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SEXUAL HEALTH

Sexual mixing patterns among male–female partnerships in Melbourne, Australia

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ABSTRACT

Background. Individuals who have both opposite- and same-sex partners have the potential to pass sexually transmitted infections (STIs) between high- and low-risk populations. Our aim was to examine assortative sexual mixing in terms of same-sex activity among male–female partnerships. **Methods.** This was a retrospective repeated cross-sectional study of male–female partnerships attending the Melbourne Sexual Health Centre (MSHC) from 2015 to 2019. Sex of sexual partners was collected via computer-assisted self-interview. We calculated the proportion of partnerships where at least one individual reported same-sex partners in the previous 12 months and the degree of assortativity by bisexuality. **Results.** A total of 2112 male–female partnerships (i.e. 4224 individuals) were included, with a median age of 27 years (IQR 23–31). Overall, 89.3% (1885/2112) of male–female partnerships did not report any other same-sex partners; however, in 9.5% (201/2112) of partnerships, same-sex partners were reported by one individual and in 1.2% (26/2112) of partnerships, both individuals reported same-sex partners. Bisexuality appeared to be slightly assortative in male–female partnerships ($r = 0.163$, 95% CI: 0.150–0.176; $P < 0.001$). **Conclusion.** One in 10 individuals in male–female partnerships had at least one same-sex partner within the previous 12 months. Individuals were minorly selective by bisexuality, suggesting the patterns of bisexual mixing in male–female partners are more variable and this may have a significant impact on STI transmission in heterosexual populations.

Keywords: assortativity, bisexual, heterosexual, mixing, opposite-sex, same-sex, sexual activity, sexual behaviour, sexual mixing, sexual networks, sexual orientation, sexual partners, sexual practice.

Introduction

In the last decade, there has been a notable increase in diagnoses of sexually transmitted infections (STIs) in the Australian heterosexual population.[1] Australian national surveillance data showed that the rate of gonorrhoea notifications increased by 60% among women between 2012 and 2018.[2] This rise in STIs in heterosexuals is not well-understood, although genomic analysis of isolates of *Neisseria gonorrhoeae* from Melbourne in 2017 provided evidence of transmission between different population risk groups (i.e. between men who have sex with men (MSM) and heterosexuals) suggesting that connections exist between these key populations.[3] Recent Australian-based research found that there is no significant difference in urethral gonorrhoea positivity between men who have sex with men only and men who have sex with men and women, suggesting gonorrhoea transmission could subsequently be occurring between bisexual men and women.[4] Additionally, a study from a Melbourne centre found an increase in chlamydia positivity among lesbian women from no cases in 2011 to 2.7% in 2019 among those tested for STIs,[5] which raises questions regarding potential transmission of STIs from heterosexual populations by bisexual women to lesbian women, and whether sexual mixing has increased over a similar time period.

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Sexual mixing is a concept suggesting that individuals with similar characteristics tend to mix together.[6] For example, past studies have shown that individuals tend to have sexual partners of a similar age.[7] Furthermore, individuals with a high number of sexual partners are found to be more likely to mix with individuals who also have a high number of sexual partners.[7] When this occurs, it can increase the spread of STIs in a population more than would occur if partners mixed randomly. The bisexual population has a unique role in transmitting STI between different population risk groups. Most of the studies on the bisexual population are conducted among bisexual MSM. Additionally, these studies rarely examine whether bisexual men's partners are bisexual.[4] To the best of our knowledge, there have been very limited studies examining men and women having a partner who is bisexual. It is also unclear whether bisexual individuals are more likely to mix with other bisexual individuals than by random chance. Understanding the sexual mixing by bisexuality among male–female partnerships will provide an important key parameter for predictive mathematical models on STI transmission (i.e. the number of bisexual individuals who have bisexual partners will inform mathematical models for STI transmission from this bridging population). Therefore, the aim of this study was to investigate the sexual mixing patterns by bisexuality using linked partnership data for partnerships with a man and a woman attending a sexual health clinic in Melbourne, Australia, and whether these patterns have changed over the study period.

Materials and methods

Study design and population

This was a retrospective repeated cross-sectional study of clients attending the Melbourne Sexual Health Centre (MSHC), Australia, from 2015 to 2019. The MSHC is a public HIV and STI clinic that offers a wide variety of services such as testing, diagnosis and treatment of HIV and STIs. The MSHC provided over 52 000 consultations in 2019.[8]

Data collection

New and existing clients who had not attended the MSHC within the previous 3 months were invited to complete a questionnaire using a computer-assisted self-interview (CASI) system upon arrival. This questionnaire was part of routine clinical care and management, and collected data on client demographic characteristics and sexual practices. As part of CASI, individuals were asked if their partner was also being seen at the MSHC on the same day. If they answered yes, individuals were asked to provide their partner's name on the CASI. Individuals were matched to their partner if both individuals attended the MSHC as a client. For the purpose of this study, we also identified and matched partners who attended the MSHC within 5 days of each other. Demographic characteristics such as age, country of birth, gender of partners in the previous 12 months, number of sexual partners, intravenous drug use in the previous 12 months, and current sex work status were extracted from the CASI. Clients could choose to decline to answer some questions, and unanswered questions were considered as 'no information'. Total sexual partners were defined as the addition of the number of both male and female partners in the previous 12 months, excluding the individuals' attending sexual partner(s) at the time of consultation.

Each participant was assigned a unique de-identified study number, and partnerships were assigned a unique partnership number shared by both individuals for partner matching during statistical analyses. Chart review was performed for checking and validating the partnerships.

Selection criteria

Male–female partnerships were included in this study if they: (a) attended and were seen at the MSHC on the same day or within 5 days after the first individual in the partnership's consultation; (b) reported the name of their partner on the CASI or to the clinician in their medical file; and (c) neither individual in the partnership self-reported as transgender, intersex, or a different non-binary gender on the CASI. Partnerships were subsequently excluded from this study if: (a) one or both individuals had ever engaged in sex work during their lifetime; or (b) either partner was under the age of 16 years. Sex workers were excluded from this study as the CASI questionnaire did not ask the sex of clients in the previous 12 months; additionally, sexual practices, STI prevention practices, and sexual orientation may differ between clients and non-commercial partners. If the same partnership attended the MSHC more than once during the study period, we only included the first presentation in this analysis.

Statistical analysis

We reported the number and proportion of the type of partnerships. Median and interquartile ranges (IQR) were reported for continuous variables, such as age and number of total sexual partners. *P* values were calculated using a Mann–Whitney *U* test to compare continuous variables between groups and a Chi-squared test to compare categorical variables between groups. Statistical significance was achieved at <0.05 for all significance tests.

We calculated the Newman's assortativity coefficient (r) by using a ($k \times k$) mixing matrix to determine mixing patterns of sexual orientations by sex of individuals, as per the following formula:

$$r = \frac{\Sigma_i e_{ii} - \Sigma_i a_i b_i}{1 - \Sigma_i a_i b_i},$$

in which r is the value of Newman's assortativity coefficient, e_{ii} is the sum of the proportion of partnerships with the same reported sex of sexual partner(s) (i.e., both bisexual or both heterosexual), and a_i and b_i are the row and column sums of the ($k \times k$) matrix, respectively.[6] The Newman's assortativity coefficient ranges between −1 and +1, in which a r value of +1 denotes perfect assortativity, 0 denotes no assortativity, and −1 denotes perfect disassortativity; 95% confidence intervals (CI) were also calculated by deriving and applying the variance from the above formula. For the overall assortativity analysis, couples were pooled across all 5 years. The data was additionally analysed and reported by year in order to determine whether there has been any significant change over the study period.

All analyses were conducted using SPSS (version 26; IBM Corp., Armonk, NY, USA).

Ethics approval

Ethics approval for this study was provided by the Alfred Hospital Ethics Committee, Melbourne, Australia (project number: 197/20). As this was a study involving retrospective data analysis, informed consent was waived by the Alfred Hospital Ethics Committee. This study was performed in accordance with relevant guidelines and regulations.

Results

From 2015 to 2019, we identified 2562 male–female partnerships who attended the MSHC for consultations either on the same day or within 5 days of each other. After excluding subsequent presentations of the same partnership (n = 192), partnerships where at least one of the individuals in the partnership was aged <16 years (n = 2), and partnerships where either of the individuals had ever engaged in sex work during their lifetime (n = 256), there were 2112 male–female partnerships (4224 individuals) included in the final analysis (Fig. 1).

Of the 2112 men included in the analysis, 2034 (96.3%) men had female partners only and 78 (3.7%) men had both female and male partners in the previous 12 months. Of the 2112 women, 1937 (91.7%) women had male partners only and 175 (8.3%) women had both male and female partners in the previous 12 months (Table 1).

The median age of all individuals was 27 years (IQR 23–31) (Table 1). Men who had both male and female partners in the previous 12 months were older than men who had only female partners in the previous 12 months (median age 32 vs 27 years; $P < 0.001$). However, there was no difference in age between women who had both male and female partners and women who had only male partners in the last 12 months (median age 27 vs 26; $P = 0.054$). The median age for all men was significantly older than the median age for women (median age 28 vs 26; $P < 0.001$). Among 4224 individuals, 37.5% (n = 1584) were born in Australia. Among 2640 individuals who were born overseas, the top three countries were the United Kingdom (11.1%, n = 294), France (10.2%, n = 269) and China (5.2%, n = 136).

There was a small proportion of individuals (1.1%, 47/4224) who had injected drugs in the previous 12 months, but this proportion did not differ between men who had male and female partners and men who had only female partners ($P = 0.376$), nor between women who had both male and female partners and women who had only male partners ($P = 0.405$).

In terms of partnerships, there were 89.3% (n = 1885) where both individuals had only opposite-sex partners; 2.5% (n = 52) where men who had both male and female partners were with women who had only male partners;

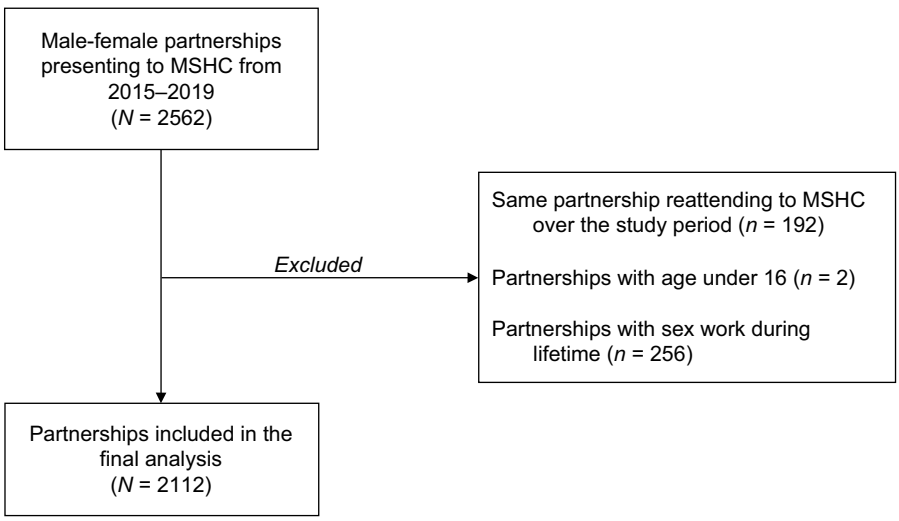

Fig. 1. Flow chart of study participant selection process.

Table 1. Demographic characteristics of 4224 individuals, stratified by sexual practice.

	Men with only opposite-sex partners, *N* = 2034	Men with both opposite and same-sex partners, *N* = 78	*P* value	Women with only opposite-sex partners, *N* = 1937	Women with both opposite and same-sex partners, *N* = 175	*P* value	Total, *N* = 4224
Age (years)							
Median [IQR]	27 [24–32]	32 [27–42]	<0.001	26 [23–30]	27 [23–32]	0.054	27 [23–31]
Born in Australia, *n* (%)			0.015			0.001	
Yes	834 (41.0)	44 (60.3)		628 (32.4)	78 (44.6)		1584 (37.5)
No	1145 (56.3)	31 (39.7)		1252 (64.6)	88 (50.3)		2516 (59.6)
No information	55 (2.7)	3 (3.8)		57 (2.9)	9 (5.1)		124 (2.9)
Injected drug use in the previous 12 months, *n* (%)			0.376			0.405	
Yes	30 (1.5)	3 (9.0)		12 (0.6)	2 (1.1)		47 (1.1)
No	1988 (97.7)	74 (94.9)		1903 (98.2)	169 (96.6)		4134 (97.9)
No information	16 (0.8)	1 (1.3)		22 (1.1)	4 (2.3)		43 (1.0)
Total casual sexual partners							
Median [IQR]	1 [0–4]	5 [3–12]	<0.001	1 [0–3]	6 [3–10]	<0.001	1 [0–4]

7.1% (n = 149) where men who had only female partners were with women who had both male and female partners; and 1.2% (n = 26) where both partners had same-sex and opposite-sex partners (Table 2). There was at least one individual with both same-sex and opposite-sex partners in 10.7% (227/2112) of partnerships. There was no statistically significant trend in the proportion of types of partnerships from 2015 to 2019.

There was weak positive assortativity mixing by bisexuality in male–female partnerships (r = 0.163, 95% CI: 0.150–0.176; P < 0.001) and this mixing pattern did not change significantly over the study period, suggesting that though individuals with both opposite- and same-sex partners were statistically slightly more likely to have a partner who was also had both opposite- and same-sex partners, this link was not strong and thus individuals were not highly selective by bisexuality (Table 3).

The median number of sexual partners for 4224 individuals was 1 (IQR 0–4). Men who had both opposite and same-sex partners had a median number of 5 (IQR 3–12) total sexual partners versus 1 (IQR 0–4) for men who only had opposite-sex partners (P < 0.001). The median number of total sexual partners for women was 6 (IQR 3–10) for women who had both opposite and same-sex partners and 1 (IQR 0–3) for women who only had opposite-sex partners (P < 0.001). There was no significant difference in partner number between men and women who had both opposite and same-sex partners, however, men who had only opposite-sex partners had more sexual partners than women who had only opposite sex partners (P < 0.001).

Discussion

In this study of 4224 individuals in male–female partnerships, we found that approximately 1 in 10 partnerships comprised of at least one individual who also had same-sex partners. However, male–female partnerships in which both individuals

Table 2. Number and proportion of types of partnerships between 2015 and 2019.

	2015 *n* (%)	2016 *n* (%)	2017 *n* (%)	2018 *n* (%)	2019 *n* (%)	Total *n* (%)	P_{trend} value
Total partnerships	404	389	368	497	454	2112	–
Both opposite-sex partners only	361 (89.4)	345 (88.7)	335 (91.0)	444 (89.3)	400 (88.1)	1885 (89.3)	0.547
Man has both opposite- and same-sex partners and woman has only opposite-sex partners	12 (3.0)	10 (2.6)	9 (2.4)	11 (2.2)	10 (2.2)	52 (2.5)	0.258
Man has only opposite-sex partners and woman has both opposite- and same-sex partners	30 (7.4)	24 (6.2)	22 (6.0)	36 (7.2)	37 (8.1)	149 (7.1)	0.340
Both have opposite- and same-sex partners	1 (0.2)	10 (2.6)	2 (0.5)	6 (1.2)	7 (1.5)	26 (1.2)	0.287

Table 3. k × k matrix of partnership types for Newman's assortativity co-efficient formula among 2112 male–female partnerships.

Male–female partnerships	Bisexual male	Heterosexual male
Bisexual female	26	149
Heterosexual female	52	1885

had same-sex partners was not common (1.2%). Overall, there was weak assortativity among individuals in opposite-sex relationships in terms of also having same sex partners; that is, individuals who had other same-sex partners were slightly more likely to be in a partnership with an individual who also had other same-sex partners than would be expected to have occurred by chance. This observation provides opportunity for accelerated transmission of STIs from MSM populations to both heterosexual women and women who have sex with women populations.

Additionally, individuals with both opposite- and same-sex partners reported a higher number of sexual partners than individuals who only had opposite-sex partners. Understanding the bisexual mixing pattern is important for HIV/STI transmission between gay, bisexual, and heterosexual populations.

Although this study appears to be the first of its kind to focus on bisexual activity in individuals of male–female partnerships in Australia, these results are consistent with another study from the United Kingdom. An analysis of 943 heterosexual couples from the 2010 UK Health Survey reported that individuals who ever had a same-sex experience in their lifetime were significantly more likely to have a partner who had also had same-sex experiences (observed/expected ratio 8.7; $P < 0.001$).[9] However, the UK study notably includes all lifetime partners rather than just sexual partners from the previous 12 months, which may have contributed to the differing effect sizes between the two studies.

We calculated Newman's assortativity coefficient to examine the assortative sexual mixing by bisexuality in male–female partnerships and we found that the assortativity coefficient (r) was 0.163, suggesting individuals who have same-sex partners do not always mix with others who also have same-sex partners. The low assortativity coefficient means that heterosexual individuals do not always mix with heterosexual individuals, or bisexual individuals do not always mix with bisexual individuals, suggesting that there is some sexual mixing between heterosexual and bisexual individuals in male–female partnerships. However, it is important to interpret this assortativity coefficient with caution, as we only measured the assortativity based on one partner; this assortativity coefficient may change if multiple partners are considered in the calculation. The low level of assortativity by bisexuality may be explained by social attitudes towards bisexuality; bisexual individuals often have difficulty disclosing their sexual orientation to their partners, especially in male–female partnerships, due to fear of being misunderstood and of rejection.[10] These findings may have some public health implications, in that transmission of STIs across populations by bisexual individuals may be impacted by non-disclosure of bisexuality to new partners.

Our findings that men and women with both opposite- and same-sex partners had more partners than those with only opposite-sex partners and that among those with only opposite-sex partners men had more partners than women, are consistent with the Second Australian Study of Health and Relationships (ASHR2) conducted in 2012–13, which found having multiple partners was associated with self-reported bisexuality, and that men reported more sexual partners than women.[11]

This study has several limitations. First, the CASI does not collect information on sexual orientation and thus we focused on sexual behaviours in the previous 12 months rather than stratifying partnerships by sexual identity. Sexual orientation based on sexual practices in the previous 12 months may not necessarily correlate with an individual's self-identified sexual orientation, and therefore data must be interpreted with caution for use in clinical settings. Furthermore, individuals who have opposite- and same-sex partners in our study are biased toward having more sex partners, given our selection criteria required them to have had an opposite and same-sex partner in the previous 12 months.

Second, we were unable to distinguish whether individuals were attending with their regular or casual sexual partners. Further research with a methodology that specified regular partnership data could show different assortativity and demographic patterns than found in this paper, as mixing patterns may differ between regular and casual partners. Third, estimates of bisexuality determined from this study population should be interpreted cautiously and may not be generalisable to other populations, as individuals attending a sexual health clinic may have multiple partners. Further research will be required to explore the sexual mixing within a sexual network with multiple partners. Additionally, partnerships may have attended the clinic more than once, and only the first date of attendance was analysed in order to be consistent for all partnerships. It is possible that partnerships would have different sex practices in different years of attendance to the clinic. Finally, this study was conducted at a public sexual health centre in Victoria, Australia. Clients attending a sexual health clinic may be more likely to be sexually active than the general population and therefore our results may not be generalisable to the entire Australian population or other settings.

In this study examining male–female partnerships in Melbourne, Australia, men and women who had both opposite- and same-sex partners demonstrated differing number and types of sexual partners compared to individuals with only opposite-sex partners. There was at least one individual who had both opposite and same-sex partners in 10.7% of partnerships. Individuals with both opposite and

same-sex partners had more casual sexual partners than heterosexual individuals. There was low assortativity by bisexuality, indicating that bisexual and heterosexual individuals do not always mix within their own groups by sexual practice. These sexual mixing behaviours may have implications for STI transmission, especially in terms of transmission from MSM populations to female populations. Further research, including mathematical modelling, is required to explore the degree of transmission by bisexual individuals, the impact this may have on STI epidemiology, and potential targets for preventative health measures specifically for bisexual individuals.

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Data availability. All relevant data is included in the manuscript.

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Author contributions. EPFC and CKF planned, conceived, and designed the study. ER performed partner matching. KEG conducted the statistical analysis and wrote the first draft of the manuscript. EPFC and TRP gave statistical advice and oversaw the study. All authors revised the manuscript critically for important intellectual content, and approved the final version of the manuscript.

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