# Egocentric sexual network analysis among gay and bisexual men who have sex with men with and without monkeypox infection

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**Funding**

This research was supported by CIBER (Strategic Action for Monkeypox) - Consorcio Centro de Investigación Biomédica en Red- (CB 2021), Instituto de Salud Carlos III, Ministerio de Ciencia e Innovación and Unión Europea – NextGenerationEU.

**Declarations**

Authors did not state any competing interests.

**Key messages**

- **What is already known on this topic:** Existing studies on sexual network analysis among men who have sex with men (MSM) have primarily concentrated on examining HIV-related risk behaviors. However, there have been notable occurrences of mpox virus outbreaks within dense sexual networks of gay and bisexual men who have sex with other men (referred to as GBMSM).
- **What this study adds:** This study is the first to depict and compare the attributes of GBMSM's sexual networks in association with mpox in Spain and has the strength of a case control approach.
- **How this study might affect research, practice or policy:** Our research highlights important variables to be considered when tailoring prevention measurements if there should be another mpox outbreak.

## Abstract

**Objectives**: Recent outbreaks of the mpox virus (mpoxv) have been detected in dense sexual networks of gay and bisexual men who have sex with men (GBMSM). The objective of this study is to describe and compare the epidemiological and behavioral characteristics, as well as the sexual networks, of GBMSM individuals diagnosed with mpox in Spain.

**Methods:** A prospective case-control study was conducted in Spain from July 2022 to February 2023. The study targeted a key population of GBMSM who are aged 18 years or older. Study participants were categorized into cases - those who were diagnosed with mpoxv infection - and controls - those who were not diagnosed. We examined and compared the sexual network characteristics of two groups: mpox-positive (mpox-P) and mpox-negative (mpox-N) egos using Chi-square, t, and Wilcoxon tests to examine the differences between the two groups in each section. Finally, we conducted uni- and multivariable logistic regressions to determine the factors associated with mpox infection.

**Results**: Among the 105 participants, 35 (33.3%) individuals were mpox positive (mpox-P). Compared to mpox negative (mpox-N), mpox-P respondents more frequently reported syphilis (mpox-P: 31.4%; mpox-N: 12.9%) and HIV (mpox-P: 45.7%; mpox-N: 18.6%). It was more common among mpox-P individuals to have had at least one sexual contact with a confirmed mpox case (mpox-P: 62.5%; mpox-N: 8.3%). In the egocentric network analysis, mpox-P respondents had a higher prevalence of group sex with alters (mpox-P: 18.5%; mpox-N: 8.9%), and one-time sexual partners (mpox-P: 46.1%; mpox-N: 31.7%) were more prevalent in the sexual networks of mpox-P. Additionally, their network was less heterogeneous (mpox-P: 0.22; mpox-N: 0.31).

**Conclusions**: Our findings highlight and specify the role of demographic, epidemiological, and sexual network characteristics in the transmission of mpoxv during

78 the outbreak in Spain. These findings have important implications for future prevention
79 efforts.

80 **Keywords:** Monkeypox, Men who have sex with men, social network analysis, Spain

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96 **Introduction**

Mpox (mpox, formerly known as monkeypox) is a viral infection that is endemic to central and western Africa, (McCollum & Damon, 2014) and a wide range of animals, including rodents, are possible reservoirs (Di Giulio & Eckburg, 2004). As of 18th April 2023, a total of 7,383 cumulative cases of mpox had been reported in Spain (Instituto de Salud Carlos III, 2023), which represents the highest number of cases reported in Europe since the beginning of the non-endemic outbreaks (European Centre for Disease Prevention and Control/WHO Regional Office for Europe, 2023). Recent spill over events to humans are documented and large outbreaks are reported (Nolen et al., 2016). Before, May 2022 mpox reported cases were linked to travels to an endemic region (Costello et al., 2022, 2022). However, in the 2022 global outbreak, travel links to an endemic country were not identified (GOV.UK., 2022). During this outbreak, mpox cases predominantly occurred among gay and bisexual men who have sex with men (GBMSM) (GOV.UK., 2022), which suggests that transmission is possibly associated with sexual networks. Despite the absence of sexual transmission patterns of mpox in the past (Daskalakis et al., 2022), it is plausible that mpox has had a substantial transmission potential in the sexual networks of men who have sex with men (MSM) (Endo et al., 2022; Tarín-Vicente et al., 2022).

Previous research on network analysis among MSM predominantly focused on HIV-related risk behaviors such as condom use (Janulis et al., 2018) and PrEP (Shrader et al., 2021), or other sexually transmitted infections (STIs) (Ramadhani et al., 2017). In the study of Shrader et al. (2021) among Latinx MSM, it was found that those who disclosed their PrEP use to their sexual partners in their sexual network were less likely to use a condom. Other studies on MSM and their sexual and social networks have shown that mixing of reported networks may influence risk behaviours (Janulis et al., 2018). For example, in a study among young MSM found that Black participants were more likely

122 to have higher race/ethnicity homophily within their sexual network meaning they were
123 more likely to be sexually active with other Black men. This, combined with existing
124 disparities in HIV, contributes to the spread of HIV among Black young MSM (Janulis
125 et al., 2018). The transmission of monkeypox virus (mpoxv) infection may also be
126 associated with sexual networks. A study on heavy-tailed sexual networks and mpox
127 outbreaks in non-endemic regions suggest that large sexual network sizes can explain the
128 disproportionate growth of mpox cases among MSM (Endo et al., 2022). Sexual networks
129 characterized by many one-time partners, which results in increased connectivity (i.e.
130 density) in a sexual network, may also be associated with mpoxv transmission due to its
131 short and symptomatic contagious period (Spicknall et al., 2022). Recent evidence also
132 suggests that contagious period could be asymptomatic (Ferré et al., 2022), which could
133 result in even greater spread of mpox within dense sexual networks.

134 Mpox infection can be transmitted through sustained face-to-face contact, cutaneous
135 routes from a person with not yet healed lesions, and via fomites and there is no biological
136 evidence that mpox has a tendency to infect MSM (Daskalakis et al., 2022). However,
137 the recent global outbreak of monkeypox has shown transmission dynamics similar to
138 those of sexually transmitted infections, with mounting evidence that sexual contact is
139 the most common mode of transmission (Allan-Blitz & Klausner, 2023). Denser sexual
140 networks are an indication of higher contact rates among people, which create more
141 opportunities for transmission and, thus, are more risky (Doherty et al., 2009) and it has
142 been shown that networks of MSM are densely connected (Endo et al., 2022). Therefore,
143 characteristics of sexual networks of MSM could be associated with the rapid spread of
144 mpox. To our best knowledge, no study has described a relationship between the
145 characteristics of egocentric sexual networks of MSM and mpox infection in Spain.

Therefore, the objective of this study is to first, describe and compare the epidemiological and behavioral characteristics, and the characteristics of sexual networks between GBMSM diagnosed and undiagnosed with mpox in Spain, and determine the factors associated with mpox infection among GBMSM.

## Data and methodology

### Study design and study population

A prospective case-control study was conducted in Spain from July 2022 to February 2023. The study targeted a key population GBMSM who are aged 18 years or older. Study participants were categorized into cases - those who were diagnosed with mpoxv infection - and controls - those who were not diagnosed. Cases were recruited from six STIs clinics or hospitals in Spain (Madrid and Barcelona). Inclusion criteria for cases were adult individuals with a confirmed mpoxv infection by PCR within the last 3 months, consenting to participate and willing to comply with the requirements of the protocol. Exclusion criteria were severe disease, defined as requiring hospital admission, inability to consent and/or comply with trial protocol.

Controls were recruited through cases, among participants of another study on mpox, or a dissemination campaign consisting in a video posted on social media. Both cases and controls were considered egos in the study. Controls were excluded if they had had sexual contact with a person diagnosed with mpox within the last 21 days, lived with a person diagnosed within the last 21 days, or were diagnosed with mpox.

Participants were interviewed via 40-minute phone calls by interviewers trained in GBMSM counselling to collect information on their socio-demographic background, sexual behavior, and specific characteristics related to mpox. Each case was matched with

two controls, with similar characteristics: 1) age (+/- 5 years) and 2) sexual behavior (GBMSM).

Informed consent was obtained from all participants online, and they were all compensated €50 for completing the interview. The study protocol was approved by the Ethics Committee of the Hospital Germans Trias i Pujol (PI-22-156).

**Data collection**

Trained personnel conducted telephone surveys, and responses were recorded on paper. The field coordinator harmonized all surveys, data entry was performed at the epidemiological center by trained staff. An adhoc database was developed using REDCap (REDCap systems, Universidad de Vanderbilt, US). The following data were collected through the survey; socio-demographics including year and country of birth, sex assigned at birth, gender identity, sexual orientation, level of education, monthly income, number of cohabitants, engagement in sex work; substance use including drug use in the last year, chemsex practice; recent sexual behavior (<21 or 30 days) including number of sexual partners, sexual practices, and condom use; history of smallpox vaccination; possible exposures to mpoxv in the last 21 or 30 days including close contact with a mpox case, contact with animals, travel history, occupational exposure; health-related variables including history of diagnosis of STIs, enteric infections, and scabies; serological status regarding HIV; PrEP use; and barriers to accessing healthcare services.

In addition, in the egocentric sexual network section, the survey collected information about their last five sexual partners in the past 6 months. Previous research has shown that five is the optimal number for network analysis (Burt, 1984). The following information was collected about their partners: gender, country of birth, age, how long they had known each other, type of relationship, frequency of sexual activity,

194 condom use, sexual practices, drug use during sexual activity, likelihood of a new sexual
195 encounter, where they had their last sexual practice, and if they believed whether these
196 five sexual partners had had sexual intercourse with each other in the last 6 months.

197 Since this study was conducted as a case–control study based on mpox infection,
198 we simply coded cases as mpox-positive (mpox-P) and controls as mpox-negative (mpox-
199 N).

200 **Measures**

201 ***Ego-level variables***

202 **Number of alters** – Number of alters refer to sexual partners of egos, which have
203 been reported in the sexual network section of the questionnaire. Egos could report up to
204 five alters with whom they have had sex with last, in the past six months.

205 **Sexual Network Size** – Network size is calculated by the total number of partners
206 in the past 21 days (30 days for mpox-N) and including up to five alters named in the
207 sexual network section of the questionnaire.

208 ***Ego-alter level variables***

209 **Alter attributes** – Alter level measures included egos' report on alters'
210 demographics, egos' condom use, group sex, and drug use frequency with alters, and
211 place where ego had sex with alters. Demographics included alters' gender (cis man, cis
212 woman, trans woman, trans man), country of birth (Spain, outside of Spain), and age.
213 Ego's condom use, group sex, and drug use frequency with alters were coded as never,
214 sometimes/rarely, and always/mostly. Finally, place where ego had sex with alters was
215 coded as a house/hotel and sex club/cruising.

**Heterogeneity** – These variables measure the similarity of alters in an ego's network. The score is based on Blau's Index (Blau, 1977), and the score ranges from 0 to 1; with higher scores indicating higher heterogeneity. We used this scoring to estimate tie strength heterogeneity, condom use heterogeneity, drug use heterogeneity, and group sex heterogeneity.

**Ego-alter Homophily Index (E-I)** – Variables in this section measure the egos' propensity to have ties to alters with whom they share similar characteristics. The scores range from -1 to 1, -1 corresponding to completely homophilous egos, and 1 to completely heterophilous egos. We used this scoring to estimate the E-I for gender (i.e. same gender as ego), country of birth, and age.

***Alter-alter level variables***

**Sexual network density** – Sexual network density of each ego is the proportion of possible ties among alters reported by egos. In the questionnaire, egos were asked the following question: "Do you think [NAME OF ALTER] has had sexual relations with [NAME OF THE ALTER] (in the last 6 months)?" The density was calculated by summing the number of sexual connections observed between alter-alter pairs and divided by the number of possible pairs. This variable ranged from 0 to 1; with 0 indicating the least density (i.e., none of the have had sex with another alter) and 1 indicating highest density (i.e., all of the alters have had sex with each other) (Tieu et al., 2015).

**Statistical analysis**

For the descriptive analyses, we segregated all the analysis by mpox diagnoses. Firstly, using Chi-square and Wilcoxon test analyses, we describe and compare the characteristics of egos. Next, we describe and compare the sexual network characteristics

of mpox-P and mpox-N egos' in four sections; network variables, alter attributes, ego-alter ties, and alter-alter ties, using chi-square and t-test. In ego-alter analysis we do not present if there is a missing information. Second, we conducted univariable logistic analyses to determine what variables associate with mpox infection, and these models produced odd ratios (OR). With only including significant variables from univariable analyses, we then estimated a multivariable model which produced adjusted odd ratios (aOR). We eliminated variables based on their non-significance until we reached a final multivariable model, and the final model was adjusted by age and country of birth, regardless of their p-value in the univariable analysis. All analyses were conducted using E-Net software and Stata version 15SE.

## Results

**[Table 1 about here]**

Among the 105 participants, 35 (33.3%) individuals were mpox-P. Our analysis revealed that mpox-P individuals had less frequent university or higher degree education (mpox-P: 48.6%; mpox-N: 74.3), and had travelled less recently (mpox-P: 20.0%; mpox-N: 65.7%). Additionally, they reported having fewer sexual partners who had travelled (mpox-P: 21.2%; mpox-N: 44.9%), and had less frequent MDMA (mpox-P: 5.9%; mpox-N: 27.5%) or cocaine (mpox-P: 11.8%; mpox-N: 20.3%) use in the past 30 days. We also found that the proportion of vaccination against mpox was less frequent among mpox-P (mpox-P: 22.9%; mpox-N: 52.9%). Furthermore, it was more frequent among mpox-P individuals to report syphilis in last 12 months (mpox-P: 31.4%; mpox-N: 12.9%) and HIV (mpox-P: 45.7%; mpox-N: 18.6%), it was more frequent among mpox-P to have had at least one sexual contact with a confirmed mpox case (mpox-P: 62.5%; mpox-N: 8.3%), and mpox-P diagnosis was associated with having met at least one sex partner at a

264 darkroom (mpox-P: 12.1%; mpox-N: 1.4%) or at the gym (mpox-P: 12.1%; mpox-N:
265 1.4%) in the past 21 days, and to have had intercourse with a partner they did not know
266 previously (mpox-P: 60.6%; mpox-N: 30.4%).

267 **[Table 2 about here]**

268 The mean sexual network sizes of mpox-P (mean=5.4; SD=6.08) and mpox-N
269 (mean=5.0, SD=4.36) individuals were not significantly different (p-value = 0.679; Table
270 2) between groups. The study included 309 alters reported by mpox-N egos (median of
271 4.4 alters/ego) and 157 alters reported by mpox-P egos (median of 4.4 alters/ego). In
272 comparison to mpox-N individuals, mpox-P individuals had more alters whose country
273 of birth was Spain (mpox-P: 55.1%; mpox-N: 44.8%). It was more frequent among Mpox-
274 P individuals to having had sex with alters always/mostly in a group sex setting (mpox-
275 P: 18.5%; mpox-N: 8.9%) and having stranger/client tie with alters (mpox-P: 46.1%;
276 mpox-N: 31.7%). A descriptive analysis of ego-alter ties has shown that mpox-P egos had
277 less heterogeneous sexual network (mpox-P: 0.22%; mpox-N: 0.31%) than mpox-N. The
278 density of sexual networks was not statistically significant between mpox-P and mpox-N
279 (0.12 and 0.11 respectively).

280 **[Table 3 about here]**

281 In Table 3, we present the uni and multivariable analysis. In the final model, we
282 found that country of birth being outside of Spain (aOR=7.49, 95% CI: 1.86-30.15) and
283 reporting stranger/client ties (aOR=10.3, 95% CI: 1.39-76.6) with alters in the egocentric
284 network analysis were associated with increased risk of mpox infection. Having travelled
285 (aOR=0.01, 95% CI: 0.00-0.08), MDMA (aOR=0.00, 95% CI: 0.00-0.19) and poppers
286 (aOR=0.16, 95% CI: 0.03-0.80) use in the past year, being vaccinated for mpox

(aOR=0.07, 95% CI: 0.02-0.24), and tie strength heterogeneity (aOR=0.01, 95% CI: 0.00-0.42) were associated with lower risk of mpox infection.

## Discussion

To the best of our knowledge, this is the first study to systematically describe and compare the epidemiological and behavioral characteristics, and the sexual networks between GBMSM diagnosed and undiagnosed with mpox in Spain. First and foremost, our results showed that mpox was not only associated to demographic and epidemiological characteristics of respondents, but, as reported for other STIs (Biała & Inglot, 2022), also to the sexual network characteristics of GBMSM. We found that increased prevalence of mpox was found among men who reported meeting their sexual partners at the gym or in a darkroom, or who did not know their sexual partner before the encounter. We found that mpox-P individuals reported fewer steady relationship types compared to mpox-N. Also, egocentric network analysis showed that mpox-P individuals had less heterogeneous sexual networks compared to mpox-N individuals, which means that the sexual ties of mpox-P were defined more by one-type of sexual tie, which was more likely to be one-time sexual encounters. In the multivariable analysis, we found that not being born in Spain, having been vaccinated against mpox, reporting stranger/client ties with alters were risk factors for mpox infection. Our results corroborate previous research arguing that sexual networks with concurrent sexual patterns heighten the mpox transmission risk (Spicknall et al., 2022).

Respondents diagnosed with mpox (34.3%) and their sexual partners had travelled less and their prevalence of sexual contact with a diagnosed case of mpox was higher than mpox-N respondents. In line with our results, a study among mpox positive individuals showed that while less than half of the respondents (112/236, 47%) reported being in

311 contact with a confirmed mpox case, 95% of those who did reported a sexual contact
312 (Mailhe et al., 2023). Together with our results, this difference in prevalence in sexual
313 contact with a mpox case may reflect the emerging role of sexual transmission of mpox
314 in non-endemic countries, more so than previously identified travel links (Antinori et al.,
315 2022; GOV.UK, 2022). Consistent with previous evidence (Ortiz-Saavedra et al., 2023),
316 our study found that mpoxv infection was more prevalent among HIV positive and those
317 who self-reported having had syphilis. According to a study conducted in Canary Islands
318 (Spain), 60% of the 42 male patients diagnosed with mpox were found to be people living
319 with HIV (Betancort-Plata et al., 2022). The research revealed that those with HIV had a
320 greater incidence of perioral lesions, pharyngitis, and STI coinfection (Betancort-Plata et
321 al., 2022).

322 Unexpectedly, our study revealed that individuals who have never used MDMA
323 or cocaine had a higher prevalence of mpox. Similarly, we found that MDMA and popper
324 use in the past year was inversely associated with mpox infection. This finding differs
325 from previous research on other types of STIs (Biała & Inglot, 2022), which have shown
326 that recreational drug use is associated with increased odds of infection. However, we
327 also found that using substances in the context of sex with alters was not significant. It is
328 possible that our results differ from other studies in terms of use of substances because of
329 the recruitment of the non-randomized controls for this study. This limitation may have
330 influenced our results because the difference in recruitment strategies may have led to
331 non-comparable outcomes for certain variables.

332 There was no significant variation in the reported density of sexual networks
333 between mpox-P and mpox-N respondents. Studies on HIV transmission have
334 demonstrated that the density of sexual networks increases the risk of contracting HIV
335 infection (Smith et al., 2004), even among individuals with low levels of behavioral risk

(Amirkhanian, 2014). Since mpoxv has numerous transmission routes which include close contact, the density of sexual networks may still contribute to higher transmission rates. Further research is required to explore the impact of network density among GBMSM.

There are several potential limitations to this study that need to be acknowledged. Firstly, by design the study sample may not be representative of all GBMSM in Spain and due to the enrolment in the main study design and exclusion of referred participants, such as not consenting to the study and having experienced a severe disease, include some additional selection biases. Secondly, our study may suffer from selection bias due to its case-control approach in the data collection. The recruitment of controls in this study had more variety of channels of recruitment, which can lead to the selection probabilities of exposed and unexposed cases and controls from the target population are differential and not proportional. However, we only included controls who were matched to the cases by similar characteristics [age (+/- 5 years) and 2) sexual behavior (GBMSM)], therefore, minimizing the possible selection bias. Third, all the data collected were self-reported by respondents, leading to egocentric analysis, which is susceptible to projection and social desirability bias. As a result, participants may not have been certain about the information regarding their network members, especially their anonymous and actual sexual relations between their named sex partners. This uncertainty might have resulted in imperfect reporting of these factors. In particular, the sexual network density measure of partners within networks may have measurement bias, as participants may not have had direct knowledge of their partners' other sexual relations. Lastly, this study limited the number of named alters to be a maximum of five based on previous studies (Burt, 1984) and the ego network structure may be affected by this limit. In light of these limitations, the study

360 focused on descriptors of network members that best describe them, while acknowledging
361 that overlapping categories may exist.

362 This study is the first to depict and compare the attributes of GBMSM's sexual
363 networks in association with mpox in Spain. Our findings emphasize the significant
364 influence of individual and sexual network traits on the occurrence of mpox among
365 GBMSM, such as HIV serostatus, meeting sexual partners at gyms/sex venues,
366 encounters with multiple partners and drug use. Individuals with co-infection of mpox
367 with HIV or other STIs should be taken into consideration when prioritizing who to target
368 within prevention measures. Furthermore, early interventions focused on core groups are
369 crucial for decreasing the incidence and eventually prevent future outbreaks of mpox. Our
370 results confirm that, prevention strategies would benefit from including peers and
371 community entities with access to these core groups, for instance by means of night life
372 venues and other types of GBMSM parties where having sex with multiple partners and
373 drug use occurs. Considering these findings would increase the effectiveness of
374 preventive interventions in the event of new outbreaks of mpox in non-endemic areas.

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383 Table 1. Characteristics of Egos by Mpox Infection

| | Total (N= 102) N – *median (IQR)* | MPX Positive (n = 35) N (%) – *median (IQR)* | MPX Negative (n = 70) N (%) – *median (IQR)* | p-value (chi-square test – *Wilcoxon*) |
|---|---|---|---|---|
| **Age, median (IQR)** | *33.23 (29.09-40.42)* | *33.1 (28.45-38.47)* | *33.26 (29.45-40.81)* | *0.586* |
| **Country of birth:** | | | | 0.189 |
| Spain | 56 (53.3) | 15 (42.9) | 41 (58.6) | |
| Outside of Spain | 49 (46.7) | 20 (57.1) | 29 (41.4) | |
| **Income** | | | | 0.437 |
| 1249€ or less | 41 (39) | 16 (45.7) | 25 (35.7) | |
| 1250€ or more | 64 (61) | 19 (54.3) | 45 (64.3) | |
| **Education** | | | | **0.016** |
| Primary/secondary/technical | 36 (34.3) | 18 (51.4) | 18 (25.7) | |
| Universitary/higher | 69 (65.7) | 17 (48.6) | 52 (74.3) | |
| **Sexual orientation** | | | | 0.264 |
| Gay | 97 (92.4) | 34 (97.1) | 63 (90) | |
| Bisexual | 8 (7.6) | 1 (2.9) | 7 (10) | |
| **Travelled recently[1]** | | | | **<0.001** |
| Yes | 53 (50.5) | 7 (20.0) | 46 (65.7) | |
| No | 52 (49.5) | 28 (80.0) | 24 (34.3) | |
| **Number of co-habitants** | | | | 0.41 |
| Lives alone | 18 (17.1) | 8 (22.9) | 10 (14.3) | |
| 1 or more co-habitants | 87 (82.9) | 27 (77.1) | 60 (85.7) | |
| **Vaccinated for MPX** | | | | **0.012** |
| Yes | 45 (42.9) | 8 (22.9) | 37 (52.9) | |
| No + DK/DA[a] | 50 (47.6) | 22 (62.9) | 28 (40) | |
| **On PrEP** | | | | 0.895 |
| Yes | 37 (48.7) | 10 (52.6) | 27 (47.4) | |
| No | 39 (51.3) | 9 (47.4) | 30 (45.6) | |
| **Sexual contact with MPX[2]** | | | | **0.018** |
| Yes | 6 (30) | 5 (62.5) | 1 (8.3) | |
| No | 14 (70) | 3 (37.5) | 11 (91.7) | |
| **Sexual partner travelled[3]** | | | | **0.036** |
| Yes | 38 (37.3) | 7 (21.2) | 31 (44.9) | |
| No + DK/DA[a] | 64 (62.7) | 26 (78.8) | 38 (55.1) | |
| **Met sex partner at darkroom[3]** | | | | **0.038** |
| Yes | 5 (4.9) | 4 (12.1) | 1 (1.4) | |
| No | 96 (94.1) | 29 (87.9) | 67 (97.1) | |
| **Met sex partner at gym[3]** | | | | **0.038** |
| Yes | 5 (4.9) | 4 (12.1) | 1 (1.4) | |
| No | 96 (94.1) | 29 (87.9) | 67 (97.1) | |
| **Knew sex partner before[4]** | | | | **0.008** |
| Yes | 60 (58.8) | 13 (39.4) | 47 (68.1) | |
| No | 41 (40.2) | 20 (60.6) | 21 (30.4) | |
| **HIV[5,]** | | | | **0.007** |
| Positive | 29 (27.6) | 16 (45.7) | 13 (18.6) | |
| Negative | 76 (72.4) | 19 (54.3) | 57 (81.4) | |
| **Had Chlamydia[5,6]** | | | | 0.934 |
| Yes | 23 (21.9) | 7 (20) | 16 (22.9) | |
| No | 82 (78.1) | 28 (80) | 54 (77.1) | |
| **Had Gonorrhoea[5,6]** | | | | 0.31 |
| Yes | 28 (26.7) | 12 (34.3) | 16 (22.9) | |
| No | 77 (73.3) | 23 (65.7) | 54 (77.1) | |
| **Had Syphilis[5,6]** | | | | **0.043** |
| Yes | 20 (19) | 11 (31.4) | 9 (12.9) | |
| No | 85 (81) | 24 (68.6) | 61 (87.1) | |
| **Alcohol use** | | | | 0.050 |
| Never | 6 (5.8) | 4 (11.8) | 2 (2.9) | |
| Past 30 days | 92 (89.3) | 27 (79.4) | 65 (94.2) | |
| Past year | 5 (4.9) | 3 (8.8) | 2 (2.9) | |
| **GHB/L use** | | | | 0.843 |
| Never + DK/DA[a] | 63 (61.2) | 20 (58.8) | 43 (62.3) | |
| Past 30 days | 22 (21.4) | 7 (20.6) | 15 (21.7) | |

| | | | | |
|---|---|---|---|---|
| Past year | 18 (17.5) | 7 (20.6) | 11 (15.9) | |
| **Ecstasy use** | | | | 0.373 |
| Never | 58 (56.3) | 22 (64.7) | 36 (52.2) | |
| Past 30 days | 23 (22.3) | 5 (14.7) | 18 (26.1) | |
| Past year | 22 (21.4) | 7 (20.6) | 15 (21.7) | |
| **Ketamine use** | | | | 0.313 |
| Never | 71 (68.9) | 24 (70.6) | 47 (68.1) | |
| Past 30 days | 16 (15.5) | 3 (8.8) | 13 (18.8) | |
| Past year | 16 (15.5) | 7 (20.6) | 9 (13) | |
| **Poppers use** | | | | 0.062 |
| Never + DK/DA[a] | 39 (37.9) | 17 (50) | 22 (31.9) | |
| Past 30 days | 44 (42.7) | 9 (26.5) | 35 (50.7) | |
| Past year | 20 (19.4) | 8 (23.5) | 12 (17.4) | |
| **Viagra use** | | | | 0.368 |
| Never | 60 (58.3) | 18 (52.9) | 42 (60.9) | |
| Past 30 days | 31 (30.1) | 10 (29.4) | 21 (30.4) | |
| Past year | 12 (11.7) | 6 (17.6) | 6 (8.7) | |
| **Cocaine use** | | | | **0.049** |
| Never | 65 (63.1) | 27 (79.4) | 38 (55.1) | |
| Past 30 days | 18 (17.5) | 4 (11.8) | 14 (20.3) | |
| Past year | 20 (19.4) | 3 (8.8) | 17 (24.6) | |
| **MDMA use** | | | | **0.001** |
| Never + DK/DA[a] | 60 (58.3) | 28 (82.4) | 32 (46.4) | |
| Past 30 days | 21 (20.4) | 2 (5.9) | 19 (27.5) | |
| Past year | 21 (20.4) | 3 (8.8) | 18 (26.1) | |
| Missing | 1 (1) | 1 (2.9) | 0 (0) | |
| **Chemsex** | | | | 0.912 |
| Never | 58 (56.3) | 19 (55.9) | 39 (56.5) | |
| Past 30 days | 20 (19.4) | 6 (17.6) | 14 (20.3) | |
| More than 30 days ago | 25 (24.3) | 9 (26.5) | 16 (23.2) | |

[a] Do not know or do not answer. [1] 21 days before the symptoms started for MPX diagnosed and past 30 days for MPX negative.[2] Asked for those who had contact with MPX. [3] Past 30 days; sexual partner that had contact with in the past 21 days. [4] Already knew the partner; fuckbuddies and/or friends with benefits. [5] Self-reported. [6] In the past 12 months.

402 Table 2. Sexual Network Characteristics of Egos by Mpox Infection

| | Ego is MPX Positive (n = 35) N (%) – **min-max** (*mean, SD)* | Ego is MPX Negative (n = 70) N (%) – **min-max** (*mean, SD)* | p-value (chi-square test – *t-test*) |
|---|---|---|---|
| ***Network variables*** | | | |
| **Network size**[a] | **0-31** *(5.4, 6.08)* | **0-20** *(5.0, 4.36)* | *0.679* |
| **Number of alters** | 157 | 309 | |
| ***Alter attributes*** | | | |
| **Gender** | | | |
| Cis male | 153 (97.5%) | 308 (99.7%) | 0.214 |
| Trans male | 2 (1.3%) | 1 (0.3%) | |
| I don't know | 2 (1.2%) | 0 (0.0%) | |
| **Country of birth** | | | **0.036** |
| Spain | 86 (55.1%) | 138 (44.8%) | |
| Outside of Spain | 70 (44.9%) | 170 (55.2%) | |
| **Age** | | | 0.066 |
| 19-35 | 75 (71.4%) | 176 (59.5%) | |
| 36-45 | 20 (19.1%) | 90 (30.4%) | |
| 46+ | 10 (9.5%) | 30 (10.1%) | |
| **Condom Use**[1] | | | 0.118 |
| Never-mostly | 117 (80.1%) | 225 (74.5%) | |
| Always | 29 (19.9%) | 77 (25.5%) | |
| **Drug use**[1] | | | 0.050 |
| Never | 106 (71.6%) | 241 (80.3%) | |
| Sometimes-rarely | 7 (4.8%) | 16 (5.3%) | |
| Always-mostly | 35 (23.6%) | 43 (23.4%) | |
| **Group sex**[1, 2] | | | **0.005** |
| Never | 119 (78.8%) | 258 (85.2%) | |
| Sometimes-rarely | 4 (2.7%) | 18 (5.9%) | |
| Always-mostly | 28 (18.5%) | 27 (8.9%) | |
| **Place of sex**[1] | | | 0.125 |
| A house/hotel | 110 (82.7%) | 250 (85.9%) | |
| Sex club/cruising | 23 (17.3%) | 41 (14.1%) | |
| ***Ego-alter ties*** | | | |
| **Tie strength** | | | **0.004** |
| Spouse/boyfriend | 7 (4.6%) | 32 (10.5%) | |
| Sexual partner/fuckbuddy/acquaintance | 75 (49.3%) | 177 (57.8%) | |
| Stranger/client | 70 (46.1%) | 97 (31.7%) | |
| **Tie strength heterogeneity** | *0.22* | *0.31* | ***0.014*** |
| **Condom use heterogeneity** | *0.17* | *0.16* | *0.837* |
| **Drug use heterogeneity** | *0.11* | *0.11* | *0.425* |
| **Group sex heterogeneity** | *0.06* | *0.11* | *0.152* |

| | | | |
|---|---|---|---|
| **Gender homophily (E-I index)** | *-0.95* | *-0.99* | *0.203* |
| **Country of birth homophily (E-I index)** | *0.22* | *0.16* | *0.559* |
| **Age homophily (E-I index)** | *0.86* | *0.85* | *0.381* |
| ***Alter-Alter Ties*** | | | |
| **Density[3]** | *0.12* | *0.11* | *0.836* |

Notes: [a]Network size is calculated by the total number of partners in the past 21 days, including up to five alters named in the network section of the questionnaire.[1] With the named sexual partner. [2] Frequency of having sex with the named partner in a group sex setting. [3] Sexual network density was calculated as how many alters named by ego had sex with each other (value 1; all alters of the ego had sex with eachother, value 0; none of them had sex with each other).

418 Table 3. Univariable and multivariable logistic analyses

| | Mpox Positive (Ref.: mpox negative) OR (95%CI) | Mpox Positive (Ref.: mpox negative) aOR (95%CI) |
|---|---|---|
| **Age** | 1.00 (0.94-1.05) | 0.99 (0.91-1.08) |
| **Country of birth (Ref.: Spain)** | | |
| Outside of Spain | 1.69 (0.72-3.95) | 7.49 (1.86-30.15)[b] |
| **Travelled (Ref.: No)** | | |
| Yes | 0.11 (0.04-0.31)[c] | 0.01 (0.00-0.08)[c] |
| **MDMA use (Ref.: Never)** | | |
| Past 30 days | 0.18 (0.04-0.70)[a] | 0.31 (0.05-1.73) |
| Past year | 0.12 (0.02-0.60)[a] | 0.00 (0.00-0.19)[b] |
| **Poppers use (Ref.: Never)** | | |
| Past 30 days | 0.78 (0.25-2.45) | 0.27 (0.04-1.48) |
| Past year | 0.32 (0.11-0.87)[a] | 0.16 (0.03-0.80)[a] |
| **Vaccinated for mpox (Ref.: No)** | | |
| Yes | 0.24 (0.09-0.64)[b] | 0.07 (0.02-0.24)[c] |
| **Education (Ref.: Primary/secondary/technical)** | | |
| University/higher | 0.24 (0.10-0.61)[b] | - |
| *Network variables* | | |
| **Tie strength (Ref.: Spouse/boyfriend)** | | |
| Sexual partner/fuckbuddy/acquaintance | 1.93 (0.76-4.89) | 1.97 (0.31-12.4) |
| Stranger/client | 3.29 (1.36-7.94)[b] | 10.3 (1.39-76.6)[a] |
| **Tie strength heterogeneity** | 0.07 (0.01-0.49)[b] | 0.01 (0.00-0.42)[a] |
| Observations | - | 98 |

419 Notes: [a] $p < .05$, [b] $p < .01$, [c] $p < .001$. OR: Odd ratio. aOR: Adjusted odd ratio.

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