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# Kissing, fellatio, and anilingus as risk factors for oropharyngeal gonorrhoea in men who have sex with men: A cross-sectional study

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## Summary

**Background** Our aim was to determine whether exposure to the anatomical sites (oropharynx, penis, or anus) of male partners of men who have sex with men (MSM) were independent risk factors for oropharyngeal gonorrhoea after adjusting for exposures to these sites.

**Methods** In this cross-sectional study, we invited MSM who attended the Melbourne Sexual Health Centre (MSHC) in Victoria, Australia between 26-November 2018 and 31-December 2020 to complete a survey of their sexual practices in the past three months. We collected data on the number of male partners with whom men engaged in sexual activities that exposed their oropharynx to their partners' oropharynx (kissing), penis (fellatio), and anus (rimming or anilingus). Only men who were aged  $\geq 16$  years, tested for oropharyngeal gonorrhoea and did not have indeterminate or invalid results were included in the final analysis. We conducted univariable and multivariable logistic regression analyses to investigate associations between oropharyngeal gonorrhoea and the three exposures to the oropharynx.

**Findings** The median age of the 2,322 men who completed the survey was 31 years (IQR: 26-40), and 5.2% ( $n = 120$ ) were diagnosed with oropharyngeal gonorrhoea. Our univariate analysis showed that oropharyngeal gonorrhoea was significantly associated with increasing number of kissing ( $p_{\text{trend}} < 0.0001$ ), rimming ( $p_{\text{trend}} < 0.0001$ ) and fellatio ( $p_{\text{trend}} < 0.0001$ ) partners. After adjusting for all three exposures, oropharyngeal gonorrhoea was associated with increasing number of kissing ( $p_{\text{trend}} = 0.014$ ) and rimming partners ( $p_{\text{trend}} = 0.037$ ) but not fellatio ( $p_{\text{trend}} = 0.61$ ).

**Interpretation** Our data suggest kissing and rimming are important practices in oropharyngeal gonorrhoea transmission in MSM. Novel interventions which target the oropharynx are required for gonorrhoea prevention.

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**Keywords:** Tongue kiss; MSM; Oropharyngeal gonorrhoea; Oral sex; Rimming

## Introduction

Gonorrhoea disproportionately affects gay, bisexual, and other men who have sex with men (MSM) and has substantially increased in many high-income countries since the 2010s.<sup>1,2</sup> In Australia, the incidence of

gonorrhoea among MSM attending sexual health clinics has increased from 14.1 per 100 person-years in 2010 to 24.6 per 100 person-years in 2017, and the most significant increase in incidence was in anorectal and oropharyngeal infections.<sup>3</sup>

Reducing the incidence of gonorrhoea is a global public health priority because of the increase in antimicrobial resistance (AMR),<sup>4</sup> particularly at the oropharynx, which is an important anatomical site for the development of AMR through horizontal gene transfer.<sup>5-8</sup> Gonorrhoea prevention programs have primarily focused on increasing condom use. However, condoms

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### Research in context

#### Evidence before this study

We searched PubMed and MEDLINE databases using the search strategy: “gonorrhoea” OR “gonorrhea” AND “kissing” on 3 January 2022, without language restrictions. We found three cross-sectional studies and two cohort studies examining the associations between kissing, fellatio, and/or anilingus (rimming), and oropharyngeal gonorrhoea among men who have sex with men (MSM). However, these studies generated contrasting results due to differences in sample size and methodology. In particular, the cross-sectional studies were unable to statistically adjust for the three exposures to the oropharynx through kissing, fellatio and rimming.

#### Added value of this study

This is the largest study that examines the associations between oropharyngeal gonorrhoea and the three exposures to the oropharynx through kissing, fellatio, and rimming. Our findings show that kissing and rimming are significant risk factors for oropharyngeal gonorrhoea among MSM, and fellatio was not a statistically significant risk factor for oropharyngeal gonorrhoea.

#### Implications of all the available evidence

Our data provide the substantial empiric evidence for the recently hypothesised paradigm that transmission routes other than fellatio also play a significant role in gonorrhoea transmission among MSM. The increasing incidence of gonorrhoea and the emergence of extensively antimicrobial-resistant *Neisseria gonorrhoeae*, call for more research and stronger evidence on novel interventions which target the oropharynx.

may not be effective for preventing oropharyngeal gonorrhoea because condoms are not commonly used during oral sex among MSM.<sup>9</sup> Additionally, substantial reductions in condom use for anal sex which coincided with treatment as prevention (TasP)<sup>10</sup> and the availability of HIV pre-exposure prophylaxis (PrEP) in the late 2010s among MSM, make strategies to promote this approach challenging.<sup>2,11</sup> This has led some investigators to explore the transmission of gonorrhoea in more detail to determine novel and effective interventions.<sup>12</sup>

Past studies have shown that *N. gonorrhoeae* can be cultured in the saliva of individuals who have oropharyngeal gonorrhoea,<sup>13,14</sup> suggesting that viable *N. gonorrhoeae* can be transmitted when saliva is exchanged through tongue-kissing,<sup>13,14</sup> and this contention is also supported by several epidemiological studies.<sup>15,16</sup> A number of cross-sectional studies have investigated kissing as a risk factor for oropharyngeal gonorrhoea in MSM,<sup>16–18</sup> but some of these studies reported exposures to all three anatomical sites of partners among male-male partnerships using categorical data (i.e.,

‘never’, ‘occasionally’ or ‘often’) that seemed somewhat unclear or subjective<sup>17</sup> and/or did not measure kissing in the absence of sex.<sup>18</sup> Thus, these studies were not able to find the independent association between kissing and oropharyngeal gonorrhoea.<sup>17,18</sup>

A previous study from Chow *et al.* (2019) found that increasing number of kissing-without-sex partners (i.e., kissing in the absence of sex) and kissing-with-sex partners (i.e., kissing in the presence of anal sex, fellatio and/or rimming [anilingus]) are both independent risk factors for oropharyngeal gonorrhoea in MSM, but not with sex-only partners (i.e., having anal sex, fellatio and/or rimming in the absence of kissing).<sup>16</sup> However, one of the limitations in Chow *et al.*'s study was that it did not collect data on the other exposures to the oropharynx, such as fellatio and rimming, separately,<sup>16</sup> and could not statistically adjust for these three exposures to the oropharynx. Therefore, we aimed to investigate whether kissing is an independent risk factor for oropharyngeal gonorrhoea in MSM, adjusting for exposure to the oropharynx from the partner's penis through fellatio, and from the partner's anus through rimming.

## Methods

### Study setting and population

Between 26-November 2018 and 31-December 2020, we conducted a cross-sectional study named the “Kissing, Oral Sex and Sexually transmitted infections” (KOSS) study at the Melbourne Sexual Health Centre (MSHC) in Victoria, Australia. MSHC is a public sexual health clinic that provides free HIV and STI testing and treatment. Upon arrival, clients are required to register their visit and complete a series of questions as part of routine care through computer-assisted self-interview (CASI). These questions collected information on their demographic characteristics (e.g., age, countries of birth) and sexual practices (e.g., number of partners and condom use) but did not collect information on kissing, fellatio, and rimming. After completing the routine questions, MSM aged  $\geq 16$  years were invited to participate in the KOSS study via CASI, which included additional questions asking about the number of partners involved in kissing, fellatio, and rimming in the past three months. We excluded men who were aged  $< 16$  years, did not test for oropharyngeal gonorrhoea and had indeterminate or invalid results. We defined MSM as men who had sex with other men in the past 12 months. MSM included gay men who only had sex with other men and bisexual men who had sex with both men and women in the past 12 months. Men were provided with a brief description of the study and a plain language statement approved by the ethics committee and were required to provide their implied consent to participate in the KOSS study by selecting ‘Yes, I agree’ or ‘Decline’ before commencing the additional questions. Participation was

voluntary, and none were paid for completing the study. This study was approved by the Alfred Hospital Ethics Committee, Melbourne, Australia (668/18). This manuscript is reported as per the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) Guidelines.<sup>19</sup>

### Measurement

Given that we aimed to identify the association between exposures to the oropharynx and oropharyngeal gonorrhoea, data on receiving fellatio (i.e., participant's penis in partner's mouth) and receiving rimming (i.e., partner's mouth/tongue around/in participant's anus) were not collected. We defined kissing as tongue-kissing, fellatio as performing fellatio (partner's penis was in participant's mouth) and rimming as performing anilingus (participant's mouth/tongue around/in partner's anus). In the KOSS study, participants were asked to report the number of male partners with whom they engaged in the following activities in the past three months: kissing, fellatio, and rimming. We also extracted routinely collected data on participants' demographic characteristics (i.e., age and country of birth), HIV status, current PrEP use and information about their sexual contact with someone known to have gonorrhoea. Routine triple-site testing for gonorrhoea was offered to all MSM attending MSHC, regardless of the presence of symptoms as per the Australian guidelines.<sup>20</sup> Additionally, we extracted oropharyngeal, anorectal, and urethral gonorrhoea diagnoses among men who participated in the KOSS study. Oropharyngeal and anal swabs, and first pass urine samples were tested by nucleic acid amplification test (NAAT) for *Neisseria gonorrhoeae* using Aptima Combo 2<sup>®</sup> Assay (Hologic Panther system; Hologic, San Diego, CA, USA).

### Statistical analyses

We assumed 1% of men in the unexposed group (no kissing) and 6% of men in the exposed group (kissing) would have oropharyngeal gonorrhoea. Based on a previous study,<sup>21</sup> approximately 90% of men kissed their male sexual partner and therefore, we assumed a 1:10 unexposed:exposed ratio. With the 80% power and 5% significance level, we would need 1691 men for our study. Our study period included several months of the COVID-19 pandemic. Past studies have shown that MSM have changed or reduced their sexual practices during the COVID-19 pandemic<sup>22,23</sup> and therefore, we over-recruited men to ensure that the number of participants is sufficient in both the unexposed and exposed groups.

Men who completed the KOSS study and who also were tested for oropharyngeal gonorrhoea on the day they completed the survey were included in the final analysis. The survey collected data on men's number of

partners and therefore, if the same individual completed the survey multiple times in the past three months, we only included the first completed response in this analysis. We calculated descriptive statistics, including median for continuous variables and proportion and 95% confidence intervals (CI) using binomial exact methods for categorical variables. Age was categorised into four groups (i.e., 16-25, 26-35, 36-45, >45 years). The number of kissing, fellatio and rimming partners in the past three months were categorised into four groups (0, 1-2, 3-4, >4). We examined the age-related *p*-values for trend in the median of partners using Jonckheere–Terpstra tests.

Univariable logistic regression was performed to examine the risk factors (e.g., demographic characteristics, and the number of kissing, fellatio, and rimming partners in the past three months) associated with oropharyngeal gonorrhoea. Variables with  $p < 0.1$  in the univariable analyses were considered as potential confounding factors and were included in the multivariable logistic regression model. Additionally, we considered all exposures to the oropharynx as confounding factors, and they were included in the multivariable logistic regression model. Crude and adjusted odds ratios (OR) and the 95% confidence intervals (CI) were reported. We also calculated the *P* for trend for ordinal covariates (i.e., the number of kissing, fellatio and rimming partners and age) to examine the monotone relationships between exposure factors and outcome. *P* for trend for ordinal covariates was determined by testing the slope of the regression line whether it was equal to zero.<sup>24</sup> We estimated multicollinearity between the set of variables included in the multivariable logistic regression model using variance inflation factors (VIFs). The VIFs for the variables included in our multivariable logistic regression model were  $< 10$ , which is not problematic to our model's estimations. All statistical analyses were conducted using Stata (Version 17, College Station, Texas, USA).

### Role of funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. EPFC and JT had access to all data within the study and JT had final responsibility for the decision to submit for publication.

### Results

A total of 21,960 MSM were invited to participate in the KOSS study, and 2,546 (11.6%) consented to participate. Men who participated were significantly older than men who did not participate (median = 31.0 [IQR: 26-40] vs. 31 [IQR: 26-37]),  $p < 0.0001$ ). Australian-born men were more likely to participate than overseas-born men (52.1% vs. 47.9%,  $p = 0.0010$ ). In this analysis, we

|                                 | Total n (%) |
|---------------------------------|-------------|
| <b>Age, median (IQR)</b>        | 31 (26-40)  |
| <b>Country of birth</b>         |             |
| Australia                       | 1129 (48.6) |
| Overseas                        | 1077 (46.4) |
| Unknown                         | 116 (5.0)   |
| <b>Sexual orientation</b>       |             |
| Gay <sup>a</sup>                | 2024 (87.2) |
| Bisexual                        | 298 (12.8)  |
| <b>HIV/PrEP status</b>          |             |
| HIV negative not on PrEP        | 1756 (75.6) |
| HIV negative on PrEP            | 490 (21.1)  |
| HIV positive                    | 76 (3.3)    |
| <b>Known gonorrhoea contact</b> |             |
| No                              | 2193 (94.4) |
| Yes                             | 129 (5.6)   |

**Table 1: Sociodemographic characteristics of 2322 MSM.**

<sup>a</sup> Men who only have sex with other men.

IQR, interquartile range.

HIV, human immunodeficiency virus.

PrEP, pre-exposure prophylaxis for HIV.

excluded 224 men because 209 did not test for oropharyngeal gonorrhoea, 13 had indeterminate results, and two had invalid results. The remaining 2,322 MSM were included in the final analysis (Table 1); their age ranged from 17 to 87 years, with a median of 31 (IQR: 26-40), and almost half were born in Australia (48.6%,  $n = 1129$ ). The majority were men who only had sex with other men (87.1%,  $n = 2024$ ). There were 3.3% ( $n = 76$ ) men living with HIV and 21.1% ( $n = 490$ ) taking HIV PrEP.

Overall, the oropharyngeal gonorrhoea positivity was 5.2% (95% CI 4.3% to 6.1%; 120/2322), anorectal gonorrhoea was 5.4% (95% CI 4.5% to 6.4%; 117/2157), and urethral gonorrhoea was 2.1% (95% CI 1.6% to 2.8%; 48/2282). Of the 2,322 MSM, 91.0% (95% CI 89.7% to 92.1%;  $n = 2112$ ) had kissed, 88.5% (95% CI 87.1% to 89.7%;  $n = 2054$ ) fellated, and 53.2% (95% CI 51.1% to 55.2%;  $n = 1235$ ) rimmed at least one male partner in the past three months. There were 50.8% (95% CI 48.7% to 52.8%;  $n = 1179$ ) of men who had all three oral exposures (i.e., kissed, fellated, and rimmed) with at least one male partner in the past three months. Of the 127 men who reported not having had kissing, fellatio, and rimming partners, one tested positive for oropharyngeal gonorrhoea.

The median number of partners who men kissed was 3 (IQR:2-6), the median number of partners to whom men gave fellatio was 2 (IQR:1-5) and the number of partners who men rimmed was 1 (IQR: 0-2) in the past three months (Table 2). The median number of partners who men kissed significantly increased with increasing age ( $p_{\text{trend}} = 0.045$ ) but declined for men over 45 years old. The number of

| Age (years)            | Number of partners<br>Median (IQR) | $P_{\text{trend}}^a$ |
|------------------------|------------------------------------|----------------------|
| <b>Kissing</b>         |                                    |                      |
| 16-25                  | 3 (2-6)                            | 0.045                |
| 26-35                  | 4 (2-7)                            |                      |
| 36-45                  | 3 (2-7)                            |                      |
| >45                    | 3 (1-6)                            |                      |
| <b>All<sup>b</sup></b> | <b>3 (2-6)</b>                     |                      |
| <b>Fellatio</b>        |                                    |                      |
| 16-25                  | 3 (1-4)                            | 0.13                 |
| 26-35                  | 2 (1-4)                            |                      |
| 36-45                  | 3 (1-5)                            |                      |
| >45                    | 3 (1-5)                            |                      |
| <b>All<sup>b</sup></b> | <b>2 (1-5)</b>                     |                      |
| <b>Rimming</b>         |                                    |                      |
| 16-25                  | 0 (0-1)                            | <0.0001              |
| 26-35                  | 1 (0-2)                            |                      |
| 36-45                  | 1 (0-2)                            |                      |
| >45                    | 1 (0-2)                            |                      |
| <b>All<sup>b</sup></b> | <b>1 (0-2)</b>                     |                      |

**Table 2: Median number of kissing, fellatio, and rimming partners in the past 3 months, stratified by age.**

<sup>a</sup> P value for trend from Jonckheere–Terpstra test.

<sup>b</sup> Unstratified means and medians.

IQR: interquartile range.

partners to whom men gave fellatio varied across age groups ( $p_{\text{trend}} = 0.13$ ). The median number of partners who men rimmed significantly increased with increasing age ( $p_{\text{trend}} < 0.0001$ ).

Among 27 men (1.1%) who only had kissing-only partners in the past three months, one man (3.5%; 95% CI 0.1% to 19.0%) had oropharyngeal gonorrhoea, and none had anorectal or urethral gonorrhoea. Of the six men (<0.1%) who only performed fellatio and did not kiss anyone in the past three months, none had oropharyngeal, anorectal, or urethral gonorrhoea (0%, 95% CI 0% to 45.9%). Similarly, two men (<0.1%) who only had performed rimming, none had oropharyngeal, anorectal, or urethral gonorrhoea (0%, 95% CI 0% to 84.1%).

Men who reported sexual contact with someone known to have gonorrhoea had the highest adjusted odds of having oropharyngeal gonorrhoea (aOR 5.0; 95% CI 3.06 to 8.20) (Table 3). In the multivariable analysis, increasing number of kissing partners was significantly associated with oropharyngeal gonorrhoea ( $p_{\text{trend}} = 0.014$ ) (Table 3). The multivariable analysis also showed that increasing number of rimming partners was significantly associated with oropharyngeal gonorrhoea ( $p_{\text{trend}} = 0.037$ ) (Table 3). However, there was no association between oropharyngeal gonorrhoea and the number of fellatio partners. Men who only had sex with men, and men currently taking PrEP, were significantly more likely to have oropharyngeal gonorrhoea in the

| Risk factors  | Individuals, n | Oropharyngeal gonorrhoea positivity, n (%) | Crude OR (95% CI) | P value              | Adjusted OR (95% CI) | P value            |
|---|----------------|--|-------------------|----------------------|----------------------|--------------------|
| <b>Number of kissing partners in the past 3 months</b>  |                |  |                   | <0.0001 <sup>a</sup> |                      | 0.014 <sup>a</sup> |
| 0   | 210            | 3 (1.4)                                    | 1 (ref)           | -                    | 1 (ref)              | -                  |
| 1-2   | 682            | 18 (2.6)                                   | 1.87 (0.55-6.41)  | 0.32                 | 1.81 (0.48-6.88)     | 0.38               |
| 3-4   | 531            | 24 (4.5)                                   | 3.27 (0.97-10.97) | 0.055                | 2.58 (0.68-9.81)     | 0.16               |
| >4  | 899            | 75 (8.3)                                   | 6.28 (1.96-20.11) | 0.0020               | 3.59 (0.95-13.55)    | 0.061              |
| <b>Number of fellatio partners in the past 3 months</b> |                |  |                   | <0.0001 <sup>a</sup> |                      | 0.61 <sup>a</sup>  |
| 0   | 286            | 9 (3.2)                                    | 1 (ref)           | -                    | 1 (ref)              | -                  |
| 1-2   | 885            | 27 (3.1)                                   | 0.97 (0.45-2.08)  | 0.94                 | 0.73 (0.32-1.69)     | 0.46               |
| 3-4   | 567            | 32 (5.6)                                   | 1.84 (0.87-3.91)  | 0.11                 | 0.83 (0.35-1.99)     | 0.68               |
| >4  | 584            | 52 (8.9)                                   | 3.23 (1.46-7.13)  | 0.0028               | 0.99 (0.41-2.42)     | 0.98               |
| <b>Number of rimming partners in the past 3 months</b>  |                |  |                   | <0.0001 <sup>a</sup> |                      | 0.037 <sup>a</sup> |
| 0   | 1087           | 37 (3.4)                                   | 1 (ref)           | -                    | 1 (ref)              | -                  |
| 1-2   | 785            | 38 (4.8)                                   | 1.44 (0.91-2.29)  | 0.12                 | 1.15 (0.32-1.69)     | 0.57               |
| 3-4   | 219            | 19 (8.7)                                   | 2.70 (1.52-4.78)  | 0.0007               | 1.55 (0.82-2.92)     | 0.18               |
| >4  | 231            | 26 (11.3)                                  | 3.60 (2.13-6.10)  | <0.0001              | 1.85 (0.97-3.52)     | 0.061              |
| <b>Age (years)</b>                                      |                |  |                   | 0.085 <sup>a</sup>   |                      | 0.081 <sup>a</sup> |
| 16-25   | 484            | 30 (6.1)                                   | 1.81 (0.96-3.42)  | 0.065                | 1.89 (0.97-3.68)     | 0.059              |
| 25-35   | 1037           | 55 (5.3)                                   | 1.54 (0.86-2.75)  | 0.15                 | 1.41 (0.78-2.58)     | 0.26               |
| 35-45   | 374            | 20 (5.3)                                   | 1.55 (0.78-3.08)  | 0.21                 | 1.41 (0.70-2.86)     | 0.34               |
| >45   | 427            | 15 (3.5)                                   | 1 (ref)           | -                    |                      |                    |
| <b>Country of birth</b>                                 |                |  |                   |                      |                      |                    |
| Australia   | 1129           | 66 (5.9)                                   | 1 (ref)           | -                    |                      |                    |
| Overseas  | 1077           | 51 (4.7)                                   | 0.80 (0.55-1.17)  | 0.25                 |                      |                    |
| Unknown   | 116            | 3 (2.6)                                    | 0.43 (0.13-1.38)  | 0.16                 |                      |                    |
| <b>Sexual orientation</b>                               |                |  |                   |                      |                      |                    |
| Bisexual  | 298            | 8 (2.7)                                    | 1 (ref)           | -                    | 1 (ref)              | -                  |
| Gay <sup>b</sup>  | 2024           | 112 (5.5)                                  | 2.12 (1.03-4.40)  | 0.043                | 1.37 (0.64-2.93)     | 0.42               |
| <b>HIV/PrEP status</b>                                  |                |  |                   |                      |                      |                    |
| HIV negative not on PrEP                                | 1756           | 79 (4.5)                                   | 1 (ref)           | -                    | 1 (ref)              | -                  |
| HIV negative on PrEP                                    | 490            | 37 (7.6)                                   | 1.73 (1.16-2.60)  | 0.0076               | 1.15 (0.74-1.81)     | 0.53               |
| HIV positive  | 76             | 4 (5.3)                                    | 1.18 (0.42-3.31)  | 0.75                 | 0.89 (0.30-2.65)     | 0.84               |
| <b>Known gonorrhoea contact</b>                         |                |  |                   |                      |                      |                    |
| No  | 2193           | 93 (4.2)                                   | 1 (ref)           | -                    | 1 (ref)              | -                  |
| Yes   | 129            | 27 (20.9)                                  | 5.98 (3.73-9.59)  | <0.0001              | 5.01 (3.06-8.20)     | <0.0001            |

**Table 3: Risk factors for oropharyngeal gonorrhoea among 2322 MSM.**

<sup>a</sup> P for trend for categorical variables.  
<sup>b</sup> Men who only have sex with other men.  
CI: confidence interval; OR: odds ratio.

univariable analyses but not in the multivariable analysis (Table 3). Additionally, oropharyngeal gonorrhoea positivity was not associated with increasing age and country of birth in the univariable analyses.

## Discussion

This is the largest study to collect data on exposures to the oropharynx of men from the three key anatomical sites of their partners, and thus, was able to statistically adjust for

these exposures. We found that oropharyngeal gonorrhoea was associated with exposure to a partner's mouth through kissing, and anus through rimming, but not to a partner's penis through fellatio. Given gonococcal infections at the oropharynx and anorectum are often asymptomatic, kissing and rimming can contribute to a proportion of oropharyngeal infections. Despite our results showing no significant association between oropharyngeal gonorrhoea and fellatio, it is likely that some transmission occurs, but its frequency will depend on the

prevalence of urethral gonorrhoea in the population. It is important to note that most urethral gonorrhoea infections are symptomatic,<sup>25</sup> thus, we anticipated that it is unlikely men would perform fellatio on other men with urethral discharge. Our results provide further evidence that gonorrhoea can be transmitted through tongue-kissing<sup>16–18</sup> and adds to an accumulating body of evidence that the oropharynx plays a significant role in the transmission of oropharyngeal gonorrhoea. These data also provide further evidence for the oro-anal and oropharynx-oropharynx transmission route, which are alternative to the generally accepted view that oropharyngeal gonorrhoea is primarily acquired from the partner's infected penis through fellatio.<sup>12</sup>

Several previous studies have investigated whether kissing is a risk factor for oropharyngeal gonorrhoea (Supplementary Table 1), but these studies generated contrasting results due to small sample size or differences in methodology. The first study was conducted in 2003 by Templeton *et al.* and involved 1427 men, of whom 65 had oropharyngeal gonorrhoea.<sup>17</sup> While Templeton *et al.*'s study collected data for sexual practices, such as kissing, fellatio and rimming, they did not measure these practices with individual partners and instead, measured these exposures to the oropharynx from casual sex partners using three categories ('never', 'occasionally' or 'often') over the past 6 months. This approach made it difficult to accurately measure each exposure or to statistically adjust for each exposure in their analysis. Templeton *et al.*'s study found wet kissing (with insertion of tongue) was associated with oropharyngeal gonorrhoea in the univariate analysis but not in the multivariate analysis. Both fellatio and rimming were associated with oropharyngeal gonorrhoea in the univariate analysis, but only for rimming was significant in the multivariate analysis.

Another study, conducted in 2015, by Cornelisse *et al.* compared 177 men with oropharyngeal gonorrhoea age-matched with 177 men without oropharyngeal gonorrhoea.<sup>18</sup> Cornelisse *et al.*'s study collected data on the number of casual sex partners with whom men kissed, fellated, and rimmed during sex in the past three months. Kissing and fellatio were associated with oropharyngeal gonorrhoea in the univariable analysis, but these associations were not found in their adjusted analysis. The authors commented that due to high correlations between kissing, fellatio, and rimming, there was limited power to determine independent contributions from these exposures in their adjusted analysis.

A study that is similar to our current study was conducted in 2016 by Chow *et al.* and it involved 3677 men, of whom 229 had oropharyngeal gonorrhoea. Chow's study collected data on the number of kissing-without-sex and kissing-with-sex partners but did not collect data on fellatio and rimming partners, separately. However, they did include fellatio and rimming in their broad definition of sex (involving fellatio, anal sex, or rimming).<sup>16</sup> The authors

found that oropharyngeal gonorrhoea was significantly associated with kissing-without-sex and kissing-with-sex, but not with sex-only in both of their univariate and multivariate analyses. Given that they did not collect exposure to the oropharynx from fellatio or rimming, separately, they were unable to statistically adjust for these exposures in their investigation of kissing as an independent risk factor for oropharyngeal gonorrhoea.

Two cohort studies have investigated the association between incident oropharyngeal gonorrhoea and kissing, fellatio, and rimming. A 12-week cohort study by Chow *et al.* involved weekly sampling of 100 men and found that incidence for oropharyngeal gonorrhoea was 62/100 person-years, and that incident oropharyngeal gonorrhoea was associated with the number of kissing and fellatio partners, but not rimming partners.<sup>15</sup> Additionally, the only sexual practice that all of the 14 men with oropharyngeal gonorrhoea had engaged in the past week was kissing, with two of the 14 reporting no fellatio and 6 reporting no rimming.<sup>15</sup> Another cohort study, with a 48-week follow-up, conducted by Barbee *et al.* involved 140 men and found the incidence for oropharyngeal gonorrhoea was 32/100 person-years.<sup>26</sup> Like Chow *et al.*, Barbee *et al.* found that kissing, fellatio, and rimming were all common and reported that 15% of oropharyngeal infections occurred in the absence of fellatio.<sup>26</sup> Chow *et al.* and Barbee *et al.* suggested that their data supported the proposition that kissing was responsible for a substantial proportion of oropharyngeal infections.

Despite its strengths over previous cross-sectional studies that examined the association between kissing and oropharyngeal gonorrhoea, our study has several limitations. First, our study was a cross-sectional study conducted at an urban sexual health clinic, and therefore, our findings may not be representative of a wider MSM population and in other settings. Second, our study has a low participation rate (11.6%) which may have resulted in some systematic differences between men who participated and those who did not, such as differences in sexual practices that expose men's oropharynx. However, our analysis was not about the features of those who participated but about a comparison within those who participated so this bias may be less important. While past studies have shown that there was no relationship between low participation rate and study validity,<sup>27,28</sup> caution should be taken when making inferences based on our findings. Future longitudinal studies may be required to draw conclusions on the causative relationship between kissing and oropharyngeal gonorrhoea. Third, we collected our exposure period as three months and oropharyngeal gonorrhoea may last considerably less than three months. Of interest, our analysis of exposures in the last month was essentially identical (not shown). Fourth, our study included a period of the COVID-19 pandemic, and therefore, kissing, and sexual practices might have changed over time.<sup>22,23</sup> Fifth, we changed clinician-collected oropharyngeal swabs to self-

collected oropharyngeal swabs in March 2020 to minimise the exposure to SARS-CoV-2 among healthcare workers during the COVID-19 pandemic; however, there was no significant difference in oropharyngeal gonorrhoea positivity.<sup>29</sup>

Determining whether kissing is a risk factor for oropharyngeal gonorrhoea is necessary to develop effective intervention programs, particularly given the suggestion that oropharyngeal gonorrhoea may be a major site for onward gonorrhoea transmission. These interventions will be challenging given that kissing is the most common activity in MSM<sup>21</sup> and heterosexuals,<sup>30,31</sup> and one of the sexual practices that individuals are least willing to give up. Nevertheless, investigators are working to determine if vaccination<sup>32</sup> may have a role in gonorrhoea prevention. Only by understanding gonorrhoea transmission more fully will it be possible to develop interventions for its prevention.

#### Contributors

EPFC and CKF conceived and designed the study. JSH and FK assisted with the study design. JT performed the data analyses and wrote the first draft of the manuscript. EPFC provided statistical advice. EPFC and CKF provided supervision of the project. KM assisted with the project management. All authors assisted with data interpretation. EPFC and JT accessed and verified all the data within this study. All authors were involved in revising the manuscript for important intellectual content and approved the final version.

#### Data sharing statement

The data that support the findings of this study are available on request from the corresponding authors (EPFC), with the permission of the Alfred Hospital Ethics Committee. Restrictions apply to the availability of these data, which were used under license for this study.

#### Declaration of interests

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#### Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.eclinm.2022.101557](https://doi.org/10.1016/j.eclinm.2022.101557).

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