DNA	Deoxyribonucleic acid
DPS	Provincial Health Division
DRC	Democratic Republic of Congo
HGR	Hôpital Général de Référence
HIV	Human Immunodeficiency Virus
INRB	Institut National de Recherches Biomédicales (French national biomedical research institute)
MDR	Diarrheal and respiratory diseases
mpox	Monkey Pox
MPXV	MonkeyPox Virus
PCR	Polymerase Chain Reaction
RN	Route Nationale
STI	Sexually transmitted infection
TBC	Tuberculosis
UCB	Catholic University of Bukavu
UK	United Kingdom

ZS Health Zone

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12879-025-12150-4.

Supplementary Material 1

Acknowledgements
We would like to thank the Kamituga Health Zone (KHZ) for their valuable collaboration during the study.

Author contributions
GN, LM, EL, AM and PM contributed substantially to the data analysis and drafting of the first version of the manuscript; GN, LM, EL, MH, MS, GB and PM contributed to the drafting of the manuscript and agree with the results and conclusions of the manuscript. All authors have read the submitted manuscript.

Funding
N/A.

Data availability
All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate
To be carried out, this work had the approval of the Ethical Review Committee of the Catholic University of Bukavu under the reference UCB/CIES/NC/012/2023. Informed consent was obtained, and the patient was interviewed only after approval, or, if the participant was a minor, parental permission was obtained. Furthermore, the study respected the ethical principles of propriety and beneficence required for any scientific study, and preserved the anonymity of the subjects in order to guarantee their confidentiality.

Consent for publication
N/A.

Competing interests
The authors declare no competing interests.

Author details
[1]Université Catholique de Bukavu, Ecole Régionale de Santé Publique, Bukavu, République Démocratique du Congo
[2]School of Public Health, Université Libre de Bruxelles, Brussels, Belgium
[3]Centre de Recherche en Sciences Naturelles, Lwiro, République Démocratique du Congo
[4]Université de Kaziba, Faculty of Medicine, Kaziba, République Démocratique du Congo
[5]Zone de Santé de Kamituga, Kamituga, République Démocratique du Congo
[6]Institut Supérieur des Techniques Médicales Kanyamulande, Walungu, République Démocratique du Congo
[7]Cliniques Universitaires St-Luc, Division of Endocrinology & Nutrition, Bruxelles, Belgium

Received: 2 October 2024 / Accepted: 10 November 2025
Published online: 12 December 2025

References

1. Von Magnus P, Andersen E, Petersen K, Birch-Andersen A. Une maladie semblable à La variole Chez les singes cynomolgus. Chemin Acta Micro Scand. 1959.
2. Ladnyj ID, Ziegler P, Kima E. A human infection caused by Monkeypox virus in Basankusu Territory, Democratic Republic of the congo. Bull World Health Organ. 1972;46(5):593–7.
3. Yinka-Ogunleye A, Aruna O, Ogoina D, Aworabhi N, Eteng W, Badaru S, et al. Reemergence of human Monkeypox in Nigeria, 2017. Emerg Infect Dis Juin. 2018;24(6):1149–51.
4. Organisation Mondiale de la Santé. Mpox (variole du singe) - République démocratique du Congo. 23 nov 2023; Disponible sur: https://www.who.int/emergencies/disease-outbreak-news/item/2023-DON493
5. Cuérel A, Favre G, Vouga M, Pomar L. Monkeypox and pregnancy: latest updates. Viruses 14 Nov. 2022;14(11):2520.
6. Schwartz DA, Pittman PR. Mpox (Monkeypox) in pregnancy: viral clade differences and their associations with varying obstetrical and fetal outcomes. Viruses 28 Juill. 2023;15(8):1649.
7. Low N, Bachmann LH, Ogoina D, McDonald R, Ipekci AM, Quilter LAS, et al. Mpox virus and transmission through sexual contact: Defining the research agenda. PLOS Med. 17 janv. 2023;20(1):e1004163.
8. Clinical manifestations and outcomes of human mpox infection. From 1970 to 2023: A systematic literature review. Clin Infect Pract 1 Nov. 2024;24:100397.
9. Zumla A, Rosenthal PJ, Sam-Agudu NA, Ogoina D, Mbala-Kingebeni P, Ntoumi F, et al. The 2024 public health emergency of international concern: A global failure to control Mpox. Am J Trop Med Hyg 8 Janv. 2025;112(1):17–20.
10. Wick JM, Pelliccione A, Lee-Rodriguez C, Tran HN, McCleskey PE, Nichol A, et al. An atypical presentation of Mpox transmitted between transgender men through oral sex. Sex Transm Dis Oct. 2023;50(10):685–6.
11. Mitjà O, Ogoina D, Titanji BK, Galvan C, Muyembe JJ, Marks M, et al. Monkeypox Lancet Lond Engl. 2023;401(10370):60–74.
12. Masirika LM, Udahemuka JC, Ndishimye P, Martinez GS, Kelvin P, Nadine MB, et al. Epidemiology, clinical characteristics, and transmission patterns of a novel Mpox (Monkeypox) outbreak in eastern Democratic Republic of the Congo (DRC): an observational, cross-sectional cohort study [Internet]. 2024 [cité 19 août 2024]. Disponible sur: https://doi.org/10.1101/2024.03.05.24303395
13. Kaler J, Hussain A, Flores G, Kheiri S, Desrosiers D, Monkeypox. A comprehensive review of transmission, pathogenesis, and manifestation. Cureus [Internet]. 3 juill 2022 [cité 19 août 2024]; Disponible sur: https://www.cureus.com/articles/100707-monkeypox-a-comprehensive-review-of-transmission-pathogenesis-and-manifestation
14. Masirika LM, Udahemuka JC, Schuele L, Ndishimye P, Otani S, Mbiribindi JB, et al. Ongoing Mpox outbreak in Kamituga, South Kivu province, associated with Monkeypox virus of a novel clade I sub-lineage, Democratic Republic of the Congo, 2024. Eurosurveillance [Internet]. 14 mars 2024 [cité 19 août 2024];29(11). Disponible sur: https://www.eurosurveillance.org/content/https://doi.org/10.2807/1560-7917.ES.2024.29.11.2400106
15. Organisation Mondiale de la Santé. CRISE HUMANITAIRE COMPLEXE ET EPIDEMIES, Rapport de la situation, semaine 8 2024. févr 2024; Disponible sur: https://www.afro.who.int/sites/default/files/2024-03/SITREP%20EPR%20S8%20Crise%20Urgence%20Humanitaire%20Complexe%20%26%20L3%20_10%20Mars%202024.pdf
16. Zone de Santé de Kamituga. Plan d'Action Opérationnel Consolidé 2023. 2024.
17. Zone de Santé de Kamituga. Rapport Annuel 2021. 2022.
18. Médecins Sans Frontières. Sud-Kivu: MSF combat l'épidémie de choléra et cible les causes de sa transmission à Kamituga. 27 mai 2024; Disponible sur: https://www.msf.org/fr/rdcongo/sud-kivu-msf-combat-l%E2%80%99%C3%A9pid%C3%A9mie-de-chol%C3%A9ra-et-cible-les-causes-de-sa-transmission-%C3%A0-kamituga
19. Mizushima D, Shintani Y, Takano M, Shiojiri D, Ando N, Aoki T, et al. Prevalence of asymptomatic Mpox among men who have sex with men, Japan, January–March 2023. Emerg Infect Dis [Internet]. sept 2023 [cité 19 août 2024];29(9). Disponible sur: https://wwwnc.cdc.gov/eid/article/29/9/23-0541_article
20. Niu L, Liang D, Ling Q, Zhang J, Li Z, Zhang D, et al. Insights into Monkeypox pathophysiology, global prevalence, clinical manifestation and treatments. Front Immunol 21 Mars. 2023;14:1132250.
21. Bunge EM, Hoet B, Chen L, Lienert F, Weidenthaler H, Baer LR, et al. The changing epidemiology of human monkeypox—A potential threat? A systematic review. Gromowski G, éditeur. PLoS Negl Trop Dis 11 févr. 2022;16(2):e0010141.
22. Rimoin AW, Mulembakani PM, Johnston SC, Lloyd Smith JO, Kisalu NK, Kinkela TL, et al. Major increase in human Monkeypox incidence 30 years after

smallpox vaccination campaigns cease in the Democratic Republic of congo. Proc Natl Acad Sci. 2010 Sep;14(37):16262–7.
23. Monkeypox multi. -country outbreak - second update. 2022.
24. World Health Organization. Direct-General declares the ongoing monkeypox outbreak a Public Health Emergency of International Concern. 2022; Disponible sur: http://www.who.int/europe/news/item/23-07-2022-who-director-general-declaresthe-ongoingmonkeypox-outbreak-a-public-health-event-of-international-concern
25. Hantz S, Mafi S, Pinet P, Deback C. De La variole du Singe à La Mpox Ou La réémergence d'une ancienne zoonose. Rev Francoph Lab Juin. 2023;2023(553):25–37.
26. Breman JG. Monkeypox chez l'homme Bulletin de l'Organisation mondiale de la Sante. 2018.
27. Khodakevich L, Szczeniowski M, Manbu-ma-Disu null, Jezek Z, Marennikova S, Nakano J, et al. The role of squirrels in sustaining monkeypox virus transmission. Trop Geogr Med. avr. 1987;39(2):115–22.
28. Radonić A, Metzger S, Dabrowski PW, Couacy-Hymann E, Schuenadel L, Kurth A, et al. Fatal Monkeypox in Wild-Living sooty Mangabey, Côte d'Ivoire, 2012. Emerg Infect Dis Juin. 2014;20(6):1009–11.
29. Nolen LD, Osadebe L, Katomba J, Likofata J, Mukadi D, Monroe B, et al. Extended Human-to-Human transmission during a Monkeypox outbreak in the Democratic Republic of the congo. Emerg Infect Dis Juin. 2016;22(6):1014–21.
30. Mbala PK, Huggins JW, Riu-Rovira T, Ahuka SM, Mulembakani P, Rimoin AW, et al. Maternal and fetal outcomes among pregnant women with human Monkeypox infection in the Democratic Republic of congo. J Infect Dis 1 Nov. 2017;216(7):824–8.
31. Sah R, Abdelaal A, Reda A, Katamesh BE, Manirambona E, Abdelmonem H, et al. Monkeypox and its possible sexual transmission: where are we now with its evidence? Pathogens. 17 août. 2022;11(8):924.
32. World Health Organization. Mpox (Monkeypox) Outbreak: Global Trends [Internet]. 2023. Disponible sur: https://worldhealthorg.shinyapps.io/mpx_global/#6_Literature_Summary__Epidemic_Parameters
33. Adler H, Gould S, Hine P, Snell LB, Wong W, Houlihan CF, et al. Clinical features and management of human monkeypox: a retrospective observational study in the UK. Lancet Infect Dis août. 2022;22(8):1153–62.
34. CDC. Mpox. 2024 [cité 9 févr 2025]. Past U.S. Cases and Outbreaks. Disponible sur: https://www.cdc.gov/mpox/outbreaks/past-us-cases/index.html
35. Vaughan A, Aarons E, Astbury J, Balasegaram S, Beadsworth M, Beck CR, et al. Two cases of Monkeypox imported to the United Kingdom, Eurosurveillance. 2018 Sep;20(38):1800509.
36. Vaughan A, Aarons E, Astbury J, Brooks T, Chand M, Flegg P, et al. Human-to-Human transmission of Monkeypox Virus, united Kingdom, October 2018. Emerg Infect Dis Avr. 2020;26(4):782–5.
37. Sun Y, Nie W, Tian D, Ye Q. Human Monkeypox virus: epidemiologic review and research progress in diagnosis and treatment. J Clin Virol 1 Avr. 2024;171:105662.
38. Karagoz A, Tombuloglu H, Alsaeed M, Tombuloglu G, AlRubaish AA, Mahmoud A, et al. Monkeypox (mpox) virus: Classification, origin, transmission, genome organization, antiviral drugs, and molecular diagnosis. J Infect Public Health Avr. 2023;16(4):531–41.
39. Jezek Z, Arita I, Szczeniowski M, Paluku KM, Ruti K, Nakano JH. Human Tanapox in zaire: clinical and epidemiological observations on cases confirmed by laboratory studies. Bull World Health Organ. 1985;63(6):1027–35.
40. Jezek Z, Szczeniowski M, Paluku KM, Mutombo M. Human monkeypox: clinical features of 282 patients. J Infect Dis 1 août. 1987;156(2):293–8.
41. Monkeypox virus. manifestations dermatologiques. Disponible sur: https://www.sfdermato.org/upload/news/groupemonkeypeauxfinal-1.pdf

Publisher's note