HIV Infection and Sexual Risk among Men Who Have Sex with Men and Women (MSMW): A Systematic Review and Meta-Analysis

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Abstract

Objectives: To estimate the number of men who have sex with men and women who are HIV-positive in the United States, and to compare HIV prevalence rates between men who have sex with men and women, men who have sex with men only, and men who have sex with women exclusively.

Methods: Following PRISMA guidelines, we conducted a systematic review and meta-analysis of reports referencing HIV prevalence and men who have sex with men and women. We searched PubMed and Ovid PsycINFO for peer-reviewed, U.S.-based articles reporting on HIV prevalence among men who have sex with men and women. We conducted event rate, effect size, moderation and sensitivity analyses.

Results: We estimate that 1.0% of U.S. males are bisexually-behaving, and that 121,800 bisexually-behaving men are HIV-positive. Men who have sex with men and women are less than half as likely to be HIV-positive as men who have sex with men only (16.9% vs. 33.3%; OR = 0.41, 95% CI: 0.31, 0.54), but more than five times as likely to be HIV-positive as men who have sex with women exclusively (18.3% vs. 3.5%; OR = 5.71, 95% CI: 3.47, 9.39). They are less likely to engage in unprotected receptive anal intercourse than men who have sex with men only (15.9% vs. 35.0%; OR = 0.36, 95% CI: 0.28, 0.46). Men who have sex with men and women in samples with high racial/ethnic minority proportions had significantly higher HIV prevalence than their counterparts in low racial/ethnic minority samples.

Conclusions: This represents the first meta-analysis of HIV prevalence in the U.S. between men who have sex with men and women and men who have sex with men only. Data collection, research, and HIV prevention and care delivery specifically tailored to men who have sex with men and women are necessary to better quantify and ameliorate this population’s HIV burden.

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Introduction

Since the beginning of the epidemic, HIV transmission researchers have suggested that men who have sex with men and women (MSMW) are integral viral bridges, responsible for the spread of HIV and other sexually transmitted infections (STI) from a discrete population – men who have sex with men (MSM) – to the general population of heterosexuals [1–4]. Studies have indicated that a substantial proportion of HIV/AIDS diagnoses among American women may be attributable to bisexually-behaving male partners, though estimates are widely varied, ranging from one percent to 18% [5–7]. Others have calculated that MSMW pose high secondary HIV transmission risks; that sexual transmission of HIV from MSMW may especially elevate HIV prevalence among Black heterosexual women; and that MSMW increase the breadth and density of socio-sexual networks, potentiating the spread of HIV across communities [4,8–11].

Nationally representative population-based surveys have consistently estimated that past-year MSMW comprise 0.3% to 1.6% of U.S. males [12–15]. The composition of MSMW in these surveys is somewhat less than the proportion of men who have sex with men only (MSMO), albeit variable according to length of...
recall window of bisexual behavior: looking through five-year windows, estimated proportions of these two distinct groups of MSM roughly equalize [14,15]. Researchers have recently estimated that past-year MSM comprise 2.9% of the U.S. male population, and that 500,000 U.S. MSM are living with HIV [16,17]. To date, however, estimates of HIV infection rates among MSMW are unavailable via the HIV/AIDS Surveillance System, which does not distinguish among MSM, although current federally-promoted HIV Counseling and Testing forms functionally collect bisexual behavior data. Meaningful national estimates of MSMW-specific HIV/AIDS transmission and acquisition are subject to significant recall bias limitations when reliant on secondhand information: knowledge of male partners’ bisexuality may be limited and, therefore, uncertainly reported [6,18–20]. Few studies have attempted to model the number and proportion of HIV acquisitions and transmissions attributable to MSMW via sex with male and female partners. Press accounts sensationalizing few studies have assessed HIV prevalence among males, and what factors lower HIV prevalence than men who have sex with men only (MSMO)? Second, do MSMW in the United States have significantly higher HIV prevalence than men who have sex with women exclusively (MSWE)? Third, what moderating factors among MSMW in the United States significantly affect their HIV risk behavior; and whether each study contained race/ethnicity subgroup data by sexual behavior group in samples as a whole and for each outcome domain. Denominators for HIV testing excluded those whose results were indeterminate/inconclusive/unknown. Disagreements that occurred between researchers during data extraction and coding were resolved through discussion.

When multiple articles based on the same study were identified, the most comprehensive study was chosen for meta-analytic inclusion. When a single study presented data for more than one sample (i.e. cross-sectional HIV testing data in different years), we considered it as more than one study. Codes were conceived of as fitting one of four categories: 1) predictor variables (gender of sexual partners); 2) outcome variables (prevalence of HIV infection; prevalence of bisexual behavior; prevalence of STI infection; prevalence of sexual risk behavior); 3) potential moderator variables (recall window of bisexual behavior; study location; sampling procedure; target population; HIV test basis); and 4) effect size data. Moderators were later dichotomized according to whether they met parameters for target population (more than 90% of participants were Black and/or Latino; sampling strategy (probability-based); data collection date (2000 or after); HIV test basis (serological); recall window for bisexual behavior (one year or more); and location (whether recruitment was conducted in one of the 12-highest HIV/AIDS prevalence metropolitan statistical areas, as defined by CDC) [27]. Additional codes were developed to capture the rates and numbers of total MSM (MSMO+MSWE) and HIV-positive MSM in each study.

Analytic Approach

We conducted meta-analyses according to established methods, using NIH-supported software [28,29]. Four primary meta-analyses were then conducted: (1) comparing HIV prevalence between MSMW, MSMO, and MSWE; (2) comparing sexual risk behavior between MSMO, MSMW, and MSWE; (3) assessing moderators of HIV prevalence within MSMW and within MSMO; and (4) assessing moderators of bisexual behavior and HIV prevalence within MSM. For between-group meta-analyses,
odds ratios were used as principal summary measures. For within-
group meta-analyses, event rates were used as principal summary
measures. Differences in HIV prevalence and bisexual behavior
might vary substantially due to methodological issues that could
serve to increase heterogeneity and influence pooled outcomes.
We assessed heterogeneity by calculating a Q statistic to evaluate
how much between-study heterogeneity was due to chance. We
used mixed effects models to test differences in pooled prevalence
estimates, employing a fixed effect approach across subgroups and
a random effects model within subgroups. Weighted mean
prevalence (event rates) for outcomes were estimated by comput-
ing weighted means, assigning weights to each study that were the
inverse of that study’s variance plus an estimate of the variance
between studies to account for differing sampling methodologies
[28]. For each comparative meta-analytic domain, we conducted
sensitivity analyses examining the effect of outliers, using an
approach that compared the weighted mean percentage of HIV
prevalence between groups with estimates obtained after iterations
using \( k - 1 \) findings, where \( k \) is equal to the number of studies (i.e.,
removing a finding and re-calculating the weighted mean
percentage; then, repeating that process until each finding was
separately removed and results re-calculated). To investigate
potential publication bias, we utilized Egger’s regression test and
examined the symmetry of funnel plots for each comparative
meta-analytic domain. For our analysis comparing HIV preva-
lence between MSMO and MSMW, we conducted an Orwin’s
fail-safe n test to estimate how many additional studies would need
to be included make effect sizes insignificant.

Finally, we used event rates of HIV prevalence within MSMW,
bisexual behavior within MSM, and HIV-positive MSMW within
HIV-positive MSM, and paired them with HIV/AIDS surveil-
lance data, standard estimates of proportions of MSM in the
United States, and U.S. Census data to estimate population sizes
of total MSMW and HIV-positive MSMW, adapting an approach
developed by researchers at the Centers for Disease Control and
Prevention (CDC) [16].

Results

Search Results

3921 unique reports were initially identified in PubMed and
PsycINFO, of which 486 were duplicative. 1764 reports were
excluded because they reported on studies outside of the United
States. 588 studies were excluded because participants were all
HIV negative or HIV+ by design. 314 reports were
excluded because they did not measure HIV status. The 769
reports remaining were subjected to full-text reviews: of these, 87
reports were excluded because they reflected only qualitative research;
and 641 were excluded because they did not report on HIV
prevalence among MSMW. Of 41 remaining studies, eight were
non-primary reports; and five studies conflated bisexual behavior
and identity in a single measure for bisexual males or were

Figure 1. Flow diagram of included and excluded records.
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Table 1. Study characteristics of 33 samples included in meta-analysis*.

| Lead author, Date | Location | Target population | Recall window | Sampling strategy | MSMW (n) | % MSMW | Age | Race | HIV test basis | % HIV+ MSMW | % HIV+ MSMO | % HIV+ MSWE |
|-------------------|----------|-------------------|---------------|-------------------|---------|--------|-----|------|----------------|-------------|-------------|-------------|
| Bacon, 2006       | San Francisco, CA | YMSM-IDU | D | 3 | 206 | 90.8 | Median age: 23 (16–29) | 80% white, 20% nonwhite. | 1 | 8.7 | 42.9 | – |
| Bowers, 2011      | Los Angeles, CA | Substance-using MSM | n/a | 3 | 310 | 43.5 | MSMW mean age: 34.8 | Among MSMW: 51% white, 26% Black, 9% Hispanic, 14% other. | 0 | 18.5 | 39.2 | – |
| Cassels, 2010      | 7 cities | American Indian/ Alaskan Native LGBT | D | 2, 3 | 32 | 19.3 | Median age: 45–67. | 100% American Indian/ Alaskan Native | 0 | 23.1 | 37.8 | – |
| Catania, 2001      | SF, NY, LA, Chi. | MSM | D | 5 | 385 | 14.7 | Median age: 30–39. | 79% white, 4% AA, 10% Hispanic, 4% Asian, 3% Native American, <1% other. | 1** | 10.1 | 19 | 0 |
| Flores, 2009       | 13 cities | MSM | A | 1 | 1494 | 14.5 | Mean age: 21.3 | 28% Black, 10% A/PI, 37% Latino, 22% White. | 0 | 0.6 | 1.6 | – |
| Fuller, 2005       | New York, NY | Substance-using MSM | A | 3 | 47 | 49.5 | Median age: 28 (18–40) | 44% Hispanic, 46% Black, 10% white/other. | 1 | 4.3 | 45.8 | – |
| German, 2011a      | Baltimore, MD | MSM | B | 1 | 216 | 33.5 | Median age: 34 (18–69) | 31% white, 62% African American, 6% other. | 1 | 31.5 | 40.8 | – |
| German, 2011b      | Baltimore, MD | MSM | B | 1 | 109 | 24.3 | Median age: 30 (18–72) | 23% white, 71% African American, 5% other. | 1 | 30.3 | 39.8 | – |
| Gorbach, 2009      | Los Angeles, CA | Substance user or MSM | A | 2 | 461 | 51.7 | Mean age: 42.7. | 19.1% white, 52.8% Black, 22% Hispanic. | 1 | 11.9 | 64 | 4.3 |
| Kalichman, 1998    | Not provided | MSM | B | 3 | 146 | 23.6 | Mean age: 35.1 (18–70) | 82% white, 7% Hispanic, 6% African American, 5% other. | 0 | 3.6 | 19.5 | – |
| Kral, 2005         | San Francisco, CA | MSM-IDU | A | 3 | 157 | 44.0 | Median age: >40. | 62% white, 19% African American, 4% Latino, 14% other. | 1 | 19.7 | 36.5 | – |
| Latkin, 2011       | Baltimore, MD | Black MSM | A | 3 | 79 | 33.8 | Mean age: 38. | 100% Black. | 1 | 30.4 | 52.3 | – |
| Lehner 1998        | NYC | Males in STD clinic | D | 4 | 147 | 73.9 | n/a | 41% African American, 54% Hispanic, 4% white. | 1 | 34.7 | 69.2 | 9.6 |
| Levin, 2009        | Seattle, WA | General (18–39 year-olds) | D | 5 | 43 | 59.7 | Mean age: 35 | 34% white, 45% African American, 17% Latino, 4% other (for MSMW). | 1 | 24.4 | 53.8 | 9.2 |
| Lewis, 1994        | San Francisco, CA | Sexually active IDU | D | 3 | 49 | 51.6 | Ages 18–39. | 6% Asian, 7% African American, 79% white, 4% Hispanic, 4% other. | 0 | 7 | 20.7 | 0 |
| McKirnan, 1995     | Chicago, IL | Young MSMW | C | 3 | 536 | * | Mean age: 25 (18–30). | 52% Black, 48% white. | 0 | 6.9 | – | – |
| Molitor, 1998      | CA (state) | Sexually active non-IDU | 4 | 16,290 | 50.4 | Median age: 20–29. | 56.1% white; 24.6% Latino/a; 10.4% Black; 4.6% API; 50.8% male. | 1 | 5.0 | 6.7 | 0.5 |
| Myers, 1997        | Los Angeles, CA | Black males | B | 3 | 81 | 32.4 | Mean age: 34.5. | 100% Black. | 1 | 58 | 74.6 | 6.8 |
| Lead author, Date | Location          | Target population  | Recall window | Sampling strategy | MSMW (n) | % MSMW | Age           | Race                  | HIV test basis | % HIV+, MSMW | % HIV+, MSMO | % HIV+, MSWE |
|------------------|-------------------|---------------------|---------------|-------------------|----------|--------|---------------|-----------------------|----------------|--------------|--------------|--------------|
| Operario, 2011   | Oakland, CA       | Black MSMW          | C             | 6                 | 68       | *      | Median age: 44.6 (21–65); 100% Black. | 100% Black.    | 0              | 21.4         | –            | –            |
| Roffman, 1990    | Seattle, WA       | MSM                 | B             | 3                 | 32       | 30.2   | Mean age = 45 (22–71); MSMW: 94% White, 6% Black, MSMO, 90% White, 10% Black/other. | 0              | 0.0           | 33.3         | –            | –            |
| Salazar, 2010    | Atlanta, GA       | Male IDU            | B             | 2                 | 38       | –      | Mean age: 45 (22–71); 5% African American, 36% white, 1.5% Hispanic. | 0              | 26.3          | –            | 7.1          | –            |
| Siegel, 2008     | NYC               | MSMW                | A             | 3                 | 46       | *      | Mean age: 39.6 (20–60); 41% African American, 35% Hispanic, 22% white, 2% Asian. | 0              | 20.9          | –            | –            | –            |
| Tieu, 2012       | NYC               | Black MSM           | A             | 3                 | 84       | 25.8   | Median age: 41; 100% Black. | 1              | 50.0          | 66.9         | –            | –            |
| Torian, 1996     | NYC               | MSM                 | Not provided  | 4                 | 79       | 21.6   | Median age: 25–29. | 32% white, 48% AA, 24% Hispanic, 3% other. | 1              | 32.9         | 34.5         | –            | –            |
| Torian, 2000     | NYC               | MSM in STD clinic   | Not provided  | 4                 | 25       | 36.2   | n/a | n/a | 28% white, 43% African American, 19% Hispanic, 9% mixed/other. | 1              | 43.4         | 47.6         | –            | –            |
| Torian, 2002a    | NYC               | MSM in STD clinic   | Not provided  | 4                 | 145      | 27.6   | n/a | n/a | 37% white, 30% African American, 24% Hispanic, 9% other/mixed. | 1              | 14.3         | 19.5         | –            | –            |
| Torian, 2002b    | NYC               | MSM in STD clinic   | Not provided  | 4                 | 133      | 30.5   | n/a | n/a | 37% white, 30% African American, 36% white, 11% mixed/other. | 1              | 7.9          | 6.2          | –            | –            |
| Valleroy, 2000   | 7 cities          | YMSM                | D             | 1                 | 2117     | 61.4   | Range: 15–22; 17% African American, 6% Asian, 30% Hispanic, 36% white, 11% mixed/other. | 1              | 7.9          | 6.2          | –            | –            |
| Washington, 2010 | Baltimore, MD     | Black MSMW-IDU      | Not provided  | 3                 | 105      | *      | Mean age: 31.6; 90% African American; 10% Latino/African American. | 0              | 65.1         | –            | –            | –            |
| Wheeler, 2008    | NYC; Philadelphia | Black MSM           | A             | 2                 | 226      | 27.5   | Median age: 40–49; 100% Black. | 1              | 40.7         | 60.1         | –            | –            |
| Williams, 2009   | Chicago, IL       | Substance user or MSM | A          | 2                 | 343      | 71.3   | Mean age: 44 (17–70); 6% white, 80% Black, 13% Hispanic, 1% other. | 1              | 11.4         | 53.6         | 4.7          | –            |
| Wood, 1993       | Seattle, WA       | MSM in STD clinic   | B             | 4                 | 494      | 9.0    | n/a | n/a | 12.3          | 24.1         | –            | –            |
| Zule, 2009       | Central North Carolina | Substance user or MSM | C          | 2                 | 175      | 64.3   | Median age: 35; 77% African American, 20% white. | 1              | 12           | 38.1         | 4.9          | –            |

*Table notes: Recall window refers to the recall window of bisexual behavior in each study (A = MSMW ≤6 months; B = MSMW ≤1 year; C = MSMW < 3 years; D = MSMW ≥3 years). Sampling strategy refers to recruitment technique (1 = time/location sampling; 2 = respondent-driven sampling; 3 = convenience sampling; 4 = HIV/STI clinic sampling; 5 = population-based sampling). HIV test basis refers to the form of assessment of HIV status (0 = self-report; 1 = serologic).

**Refers to studies that focused only on MSMW.

*Catania et al inferred the validity of participants’ self-reports by conducting a representative sample of serologic testing.

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Meta Analysis

Figure 2. HIV prevalence among MSMW, compared to MSMO, U.S.
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Meta Analysis

Figure 3. HIV prevalence among MSMW, compared to MSWE, U.S.
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Table 2. Mixed effect size moderators of HIV prevalence among MSMW relative to MSMO.

| Number of studies | Q-statistic (moderator class) | HIV prevalence estimate, MSMW (95% CI) | Odds ratio (95% CI) | P-value |
|-------------------|-------------------------------|----------------------------------------|---------------------|---------|
|                   | Subgroup categories           | Date of data collection                | Pre-2000            | 15      | 0.58 (0.45, 0.73) | 0.001   | 6.8*    |
|                   |                               | Study locale                          | Zone with high HIV/AIDS | 21     | 0.41 (0.29, 0.59) | 0.01    | 0.01    |
|                   |                               | Other area                            | Probability         | 10     | 0.35 (0.26, 0.46) | 0.05    | 0.35    |
|                   |                               | Behavioral recall window              | ≤12 months          | 15     | 0.31 (0.21, 0.46) | 0.01    | 0.12    |
|                   |                               | Assessment of HIV status              | Self-report         | 8      | 0.49 (0.32, 0.73) | 0.01    | 0.74    |
|                   |                               |                                    | Serologic           | 6      | 0.39 (0.29, 0.52) | 0.01    | 0.01    |
|                   |                               |                                    |                     | 22     | 0.41 (0.31, 0.52) | 0.01    | 0.01    |

*Indicates moderation at p < 0.01.

**Table 2** shows the study characteristics of each of these samples.

HIV Prevalence

We found significant differences in HIV prevalence by sexual behavior and by locale: we found higher HIV prevalence in studies undertaken in the 12 CDC-defined high HIV/AIDS incidence locales (20.9% vs. 10.1%; Q-statistic = 5.4, P < 0.05). Recall window; data collection date; sampling method; and HIV test basis did not significantly moderate HIV prevalence within MSMW. Within MSMW, HIV prevalence rates were significantly moderated by target population: we found higher HIV prevalence in studies with greater than 90% minorities (32.7% vs. 13.2%; Q-statistic = 7.7, P < 0.01); and by locale: we found higher HIV prevalence in studies undertaken in the 12 CDC-defined high HIV/AIDS incidence locales (20.9% vs. 10.1%; Q-statistic = 5.4, P < 0.05).

We found only one paper that presented data that compared HIV infection between MSMW of different races, and only one other paper presented data comparing HIV infection between Hispanic and non-Hispanic MSMW. Only two studies compared risk behavior among MSMW by race/ethnicity. No studies within this meta-analysis reported data comparing STI infection in MSMW by race/ethnicity. Given the lack of subgroup data, we
were not able to perform separate meta-analyses on the prevalence of HIV, STI, or risk behavior by race/ethnicity categories.

Prevalence of Bisexual Behavior and Population Estimation

The weighted mean prevalence of bisexual behavior within the larger population of men who have sex with men (MSM) sampled across 28 studies was 38.5% (95% CI: 30.1%, 47.7%). It was 33.8% (95% CI: 23.7%, 45.6%) across 15 studies that assessed bisexual behavior over a time frame of one year or less. Recall window of bisexual behavior (Q-statistic = 4.4, P<.05) was the only significant moderator of the rate of bisexual behavior among MSM: longer recall windows were associated with higher proportions of bisexual behavior (data not shown). We used the estimated proportion of 33.8% for past-year MSMW/MSM with the CDC estimate that 580,000 MSM were currently living with HIV to predict that 21.0% of those, or 121,800, were past-year MSMW [17]. Although these estimates appear quite different, their 95% confidence intervals overlap – see Table 3.

STI and Sexual Risk Behavior Prevalence

As Table 4 shows, four studies that assessed HIV prevalence among MSMW also assessed STI prevalence among MSMO. Three of these studies [51,57,60] assessed STI generally – e.g., “any STI history” – while one study [42] assessed self-reports of several STI non-exclusively: for this study, we included only history of human papillomavirus (HPV). There were no significant differences in STI rates between MSMW and MSMO in these studies (22.0% vs. 26.6%; OR = 0.87, 95% CI: 0.67, 1.13). Three studies examined STI prevalence among both MSMW and MSWE, of which two studies reported on STI generally [49,60] and one study assessed self-reports of several STI non-exclusively, for which we included only history of HPV [42]. No significant differences were found in STI prevalence between MSMW and MSWE (17.2% vs. 7.3%; OR = 2.64, 95% CI: 0.73, 9.51).

MSMW were significantly less likely to engage in unprotected receptive anal intercourse (URAI) than MSMO (15.9% vs. 35.0%; OR = 0.36, 95% CI: 0.28, 0.46), but there were no significant differences in STI prevalence between MSMW, MSMO, and MSWE.

Table 3. Population estimates of MSMW and HIV-positive MSMW in the United States.

| Data source | Original measure | Estimate (95% CI) | Newly derived measure | Newly derived estimate (95% CI) |
|-------------|-----------------|------------------|----------------------|-------------------------------|
| A. Purcell et al (2012) | Proportion of past-year MSM among males ≥13 years old | 0.29 (0.26,0.32) | % of U.S. males ≥13 years who are past-year MSMW (A*D) | 0.98% (0.6%, 1.5%) |
| B. CDC (2011) | No. of MSM living with HIV/AIDS | 580,000 (540,000; 620,000) | No. of past-year MSMW who are HIV+ (B*E) | 121,800 (79,380; 179,180) |
| C. U.S. Census (2011) | No. of males ≥13 years old | 122,852,862 | No. of past-year MSMW in U.S. (A*C*D) | 1,204,204 (757,019; 1,792,669) |
| D. Meta-analysis | Past-year MSMW/MSM | 0.338 (0.237,0.456) | % of HIV+ past-year MSMW of U.S. males >13 years (A*D*F) | 0.23% (0.10%, 0.48%) |
| E. Meta-analysis | Proportion of HIV+ past-year MSMW/HIV+ MSM | 0.210 (.147,0.289) | – | – |
| F. Meta-analysis | HIV prevalence rate of past-year MSMW | 0.233 (.157,0.331) | Number of past-year MSMW who are HIV+ (A*C*D*F) | 280,580 (118,852; 593,373) |

Table 4. STI and sexual risk behavior differences between MSMW, MSMO, and MSWE.

| Outcome variables | Comparison group | Number of studies | Odds ratio (95% CI) | Effect size P-value | Event rate estimate, MSMW (95% CI) | Event rate estimate, comparison (95% CI) |
|------------------|-----------------|------------------|--------------------|--------------------|-------------------------------|----------------------------------|
| STI diagnosis or symptoms* | MSMO | 4 | 0.87 (0.67, 1.13) | .287 | 22.0% (5.2%, 58.6%) | 26.6% (8.8%, 57.7%) |
| | MSWE | 3 | 2.64 (0.73, 9.51) | .138 | 17.2% (4.7%, 46.9%) | 7.3% (3.0%, 16.4%) |
| UAI | MSMO | 4 | 0.91 (0.58, 1.42) | .665 | 32.7% (22.1%, 45.3%) | 33.1% (26.6%, 40.4%) |
| | MSMW | 4 | 0.36 (0.28, 0.46) | <.001 | 15.9% (10.6%, 23.0%) | 35.0% (28.1%, 42.5%) |
| URAI with male | MSMO | 4 | 1.08 (0.87, 1.34) | .490 | 36.5% (25.0%, 49.9%) | 34.7% (25.1%, 45.8%) |
| URAI with female | MSWE | 2 | 1.80 (1.29, 2.52) | .001 | 16.6% (10.1%, 26.0%) | 10.4% (8.5%, 12.6%) |
| UWI | MSWE | 4 | 0.61 (0.27, 1.39) | .237 | 43.8% (29.4%, 59.4%) | 55.6% (45.8%, 65.0%) |

*All studies included measured any STI rather than individual kinds of STI, except one [42]; for this study, we used data only on human papillomavirus symptoms/diagnosis in these analyses.  
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Discussion

This study, insofar as we are aware, is the first meta-analysis of HIV prevalence among bisexually behaving men in the United States. It provides valuable information about their risk of HIV infection relative to men who have sex exclusively with either men or women. The large effect sizes we report here place MSMW squarely between MSMO and MSWE in HIV prevalence. These results are robust even using conservative mixed effects models, and are not significantly affected by methodological moderator variables except for post-HAART data collection dates. This finding, coupled with our within-group moderation results, suggests that HIV prevalence rates among MSMW are increasing less rapidly than among MSMO, perhaps due to relatively fewer URAI exposures among a pool of MSM whose collective viremia is steadily decreasing. It is not surprising to have found that MSMW have higher rates of HIV compared with MSWE, given that they engage in risk behaviors (URAI) that MSWE do not engage in, and that their male sexual partners have a far higher rate of HIV infection than the female sexual partners of MSWE. It is also not surprising to have found that racial/ethnic minority MSMW experience higher HIV prevalence rates than their counterparts; this mirrors research on MSM in general [61,62]. It may be surprising, however, to have found MSMW to host such substantially reduced odds of HIV infection compared with MSMO. The literature contains conflicting evidence that MSMW have fewer male sex partners than MSMO [62] or multiple sex partners in general [40,42,63–66]. Our meta-analysis found that MSMW were significantly less likely to report engaging in URAI than MSMO, which may explain their reduced odds for HIV infection. There is additional evidence beyond the HIV prevalence literature that bisexually behaving men may be less likely to engage in URAI than their exclusively homosexual counterparts [63,67–70]. That MSMW have less HIV and report less URAI than MSMO may be a consequence of their less frequent engagement in receptive anal intercourse in general than men who have sex with men exclusively [38]. On the other hand, we found no significant differences among MSMW and exclusively heterosexual men in unprotected vaginal intercourse; or between MSMW and MSMO engaging in UAI with men, though MSMW were more likely than MSWE to engage in UAI with women. Formative research analyzing differences in unprotected insertive intercourse rates among these three groups has been equivocal [71–73].

Our findings on prevalence of bisexually behavior within larger populations of MSM aligns closely with previous population-based research in the United States and Europe, in which relative proportions of MSMW and MSMO vary by the timeframe assessed in the recall measure for bisexual behavior: lifetime measures have tended to favor greater proportions of MSMW than MSMO, while past-year measures have tended to favor greater proportions of MSMO than MSMW [12–15,74]. Our estimate that past-year MSMW comprise approximately 1% of the U.S. male population is consistent with previous findings from population-based research.

The extraordinarily high HIV prevalence rates found for MSMW, MSMO, and MSWE in this review should be interpreted with caution; these rates may be inflated as a result of sampling frames that are not nationally representative and were composed of very high-risk men, such as injection drug users and STI clinic attendees living in high HIV/AIDS prevalence cities. Thus, the results we have reported that compare HIV rates and effect sizes between groups are likely more reliable than within-group findings. For this reason, our estimate of the number of MSMW living HIV that derives from the proportion of HIV-positive past-year MSMW within HIV-positive MSM is likely more reliable than our estimate derived from a within-MSMW HIV event rate. This finding – that 121,800 past-year MSMW in the U.S. are living with HIV – suggests two important conclusions. First, bisexual behavior men compose a small but significant proportion of the population of MSM infected with HIV. Little if any research has been conducted that tests how well MSMW have been linked to and retained in care. There is evidence that MSMW have not been effectively reached by existing HIV prevention interventions; may be less likely to disclose same-sex behaviors to health care providers and to have been tested for HIV than their MSMO peers; and may be more likely to be unaware of their HIV positivity and comparatively reluctant to disclose their HIV status to sexual partners, possibly due to greater dissociation from gay communities and higher homonegativity [34,57, 62,70,75,76]. Given these challenges, HIV-positive MSMW constitute a population that could greatly benefit from dedicated HIV prevention and care interventions. Second, the dominant research trope that examines HIV risk among MSMW within their potential to serve as a bridge population from one community to another (read: the homosexual male community to the heterosexual female community) has likely been overstated. Though our findings suggest that MSMW present potential to both acquire and transmit HIV, heterosexual women appear as likely to encounter an HIV-positive male sexual partner who acquired HIV through injection drug use (IDU) or through heterosexual sex, given CDC estimates that 110,900 heterosexual males and 131,600 heterosexual male IDU are living with HIV/AIDS [17]. Using the same logic, an MSMW would be almost four times as likely to encounter another MSMW who was HIV-positive (458,200) than an HIV-positive MSMW. In view of these comparisons, we suggest that (1) at the population level, MSMW likely present no greater risk of HIV transmission to women than exclusively heterosexual partners; (2) MSMW likely present substantially less risk of HIV transmission to men than MSMO; (3) the dizzyingly disparate HIV rate ratios reported among MSM are likely even higher if measured specifically for MSMO; and (4) the HIV/AIDS risk that MSMW themselves face from each other, from MSMO, and from their female sexual partners is currently under-researched and unmitigated by dedicated intervention development and delivery attuned to bisexually behaving men and their particular needs [16,21].

This systematic review and meta-analysis has several important limitations. First, our primary eligibility criterion of HIV prevalence assessment excluded several articles that solely presented secondary findings, such as STI and risky sexual behavior, of import to this analysis. Search strategies that target STI among MSMW, or risky sexual behavior among MSMW, may lead to different results in these domains. The paucity of existing research, as we have noted above, did not allow for subgroup analyses of HIV prevalence by race/ethnicity both within MSMW and compared to their peers. Our comparison of
MSMW and MSWE may constitute a highly conservative (though still robust and highly significant) effect size: the majority of studies that included MSMW in our review and meta-analysis did so using very high-risk samples, such as street-based illicit substance users and their sexual partners or STI clinic attendees [37,41,54,58,60]. We did not code for sexual identity, because it is an imperfect corollary of sexual behavior, but it may have proven an important moderator of HIV risk among MSMW [39,46,65,72,77–82]. Most important, though we attempted to be as inclusive as possible, our PubMed and Ovid PsyINFO searches may have excluded relevant studies from this systematic review and meta-analysis, for instance those that report HIV rates among gay men or MSMW but that also contain relevant tabular data referencing bisexual behavior, or health department reports and/or conference abstracts that may meet this review’s criteria but were not peer-reviewed articles. A strategy to include such grey literature may have reduced the indication of publication bias within this meta-analysis. While we acknowledge these limitations, we suggest that the robustness of our results, their internal consistency, and their external congruence with other studies indicate their validity and generalizability.

Our findings have important implications for HIV prevention and care planning, priority-setting, and intervention development. Local and state HIV care and prevention planning groups rely on national data to constitute HIV prevention and care plans; to set priority populations; and to recommend intervention placement and training to service providers. Exclusion of MSMW as a specified risk category in HIV/AIDS surveillance reports creates an environment wherein bisexualy behaving men are more easily ignored by organizations receiving funding to provide HIV prevention and care, and wherein HIV rates specific to MSMW are likely diluted. There are currently no HIV prevention interventions that target bisexually behaving men in the CDC’s Diffusion of Effective Behavioral Interventions portfolio, which has been the gold standard for intervention diffusion and deployment for the last several years, though promising intervention designs for racial/ethnic minority MSMW are being evaluated, representing a long-overdue development that may provide models for reaching other MSMW effectively [82,83]. Our results suggest a need to collect and report bisexual behavior in our local, state, and national HIV/AIDS and STI surveillance systems and within HIV intervention design, development, and delivery. Further formative research on HIV risk (such as synergistic epidemics, or syndemics) and protective factors (such as resiliencies) particular to MSMW is necessary to intervention development, as are meta-analyses specific to risky sexual behavior, mental health, and STI among MSMW and longitudinal research into bisexual men’s physical and psychosocial health over time. At present, while research is emerging lately, data are insufficient to estimate HIV prevalence differences between MSMW of specific races and ethnicities or to assess HIV incidence among MSMW. Nonetheless, our findings indicate that MSMW who are racial/ethnic minorities suffer disparate HIV burden and deserve particular attention in prevention and care research and delivery.

Though our literature search uncovered hundreds of articles purporting to assess HIV risk among “gay and bisexual” men, only a small fraction of these effectively differentiated those populations. Our results show that, in terms of HIV prevalence and risk behavior, MSMW and MSMO are quite distinct. Those few researchers studying HIV among MSMW have for years recommended more precise data collection and intervention design specific to MSMW [3,25,44,84]. It is past time to heed their calls. Only a combination of MSMW-targeted research and improved data collection and reporting will allow our national, state, and local HIV prevention and care planning groups to effectively address the acquisition and transmission risks of bisexually behaving men in the United States.

Supporting Information

Appendix S1 Electronic Search Strategy (PubMed Database).
(DOCX)

Checklist S1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist.
(DOC)

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Author Contributions

Conceived and designed the experiments: MRF CW MLK NM RS AS. Performed the experiments: MRF CW MLK. Analyzed the data: MRF. Wrote the paper: MRF CW MLK RS AS NM.

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