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A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

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Complete List of Authors:	Meads, Catherine; Anglia Ruskin University, Faculty of Health, Social Care and Education Martin, Adam; Academic Unit of Health Economics, Leeds Institute of Health Sciences Grierson, Jeffrey; Anglia Ruskin University, Faculty of Health, Social Care and Education Varney, Justin; Public Health England, Adult Health and Wellbeing
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Title: A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

Authors: Catherine Meads[1], Adam Martin[2], Jeffrey Grierson[1], Justin Varney[3]

Corresponding author: C Meads – email: catherine.meads@anglia.ac.uk

1. Faculty of Health, Social Care and Education, Anglia Ruskin University, Cambridge, UK

2. Academic Unit of Health Economics, Leeds Institute of Health Sciences, University of Leeds, Leeds, UK

3. Public Health England

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Abstract

Objectives

Sexual minority women (SMW) experience higher chronic-disease risk-factors than heterosexual counterparts. However, it was unclear if these risks translate into higher physical-condition rates. This systematic review evaluates cardiovascular disease (CVD), hypertension, respiratory disease and diabetes mellitus in SMW.

Methods

Prospero database registration: CRD42016050299. Included were studies reporting mortality, incidence or prevalence of the above listed conditions in SMW compared to heterosexual women. Databases (platforms) searched from 2010 to December 2016 were Medline (OVID), Embase (Elsevier), Cinahl (Elsevier), PsycInfo (Ovid), Social Policy and Practice (Ovid), Cochrane CENTRAL (Cochrane Library), Science Citation Index (Web of Science), CAB abstracts (Ovid). Search terms included MeSH terms and text words. Extensive additional searches were conducted in specialist academic journals and websites.

Two reviewers checked study eligibility. One independently extracted data and assessed quality, checked by a second, with disagreements resolved through discussion. The CASP cohort checklist was used to assess risk-of-bias. Meta-analysis was conducted where more than four studies reported same outcomes, with Comprehensive Meta-analysis software using adjusted odds ratios (AORs) and random-effects models. Heterogeneity was assessed using I^2 test.

Results

Identified were 23,103 citations, 692 full-texts screened, and 16 studies included (in 18 papers). One reported mortality (from Denmark), none incidence and 15 prevalence (14 USA, 1 Australia). Same-sex-cohabiting women had higher mortality rates compared to opposite-sex-cohabiting women in CVD (Hazard Ratio (HR)=1.37 (95%CI=1.22-1.54) and respiratory disease (HR=2.10 (95%CI=1.74-2.53). AOR meta-analyses of seven studies showed higher asthma rates in lesbians (OR=1.44 (95%CI=1.27-1.64)I^2=0%) and bisexual women (OR=1.64 (95%CI=1.41-1.89)I^2=0%) but no differences for CVD (five studies), hypertension (five studies) or diabetes mellitus (seven studies).

Conclusions

These new health inequalities estimates require further confirmatory epidemiological studies, and investigation into potential environmental, hormonal, physiological, psychological or genetic causes. This would be supported by routine collection of sexual-identity measures in population-level epidemiological surveys.

Strengths and limitations of this study

- A major strength is that this is the first numerical estimate of the relative prevalence of diabetes mellitus, cardiovascular and respiratory diseases in lesbians and bisexual women.
- We used extensive searches from a number of different sources, not just electronic databases and reference lists but also in specialist academic journals and websites to ensure we found all relevant studies.
- We used a wide definition of SMW to include identity, behaviour and partnership to be able to include all SMW irrespective of being sexually active or in a partnership. This will widen the generalizability of the systematic review.
- Considerable efforts were made to avoid double counting of participants from different studies when entering data but some double-counting may have occurred due to the nature of the surveys used in the studies.
- We used adjusted odds ratios to meta-analyse, which means that the results were more comparable than using unadjusted prevalence estimates. However, none of the AORs were adjusted for smoking status, which is a limitation of the included studies.

Background

Sexual minority women (SMW) include lesbians, bisexual women, women who have sex with women, women who have sex with men and women, and women who are married to or cohabit with another woman in a committed relationship. Public Health England estimates that at least 2.5% of the population identify at lesbian, gay or bisexual[1].

In general, SMW populations experience disproportionate behavioural risks to health and higher chronic disease risk factors than their heterosexual counterparts [2,3]. Chronic disease risk factors include poor diet, lack of exercise, obesity, smoking, excessive alcohol intake, anxiety, depression, hypertension and high cholesterol levels. Due to a lack of research so far[3], it is unclear whether these risk factors translate into higher rates of physical health conditions.

Past research has highlighted some aspects of health inequalities experienced by SMW but also identified significant and persistent gaps in the evidence[2,4-7] including in relation to common physical conditions such as cardiovascular disease (CVD), respiratory tract disease and diabetes mellitus. These are some of the leading causes of death and disability for women[8] and, up to now, there have been no published summary estimates of the relative prevalence of these conditions in SMW compared to heterosexual women.

There have been two recent systematic reviews of physical health in SMW [9,10]. Eliason (2015)[9] reviewed evidence on prevalence and risk of a variety of conditions and Simoni et al (2016)[10] investigated disparities in physical health conditions in SMW. Since these systematic reviews were conducted, more prevalence studies have been published. This systematic review includes all relevant recent evidence (published from 2010 onwards) on the mortality, incidence and prevalence of specific physical health conditions of CVD, hypertension, respiratory disease and diabetes mellitus in SMW compared to heterosexual women, and conducts meta-analyses in order to derive up-to-date prevalence estimates of these conditions and determine whether there are different rates in SMW compared to heterosexual women.

Methods

A protocol was registered with the Prospero database (No. CRD42016050299) for research investigating all aspects of health and experience of healthcare in SMW, of which this project is part. The inclusion criteria for this systematic review were any published comparative studies in any language, published from 2010 onwards, comparing specific rates (see below) in SMW (any definition including identity, behaviour or cohabitation status) of any age compared to heterosexual women (any definition including identity, behaviour or cohabitation status) of any age in any country or setting. The following self-report or objectively measured rates were included: mortality, incidence and prevalence of CVD, hypertension, diabetes mellitus (any type) and respiratory diseases including asthma. .

Searches:

Database searches were conducted in two phases. First, searches were conducted by Public Health England Knowledge and Library Service in May 2015. Second, searches were conducted by the first author (CM) in December 2016 with dates from January 2015 to December 2016. Databases (platforms) searched were Medline (OVID), Embase (Elsevier), Cinahl ((Elsevier), PsycINFO (Ovid), Social Policy and Practice (Ovid), Cochrane CENTRAL (Cochrane Library), Science Citation Index (Web of Science), CAB abstracts (Ovid). EPPI-Reviewer 4, Endnote and Microsoft Excel were used to sift

citations. Search terms included MeSH terms and text words for sexual minority (for example, lesbian, bisexual, homosexual, WSW, WSMW, same sex) and for the physical conditions. Searches were not limited to English language. Example search strategies for 4 databases from the December 2016 searches are in Web Supplement 1.

In addition to database searches, reviews and summaries of lesbian, gay, bisexual & transgender (LGB&T) health were examined for relevant evidence. LGB&T Health Research Journal (all issues), Journal of Lesbian Studies (2014-16) and Journal of Gay and Lesbian Mental Health (2014-16) were searched. Previous projects by the first author (CM) were searched for relevant evidence and, from a previous project, a list of currently active researchers in LGBT health with their publications were reviewed. Web pages of several researchers known to be active in SMW research were searched. The UK National LGB&T Partnership monthly newsletter from February to October 2016 was sifted for relevant up-to-date work that had not yet been published. UK national survey websites were also sifted for information on sexual identity and health (Integrated Household Survey, Scottish Health Survey, Welsh Health Survey and Health Survey for England).

Study selection, data extraction, quality assessment and synthesis

Full text copies of references matching inclusion criteria were obtained. Two reviewers (CM and AM) checked study eligibility. One independently extracted data from studies into the report (CM) and these were checked by another reviewer (JG), with disagreements resolved through discussion. Characteristics and results of all included studies were described through narrative synthesis. Tabulation was used where there was more than one study reporting the same outcome. Where there was overlap in study populations, the largest included population was used where outcomes of interest were reported. The Critical Appraisal Skills Programme (CASP) checklist for cohort studies was used to assess quality for all studies. Since there is no established and validated quality checklist specifically for cross-sectional surveys, using the same checklist for all provided consistency in quality assessment across studies. Meta-analysis was conducted where there were four or more discrete studies reporting the same outcome. This included both unadjusted prevalence estimates (with Review Manager software 5.3), and adjusted odds ratios using inverse variance (with Comprehensive Meta-analysis version 3). Random effects models were used for both. Statistical heterogeneity was assessed using the I^2 test, using standard thresholds for high, medium and low heterogeneity[11]. There were insufficient studies reporting the same outcomes to be able to construct a meaningful funnel plot to assess publication bias.

Results

Description of studies

A total of 23,103 citations were identified, 22,763 from the first searches and 340 from the second searches. Full texts of 692 papers were screened for potential relevancy. Sixteen studies were included [12-27], described in 18 papers - the study by Clark et al (2015)[28] contained a subset of the participants in the study by Everett et al (2013) [17] and the study by Wallace (2011)[29] contained a subset of those in the study by Boehmer et al (2014) [14]. For characteristics of included studies, see Table 1 and for participant baseline characteristics, see Web Appendix Table 1.

One study examined mortality rates; Frisch and Simondsen (2013)[21] reported hazard ratios for mortality by sexual orientation in a large national cohort from Denmark by various causes of death (n=6.5 million, approximately 50% women).

No studies investigated incidence, and 15 studies investigated prevalence[10-20, 22-27]. Two were based on single waves of cohort studies (Everett et al 2013[17] (also reported in Clarke et al 2015[28]), and McNair et al 2011[26]). The first[17] was based in the USA and used Wave IV of data from the National Longitudinal Study of Adolescent Health. The second[26] used one year's data from an Australian study of young women aged 18-23 selected at random from the Australian Medicare database. The remaining 13 studies were from the USA and used one or more year's data from repeated cross sectional surveys. Eight of these used Behavioral Risk Factor Surveillance System (BRFSS) surveys, either using a national sample from different years[12,13] or for specific states (Massachusetts[15], Oregon[22], North Carolina[25], Washington State[16,19,20]). Other surveys used included; The National Health Interview Survey[23,27], The California Health Interview Survey[14,29], The Youth Risk Behaviour Surveillance System[24], The National Health and Nutrition Examination Survey[18].

One group of studies[16,19,20] reported different outcomes for different subsets (such as age ranges) of the same repeated survey for different years. Ward et al (2015)[27] investigated a subset of the population in Jackson et al (2016)[23] but Ward et al (2015) [27] reported asthma whereas Jackson et al (2016) [23] did not so both papers for this study have been included. Wallace et al (2011)[29] used a subset of the sample in Boehmer et al (2014)[14] and reported the same outcomes so these results are not reported here. Everett et al (2013)[17] and Clark et al (2015)[28] reported different outcomes from the same population so both papers for this study have been included.

Quality assessment found similar quality issues across studies, and are reported in Web Appendix Table 2. The cohort studies[17,26] reported results as if they were cross-sectional surveys by not using follow-up data. The main quality issues were that health conditions were ascertained mostly by health self-report; the main exception was in Everett et al 2013 (and Clark et al 2015)[17,28] where interviewers measured blood pressure. Also, weighted prevalence percentages were reported in several included studies (see Web Appendix Table 1), but weighting factors used were often unclear.

Main findings

For CVD mortality and for respiratory tract disease mortality, Frisch and Simondsen (2013)[21] found that same-sex cohabiting women had higher mortality rates to opposite sex cohabiting women for these diseases (HR 1.37 (95%CI 1.22 to 1.54) and HR 2.10 (95%CI 1.74 to 2.53) respectively) but that same-sex married women had similar mortality rates to opposite sex married women (HR 1.32 (95%CI 0.75 to 2.33) and HR 0.85 (95%CI 0.36 to 2.05) respectively) . The sample sizes were larger for same-sex cohabiting women (n=207 and n=111) than same sex married women (n=12 and n=5) and no conclusions can be drawn from the same sex married women data as sample sizes were too small.

Numerical prevalence results are presented in Table 2 (asthma), Web Appendix Table 3 (CVD), Web Appendix Table 4 (hypertension), and Web Appendix Table 5 (diabetes mellitus). One study[23] presented results for heart disease and stroke separately and found no difference in rates between any of the groups (see Web Appendix Table 3). One study[27] presented results for chronic obstructive pulmonary disease which found higher rates in bisexual women compared to heterosexual women but not for lesbians (prevalence in lesbians 6.0% (95%CI 3.2 to 11.0), bisexual women 13.6% (95%CI 6.9 to 25.2), heterosexual women 6.4% (95%CI 5.9 to 6.8).

Meta analysis

There were sufficient studies (i.e. n>4) presenting results for CVD, hypertension, asthma and diabetes (any type) in lesbians and in bisexual women for meta-analyses to be conducted.

Meta-analyses of unadjusted prevalence (see figures 1a and 1b, Web Appendix 2a, 2b, 3a, 3b, 4a, 4b) showed no difference in CVD (lesbian OR=0.94 (95%CI 0.73 to 1.21) and bisexual women OR=0.90 (95%CI 0.54 to 1.51)) but lower prevalence of hypertension (lesbian OR=0.82 (95%CI 0.72 to 0.94) and bisexual women OR=0.64 (95%CI 0.49 to 0.85). There was higher prevalence of asthma (lesbians OR=1.47 (95%CI 1.32 to 1.63) and bisexual women OR=1.97 (95%CI 1.71 to 2.26). For diabetes mellitus there was no difference in prevalence between lesbians and heterosexual women but lower prevalence in bisexual women (OR=0.86 (95%CI 0.65 to 1.12) and OR=0.70 (95%CI 0.54 to 0.91)).

Meta-analyses of adjusted odds ratios showed increased rates of asthma in lesbians and in bisexual women compared to heterosexual women (ORs = 1.44 (95%CI 1.27 to 1.64) I^2=0% and 1.64 (95%CI 1.41 to 1.89) I^2=0%). They showed no differences for lesbians or bisexual women compared to heterosexual women for CVD (ORs = 1.34 (95%CI 0.97 to 1.85) I^2=45% and 1.08 (95%CI 0.80 to 1.47) I^2=0%), for hypertension (ORs = 0.98 (95%CI 0.86 to 1.14) I^2=0% and 1.08 (95%CI 0.86 to 1.35) I^2=39%), and for diabetes mellitus (ORs = 1.11 (95%CI 0.91 to 1.36) I^2=0% and 1.01 (95%CI 0.75 to 1.36) I^2=51%).

Discussion

Summary of main findings

Results from a single large study reporting mortality rates[21] showed that there was no difference in cardiovascular or respiratory tract disease mortality rates in same-sex married compared to opposite sex married women, but higher mortality rates in same-sex cohabiting women compared to opposite sex cohabiting women.

Meta-analyses of adjusted odds ratios of disease prevalence showed no differences in CVD, hypertension or diabetes mellitus prevalence, but a higher prevalence of asthma in SMW compared to heterosexual women.

Discussion of main findings

A key finding was the higher prevalence, from the adjusted odds ratio meta-analysis, of asthma in lesbians and bisexual women. Asthma is caused by a mixture of genetic and environmental factors. Higher rates are associated with anxiety but it is not known if asthma causes psychological problems or if psychological problems lead to asthma[30]. Nevertheless, studies have shown higher rates of mental health problems including anxiety in SMW [31,32]. Asthma is also more common amongst those who are economically disadvantaged, and a consistent finding in studies included in the systematic review was that SMW had below average incomes[12,13,14,18,26]. Asthma is also more common amongst current or former smokers. Several included studies showed higher rates of smoking or tobacco use amongst SMW[12,13,16-18,20,22,23,25]. However, only one of the studies reporting asthma prevalence clearly controlled for smoking behaviour[12].

The finding of lower hypertension prevalence and no difference in the adjusted odds ratio meta-analysis in lesbians and bisexual women was unexpected. Higher rates of hypertension are associated with lack of exercise and obesity. Several of the included studies demonstrated higher rates of obesity [12-15,17-19,22,23] and a recent systematic review on obesity in SMW [33] also found consistently higher rates of obesity amongst SMW compared to heterosexual women. However, the rates of physical exercise in SMW is less clear. Two of the included studies showed higher rates of physical activity or exercise in lesbians and bisexual women compared to heterosexual women[13,25] whilst four showed no differences[17,19,22,23]. Hypertension is also associated with mental health difficulties, particularly depression[34], and there are higher rates of depression in SMW [31,32].

No difference in rates of diabetes mellitus were found in the meta-analysis of adjusted odds ratios, but in the unadjusted prevalence meta-analysis higher rates were found in bisexual women but not lesbians. It is unclear as to why this would occur. Risk factors for type II diabetes mellitus include hypertension, overweight/obesity, physical inactivity and unhealthy diet. Evidence on the first three are discussed above, however there is much less information available about diet. Dilley et al 2010[16] reported that the proportion eating insufficient fruits and vegetables was higher in bisexual women than lesbians and heterosexual women but Garland-Forshee et al 2014[22] showed no differences between lesbians, bisexual and heterosexual women in the proportion who met US CDC recommendations on fruit and vegetable intake.

Three of the included studies calculated that lesbians and bisexual women were at higher risk of CVD[15,18,28]. Farmer et el (2013)[18] and Clark et al (2015)[28] calculated risk scores using the Framingham General CVD Risk Score and both calculated that SMW had higher CVD risk scores. Farmer et al (2013)[18] calculated that SMW were 13.9% (95%CI 8.55 to 19.3%) older in vascular terms than their chronological age, and that this was 5.7% (95%CI 1.5% to 9.8%) greater than heterosexual women. Clark et al (2015)[28] found that average 30 year CVD risk was raised in all sexual minority groups of women, significantly so in mostly heterosexual and mostly homosexual women. Conron et al (2010)[15] also calculated CVD risk, using presence of obesity and smoking plus one other risk factor including lack of moderate physical activity, lifetime diabetes mellitus, hypertension and high cholesterol. They estimated that lesbians and bisexual women were at higher risk of CVD than heterosexual women.

It is known that there are higher rates of several CVD risk factors in SMW, including overweight/obesity, diabetes mellitus, tobacco use (all discussed above) high cholesterol and harmful use of alcohol (discussed below). Hence the finding of no difference in CVD rates was surprising. Also, since the systematic review found higher rates of asthma, if this was due to higher rates of smoking, it would be expected that there would be correspondingly higher rates of CVD.

Several of the included studies reported higher rates of harmful alcohol use in lesbians and bisexual women compared to heterosexuals[13,16-18,20,22,23]. Several also reported cholesterol levels - one found lower cholesterol levels in lesbians and bisexual women[17] but most found no significant differences[16,20,22]. Matthews et al, 2014[25] found that twice as many lesbians and bisexual women than heterosexual women were not having their cholesterol checked (32.5% vs 13.8%), but the implications of this are unclear.

Strengths and weaknesses of the study

The strengths of the current systematic review include extensive searches from a number of different sources. We used a wide definition of SMW to include identity, behaviour and partnership. It is acknowledged that these are different concepts and women can identify as lesbian or bisexual without being sexually active or being in a partnership. Also some women identify as lesbian whilst having sex with men and some women identify as heterosexual whilst having sex with women. Most of the studies also used self-report for the physical conditions, and this may result in responder bias, but it is unclear why responder bias might be stronger in SMW than heterosexual respondents. Also, almost all of the included studies were conducted in USA, so results may not be generalizable to other countries. Also, it is known that SMW have less insurance coverage and poorer access to healthcare in USA[35]. The precise questions on health used in the BRFSS questionnaires asked whether the respondent had been 'told by a health care professional' that they had had the named condition. If SMW have less access to healthcare, it could be assumed that fewer would have been told they had one of the conditions investigated here. So it is possible that all of the rates may have

been underestimated, and the increased rates of asthma may be even higher than found here. In the reported results, prevalence of physical conditions were weighted to better reflect the underlying population in some of the included studies but not in others. Where the sexual minority samples were younger than the heterosexual population with which they were compared, it might be expected that the lack of weighting by age would result in underestimation of the difference in prevalence of physical health conditions, particularly CVD, hypertension and diabetes mellitus where prevalence rises by age. There were insufficient studies to be able to conduct meaningful subgroup analyses by whether or not the study had controlled for age. Furthermore, two of the studies[13,20] were unclear as to whether they weighted the reported prevalence or whether the reported weighting factors referred to the adjusted odds ratios that they also report. Some of the studies weighted by factors such as education and income which may also impact on the estimated prevalence of physical conditions. Some important factors were often not controlled for, e.g. for asthma, it would be usual to include smoking rates, which differ between SMW and heterosexual female populations. A further major limitation is that almost all of the prevalence research was from USA so it currently unclear if the findings are generalizable to other countries.

In the meta-analyses, considerable efforts were made to avoid double counting of participants from different studies when entering data and hence some studies were excluded for one or more reported outcomes[16,20,28,29]. Random effects models were used because of clinical heterogeneity of the study samples. The heterogeneity between studies in the weightings that were used for the prevalence estimates in the unadjusted meta-analyses may have introduced some bias from this loss of information about differences between the two groups. Hence there may be some inconsistency between the AORs reported in the results tables and the ORs used in the meta-analysis. The meta-analyses of AORs mitigates some of these effects. However, in both types of meta-analyses, there was heterogeneity in outcome measures (e.g. one study measured hypertension, six using self-report hypertension and one study using hypertensive medication use), although we do not expect that this impacted on the observed differences between groups, our main outcome of interest.

Strengths and weaknesses in relation to previous research

The previous systematic reviews[9,10] found fewer studies and did not conduct meta-analyses so did not quantify the physical health disparities they had found. For CVD prevalence Eliason (2014)[9] included seven studies, of which four were published before 2010, and for hypertension it included 12 studies, of which four were published before 2010. For asthma it included 13 studies, four of which were published before 2010. Some relevant results from included studies were not described, and the study by Garland-Forshee et al 2014[21] was omitted. Eliason (2014)[9] concluded that asthma was more common in SMW, but no differences were consistently found in the other chronic physical conditions she investigated, including diabetes, hypertension and CVD. Simoni et al (2016)[10] had a very brief summary of results. For CVD it found one study, for hypertension one study and for asthma four studies. All of these were included in the systematic review by Eliason (2015)[9]. Simoni et al (2016)[10] found evidence of disparities in the one included study reporting CVD[19] and in asthma, but that evidence was lacking in diabetes and hypertension. There is also little information on the prevalence of these conditions in men according to sexual orientation and no relevant systematic reviews[7].

Implications for clinicians and policy-makers

If there are higher rates of asthma in lesbians and bisexual women, this might have implications for health service delivery, particularly in primary care. Urwin and Whittaker (2016)[36] published an evaluation of the English General Practice Patient Survey (n=2,807,320 in total, 1,556,909 women)

looking at inequalities of GP use by sexual orientation for various conditions. They found that lesbians but not bisexual women were less likely to visit the GP than heterosexual women in the previous 3 months for asthma or long-term chest problem (adjusted OR=0.84 (95%CI 0.71 to 0.98 and OR=0.85 (95%CI 0.69 to 1.04)). So it is likely that SMW, particularly in the UK and possibly elsewhere, are not accessing services despite ill-health. A recent systematic review found that sexual minoritypopulations generally have difficulties with access to health services for a variety of reasons including communication difficulties, internalised homophobia, prejudicial conduct adopted by health professionals, breach of confidentiality during consultations and institutional homophobia [37]. Combined with the evidence shown in this systematic review, this suggests potentially considerable latent demand for primary care services amongst SMW and that there may be particular issues for lesbians accessing primary health care services for asthma. This evidence contributes to a bigger picture about inequality for SMW in a wide range of aspects[2,5].

This systematic review highlights the need for better routine data collection on sexual minority women as much of the current research has small sample sizes and based on countries with significantly different healthcare access and social norms around sexual identity. The introduction of an NHS information standard on sexual orientation in April 2017 [38] will start to introduce routine data capture across hospital episode statistics and disease registries, alongside training across the NHS to support staff having positive conversations about sexual orientation, which will build over time a much clearer picture of the health inequalities in this group and potentially help to reduce them.

Implications for research

This rigorously conducted systematic review has reported some important new findings on health inequalities in SMW that are hard to explain. Further research would be useful on these health inequalities, including their causes. For example, we do not know if there are consistently different hormone levels in SMW, which might be driving some of these findings, so further research on a variety of hormone levels could be very useful. This would be supported by the routine collection of sexual identity measures in population-level epidemiological studies, and the results published. Robust multi-level modelling (including sexual identity) should be conducted with large databases and cohort studies. For asthma, results from large cohort studies, controlled for risk factors such as smoking and overweight/obesity would be useful to further examine these findings. Regarding hypertension and CVD, the findings are also unexpected so investigation into potential causes would be very useful, such as possible differences in hormone levels, or other environmental, social, physiological, psychological or genetic factors that might be contributing to these results.

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Tables and figures, with web appendix

Table 1. Characteristics of included studies.

Table 2. Prevalence of asthma by sexual orientation

Figure 1. Meta-analysis of asthma in lesbians and in bisexual women

WEB APPENDIX

Web Table 1. Participant baseline characteristics

Web Table 2. CASP quality assessment results

Web Table 3. Prevalence of cardiovascular disease or CVD symptoms by sexual orientation

Web Table 4. Prevalence of hypertension or hypertensive medication use by sexual orientation

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Web Figure 1. PRISMA flow diagram

Web Figure 2a. CVD in lesbians

Web Figure 2b, CVD in bisexual women

Web Figure 3a. Hypertension in lesbians

Web Figure 3b. Hypertension in bisexual women

Web Figure 4a. Diabetes mellitus in lesbians

Web Figure 4b. Diabetes mellitus in bisexual women

Table 1. Characteristics of included studies

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
Mortality studies							
Frisch (2013)	National demographic data from Danish Civil Registration System, including mortality data	Population, marriage, living in same sex or opposite sex cohabitation for at least 1 year between 1982 and 2011, Denmark	Cohabitation record, marriage record (same sex marriage from 1989, (NB 75.6% same sex cohabiting women were same sex married)	Opposite sex cohabitation, marriage	National demographic data collection	Mortality	Population cohort Supported by – not reported (NR)
Surveys based on multi-state Behavioral Risk Factor Surveillance System (BRFSS)							
Blosnich (2013)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults in partnerships. All states, USA	Various similar in the 10 states with response options heterosexual or straight; homosexual, gay or lesbian; bisexual; other; and opposite or same sex partner.	Opposite sex partnered women	Behavioral Risk Factor Surveillance System (BRFSS) for all US States 2004.	Current asthma, lifetime asthma	Population survey. Supported by a National Research Service award
Blosnich (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. Alaska, Arizona, California, Maine, Massachusetts, Montana, New Mexico, North	Various similar in the 10 states with response options heterosexual or straight; homosexual, gay or lesbian; bisexual; other.	Heterosexual women	Behavioral Risk Factor Surveillance System (BRFSS) for 10 States 2010.	CVD symptoms, asthma, diabetes	Population survey. Supported by National Research Service awards.

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
		Dakota, Washington, Wisconsin, USA					
Surveys based on single state Behavioral Risk Factor Surveillance System (BRFSS)							
Conron (2010)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English, Spanish or Portuguese speaking non-institutionalised adults. Massachusetts, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women	Massachusetts Behavioral Risk Factor Surveillance System (BRFSS) 2001-8.	Heart disease, diabetes, asthma	Population survey. Supported by Massachusetts Department of Public Health HIV/AIDS Bureau and Ford Foundation
Garland-Forshee (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults, Oregon, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D other? (D answers excluded)	Heterosexual women	Oregon Behavioral Risk Factor Surveillance System 2005-8	Cardiovascular disease, hypertension, diabetes, asthma	Population survey. Supported by Center for Disease Control grants.
Matthews (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. North Carolina, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D other? (D answers excluded)	Heterosexual women	North Carolina Behavioral Risk Factor Surveillance System 2011	Angina or heart disease, hypertension, diabetes, asthma	Population survey. Supported by National Institute for Mental Health grant.
Dilley (2010) and	Telephone-based (landline) random digit dialled	English or Spanish speaking non-institutionali	A heterosexual or straight, B homosexu	Heterosexual women	Washington State Behavioral Risk Factor Surveillanc	Diabetes, hypertension, (asthma),	Population survey. Supported by Washington

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	interview. Had ever been told by a health professional that they had (a named condition)	sed adults. Washington, USA	al, gay or lesbian, C bisexual or D something else? (D answers excluded)		e System (BRFSS) 2003-6.		State Tobacco Prevention and Control Program and BRFSS
Fredriksen-Goldsen (2012) and	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. Washington, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women	Washington State Behavioral Risk Factor Surveillance System (BRFSS) 2003-9.	Asthma	Population survey. Supported by NIH and National Institute on Aging grants
Fredriksen-Goldsen (2013)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults aged over 50. Washington, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women aged over 50	Washington State Behavioral Risk Factor Surveillance System (BRFSS) 2003-10.	Cardiovascular disease (asthma, diabetes, hypertension),	Population survey. Supported by National Institute on Aging grant
Studies based on other US national or state surveys							
Jackson (2016) and Ward (2015)	In-person interviews using cluster-based probability sampling. Had ever been told by a health professional that they had (a named	Non-institutionalised adults. USA	Straight (not lesbian or gay); gay or lesbian; bisexual; something else? (something else answers excluded)	Straight women	National Health Interview Survey 2013-14	Diabetes, heart disease (CHD or any other kind of heart disease, angina pectoris or a myocardial infarction), stroke, hypertension Asthma	Population survey Supported by several grants including from Harvard Catalyst and NIH

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	condition), or diagnosed by a doctor (CVD)					(Ward)	
Kann (2016)	School questionnaire - based survey, nationally representative data. Had ever been told by a doctor or nurse that they had asthma	Students in grades 9–12 (aged 14-18) attending high schools, USA	Which of the following best describes you? "heterosexual (straight)," "gay or lesbian," "bisexual," or "not sure." AND During your life, with whom have you had sexual contact? "I have never had sexual contact," "females," "males," and "females and males."	Heterosexual female students AND Sexual contact with males.	Youth Risk Behavior Survellance System (YRBSS)	Lifetime asthma	Population survey Supported by Center for Disease Control and Prevention
Boehmer (2014) and	Telephone-based random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	Adults aged over 20 with telephone and living in California	Identified as heterosexual; gay or lesbian; bisexual (excluded celibate and non-sexual responses)	Heterosexual women	California Health Interview Survey 2001-7	Heart disease, hypertension, hypertensive medication, diabetes, asthma	Population survey. Supported by – NR
Wallace (2011)	Telephone-based survey.	Lesbian and bisexual women	NR	Heterosexual women	California Health Interview	(Heart disease, hypertension	Population survey. Supported

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	Question NR	aged 50-70		aged 50-70	Surveys 2003-7	, diabetes,)	by California Wellness Foundation
Farmer (2013)	In-home survey. Had ever been told by a health professional that they had diabetes or sugar diabetes, responded yes to currently taking anti-hypertensives	Adults aged 20-69 who completed the sexual behaviour survey. National, USA	Do you think of yourself as heterosexual or straight (attracted only to men); homosexual or lesbian (sexually attracted only to women); bisexual (sexually attracted to men and women); something else or not sure.	Heterosexual women	National Health and Nutrition Examination Survey (NHANES) 2001-8	Diabetes, anti-hypertensive medication	National population survey Supported by National Institute for Drug Abuse and National Institute on Alcohol Use and Alcoholism grants.
Studies based on single waves of cohort studies							
Everett (2013) and Clark (2015)	Interviewer collected Hypertension results (Everett) and diabetes from fasting blood glucose sample, non-fasting glucose sample, HbA1c or self-report health provider diagnosis or use of anti-diabetic	Follow up 10-15 years after, from sample recruited originally through schools. National, USA	100% heterosexual (straight); mostly heterosexual (straight) but somewhat attracted to people of your own sex; bisexual – attracted to males and females equally; mostly homosexual (gay)	100% heterosexual women	Wave IV of National Longitudinal Study of Adolescent Health 2007-8	Everett 2013 - Hypertension of >140 SBP and >90 DBP. Clarke 2015 - Diabetes (and antihypertensive medication)	National population cohort Supported by Eunice Shriver National Institute of Child Health and Human Development grant. (Everett 2013) and National Center for Advancing translational sciences grant. (Clarke 2015)

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	medication in previous 4 weeks (Clarke 2015)		but somewhat attracted to people of the opposite sex; 100% homosexual (gay).				
McNair (2011)	Self-completion questionnaire. Had been diagnosed or treated for a range of illnesses over the previous 3 years	Original sample aged 18-23 selected randomly from database of Medicare Australia	Exclusively heterosexual, mainly heterosexual, bisexual, mainly homosexual (lesbian)	Exclusively heterosexual women	Third survey of the young cohort of women in the Australian Longitudinal Study on Women's Health 2003	Asthma,	National population cohort Supported by Lesbian Health Fund, USA

* outcomes in brackets were reported in included study texts but not used in the systematic review due to elimination of duplicate reporting.

Table 2. Prevalence of asthma by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	15.3%# (SE 0.003)	22.2%# (SE 0.03)	1.50 (1.04 to 2.16)*	26.4%# (SE 0.04)	1.68 (1.07 to 2.63)*		
Blosnich 2013 (lifetime diagnosis)	14.6%# (NR)					26.1%# (NR)	1.72 (1.11 to 2.65)*
Blosnich 2013 (current diagnosis)	9.5% (NR)					21.4% (NR)	2.09 (1.30 to 3.36)*
Boehmer 2014£	13.7% (SE 0.16)	20.8% (SE 1.70)	1.41 (1.14 to 1.73)*	21.5% (SE 1.76)	1.52 (1.24 to 1.87)*	NR	NR
Conron 2010&	17.4%# (SE 0.3)	24.9%# (SE 2.3)	1.68 (1.32 to 2.14)	25.7%# (SE 3.1)	1.58 (1.15 to 2.18)	NR	NR
Fredriksen-Goldsen 2012&	16.5%#	19.9%#	1.23 (NR)	31.9%#	2.17 (NR)*	NR	NR
Garland-Forshee 2014&	12.1%# (11.5 to 12.7)	15.4%# (10.8 to 21.7)	1.2 (0.8 to 1.9)	25.6%# (18.6 to 34.2)	2.4 (1.5 to 3.6)*	NR	NR
Kann 2016 by sexual identity	23.0%# (21.1 to 24.9)	NR	NR	NR	NR	28.3%# (24.4 to 32.6)	NR
Kann 2016 by sexual behaviour	25.8%# (23.5 to 28.2)	NR	NR	NR	NR	31.4%# (26.9 to 36.4)	NR
Matthews 2014	15.7%#	NR	NR	NR	NR	27.7%#	1.94 (0.96 to 3.92)
McNair 2011£	9.4%	10.4%	NR	18.0%*	NR	NR	NR
Ward 2015 (current diagnosis)	8.5% (7.9 to 9.0)	9.5% (6.2 to 14.4)	1.11 (0.70 to 1.76)	12.4% (7.3 to 20.4)	1.53 (0.87 to 2.70)	NR	NR

* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Figure 1. Meta-analysis of asthma in lesbians and in bisexual women

Title: A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

Authors: Catherine Meads[1], Adam Martin[2], Jeffrey Grierson[1], Justin Varney[3]

WEB APPENDIX

Web supplement 1. Search strategy for Medline, Embase, PsycInfo and CAB Abstracts. Dec 2016

Web Table 1. Participant baseline characteristics

Web Table 2. Critical Appraisal Skills Programme (CASP) quality assessment results

Web Table 3. Prevalence of cardiovascular disease or CVD symptoms by sexual orientation

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Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Web Figure 1. PRISMA flow diagram

Web Figure 2a. CVD in lesbians

Web Figure 2b, CVD in bisexual women

Web Figure 3a. Hypertension in lesbians

Web Figure 3b. Hypertension in bisexual women

Web Figure 4a. Diabetes mellitus in lesbians

Web Figure 4b. Diabetes mellitus in bisexual women

Web Supplement 1. – Search strategy for Medline, Embase, PsycInfo and CAB Abstracts. December 2016

Database: Ovid MEDLINE(R) 1948 to Present (including In-Process & Other Non-Indexed Citations)

Search Strategy:

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1 lesbian.mp. or Homosexuality, Female/ (5704)
2 Bisexuality/ or bisexual women.mp. (4142)
3 wsw.mp. (120)
4 WSMW.mp. (5)
5 sexual orientation.mp. or Sexual Behavior/ (56050)
6 sexual identity.mp. (1251)
7 queer.mp. or Homosexuality/ (13250)
8 1 or 2 or 3 or 4 or 5 or 6 or 7 (70952)
9 limit 8 to yr="2015 -Current" (4625)
10 limit 9 to female (3011)
11 Great Britain/ or UK.mp. (276229)
12 10 and 11 (62)

SEARCH QUERY - EMBASE

(('homosexual female':ab,ti or 'bisexual female':ab,ti or 'women who have sex with women':ab,ti and [2015-2016]/py) or ('homosexual female'/exp or 'homosexual female') or 'bisexual female' or 'women who have sex with women' or wsw or wsmw) and (2015:py or 2016:py or 2017:py)) and 'united kingdom'

Database: PsycINFO <1967 to November Week 1 2016>

Search Strategy:

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1 exp Lesbianism/ or exp Sexual Orientation/ or exp Homosexuality/ or exp Bisexuality/ or lesbian$.mp. (30632)
2 bisexual women.mp. (613)
3 wsw.mp. (46)
4 wsmw.mp. (2)
5 sexual identity.mp. (3150)
6 queer.mp. (3030)
7 1 or 2 or 3 or 4 or 5 or 6 (32610)
8 limit 7 to (human and yr="2015 -Current") (3331)
9 limit 8 to female (1815)
10 Great britain.mp. (2848)
11 united kingdom.mp. (8990)

12 uk.mp. (30316)
13 british.mp. (20760)
14 gb.mp. (241)
15 english.mp. (118463)
16 scottish.mp. (2638)
17 welsh.mp. (1111)
18 irish.mp. (3268)
19 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (177759)
20 9 and 19 (57)

Database: CAB Abstracts <1973 to 2016 Week 44>

Search Strategy:

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1 exp Lesbianism/ or exp Sexual Orientation/ or exp Homosexuality/ or exp Bisexuality/ or lesbian$.mp. (2168)
2 bisexual women.mp. (25)
3 wsw.mp. (100)
4 wsmw.mp. (1)
5 sexual identity.mp. (113)
6 queer.mp. (104)
7 1 or 2 or 3 or 4 or 5 or 6 (2365)
8 limit 7 to (human and yr="2015 -Current") [Limit not valid in CAB Abstracts; records were retained] (412)
9 limit 8 to female [Limit not valid in CAB Abstracts; records were retained] (412)
10 Great britain.mp. (34833)
11 united kingdom.mp. (152174)
12 uk.mp. (170127)
13 british.mp. (188436)
14 gb.mp. (8148)
15 english.mp. (41160)
16 scottish.mp. (5784)
17 welsh.mp. (3198)
18 irish.mp. (15558)
19 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (252567)
20 9 and 19 (10)

Web Table 1. Participant baseline characteristics

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
Blosnich (2014)	51,639	Mean 47.3 (SE 0.16)	61.4% white, 3.6% black, 26.3% Hispanic	615 lesbians, 451 bisexual women	Mean 43.1 (SE 1.33) lesbians, 35.1 (SE 1.41) bisexual women	70.8% white, 4.3% black, 15.9% Hispanic lesbians, 61.1% white, 5.5% black, 24.0% Hispanic bisexual women	SMW younger, fewer partnered, lesbians more educated, more employed, bisexual women less educated, fewer employed, less income.	Age race/ethnicity, education, income	Age race/ethnicity, education, income (only conducted where bivariate analyses p<0.05)
Blosnich (2013)	53,875 opposite sex partnered	Mean 33.0 (SE 0.06)	67.5% white	433 same-sex partnered	Mean 32.7 (SE 0.69)	72.6% white	Same sex partnered lower income,	Education, income, race/ethnicity, overweight, smoking	'weighted to account for sampling design'
Boehmer (2014)	90,608	Mean 43.0 (SE 0.03)	50.1% white, 6.5% black, 13.0% Asian 24.6% Hispanic	1,265 lesbians, 1,369 bisexual women	Mean 42.4 (SE 0.47) lesbians, 36.3 (SE 0.53) bisexual women	68.5% white, 7.4% black, 4.9% Asian 11.8% Hispanic lesbians, 57.6% white, 10.0% Asian 7.0% black, 16.9% Hispanic bisexual women	SMW younger, more white, more educated, more US born, lesbians more income, bisexual women less income, fewer with health insurance	Unadjusted prevalence reported	Age, race/ethnicity, education, household income, nativity
Conron (2010)	39,701	35.2% aged 18-33	83.2% white, 4.1% black, 2.6% Asian, 8.9% Hispanic	719 lesbian, 432 bisexual women	30.4% lesbians, 65.1% bisexual women aged 18-33	87.2% white, 4.5% black, 1.2% Asian, lesbian, 5.7% Hispanic 78.9% white,	Lesbians more educated	Age, gender	Age, gender, education, income

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
						4.7% black, 5.7% Asian, 9.3% Hispanic bisexual women			
Dilley (2010)	47,505	Mean 46.3	85.6% white, 1.8% black, 3.6% Asian, 7.1% Hispanic	589 lesbian, 561 bisexual women	Mean 40.0 lesbian, 32.9 bisexual women.	85.5% white, 1.6% black, 3.1% Asian, 7.2% Hispanic	More higher education in lesbians, less in bisexual women. Lesbians and bisexuals lower income.	Assumed that unadjusted prevalence reported	Sexual orientation, age, education
Everett (2013) and	6,072	Mean 28.7 (whole sample)	NR	138 gay/mostly gay 1345 bisexual/ mostly heterosexual,	NR	NR	NR	Possibly unadjusted prevalence reported	N/A
Clarke (2015)	5713	Mean 28.8 (95%CI 28.6 to 29.1)	67.7% white	71 homosexual, 60 mostly homosexual, 154 bisexual, 1089 mostly heterosexual	Mean (95%CI) 28.9 (28.3 to 29.5), homosexual, 28.4 (27.8 to 29.0) mostly homosexual, 28.3 (27.9 to 28.6) bisexual, 28.5 (28.2 to 28.7) mostly heterosexual	White 64.1% homosexual, 73.2% mostly homosexual, 69.4% bisexual, 77.5% mostly heterosexual	NR	See above	N/A
Farmer (2013)	5,356	36.2% aged	69.8% white,	437 SMW	49.2% aged 20-29	73.4% white, 13.2% black,	SMW younger	Possibly unadjusted	N/A

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
		20-29	12.0% black, 12.9% Hispanic			8.6% Hispanic		prevalence reported	
Fredriksen-Goldsen (2012)	49,092	Mean 46.6 (SE 0.12)	83.7% white	626 lesbians, 536 bisexual women	Mean 42.9 (SE 0.81) lesbian, 32.7 (SE 0.85) bisexual women	85.4% white lesbian, 78.2% white bisexual women.	SMW younger, fewer partnered, lesbians less education, bisexual women lower income	Age	Age, education, income
Fredriksen-Goldsen (2013)	57,466	Mean 63.8 (SD 0.06)	91.8% white	562 lesbians, 291 bisexual women	Mean 58.6 (SD 0.37)	90.3% white	SMW more employed, fewer partnered, fewer less educated	Unclear weighting factors	Age, education, income
Frisch (2013)	61,993,266	Aged 18+	NR	655,941 same sex cohabiting	Aged 18+	NR	NR	(Mortality estimate - by age)	N/A
Garland-Forshee (2014)	25,602	28.8% aged 18-34	86.7% white	347 lesbians, 322 bisexual women	26.9% lesbian, 62.3% bisexual women aged 18-34	81.6% lesbians, 85.8% bisexual women white	SMW less likely to be partnered, more education, more urban residence, Lesbians more employed, Bisexual women younger, less income	Unclear weighting factors	Age, education, relationship status, rural or urban residency
Jackson (2016)	37,185	NR	68.3% white, 12.3% black, 12.9%	525 lesbians, 353 bisexual women	NR	71.4% white, 12.7% black, 12.5% Hispanic lesbian 73.5% white,	Lesbians more educated, fewer partnered, bisexual women less income	Age, ethnicity, educational attainment, annual household	Age race/ethnicity, education, income, occupational

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
			Hispanic			16.0% black, 7.2% Hispanic bisexual women		income, occupational class, health status, region of residence	class, health status, region of residence
Ward (2015)	17,399	NR	NR	296 lesbians, 121 bisexual women	NR	NR	NR	As Jackson 2016 above	Age, race/ethnicity, education, income, marriage status, employment, health insurance status, region of residence
Kann (2016) identity	6,105	NR	NR	167 lesbian, 734 bisexual women	NR	NR	NR	Sex, race/ ethnicity and grade	N/A
Kann (2016) behaviour	3,054	NR	NR	173 lesbians, 572 bisexual women	NR	NR	NR	Sex, race/ ethnicity and grade	N/A
Matthews (2014)	6,110	25.7% aged 18-34	71.3% white, 20.7% black, 5.2% Hispanic	86 SMW	40.6% aged 18-34	77.7% white, 14.1% black, 1.7% Hispanic	SMW younger, more likely to use mobile phones	Survey design	Age
McNair (2011)	8,083	25-30	NR	99 lesbians, 100 bisexual women	25-30	NR	SMW lower income, less likely to be partnered, fewer with children, more urban residence, Lesbians	Unclear weighting factors	N/A

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
							more educated, bisexual women less educated,		

Web Table 2. Critical Appraisal Skills Programme (CASP) quality assessment results

Study	1	2	3	4	5a	5b	6a	6b	9	10	11
Blosnich (2014)	Y	Y	Y	N	n	CT	N/A	N/A	Y	Y	Y
Blosnich (2013)	Y	Y	CT	N	N	CT	N/A	N/A	Y	Y	Y
Boehmer (2014)	Y	Y	Y	N	CT	N	N/A	N/A	Y	Y	Y
Clarke (2015)	Y	Y	Y	Y	N	CT	N/A	N/A	Y	Y	Y
Conron (2010)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Dilley (2010)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Everett (2013)	Y	Y	Y	Y	N	CT	N/A	N/A	Y	Y	Y
Farmer (2013)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Fredriksen-Goldsen (2012)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Fredriksen-Goldsen (2013)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Frisch (2013)	Y	Y	CT	Y	N	CT	CT	Y	Y	Y	N/A
Garland-Forshee (2014)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Jackson (2016)	Y	Y	Y	N	N	Y	N/A	N/A	Y	Y	Y

Study	1	2	3	4	5a	5b	6a	6b	9	10	11
Kann (2016)	Y	Y	Y	N	N	Y	N/A	N/A	Y	Y	Y
Matthews (2014)	Y	Y	Y	N	CT	CT	N/A	N/A	Y	Y	Y
McNair (2011)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Ward (2015)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y

The checklist questions were 1. Did the study address a clearly focused issue? 2. Was the cohort recruited in an acceptable way? 3. Was the exposure accurately measured to minimise bias? 4. Was the outcome accurately measured to minimise bias? 5a. Have the authors identified all important confounding factors? 5b) Have they taken account of the confounding factors in the design and/or analysis? 6a. Was the follow up of subjects complete enough? 6b. Was the follow up of subjects long enough? 9. Do you believe the results? 10. Can the results be applied to the local population? 11. Do the results of this study fit with other available evidence?

Web Table 3. Prevalence of CVD by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	5.8%# (SE 0.002)	5.0%# (SE 0.002)	NR	7.0%# (SE 0.024)	NR	NR	NR
Boehmer 2014£	4.9% (SE 0.11)	5.8% (SE 1.30)	1.46 (0.92 to 2.34)	3.8% (SE 0.75)	1.14 (0.75 to 1.72)	NR	NR
Conron 2010&	1.3%# (SE 0.1)	1.8%# (SE 0.6)	1.92 (0.95 to 3.87)	3.3%# (SE 2.2)	2.24 (0.53 to 9.43)	NR	NR
Fredriksen-Goldsen 2013&	10.7%#	NR	NR	NR	NR	10.5%#	1.37 (1.00 to 1.86)*
Garland-Forshee 2014&	6.2%# (5.8 to 6.6)	4.0%# (2.1 to 7.5)	1.0 (0.5 to 1.9)	1.8%# (0.6 to 6.0)	0.7 (0.2 to 2.9)	NR	NR
Jackson 2016 (heart disease)	10.8%	9.9%	0.91 (0.61 to1.35)	7.2%	0.73 (0.40 to 1.35)	NR	NR
Jackson 2016 (stroke)	3.2%	5.8%	1.96 (1.14 to 3.39)*	3.4%	1.68 (0.71 to 3.97)	NR	NR
Matthews 2014	4.1%	NR	NR	NR	NR	0.4%	0.19 (0.04 to 0.87)

* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Table 4. Prevalence of hypertension (or hypertensive medication use) by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Boehmer 2014	21.2% (SE 0.19)	19.0% (SE 1.81)	0.99 (0.77 to 1.26)	17.6% (SE 1.70)	1.21 (0.95 to 1.53)	NR	NR
Boehmer 2014 (medication use)	65.3% (SE 0.47)	66.0% (SE 4.29)	1.57 (0.90 to 2.75)	45.0% (SE 4.69)	0.74 (0.44 to 1.24)	NR	NR
Dilley 2010	22.7% (22.1 to 23.4)	14.7% (9.8 to 21.4)	1.0 (0.6 to 1.7)	17.0% (12.2 to 23.1)	1.6 (1.1 to 2.5)*	NR	NR
Everett 2013&	12.2%# (SE 0.65)	10.3%# (SE 3.21)	NR	11.4%# (SE 1.19)	NR	NR	NR
Farmer 2013£ (medication use)	14.7%	NR	NR	NR	NR	11.6%	Not statistically significant
Garland-Forshee 2014	25.6%# (24.3 to 26.8)	22.9%# (13.8 to 35.7)	1.2 (0.6 to 2.4)	12.4%# (7.5 to 19.9)	0.9 (0.5 to 1.7)	NR	NR
Jackson 2016	35.5%	32.2%	0.91 (0.74 to 1.12)	32.1%	0.96 (0.71 to 1.31)	NR	NR
Matthews 2014	33.2%	NR	NR	NR	NR	22.0%	1.00 (0.43 to 2.33)

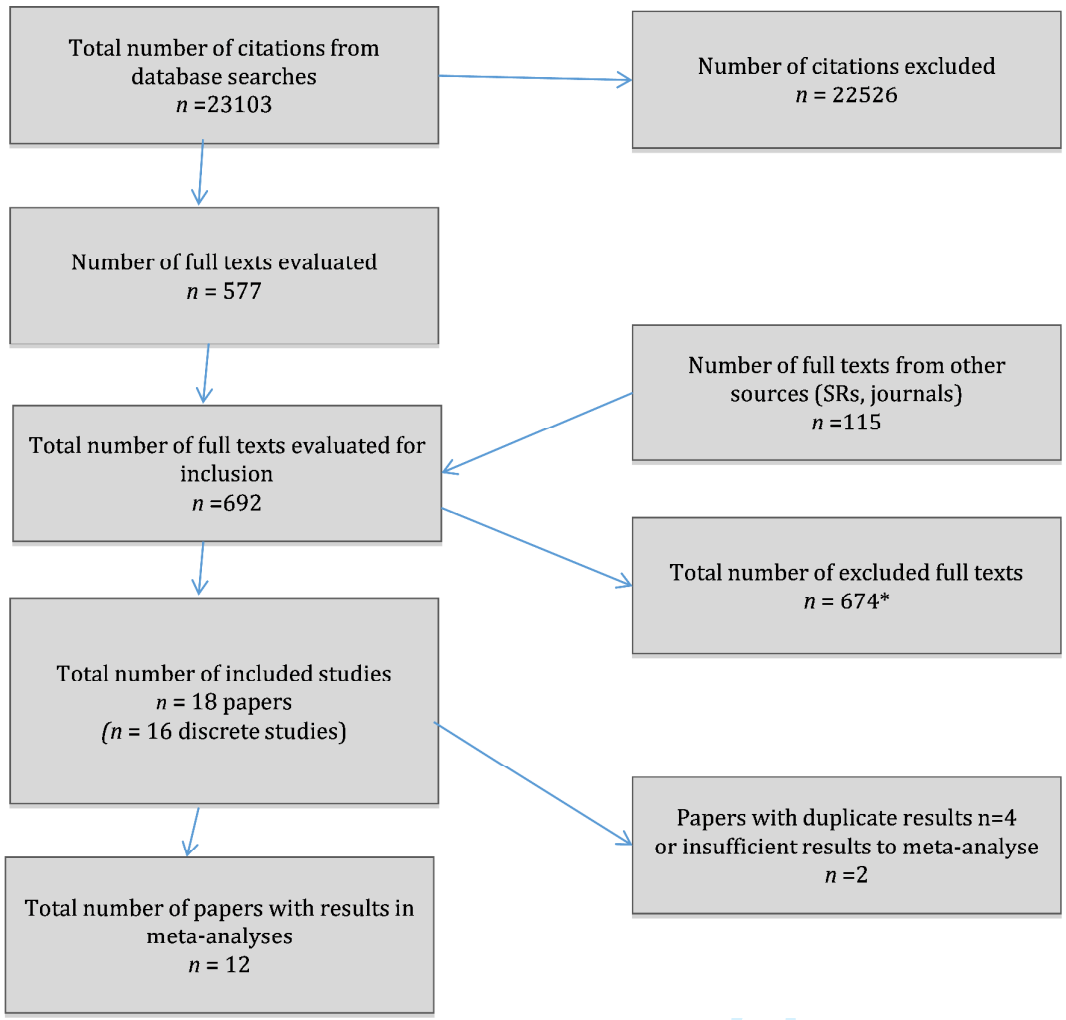
* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	10.2%# (SE 0.002)	6.8%# (SE 0.016)	NR	6.1%# (SE 0.016)	0.75 (0.44 to 1.29)	NR	NR
Boehmer 2014£	5.7% (SE 0.12)	4.6% (SE 0.74)	1.07 (0.76 to 1.50)	4.2%	1.10 (0.79 to 1.55)	NR	NR
Clark 2015	6.0%	1.9%	NR	6.8%	NR	7.2%	NR
Conron 2010	3.9% (SE 0.1)	3.8% (SE 0.9)	1.23 (0.74 to 2.06)	3.9% (SE 1.1)	1.04 (0.62 to 1.76)	NR	NR
Dilley 2010	6.3% (6.0 to 6.5)	5.1% (3.3 to 7.7)	1.3 (0.8 to 2.0)	5.8% (3.8 to 8.8)	1.8 (1.1 to 2.8)*	NR	NR
Farmer 2013	5.3%	NR	NR	NR	NR	6.4%	Not statistically significant
Garland-Forshee 2014	6.5% (6.1 to 6.8)	10.8% (4.1 to 26.0)	2.2 (0.6 to 7.8)	2.4% (1.2 to 5.0)	0.8 (0.4 to 1.6)	NR	NR
Jackson 2016	10.7%	7.7%	0.88 (0.58 to 1.34)	7.1%	0.63 (0.33 to 1.20)	NR	NR
Matthews 2014	11.3%#	NR	NR	NR	NR	4.3%#	0.55 (0.17 to 1.82)

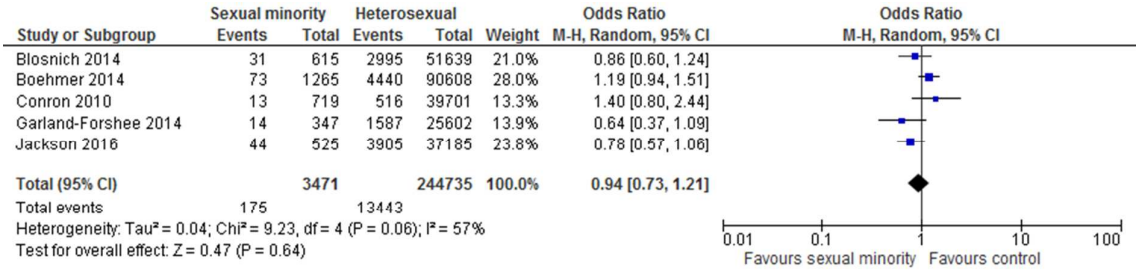
* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Figure 1. PRISMA flow diagram

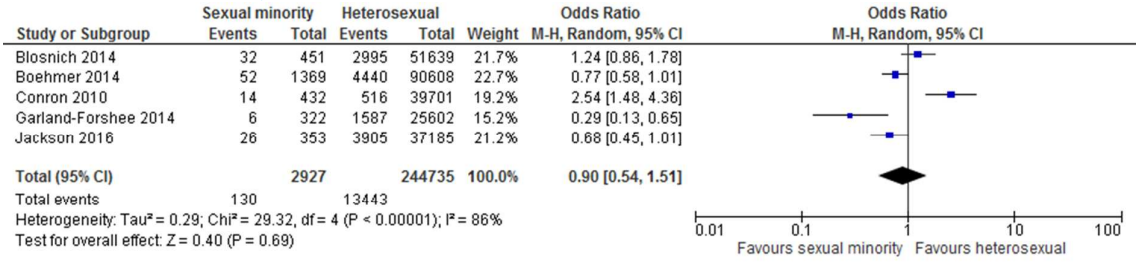


* Reasons for 674 full text exclusions: case studies = 7, diagnostic studies = 8, experimental studies = 8, in children only = 7, no comparison with heterosexual women = 1, no relevant numerical outcomes = 94, pilot studies = 2, qualitative studies = 123, results in men and women combined only = 124, reviews/editorials = 74, surveys on wrong topic = 226.

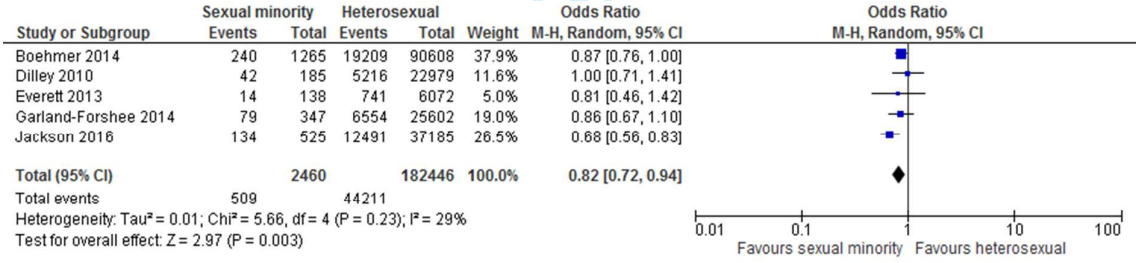
Web Figure 2a. CVD in lesbians



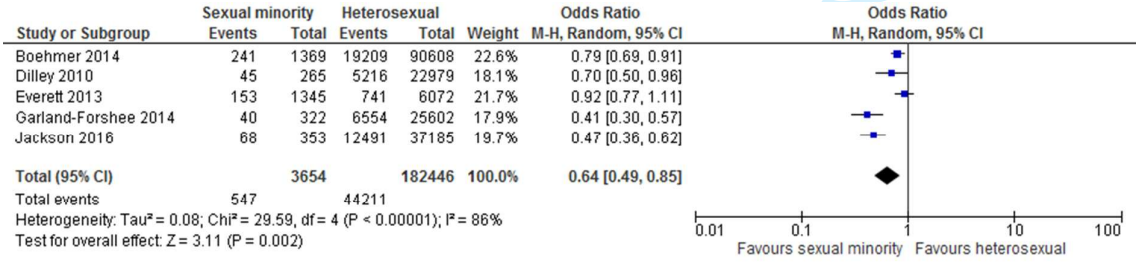
Web Figure 2b, CVD in bisexual women



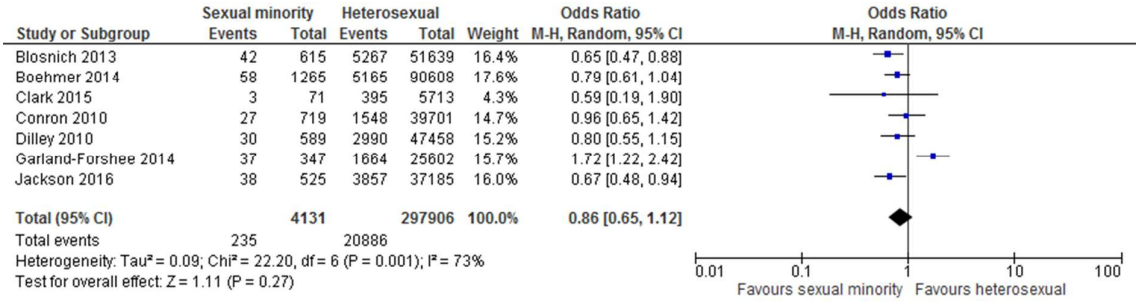
Web Figure 3a. Hypertension in lesbians



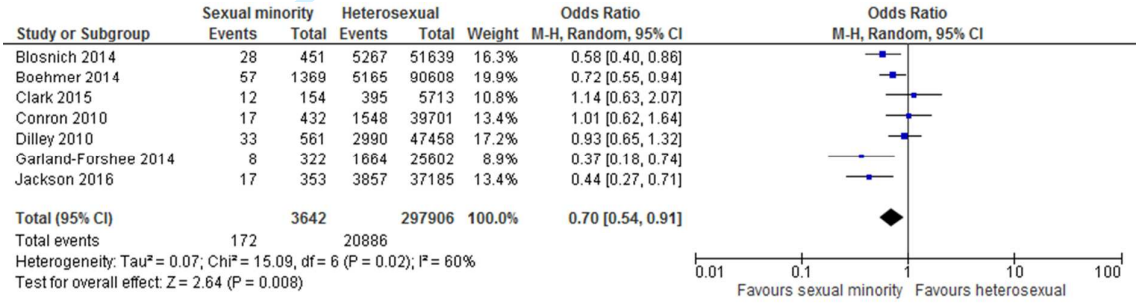
Web Figure 3b. Hypertension in bisexual women

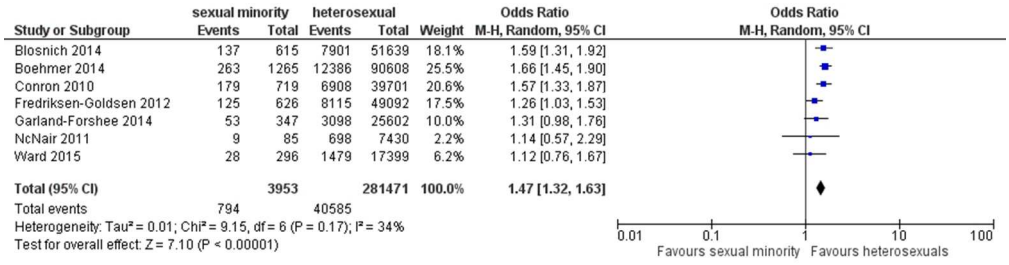


Web Figure 4a. Diabetes mellitus in lesbians



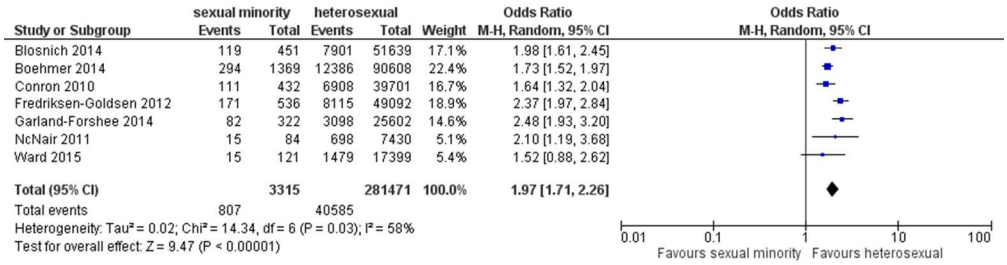
Web Figure 4b. Diabetes mellitus in bisexual women





Meta-analysis of asthma in lesbians

319x84mm (72 x 72 DPI)



Meta-analysis of asthma in bisexual women

317x84mm (72 x 72 DPI)

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4,5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	5
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	5
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5,32
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	15-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	27
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	5-7, 20, 29-31
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	21,33,34
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	See 5
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	7
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	8,9
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	9,10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	1

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Respiratory medicine, Diabetes and endocrinology, Cardiovascular medicine
Keywords:	systematic review, meta-analysis, sexual minority women, Cardiac Epidemiology < CARDIOLOGY, Epidemiology < THORACIC MEDICINE

Title: A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

Authors: Catherine Meads[1], Adam Martin[2], Jeffrey Grierson[1], Justin Varney[3]

Corresponding author: C Meads – email: catherine.meads@anglia.ac.uk

1. Faculty of Health, Social Care and Education, Anglia Ruskin University, Cambridge, UK

2. Academic Unit of Health Economics, Leeds Institute of Health Sciences, University of Leeds, Leeds, UK

3. Public Health England

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Conflicts of interest: none

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Word count: 3982

Data sharing statement: No additional unpublished data as systematic review

Contributorship statement: Justin Varney and Catherine Meads developed the research question. Catherine Meads and Adam Martin conducted the systematic review (searches, citation selection, data extraction, quality assessment). Catherine Meads wrote the systematic review and all data was checked by Adam Martin and Jeffrey Grierson. Catherine Meads conducted the meta-analysis, checked by Adam Martin. All authors edited the manuscript.

Abstract

Objectives

Sexual minority women (SMW) experience higher chronic-disease risk-factors than heterosexual counterparts. However, it was unclear if these risks translate into higher physical-condition rates. This systematic review evaluates cardiovascular disease (CVD), hypertension, respiratory disease and diabetes mellitus in SMW.

Methods

Prospero database registration: CRD42016050299. Included were studies reporting mortality, incidence or prevalence of the above listed conditions in SMW compared to heterosexual women. Databases (platforms) searched from 2010 to December 2016 were Medline (OVID), Embase (Elsevier), Cinahl (Elsevier), PsycInfo (Ovid), Social Policy and Practice (Ovid), Cochrane CENTRAL (Cochrane Library), Science Citation Index (Web of Science), CAB abstracts (Ovid). Search terms included MeSH terms and text words. Extensive additional searches were conducted in specialist academic journals and websites.

Two reviewers checked study eligibility. One independently extracted data and assessed quality, checked by a second, with disagreements resolved through discussion. The CASP cohort checklist was used to assess risk-of-bias. Meta-analysis was conducted where more than four studies reported same outcomes, with Comprehensive Meta-analysis software using adjusted odds ratios (AORs) and random-effects models. Heterogeneity was assessed using I^2 test.

Results

Identified were 23,103 citations, 692 full-texts screened, and 16 studies included (in 18 papers). One reported mortality (from Denmark), none incidence and 15 prevalence (14 USA, 1 Australia). Same-sex-cohabiting women had higher mortality rates compared to opposite-sex-cohabiting women in CVD (Hazard Ratio (HR)=1.37 (95%CI=1.22-1.54) and respiratory disease (HR=2.10 (95%CI=1.74-2.53). AOR meta-analyses of seven studies showed higher asthma rates in lesbians (OR=1.44 (95%CI=1.27-1.64)I^2=0%) and bisexual women (OR=1.64 (95%CI=1.41-1.89)I^2=0%) but no differences for CVD (five studies), hypertension (five studies) or diabetes mellitus (seven studies).

Conclusions

These new health estimates require further confirmatory epidemiological studies, and investigation into potential environmental, hormonal, physiological, psychological or genetic causes. This would be supported by routine collection of sexual-identity measures in population-level epidemiological surveys.

Strengths and limitations of this study

- A major strength is that this is the first numerical estimate of the relative prevalence of diabetes mellitus, cardiovascular and respiratory diseases in lesbians and bisexual women.
- We used extensive searches from a number of different sources, not just electronic databases and reference lists but also in specialist academic journals and websites to ensure we found all relevant studies.
- We used a wide definition of SMW to include identity, behaviour and partnership to be able to include all SMW irrespective of being sexually active or in a partnership. This will widen the generalizability of the systematic review.
- Considerable efforts were made to avoid double counting of participants from different studies when entering data but some double-counting may have occurred due to the nature of the surveys used in the studies.
- We used adjusted odds ratios to meta-analyse, which means that the results were more comparable than using unadjusted prevalence estimates. However, none of the AORs were adjusted for smoking status, which is a limitation of the included studies.

Background

Sexual minority women (SMW) include lesbians, bisexual women, women who have sex with women, women who have sex with men and women, and women who are married to or cohabit with another woman in a committed relationship. Public Health England estimates that at least 2.5% of the population identify at lesbian, gay or bisexual[1].

Chronic disease risk factors include poor diet, lack of exercise, obesity, smoking, excessive alcohol intake, anxiety, depression, hypertension and high cholesterol levels[2,3,4]. In general, SMW populations experience disproportionate behavioural risks to health and higher chronic disease risk factors than their heterosexual counterparts[5,6]. Due to a lack of research so far[6], it is unclear whether these risk factors translate into higher rates of physical health conditions.

Past research has highlighted some aspects of health inequalities experienced by SMW but also identified significant and persistent gaps in the evidence[5,7-10] including in relation to common physical conditions such as cardiovascular disease (CVD), respiratory tract disease and diabetes mellitus. These are some of the leading causes of death and disability for women[11] and, up to now, there have been no published summary estimates of the relative prevalence of these conditions in SMW compared to heterosexual women.

There have been two recent systematic reviews of physical health in SMW [12,13]. Eliason (2015)[12] reviewed evidence on prevalence and risk of a variety of conditions and Simoni et al (2016)[13] investigated disparities in physical health conditions in SMW. Since these systematic reviews were conducted, more prevalence studies have been published. This systematic review includes all relevant recent evidence (published from 2010 onwards) on the mortality, incidence and prevalence of specific physical health conditions of CVD, hypertension, respiratory disease and diabetes mellitus in SMW compared to heterosexual women, and conducts meta-analyses in order to derive up-to-date prevalence estimates of these conditions and determine whether there are different rates in SMW compared to heterosexual women.

Methods

A protocol was registered with the Prospero database (No. CRD42016050299) for research investigating all aspects of health and experience of healthcare in SMW, of which this project is part. The inclusion criteria for this systematic review were any published comparative studies in any language, published from 2010 onwards, comparing specific rates (see below) in SMW (any definition including identity, behaviour or cohabitation status) of any age compared to heterosexual women (any definition including identity, behaviour or cohabitation status) of any age in any country or setting. The following self-report or objectively measured rates were included: mortality, incidence and prevalence of CVD, hypertension, diabetes mellitus (any type) and respiratory diseases including asthma.

Searches:

Database searches were conducted in two phases. First, searches were conducted by Public Health England Knowledge and Library Service in May 2015. Second, searches were conducted by the first author (CM) in December 2016 with dates from January 2015 to December 2016. Databases (platforms) searched were Medline (OVID), Embase (Elsevier), Cinahl (Elsevier), PsycINFO (Ovid), Social Policy and Practice (Ovid), Cochrane CENTRAL (Cochrane Library), Science Citation Index (Web of Science), CAB abstracts (Ovid). EPPI-Reviewer 4, Endnote and Microsoft Excel were used to sift

citations. Search terms included MeSH terms and text words for sexual minority (for example, lesbian, bisexual, homosexual, WSW, WSMW, same sex). We then searched a large number of full texts for the physical conditions listed above. Searches were not limited to English language. Example search strategies for 4 databases from the December 2016 searches are in Web Supplement 1.

In addition to database searches, reviews and summaries of lesbian, gay, bisexual & transgender (LGB&T) health were examined for relevant evidence. LGB&T Health Research Journal (all issues), Journal of Lesbian Studies (2014-16) and Journal of Gay and Lesbian Mental Health (2014-16) were searched. Previous projects by the first author (CM) were searched for relevant evidence and, from a previous project, a list of currently active researchers in LGBT health with their publications were reviewed. Web pages of several researchers known to be active in SMW research were searched. The UK National LGB&T Partnership monthly newsletter from February to October 2016 was sifted for relevant up-to-date work that had not yet been published. UK national survey websites were also sifted for information on sexual identity and health (Integrated Household Survey, Scottish Health Survey, Welsh Health Survey and Health Survey for England).

Study selection, data extraction, quality assessment and synthesis

Full text copies of references matching inclusion criteria were obtained. Two reviewers (CM and AM) checked study eligibility. One independently extracted data from studies into the report (CM) and these were checked by another reviewer (JG), with disagreements resolved through discussion. Characteristics and results of all included studies were described through narrative synthesis. Tabulation was used where there was more than one study reporting the same outcome. Where there was overlap in study populations, the largest included population was used where outcomes of interest were reported. The Critical Appraisal Skills Programme (CASP) checklist for cohort studies was used to assess quality for all studies. Since there is no established and validated quality checklist specifically for cross-sectional surveys, using the same checklist for all provided consistency in quality assessment across studies. Meta-analysis was conducted where there were four or more discrete studies reporting the same outcome. This included both unadjusted prevalence estimates (with Review Manager software 5.3), and adjusted odds ratios using inverse variance (with Comprehensive Meta-analysis version 3). Random effects models were used for both. Statistical heterogeneity was assessed using the I^2 test, using standard thresholds for high, medium and low heterogeneity[14]. There were insufficient studies reporting the same outcomes to be able to construct a meaningful funnel plot to assess publication bias.

Results

Description of studies

A total of 23,103 citations were identified, 22,763 from the first searches and 340 from the second searches (see Web Figure 1). Full texts of 692 papers were screened for potential relevancy. Sixteen studies were included [15-30], described in 18 papers - the study by Clark et al (2015)[31] contained a subset of the participants in the study by Everett et al (2013) [20] and the study by Wallace (2011)[32] contained a subset of those in the study by Boehmer et al (2014) [17]. For characteristics of included studies, see Table 1 and for participant baseline characteristics, see Web Appendix Table 1.

One study examined mortality rates; Frisch and Simondsen (2013)[24] reported hazard ratios for mortality by sexual orientation in a large national cohort from Denmark by various causes of death (n=6.5 million, approximately 50% women).

No studies investigated incidence, and 15 studies investigated prevalence[13-23, 25-30]. Two were based on single waves of cohort studies (Everett et al 2013[20] (also reported in Clarke et al 2015[31]), and McNair et al 2011[29]). The first[20] was based in the USA and used Wave IV of data from the National Longitudinal Study of Adolescent Health. The second[29] used one year's data from an Australian study of young women aged 18-23 selected at random from the Australian Medicare database. The remaining 13 studies were from the USA and used one or more year's data from repeated cross sectional surveys. Eight of these used Behavioral Risk Factor Surveillance System (BRFSS) surveys, either using a national sample from different years[15,16] or for specific states (Massachusetts[18], Oregon[25], North Carolina[28], Washington State[19,22,23]). Other surveys used included; The National Health Interview Survey[26,30], The California Health Interview Survey[17,32], The Youth Risk Behaviour Surveillance System[27], The National Health and Nutrition Examination Survey[21].

One group of studies[19,22,23] reported different outcomes for different subsets (such as age ranges) of the same repeated survey for different years. Ward et al (2015)[30] investigated a subset of the population in Jackson et al (2016)[26] but Ward et al (2015) [30] reported asthma whereas Jackson et al (2016) [26] did not so both papers for this study have been included. Wallace et al (2011)[32] used a subset of the sample in Boehmer et al (2014)[17] and reported the same outcomes so these results are not reported here. Everett et al (2013)[20] and Clark et al (2015)[31] reported different outcomes from the same population so both papers for this study have been included.

Quality assessment found similar quality issues across studies, and are reported in Web Appendix Table 2. The cohort studies[20,29] reported results as if they were cross-sectional surveys by not using follow-up data. The main quality issues were that health conditions were ascertained mostly by health self-report; the main exception was in Everett et al 2013 (and Clark et al 2015)[20,31] where interviewers measured blood pressure. Also, weighted prevalence percentages were reported in several included studies (see Web Appendix Table 1), but weighting factors used were often unclear.

Main findings

For CVD mortality and for respiratory tract disease mortality, Frisch and Simondsen (2013)[24] found that same-sex cohabiting women had higher mortality rates to opposite sex cohabiting women for these diseases (HR 1.37 (95%CI 1.22 to 1.54) and HR 2.10 (95%CI 1.74 to 2.53) respectively) but that same-sex married women had similar mortality rates to opposite sex married women (HR 1.32 (95%CI 0.75 to 2.33) and HR 0.85 (95%CI 0.36 to 2.05) respectively) . The sample sizes were larger for same-sex cohabiting women (n=207 and n=111) than same sex married women (n=12 and n=5) and no conclusions can be drawn from the same sex married women data as sample sizes were too small.

Numerical prevalence results are presented in Table 2 (asthma), Web Appendix Table 3 (CVD), Web Appendix Table 4 (hypertension), and Web Appendix Table 5 (diabetes mellitus). They demonstrate that the way these rates were reported varied across the studies, for example some studies presented results for SMW compared to heterosexual women whereas others presented results separately for lesbians and for bisexual women. Percentages of women with conditions varied across the studies, most notably hypertension which varied from 14.7%[21] to 65.3%[17] in heterosexual women. Most studies presented AORs as well as the adjusted or unadjusted percentages but fewer gave measures of spread such as 95% CIs or standard errors (SEs). One study[26] presented results for heart disease and stroke separately and found no difference in rates between any of the groups (see Web Appendix Table 3). One study[30] presented results for chronic obstructive pulmonary disease which found higher rates in bisexual women compared to heterosexual women but not for lesbians

(prevalence in lesbians 6.0% (95%CI 3.2 to 11.0), bisexual women 13.6% (95%CI 6.9 to 25.2), heterosexual women 6.4% (95%CI 5.9 to 6.8).

Meta-analysis

There were sufficient studies (i.e. n>4) presenting results for CVD, hypertension, asthma and diabetes (any type) in lesbians and in bisexual women for meta-analyses to be conducted.

Meta-analyses of unadjusted prevalence (see figure 1, Web Appendix 2a, 2b, 3a, 3b, 4a, 4b) showed no difference in CVD (lesbian OR=0.94 (95%CI 0.73 to 1.21) and bisexual women OR=0.90 (95%CI 0.54 to 1.51)) but lower prevalence of hypertension (lesbian OR=0.82 (95%CI 0.72 to 0.94) and bisexual women OR=0.64 (95%CI 0.49 to 0.85). There was higher prevalence of asthma (lesbians OR=1.47 (95%CI 1.32 to 1.63) and bisexual women OR=1.97 (95%CI 1.71 to 2.26) and combined for all SMW OR=1.68 (95%CI 1.52 to 1.85). For diabetes mellitus there was no difference in prevalence between lesbians and heterosexual women but lower prevalence in bisexual women (OR=0.86 (95%CI 0.65 to 1.12) and OR=0.70 (95%CI 0.54 to 0.91)).

Meta-analyses of adjusted odds ratios showed increased rates of asthma in lesbians and in bisexual women compared to heterosexual women (ORs = 1.44 (95%CI 1.27 to 1.64) I^2=0% and 1.64 (95%CI 1.41 to 1.89) I^2=0%). They showed no differences for lesbians or bisexual women compared to heterosexual women for CVD (ORs = 1.34 (95%CI 0.97 to 1.85) I^2=45% and 1.08 (95%CI 0.80 to 1.47) I^2=0%), for hypertension (ORs = 0.98 (95%CI 0.86 to 1.14) I^2=0% and 1.08 (95%CI 0.86 to 1.35) I^2=39%), and for diabetes mellitus (ORs = 1.11 (95%CI 0.91 to 1.36) I^2=0% and 1.01 (95%CI 0.75 to 1.36) I^2=51%).

Discussion

Summary of main findings

Results from a single large study reporting mortality rates[24] showed that there was no difference in cardiovascular or respiratory tract disease mortality rates in same-sex married compared to opposite sex married women, but higher mortality rates in same-sex cohabiting women compared to opposite sex cohabiting women.

Meta-analyses of adjusted odds ratios of disease prevalence showed no differences in CVD, hypertension or diabetes mellitus prevalence, but a higher prevalence of asthma in SMW compared to heterosexual women.

Discussion of main findings

A key finding was the higher prevalence, from the adjusted odds ratio meta-analysis, of asthma in lesbians and bisexual women. Asthma is caused by a mixture of genetic and environmental factors. Higher rates are associated with anxiety but it is not known if asthma causes psychological problems or if psychological problems lead to asthma[33]. Nevertheless, studies have shown higher rates of mental health problems including anxiety in SMW [34,35]. Asthma is also more common amongst those who are economically disadvantaged, and a consistent finding in studies included in the systematic review was that SMW had below average incomes[15-17,21,29]. Asthma is also more common amongst current or former smokers. Several included studies showed higher rates of smoking or tobacco use amongst SMW[15,16,19-21,23,25,26,28]. However, only one of the studies reporting asthma prevalence clearly controlled for smoking behaviour[15].

The finding of lower hypertension prevalence and no difference in the adjusted odds ratio meta-analysis in lesbians and bisexual women was unexpected. Higher rates of hypertension are

associated with lack of exercise and obesity. Several of the included studies demonstrated higher rates of obesity [15-18,20-22,25,26] and a recent systematic review on obesity in SMW [36] also found consistently higher rates of obesity amongst SMW compared to heterosexual women. However, the rates of physical exercise in SMW is less clear. Two of the included studies showed higher rates of physical activity or exercise in lesbians and bisexual women compared to heterosexual women[16,28] whilst four showed no differences[20,22,25,26]. Hypertension is also associated with mental health difficulties, particularly depression[37], and there are higher rates of depression in SMW [34,35].

No difference in rates of diabetes mellitus were found in the meta-analysis of adjusted odds ratios, but in the unadjusted prevalence meta-analysis higher rates were found in bisexual women but not lesbians. It is unclear as to why this would occur. Risk factors for type II diabetes mellitus include hypertension, overweight/obesity, physical inactivity and unhealthy diet. Evidence on the first three are discussed above, however there is much less information available about diet. Dilley et al 2010[19] reported that the proportion eating insufficient fruits and vegetables was higher in bisexual women than lesbians and heterosexual women but Garland-Forshee et al 2014[25] showed no differences between lesbians, bisexual and heterosexual women in the proportion who met US CDC recommendations on fruit and vegetable intake.

Three of the included studies calculated that lesbians and bisexual women were at higher risk of CVD[18,21,31]. Farmer et el (2013)[21] and Clark et al (2015)[31] calculated risk scores using the Framingham General CVD Risk Score and both calculated that SMW had higher CVD risk scores. Farmer et al (2013)[21] calculated that SMW were 13.9% (95%CI 8.55 to 19.3%) older in vascular terms than their chronological age, and that this was 5.7% (95%CI 1.5% to 9.8%) greater than heterosexual women. Clark et al (2015)[31] found that average 30 year CVD risk was raised in all sexual minority groups of women, significantly so in mostly heterosexual and mostly homosexual women. Conron et al (2010)[18] also calculated CVD risk, using presence of obesity and smoking plus one other risk factor including lack of moderate physical activity, lifetime diabetes mellitus, hypertension and high cholesterol. They estimated that lesbians and bisexual women were at higher risk of CVD than heterosexual women.

It is known that there are higher rates of several CVD risk factors in SMW, including overweight/obesity, diabetes mellitus, tobacco use (all discussed above) high cholesterol and harmful use of alcohol (discussed below). Hence the finding of no difference in CVD rates was surprising. Also, since the systematic review found higher rates of asthma, if this was due to higher rates of smoking, it would be expected that there would be correspondingly higher rates of CVD.

Several of the included studies reported higher rates of harmful alcohol use in lesbians and bisexual women compared to heterosexuals[16,19-21,23,25,26]. Several also reported cholesterol levels - one found lower cholesterol levels in lesbians and bisexual women[20] but most found no significant differences[19,23,25]. Matthews et al, 2014[28] found that twice as many lesbians and bisexual women than heterosexual women were not having their cholesterol checked (32.5% vs 13.8%), but the implications of this are unclear.

Strengths and weaknesses of the study

The strengths of the current systematic review include extensive searches from a number of different sources. We used a wide definition of SMW to include identity, behaviour and partnership. It is acknowledged that these are different concepts and women can identify as lesbian or bisexual without being sexually active or being in a partnership. Also some women identify as lesbian whilst having sex with men and some women identify as heterosexual whilst having sex with women. Most

of the studies also used self-report for the physical conditions, and this may result in responder bias, but it is unclear why responder bias might be stronger in SMW than heterosexual respondents. Also, almost all of the included studies were conducted in USA, so results may not be generalizable to other countries. Also, it is known that SMW have less insurance coverage and poorer access to healthcare in USA[38]. The precise questions on health used in the BRFSS questionnaires asked whether the respondent had been 'told by a health care professional' that they had had the named condition. If SMW have less access to healthcare, it could be assumed that fewer would have been told they had one of the conditions investigated here. So it is possible that all of the rates may have been underestimated, and the increased rates of asthma may be even higher than found here. In the reported results, prevalence of physical conditions were weighted to better reflect the underlying population in some of the included studies but not in others. Where the sexual minority samples were younger than the heterosexual population with which they were compared, it might be expected that the lack of weighting by age would result in underestimation of the difference in prevalence of physical health conditions, particularly CVD, hypertension and diabetes mellitus where prevalence rises by age. There were insufficient studies to be able to conduct meaningful subgroup analyses by whether or not the study had controlled for age. Furthermore, two of the studies[16,23] were unclear as to whether they weighted the reported prevalence or whether the reported weighting factors referred to the adjusted odds ratios that they also report. Some of the studies weighted by factors such as education and income which may also impact on the estimated prevalence of physical conditions. Some important factors were often not controlled for, e.g. for asthma, it would be usual to include smoking rates, which differ between SMW and heterosexual female populations. A further major limitation is that almost all of the prevalence research was from USA so it currently unclear if the findings are generalizable to other countries.

In the meta-analyses, considerable efforts were made to avoid double counting of participants from different studies when entering data and hence some studies were excluded for one or more reported outcomes[19,23,31,32]. Random effects models were used because of clinical heterogeneity of the study samples. The heterogeneity between studies in the weightings that were used for the prevalence estimates in the unadjusted meta-analyses may have introduced some bias from this loss of information about differences between the two groups. Hence there may be some inconsistency between the AORs reported in the results tables and the ORs used in the meta-analysis. The meta-analyses of AORs mitigates some of these effects. However, in both types of meta-analyses, there was heterogeneity in outcome measures (e.g. one study measured hypertension, six using self-report hypertension and one study using hypertensive medication use), although we do not expect that this impacted on the observed differences between groups, our main outcome of interest.

Strengths and weaknesses in relation to previous research

The previous systematic reviews[12,13] found fewer studies and did not conduct meta-analyses so did not quantify the physical health disparities they had found. For CVD prevalence Eliason (2014)[12] included seven studies, of which four were published before 2010, and for hypertension it included 12 studies, of which four were published before 2010. For asthma it included 13 studies, four of which were published before 2010. Some relevant results from included studies were not described, and the study by Garland-Forshee et al 2014[24] was omitted. Eliason (2014)[12] concluded that asthma was more common in SMW, but no differences were consistently found in the other chronic physical conditions she investigated, including diabetes, hypertension and CVD. Simoni et al (2016)[13] had a very brief summary of results. For CVD it found one study, for hypertension one study and for asthma four studies. All of these were included in the systematic review by Eliason (2015)[12]. Simoni et al (2016)[13] found evidence of disparities in the one included study reporting CVD[22] and in asthma,

but that evidence was lacking in diabetes and hypertension. There is also little information on the prevalence of these conditions in men according to sexual orientation and no relevant systematic reviews[10].

Implications for clinicians and policy-makers

If there are higher rates of asthma in lesbians and bisexual women, this might have implications for health service delivery, particularly in primary care. Urwin and Whittaker (2016)[39] published an evaluation of the English General Practice Patient Survey (n=2,807,320 in total, 1,556,909 women) looking at inequalities of GP use by sexual orientation for various conditions. They found that lesbians but not bisexual women were less likely to visit the GP than heterosexual women in the previous 3 months for asthma or long-term chest problem (adjusted OR=0.84 (95%CI 0.71 to 0.98 and OR=0.85 (95%CI 0.69 to 1.04)). So it is likely that SMW, particularly in the UK and possibly elsewhere, are not accessing services despite ill-health. A recent systematic review found that sexual minority populations generally have difficulties with access to health services for a variety of reasons including communication difficulties, internalized homophobia, prejudicial conduct adopted by health professionals, breach of confidentiality during consultations and institutional homophobia [40]. Combined with the evidence shown in this systematic review, this suggests potentially considerable latent demand for primary care services amongst SMW and that there may be particular issues for lesbians accessing primary health care services for asthma. This evidence contributes to a bigger picture about inequality for SMW in a wide range of aspects[5,8].

This systematic review highlights the need for better routine data collection on sexual minority women as much of the current research has small sample sizes and based on countries with significantly different healthcare access and social norms around sexual identity. The introduction of an NHS information standard on sexual orientation in April 2017[41] will start to introduce routine data capture across hospital episode statistics and disease registries, alongside training across the NHS to support staff having positive conversations about sexual orientation, which will build over time a much clearer picture of the health inequalities in this group and potentially help to reduce them.

Implications for research

This rigorously conducted systematic review has reported some important new findings on health inequalities in SMW that are hard to explain. Further research would be useful on these health inequalities, including their causes. This would be supported by the routine collection of sexual identity measures in population-level epidemiological studies, and the results published. Robust multi-level modelling (including sexual identity) should be conducted with large databases and cohort studies. For asthma, results from large cohort studies, controlled for risk factors such as smoking and overweight/obesity would be useful to further examine these findings. Regarding hypertension and CVD, the findings are also unexpected so investigation into potential causes would be very useful, such as possible differences in hormone levels, or other environmental, social, physiological, psychological or genetic factors that might be contributing to these results.

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Tables and figures, with web appendix

Table 1. Characteristics of included studies.

Table 2. Prevalence of asthma by sexual orientation

Figure 1. Subgroup meta-analysis of asthma in lesbians, bisexual women and SMW

WEB APPENDIX

Web Supplement 1. – Search strategies

Web Table 1. Participant baseline characteristics

Web Table 2. CASP quality assessment results

Web Table 3. Prevalence of cardiovascular disease or CVD symptoms by sexual orientation

Web Table 4. Prevalence of hypertension or hypertensive medication use by sexual orientation

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Web Figure 1. PRISMA flow diagram

Web Figure 2a. CVD in lesbians

Web Figure 2b, CVD in bisexual women

Web Figure 3a. Hypertension in lesbians

Web Figure 3b. Hypertension in bisexual women

Web Figure 4a. Diabetes mellitus in lesbians

Web Figure 4b. Diabetes mellitus in bisexual women

Table 1. Characteristics of included studies

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
Mortality studies							
Frisch (2013)	National demographic data from Danish Civil Registration System, including mortality data	Population, marriage, living in same sex or opposite sex cohabitation for at least 1 year between 1982 and 2011, Denmark	Cohabitation record, marriage record (same sex marriage from 1989, (NB 75.6% same sex cohabiting women were same sex married)	Opposite sex cohabitation, marriage	National demographic data collection	Mortality	Population cohort Supported by – not reported (NR)
Surveys based on multi-state Behavioral Risk Factor Surveillance System (BRFSS)							
Blosnich (2013)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults in partnerships. All states, USA	Various similar in the 10 states with response options heterosexual or straight; homosexual, gay or lesbian; bisexual; other; and opposite or same sex partner.	Opposite sex partnered women	Behavioral Risk Factor Surveillance System (BRFSS) for all US States 2004.	Current asthma, lifetime asthma	Population survey. Supported by a National Research Service award
Blosnich (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. Alaska, Arizona, California, Maine, Massachusetts, Montana, New Mexico, North	Various similar in the 10 states with response options heterosexual or straight; homosexual, gay or lesbian; bisexual; other.	Heterosexual women	Behavioral Risk Factor Surveillance System (BRFSS) for 10 States 2010.	CVD symptoms, asthma, diabetes	Population survey. Supported by National Research Service awards.

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
		Dakota, Washington, Wisconsin, USA					
Surveys based on single state Behavioral Risk Factor Surveillance System (BRFSS)							
Conron (2010)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English, Spanish or Portuguese speaking non-institutionalised adults. Massachusetts, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women	Massachusetts Behavioral Risk Factor Surveillance System (BRFSS) 2001-8.	Heart disease, diabetes, asthma	Population survey. Supported by Massachusetts Department of Public Health HIV/AIDS Bureau and Ford Foundation
Garland-Forshee (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults, Oregon, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D other? (D answers excluded)	Heterosexual women	Oregon Behavioral Risk Factor Surveillance System 2005-8	Cardiovascular disease, hypertension, diabetes, asthma	Population survey. Supported by Center for Disease Control grants.
Matthews (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. North Carolina, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D other? (D answers excluded)	Heterosexual women	North Carolina Behavioral Risk Factor Surveillance System 2011	Angina or heart disease, hypertension, diabetes, asthma	Population survey. Supported by National Institute for Mental Health grant.
Dilley (2010) and	Telephone-based (landline) random digit dialled	English or Spanish speaking non-institutionali	A heterosexual or straight, B homosexu	Heterosexual women	Washington State Behavioral Risk Factor Surveillanc	Diabetes, hypertension, (asthma),	Population survey. Supported by Washington

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	interview. Had ever been told by a health professional that they had (a named condition)	sed adults. Washington, USA	al, gay or lesbian, C bisexual or D something else? (D answers excluded)		e System (BRFSS) 2003-6.		State Tobacco Prevention and Control Program and BRFSS
Fredriksen-Goldsen (2012) and	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. Washington, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women	Washington State Behavioral Risk Factor Surveillance System (BRFSS) 2003-9.	Asthma	Population survey. Supported by NIH and National Institute on Aging grants
Fredriksen-Goldsen (2013)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults aged over 50. Washington, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women aged over 50	Washington State Behavioral Risk Factor Surveillance System (BRFSS) 2003-10.	Cardiovascular disease (asthma, diabetes, hypertension),	Population survey. Supported by National Institute on Aging grant
Studies based on other US national or state surveys							
Jackson (2016) and Ward (2015)	In-person interviews using cluster-based probability sampling. Had ever been told by a health professional that they had (a named	Non-institutionalised adults. USA	Straight (not lesbian or gay); gay or lesbian; bisexual; something else? (something else answers excluded)	Straight women	National Health Interview Survey 2013-14	Diabetes, heart disease (CHD or any other kind of heart disease, angina pectoris or a myocardial infarction), stroke, hypertension Asthma	Population survey Supported by several grants including from Harvard Catalyst and NIH

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	condition), or diagnosed by a doctor (CVD)					(Ward)	
Kann (2016)	School questionnaire - based survey, nationally representative data. Had ever been told by a doctor or nurse that they had asthma	Students in grades 9–12 (aged 14-18) attending high schools, USA	Which of the following best describes you? "heterosexual (straight)," "gay or lesbian," "bisexual," or "not sure." AND During your life, with whom have you had sexual contact? "I have never had sexual contact," "females," "males," and "females and males."	Heterosexual female students AND Sexual contact with males.	Youth Risk Behavior Survellance System (YRBSS)	Lifetime asthma	Population survey Supported by Center for Disease Control and Prevention
Boehmer (2014) and	Telephone-based random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	Adults aged over 20 with telephone and living in California	Identified as heterosexual; gay or lesbian; bisexual (excluded celibate and non-sexual responses)	Heterosexual women	California Health Interview Survey 2001-7	Heart disease, hypertension, hypertensive medication, diabetes, asthma	Population survey. Supported by – NR
Wallace (2011)	Telephone-based survey.	Lesbian and bisexual women	NR	Heterosexual women	California Health Interview	(Heart disease, hypertension	Population survey. Supported

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	Question NR	aged 50-70		aged 50-70	Surveys 2003-7	, diabetes,)	by California Wellness Foundation
Farmer (2013)	In-home survey. Had ever been told by a health professional that they had diabetes or sugar diabetes, responded yes to currently taking anti-hypertensives	Adults aged 20-69 who completed the sexual behaviour survey. National, USA	Do you think of yourself as heterosexual or straight (attracted only to men); homosexual or lesbian (sexually attracted only to women); bisexual (sexually attracted to men and women); something else or not sure.	Heterosexual women	National Health and Nutrition Examination Survey (NHANES) 2001-8	Diabetes, anti-hypertensive medication	National population survey Supported by National Institute for Drug Abuse and National Institute on Alcohol Use and Alcoholism grants.
Studies based on single waves of cohort studies							
Everett (2013) and Clark (2015)	Interviewer collected Hypertension results (Everett) and diabetes from fasting blood glucose sample, non-fasting glucose sample, HbA1c or self-report health provider diagnosis or use of anti-diabetic	Follow up 10-15 years after, from sample recruited originally through schools. National, USA	100% heterosexual (straight); mostly heterosexual (straight) but somewhat attracted to people of your own sex; bisexual – attracted to males and females equally; mostly homosexual (gay)	100% heterosexual women	Wave IV of National Longitudinal Study of Adolescent Health 2007-8	Everett 2013 - Hypertension of >140 SBP and >90 DBP. Clarke 2015 - Diabetes (and antihypertensive medication)	National population cohort Supported by Eunice Shriver National Institute of Child Health and Human Development grant. (Everett 2013) and National Center for Advancing translational sciences grant. (Clarke 2015)

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	medication in previous 4 weeks (Clarke 2015)		but somewhat attracted to people of the opposite sex; 100% homosexual (gay).				
McNair (2011)	Self-completion questionnaire. Had been diagnosed or treated for a range of illnesses over the previous 3 years	Original sample aged 18-23 selected randomly from database of Medicare Australia	Exclusively heterosexual, mainly heterosexual, bisexual, mainly homosexual (lesbian)	Exclusively heterosexual women	Third survey of the young cohort of women in the Australian Longitudinal Study on Women's Health 2003	Asthma,	National population cohort Supported by Lesbian Health Fund, USA

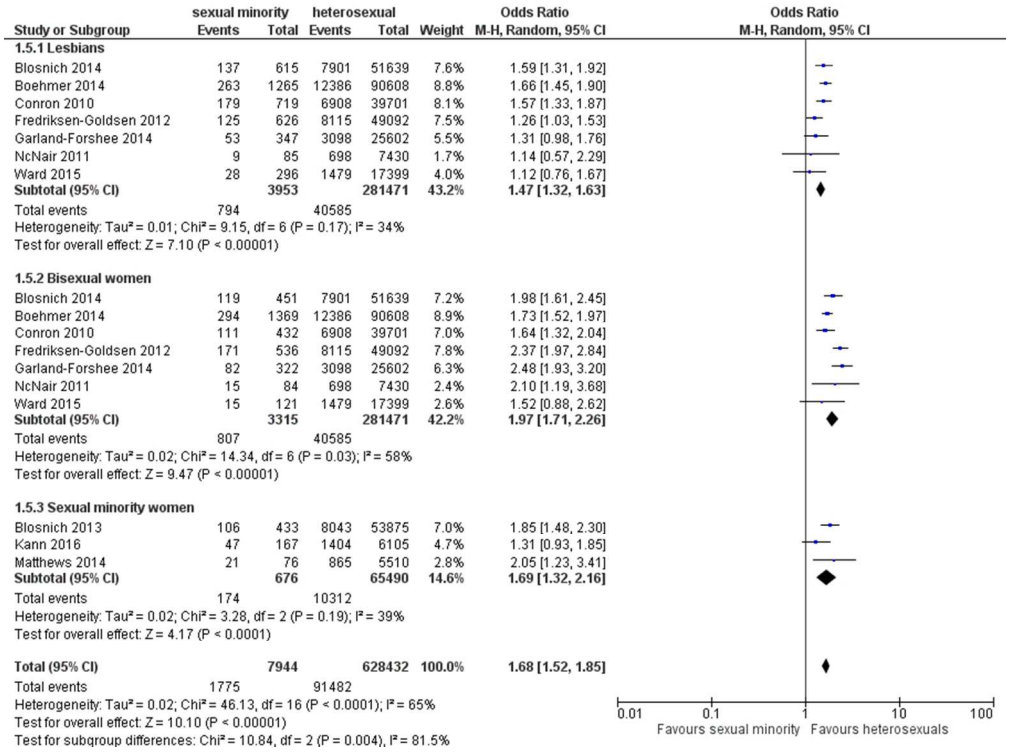
* outcomes in brackets were reported in included study texts but not used in the systematic review due to elimination of duplicate reporting.

Table 2. Prevalence of asthma by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	15.3%# (SE 0.003)	22.2%# (SE 0.03)	1.50 (1.04 to 2.16)*	26.4%# (SE 0.04)	1.68 (1.07 to 2.63)*		
Blosnich 2013 (lifetime diagnosis)	14.6%# (NR)					26.1%# (NR)	1.72 (1.11 to 2.65)*
Blosnich 2013 (current diagnosis)	9.5% (NR)					21.4% (NR)	2.09 (1.30 to 3.36)*
Boehmer 2014£	13.7% (SE 0.16)	20.8% (SE 1.70)	1.41 (1.14 to 1.73)*	21.5% (SE 1.76)	1.52 (1.24 to 1.87)*	NR	NR
Conron 2010&	17.4%# (SE 0.3)	24.9%# (SE 2.3)	1.68 (1.32 to 2.14)	25.7%# (SE 3.1)	1.58 (1.15 to 2.18)	NR	NR
Fredriksen-Goldsen 2012&	16.5%#	19.9%#	1.23 (NR)	31.9%#	2.17 (NR)*	NR	NR
Garland-Forshee 2014&	12.1%# (11.5 to 12.7)	15.4%# (10.8 to 21.7)	1.2 (0.8 to 1.9)	25.6%# (18.6 to 34.2)	2.4 (1.5 to 3.6)*	NR	NR
Kann 2016 by sexual identity	23.0%# (21.1 to 24.9)	NR	NR	NR	NR	28.3%# (24.4 to 32.6)	NR
Kann 2016 by sexual behaviour	25.8%# (23.5 to 28.2)	NR	NR	NR	NR	31.4%# (26.9 to 36.4)	NR
Matthews 2014	15.7%#	NR	NR	NR	NR	27.7%#	1.94 (0.96 to 3.92)
McNair 2011£	9.4%	10.4%	NR	18.0%*	NR	NR	NR
Ward 2015 (current diagnosis)	8.5% (7.9 to 9.0)	9.5% (6.2 to 14.4)	1.11 (0.70 to 1.76)	12.4% (7.3 to 20.4)	1.53 (0.87 to 2.70)	NR	NR

* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Figure 1. Meta-analysis of asthma in lesbians and in bisexual women



Subgroup meta-analysis of asthma in lesbians, bisexual women and SMW

319x237mm (72 x 72 DPI)

Title: A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

Authors: Catherine Meads[1], Adam Martin[2], Jeffrey Grierson[1], Justin Varney[3]

WEB APPENDIX

Web supplement 1. Search strategy for Medline, Embase, PsycInfo and CAB Abstracts. Dec 2016, Medline April 2015

Web Table 1. Participant baseline characteristics

Web Table 2. Critical Appraisal Skills Programme (CASP) quality assessment results

Web Table 3. Prevalence of cardiovascular disease or CVD symptoms by sexual orientation

Web Table 4. Prevalence of hypertension or hypertensive medication use by sexual orientation

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Web Figure 1. PRISMA flow diagram

Web Figure 2a. CVD in lesbians

Web Figure 2b, CVD in bisexual women

Web Figure 3a. Hypertension in lesbians

Web Figure 3b. Hypertension in bisexual women

Web Figure 4a. Diabetes mellitus in lesbians

Web Figure 4b. Diabetes mellitus in bisexual women

Web Supplement 1. – Search strategy for Medline, Embase, PsycInfo and CAB Abstracts. December 2016

Database: Ovid MEDLINE(R) 1948 to Present (including In-Process & Other Non-Indexed Citations)

Search Strategy:

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1 lesbian.mp. or Homosexuality, Female/ (5704)
2 Bisexuality/ or bisexual women.mp. (4142)
3 wsw.mp. (120)
4 WSMW.mp. (5)
5 sexual orientation.mp. or Sexual Behavior/ (56050)
6 sexual identity.mp. (1251)
7 queer.mp. or Homosexuality/ (13250)
8 1 or 2 or 3 or 4 or 5 or 6 or 7 (70952)
9 limit 8 to yr="2015 -Current" (4625)
10 limit 9 to female (3011)
11 Great Britain/ or UK.mp. (276229)
12 10 and 11 (62)

SEARCH QUERY - EMBASE

(('homosexual female':ab,ti or 'bisexual female':ab,ti or 'women who have sex with women':ab,ti and [2015-2016]/py) or ('homosexual female'/exp or 'homosexual female') or 'bisexual female' or 'women who have sex with women' or wsw or wsmw) and (2015:py or 2016:py or 2017:py)) and 'united kingdom'

Database: PsycINFO <1967 to November Week 1 2016>

Search Strategy:

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1 exp Lesbianism/ or exp Sexual Orientation/ or exp Homosexuality/ or exp Bisexuality/ or lesbian$.mp. (30632)
2 bisexual women.mp. (613)
3 wsw.mp. (46)
4 wsmw.mp. (2)
5 sexual identity.mp. (3150)
6 queer.mp. (3030)
7 1 or 2 or 3 or 4 or 5 or 6 (32610)
8 limit 7 to (human and yr="2015 -Current") (3331)
9 limit 8 to female (1815)
10 Great britain.mp. (2848)
11 united kingdom.mp. (8990)

12 uk.mp. (30316)
13 british.mp. (20760)
14 gb.mp. (241)
15 english.mp. (118463)
16 scottish.mp. (2638)
17 welsh.mp. (1111)
18 irish.mp. (3268)
19 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (177759)
20 9 and 19 (57)

Database: CAB Abstracts <1973 to 2016 Week 44>

Search Strategy:

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1 exp Lesbianism/ or exp Sexual Orientation/ or exp Homosexuality/ or exp Bisexuality/ or lesbian$.mp. (2168)
2 bisexual women.mp. (25)
3 wsw.mp. (100)
4 wsmw.mp. (1)
5 sexual identity.mp. (113)
6 queer.mp. (104)
7 1 or 2 or 3 or 4 or 5 or 6 (2365)
8 limit 7 to (human and yr="2015 -Current") [Limit not valid in CAB Abstracts; records were retained] (412)
9 limit 8 to female [Limit not valid in CAB Abstracts; records were retained] (412)
10 Great britain.mp. (34833)
11 united kingdom.mp. (152174)
12 uk.mp. (170127)
13 british.mp. (188436)
14 gb.mp. (8148)
15 english.mp. (41160)
16 scottish.mp. (5784)
17 welsh.mp. (3198)
18 irish.mp. (15558)
19 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (252567)
20 9 and 19 (10)

Database: OVID Medline April 2015

1 Exp Homosexuality, Female/
2 wsw.tw
3 lesbian*.tw
4 gay.tw
5 LGBT*.tw
6 homosexual*.tw
7 Exp Bisexuality/
8 bisexual*.tw
9 pan?sexual*.tw
10 queer*.tw
11 “sexual orientation”.tw
12 “sexual preference*”
13 ”sexual minorit*”.tw
14 “same sex”.tw
15 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14

Web Table 1. Participant baseline characteristics

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
Blosnich (2014)	51,639	Mean 47.3 (SE 0.16)	61.4% white, 3.6% black, 26.3% Hispanic	615 lesbians, 451 bisexual women	Mean 43.1 (SE 1.33) lesbians, 35.1 (SE 1.41) bisexual women	70.8% white, 4.3% black, 15.9% Hispanic lesbians, 61.1% white, 5.5% black, 24.0% Hispanic bisexual women	SMW younger, fewer partnered, lesbians more educated, more employed, bisexual women less educated, fewer employed, less income.	Age race/ethnicity, education, income	Age race/ethnicity, education, income (only conducted where bivariate analyses p<0.05)
Blosnich (2013)	53,875 opposite sex partnered	Mean 33.0 (SE 0.06)	67.5% white	433 same-sex partnered	Mean 32.7 (SE 0.69)	72.6% white	Same sex partnered lower income,	Education, income, race/ethnicity, overweight, smoking	'weighted to account for sampling design'
Boehmer (2014)	90,608	Mean 43.0 (SE 0.03)	50.1% white, 6.5% black, 13.0% Asian 24.6% Hispanic	1,265 lesbians, 1,369 bisexual women	Mean 42.4 (SE 0.47) lesbians, 36.3 (SE 0.53) bisexual women	68.5% white, 7.4% black, 4.9% Asian 11.8% Hispanic lesbians, 57.6% white, 10.0% Asian 7.0% black, 16.9% Hispanic bisexual women	SMW younger, more white, more educated, more US born, lesbians more income, bisexual women less income, fewer with health insurance	Unadjusted prevalence reported	Age, race/ethnicity, education, household income, nativity
Conron (2010)	39,701	35.2% aged 18-33	83.2% white, 4.1% black, 2.6% Asian, 8.9% Hispanic	719 lesbian, 432 bisexual women	30.4% lesbians, 65.1% bisexual women aged 18-33	87.2% white, 4.5% black, 1.2% Asian, lesbian, 5.7% Hispanic	Lesbians more educated	Age, gender	Age, gender, education, income

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
						78.9% white, 4.7% black, 5.7% Asian, 9.3% Hispanic bisexual women			
Dilley (2010)	47,505	Mean 46.3	85.6% white, 1.8% black, 3.6% Asian, 7.1% Hispanic	589 lesbian, 561 bisexual women	Mean 40.0 lesbian, 32.9 bisexual women.	85.5% white, 1.6% black, 3.1% Asian, 7.2% Hispanic	More higher education in lesbians, less in bisexual women. Lesbians and bisexuals lower income.	Assumed that unadjusted prevalence reported	Sexual orientation, age, education
Everett (2013) and	6,072	Mean 28.7 (whole sample)	NR	138 gay/mostly gay 1345 bisexual/ mostly heterosexual,	NR	NR	NR	Possibly unadjusted prevalence reported	N/A
Clarke (2015)	5713	Mean 28.8 (95%CI 28.6 to 29.1)	67.7% white	71 homosexual, 60 mostly homosexual, 154 bisexual, 1089 mostly heterosexual	Mean (95%CI) 28.9 (28.3 to 29.5), homosexual, 28.4 (27.8 to 29.0) mostly homosexual, 28.3 (27.9 to 28.6) bisexual, 28.5 (28.2 to 28.7) mostly heterosexual	White 64.1% homosexual, 73.2% mostly homosexual, 69.4% bisexual, 77.5% mostly heterosexual	NR	See above	N/A

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
Farmer (2013)	5,356	36.2% aged 20-29	69.8% white, 12.0% black, 12.9% Hispanic	437 SMW	49.2% aged 20-29	73.4% white, 13.2% black, 8.6% Hispanic	SMW younger	Possibly unadjusted prevalence reported	N/A
Fredriksen-Goldsen (2012)	49,092	Mean 46.6 (SE 0.12)	83.7% white	626 lesbians, 536 bisexual women	Mean 42.9 (SE 0.81) lesbian, 32.7 (SE 0.85) bisexual women	85.4% white lesbian, 78.2% white bisexual women.	SMW younger, fewer partnered, lesbians less education, bisexual women lower income	Age	Age, education, income
Fredriksen-Goldsen (2013)	57,466	Mean 63.8 (SD 0.06)	91.8% white	562 lesbians, 291 bisexual women	Mean 58.6 (SD 0.37)	90.3% white	SMW more employed, fewer partnered, fewer less educated	Unclear weighting factors	Age, education, income
Frisch (2013)	61,993,266	Aged 18+	NR	655,941 same sex cohabiting	Aged 18+	NR	NR	(Mortality estimate - by age)	N/A
Garland-Forshee (2014)	25,602	28.8% aged 18-34	86.7% white	347 lesbians, 322 bisexual women	26.9% lesbian, 62.3% bisexual women aged 18-34	81.6% lesbians, 85.8% bisexual women white	SMW less likely to be partnered, more education, more urban residence, Lesbians more employed, Bisexual women younger, less income	Unclear weighting factors	Age, education, relationship status, rural or urban residency
Jackson (2016)	37,185	NR	68.3% white, 12.3%	525 lesbians, 353 bisexual women	NR	71.4% white, 12.7% black,	Lesbians more educated, fewer	Age, ethnicity, educational attainment,	Age race/ethnicity, education,

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
			black, 12.9% Hispanic			12.5% Hispanic lesbian 73.5% white, 16.0% black, 7.2% Hispanic bisexual women	partnered, bisexual women less income	annual household income, occupational class, health status, region of residence	income, occupational class, health status, region of residence
Ward (2015)	17,399	NR	NR	296 lesbians, 121 bisexual women	NR	NR	NR	As Jackson 2016 above	Age, race/ethnicity, education, income, marriage status, employment, health insurance status, region of residence
Kann (2016) identity	6,105	NR	NR	167 lesbian, 734 bisexual women	NR	NR	NR	Sex, race/ ethnicity and grade	N/A
Kann (2016) behaviour	3,054	NR	NR	173 lesbians, 572 bisexual women	NR	NR	NR	Sex, race/ ethnicity and grade	N/A
Matthews (2014)	6,110	25.7% aged 18-34	71.3% white, 20.7% black, 5.2% Hispanic	86 SMW	40.6% aged 18-34	77.7% white, 14.1% black, 1.7% Hispanic	SMW younger, more likely to use mobile phones	Survey design	Age
McNair (2011)	8,083	25-30	NR	99 lesbians, 100 bisexual women	25-30	NR	SMW lower income, less likely to be partnered, fewer with	Unclear weighting factors	N/A

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
							children, more urban residence, Lesbians more educated, bisexual women less educated,		

Web Table 2. Critical Appraisal Skills Programme (CASP) quality assessment results

Study	1	2	3	4	5a	5b	6a	6b	9	10	11
Blosnich (2014)	Y	Y	Y	N	n	CT	N/A	N/A	Y	Y	Y
Blosnich (2013)	Y	Y	CT	N	N	CT	N/A	N/A	Y	Y	Y
Boehmer (2014)	Y	Y	Y	N	CT	N	N/A	N/A	Y	Y	Y
Clarke (2015)	Y	Y	Y	Y	N	CT	N/A	N/A	Y	Y	Y
Conron (2010)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Dilley (2010)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Everett (2013)	Y	Y	Y	Y	N	CT	N/A	N/A	Y	Y	Y
Farmer (2013)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Fredriksen-Goldsen (2012)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Fredriksen-Goldsen (2013)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Frisch (2013)	Y	Y	CT	Y	N	CT	CT	Y	Y	Y	N/A
Garland-Forshee (2014)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Jackson (2016)	Y	Y	Y	N	N	Y	N/A	N/A	Y	Y	Y

Study	1	2	3	4	5a	5b	6a	6b	9	10	11
Kann (2016)	Y	Y	Y	N	N	Y	N/A	N/A	Y	Y	Y
Matthews (2014)	Y	Y	Y	N	CT	CT	N/A	N/A	Y	Y	Y
McNair (2011)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Ward (2015)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y

The checklist questions were 1. Did the study address a clearly focused issue? 2. Was the cohort recruited in an acceptable way? 3. Was the exposure accurately measured to minimise bias? 4. Was the outcome accurately measured to minimise bias? 5a. Have the authors identified all important confounding factors? 5b) Have they taken account of the confounding factors in the design and/or analysis? 6a. Was the follow up of subjects complete enough? 6b. Was the follow up of subjects long enough? 9. Do you believe the results? 10. Can the results be applied to the local population? 11. Do the results of this study fit with other available evidence?

Web Table 3. Prevalence of CVD by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	5.8%# (SE 0.002)	5.0%# (SE 0.002)	NR	7.0%# (SE 0.024)	NR	NR	NR
Boehmer 2014£	4.9% (SE 0.11)	5.8% (SE 1.30)	1.46 (0.92 to 2.34)	3.8% (SE 0.75)	1.14 (0.75 to 1.72)	NR	NR
Conron 2010&	1.3%# (SE 0.1)	1.8%# (SE 0.6)	1.92 (0.95 to 3.87)	3.3%# (SE 2.2)	2.24 (0.53 to 9.43)	NR	NR
Fredriksen-Goldsen 2013&	10.7%#	NR	NR	NR	NR	10.5%#	1.37 (1.00 to 1.86)*
Garland-Forshee 2014&	6.2%# (5.8 to 6.6)	4.0%# (2.1 to 7.5)	1.0 (0.5 to 1.9)	1.8%# (0.6 to 6.0)	0.7 (0.2 to 2.9)	NR	NR
Jackson 2016 (heart disease)	10.8%	9.9%	0.91 (0.61 to1.35)	7.2%	0.73 (0.40 to 1.35)	NR	NR
Jackson 2016 (stroke)	3.2%	5.8%	1.96 (1.14 to 3.39)*	3.4%	1.68 (0.71 to 3.97)	NR	NR
Matthews 2014	4.1%	NR	NR	NR	NR	0.4%	0.19 (0.04 to 0.87)

* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Table 4. Prevalence of hypertension (or hypertensive medication use) by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Boehmer 2014	21.2% (SE 0.19)	19.0% (SE 1.81)	0.99 (0.77 to 1.26)	17.6% (SE 1.70)	1.21 (0.95 to 1.53)	NR	NR
Boehmer 2014 (medication use)	65.3% (SE 0.47)	66.0% (SE 4.29)	1.57 (0.90 to 2.75)	45.0% (SE 4.69)	0.74 (0.44 to 1.24)	NR	NR
Dilley 2010	22.7% (22.1 to 23.4)	14.7% (9.8 to 21.4)	1.0 (0.6 to 1.7)	17.0% (12.2 to 23.1)	1.6 (1.1 to 2.5)*	NR	NR
Everett 2013&	12.2%# (SE 0.65)	10.3%# (SE 3.21)	NR	11.4%# (SE 1.19)	NR	NR	NR
Farmer 2013£ (medication use)	14.7%	NR	NR	NR	NR	11.6%	Not statistically significant
Garland-Forshee 2014	25.6%# (24.3 to 26.8)	22.9%# (13.8 to 35.7)	1.2 (0.6 to 2.4)	12.4%# (7.5 to 19.9)	0.9 (0.5 to 1.7)	NR	NR
Jackson 2016	35.5%	32.2%	0.91 (0.74 to 1.12)	32.1%	0.96 (0.71 to 1.31)	NR	NR
Matthews 2014	33.2%	NR	NR	NR	NR	22.0%	1.00 (0.43 to 2.33)

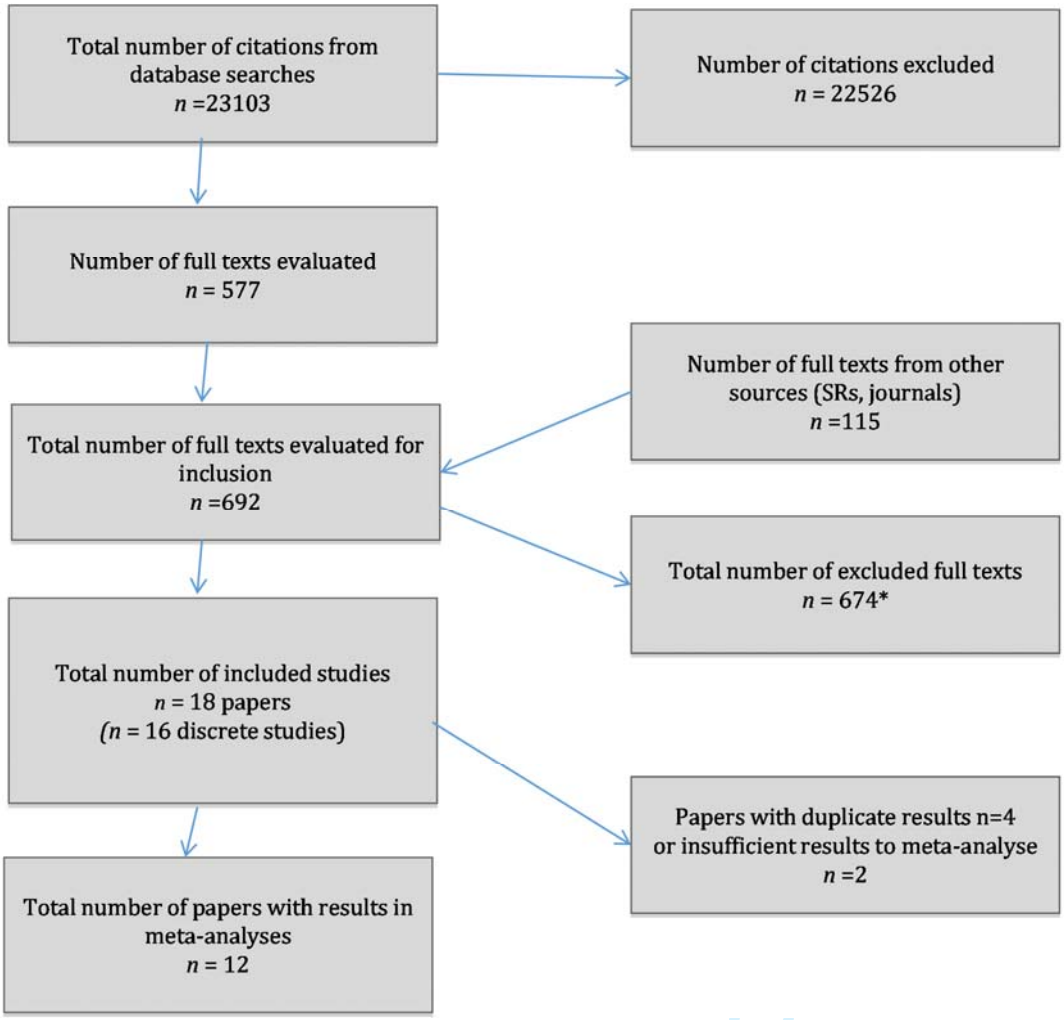
* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	10.2%# (SE 0.002)	6.8%# (SE 0.016)	NR	6.1%# (SE 0.016)	0.75 (0.44 to 1.29)	NR	NR
Boehmer 2014£	5.7% (SE 0.12)	4.6% (SE 0.74)	1.07 (0.76 to 1.50)	4.2%	1.10 (0.79 to 1.55)	NR	NR
Clark 2015	6.0%	1.9%	NR	6.8%	NR	7.2%	NR
Conron 2010	3.9% (SE 0.1)	3.8% (SE 0.9)	1.23 (0.74 to 2.06)	3.9% (SE 1.1)	1.04 (0.62 to 1.76)	NR	NR
Dilley 2010	6.3% (6.0 to 6.5)	5.1% (3.3 to 7.7)	1.3 (0.8 to 2.0)	5.8% (3.8 to 8.8)	1.8 (1.1 to 2.8)*	NR	NR
Farmer 2013	5.3%	NR	NR	NR	NR	6.4%	Not statistically significant
Garland-Forshee 2014	6.5% (6.1 to 6.8)	10.8% (4.1 to 26.0)	2.2 (0.6 to 7.8)	2.4% (1.2 to 5.0)	0.8 (0.4 to 1.6)	NR	NR
Jackson 2016	10.7%	7.7%	0.88 (0.58 to 1.34)	7.1%	0.63 (0.33 to 1.20)	NR	NR
Matthews 2014	11.3%#	NR	NR	NR	NR	4.3%#	0.55 (0.17 to 1.82)

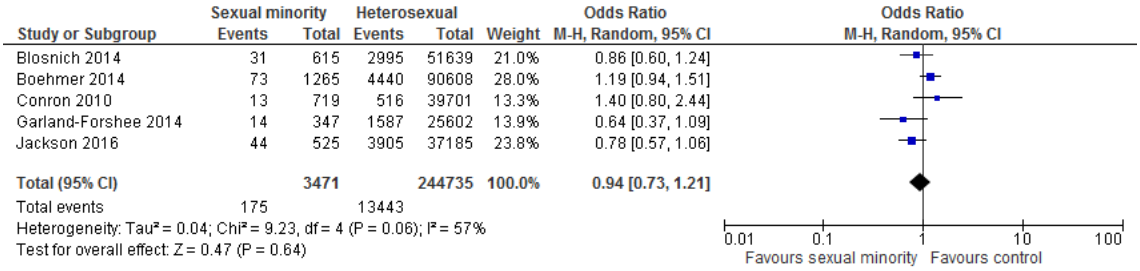
* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Figure 1. PRISMA flow diagram

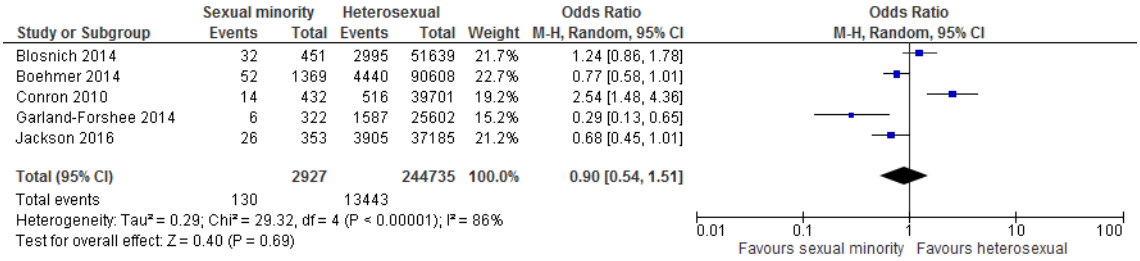


* Reasons for 674 full text exclusions: case studies = 7, diagnostic studies = 8, experimental studies = 8, in children only = 7, no comparison with heterosexual women = 1, no relevant numerical outcomes = 94, pilot studies = 2, qualitative studies = 123, results in men and women combined only = 124, reviews/editorials = 74, surveys on wrong topic = 226.

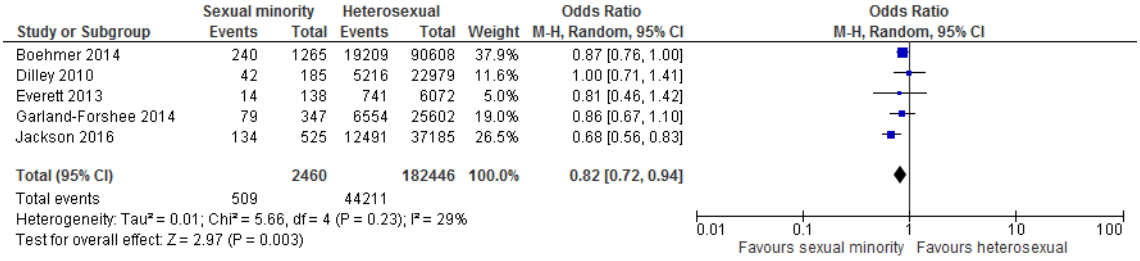
Web Figure 2a. CVD in lesbians



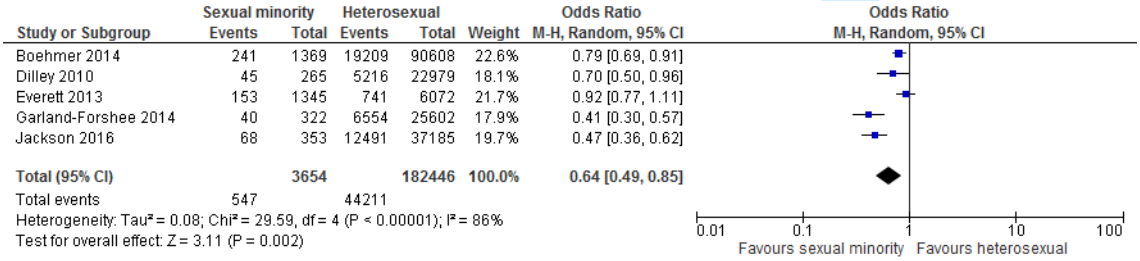
Web Figure 2b, CVD in bisexual women



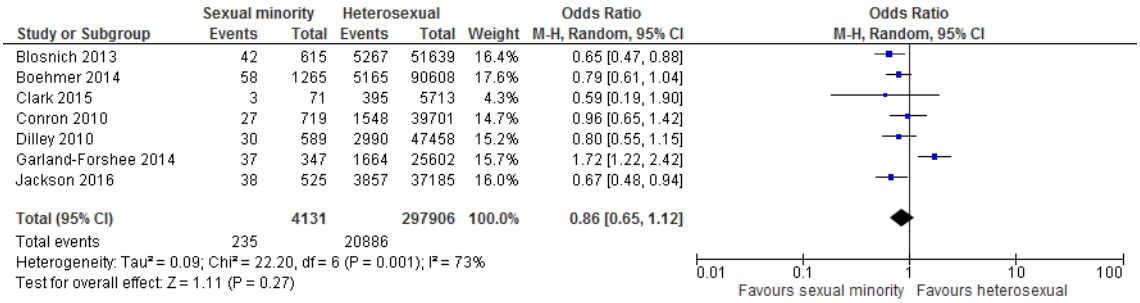
Web Figure 3a. Hypertension in lesbians



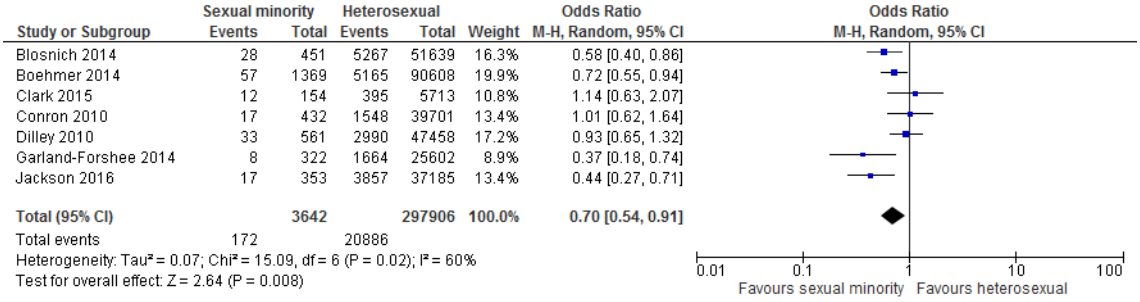
Web Figure 3b. Hypertension in bisexual women



Web Figure 4a. Diabetes mellitus in lesbians



Web Figure 4b. Diabetes mellitus in bisexual women



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4,5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	5
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	5
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5,32
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	15-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	27
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	5-7, 20, 29-31
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	21,33,34
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	See 5
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	7
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	8,9
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	9,10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	1

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

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Secondary Subject Heading:	Respiratory medicine, Diabetes and endocrinology, Cardiovascular medicine
Keywords:	systematic review, meta-analysis, sexual minority women, Cardiac Epidemiology < CARDIOLOGY, Epidemiology < THORACIC MEDICINE

Title: A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

Authors: Catherine Meads[1], Adam Martin[2], Jeffrey Grierson[1], Justin Varney[3]

Corresponding author: C Meads – email: catherine.meads@anglia.ac.uk

1. Faculty of Health, Social Care and Education, Anglia Ruskin University, Cambridge, UK

2. Academic Unit of Health Economics, Leeds Institute of Health Sciences, University of Leeds, Leeds, UK

3. Public Health England

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Conflicts of interest: none

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Data sharing statement: No additional unpublished data as systematic review

Contributorship statement: Justin Varney and Catherine Meads developed the research question. Catherine Meads and Adam Martin conducted the systematic review (searches, citation selection, data extraction, quality assessment). Catherine Meads wrote the systematic review and all data was checked by Adam Martin and Jeffrey Grierson. Catherine Meads conducted the meta-analysis, checked by Adam Martin. All authors edited the manuscript.

Abstract

Objectives

Sexual minority women (SMW) experience higher chronic-disease risk-factors than heterosexual counterparts. However, it was unclear if these risks translate into higher physical-condition rates. This systematic review evaluates cardiovascular disease (CVD), hypertension, respiratory disease and diabetes mellitus in SMW.

Methods

Prospero database registration: CRD42016050299. Included were studies reporting mortality, incidence or prevalence of the above listed conditions in SMW compared to heterosexual women. Databases (platforms) searched from 2010 to December 2016 were Medline (OVID), Embase (Elsevier), Cinahl (Elsevier), PsycInfo (Ovid), Social Policy and Practice (Ovid), Cochrane CENTRAL (Cochrane Library), Science Citation Index (Web of Science), CAB abstracts (Ovid). Search terms included MeSH terms and text words. Extensive additional searches were conducted in specialist academic journals and websites.

Two reviewers checked study eligibility. One independently extracted data and assessed quality, checked by a second, with disagreements resolved through discussion. The CASP cohort checklist was used to assess risk-of-bias. Meta-analysis was conducted where more than four studies reported same outcomes, with Comprehensive Meta-analysis software using adjusted odds ratios (AORs) and random-effects models. Heterogeneity was assessed using I^2 test.

Results

Identified were 23,103 citations, 692 full-texts screened, and 16 studies included (in 18 papers). One reported mortality (from Denmark), none incidence and 15 prevalence (14 USA, 1 Australia). Same-sex-cohabiting women had higher mortality rates compared to opposite-sex-cohabiting women in CVD (Hazard Ratio (HR)=1.37 (95%CI=1.22-1.54) and respiratory disease (HR=2.10 (95%CI=1.74-2.53). AOR meta-analyses of seven studies showed higher asthma rates in lesbians (OR=1.44 (95%CI=1.27-1.64)I^2=0%) and bisexual women (OR=1.64 (95%CI=1.41-1.89)I^2=0%) but no differences for CVD (five studies), hypertension (five studies) or diabetes mellitus (seven studies).

Conclusions

These new health estimates require further confirmatory epidemiological studies, and investigation into potential environmental, hormonal, physiological, psychological or genetic causes. This would be supported by routine collection of sexual-identity measures in population-level epidemiological surveys.

Strengths and limitations of this study

- A major strength is that this is the first numerical estimate of the relative prevalence of diabetes mellitus, cardiovascular and respiratory diseases in lesbians and bisexual women.
- We used extensive searches from a number of different sources, not just electronic databases and reference lists but also in specialist academic journals and websites to ensure we found all relevant studies.
- We used a wide definition of SMW to include identity, behaviour and partnership to be able to include all SMW irrespective of being sexually active or in a partnership. This will widen the generalizability of the systematic review.
- Considerable efforts were made to avoid double counting of participants from different studies when entering data but some double-counting may have occurred due to the nature of the surveys used in the studies.
- We used adjusted odds ratios to meta-analyse, which means that the results were more comparable than using unadjusted prevalence estimates. However, none of the AORs were adjusted for smoking status, which is a limitation of the included studies.

Background

Sexual minority women (SMW) include lesbians, bisexual women, women who have sex with women, women who have sex with men and women, and women who are married to or cohabit with another woman in a committed relationship. Public Health England estimates that at least 2.5% of the population identify at lesbian, gay or bisexual[1].

Chronic disease risk factors include poor diet, lack of exercise, obesity, smoking, excessive alcohol intake, anxiety, depression, hypertension and high cholesterol levels[2,3,4]. In general, SMW populations experience disproportionate behavioural risks to health and higher chronic disease risk factors than their heterosexual counterparts[5,6]. Due to a lack of research so far[6], it is unclear whether these risk factors translate into higher rates of physical health conditions.

Past research has highlighted some aspects of health inequalities experienced by SMW but also identified significant and persistent gaps in the evidence[5,7-10] including in relation to common physical conditions such as cardiovascular disease (CVD), respiratory tract disease and diabetes mellitus. These are some of the leading causes of death and disability for women[11] and, up to now, there have been no published summary estimates of the relative prevalence of these conditions in SMW compared to heterosexual women.

There have been two recent systematic reviews of physical health in SMW [12,13]. Eliason (2015)[12] reviewed evidence on prevalence and risk of a variety of conditions and Simoni et al (2016)[13] investigated disparities in physical health conditions in SMW. Since these systematic reviews were conducted, more prevalence studies have been published. This systematic review includes all relevant recent evidence (published from 2010 onwards) on the mortality, incidence and prevalence of specific physical health conditions of CVD, hypertension, respiratory disease and diabetes mellitus in SMW compared to heterosexual women, and conducts meta-analyses in order to derive up-to-date prevalence estimates of these conditions and determine whether there are different rates in SMW compared to heterosexual women.

Methods

A protocol was registered with the Prospero database (No. CRD42016050299) for research investigating all aspects of health and experience of healthcare in SMW, of which this project is part. Patients and the public were not involved with the design or conduct of this systematic review. The inclusion criteria for this systematic review were any published comparative studies in any language, published from 2010 onwards, comparing specific rates (see below) in SMW (any definition including identity, behaviour or cohabitation status) of any age compared to heterosexual women (any definition including identity, behaviour or cohabitation status) of any age in any country or setting. The following self-report or objectively measured rates were included: mortality, incidence and prevalence of CVD, hypertension, diabetes mellitus (any type) and respiratory diseases including asthma.

Searches:

Database searches were conducted in two phases. First, searches were conducted by Public Health England Knowledge and Library Service in May 2015. Second, searches were conducted by the first author (CM) in December 2016 with dates from January 2015 to December 2016. Databases (platforms) searched were Medline (OVID), Embase (Elsevier), Cinahl (Elsevier), PsycINFO (Ovid), Social Policy and Practice (Ovid), Cochrane CENTRAL (Cochrane Library), Science Citation Index (Web

of Science), CAB abstracts (Ovid). EPPI-Reviewer 4, Endnote and Microsoft Excel were used to sift citations. Search terms included MeSH terms and text words for sexual minority (for example, lesbian, bisexual, homosexual, WSW, WSMW, same sex). We then searched a large number of full texts for the physical conditions listed above. Searches were not limited to English language. Example search strategies for 4 databases from the December 2016 searches are in Web Supplement 1.

In addition to database searches, reviews and summaries of lesbian, gay, bisexual & transgender (LGB&T) health were examined for relevant evidence. LGB&T Health Research Journal (all issues), Journal of Lesbian Studies (2014-16) and Journal of Gay and Lesbian Mental Health (2014-16) were searched. Previous projects by the first author (CM) were searched for relevant evidence and, from a previous project, a list of currently active researchers in LGBT health with their publications were reviewed. Web pages of several researchers known to be active in SMW research were searched. The UK National LGB&T Partnership monthly newsletter from February to October 2016 was sifted for relevant up-to-date work that had not yet been published. UK national survey websites were also sifted for information on sexual identity and health (Integrated Household Survey, Scottish Health Survey, Welsh Health Survey and Health Survey for England).

Study selection, data extraction, quality assessment and synthesis

Full text copies of references matching inclusion criteria were obtained. Two reviewers (CM and AM) checked study eligibility. One independently extracted data from studies into the report (CM) and these were checked by another reviewer (JG), with disagreements resolved through discussion. Characteristics and results of all included studies were described through narrative synthesis. Tabulation was used where there was more than one study reporting the same outcome. Where there was overlap in study populations, the largest included population was used where outcomes of interest were reported. The Critical Appraisal Skills Programme (CASP) checklist for cohort studies was used to assess quality for all studies. Since there is no established and validated quality checklist specifically for cross-sectional surveys, using the same checklist for all provided consistency in quality assessment across studies. Meta-analysis was conducted where there were four or more discrete studies reporting the same outcome. This included both unadjusted prevalence estimates (with Review Manager software 5.3), and adjusted odds ratios using inverse variance (with Comprehensive Meta-analysis version 3). Random effects models were used for both. Statistical heterogeneity was assessed using the I^2 test, using standard thresholds for high, medium and low heterogeneity[14]. There were insufficient studies reporting the same outcomes to be able to construct a meaningful funnel plot to assess publication bias.

Results

Description of studies

A total of 23,103 citations were identified, 22,763 from the first searches and 340 from the second searches (see Web Figure 1). Full texts of 692 papers were screened for potential relevancy. Sixteen studies were included [15-30], described in 18 papers - the study by Clark et al (2015)[31] contained a subset of the participants in the study by Everett et al (2013) [20] and the study by Wallace (2011)[32] contained a subset of those in the study by Boehmer et al (2014) [17]. For characteristics of included studies, see Table 1 and for participant baseline characteristics, see Web Appendix Table 1.

One study examined mortality rates; Frisch and Simondsen (2013)[24] reported hazard ratios for mortality by sexual orientation in a large national cohort from Denmark by various causes of death (n=6.5 million, approximately 50% women).

No studies investigated incidence, and 15 studies investigated prevalence[13-23, 25-30]. Two were based on single waves of cohort studies (Everett et al 2013[20] (also reported in Clarke et al 2015[31]), and McNair et al 2011[29]). The first[20] was based in the USA and used Wave IV of data from the National Longitudinal Study of Adolescent Health. The second[29] used one year's data from an Australian study of young women aged 18-23 selected at random from the Australian Medicare database. The remaining 13 studies were from the USA and used one or more year's data from repeated cross sectional surveys. Eight of these used Behavioral Risk Factor Surveillance System (BRFSS) surveys, either using a national sample from different years[15,16] or for specific states (Massachusetts[18], Oregon[25], North Carolina[28], Washington State[19,22,23]). Other surveys used included; The National Health Interview Survey[26,30], The California Health Interview Survey[17,32], The Youth Risk Behaviour Surveillance System[27], The National Health and Nutrition Examination Survey[21].

One group of studies[19,22,23] reported different outcomes for different subsets (such as age ranges) of the same repeated survey for different years. Ward et al (2015)[30] investigated a subset of the population in Jackson et al (2016)[26] but Ward et al (2015) [30] reported asthma whereas Jackson et al (2016) [26] did not so both papers for this study have been included. Wallace et al (2011)[32] used a subset of the sample in Boehmer et al (2014)[17] and reported the same outcomes so these results are not reported here. Everett et al (2013)[20] and Clark et al (2015)[31] reported different outcomes from the same population so both papers for this study have been included.

Quality assessment found similar quality issues across studies, and are reported in Web Appendix Table 2. The cohort studies[20,29] reported results as if they were cross-sectional surveys by not using follow-up data. The main quality issues were that health conditions were ascertained mostly by health self-report; the main exception was in Everett et al 2013 (and Clark et al 2015)[20,31] where interviewers measured blood pressure. Also, weighted prevalence percentages were reported in several included studies (see Web Appendix Table 1), but weighting factors used were often unclear.

Main findings

For CVD mortality and for respiratory tract disease mortality, Frisch and Simondsen (2013)[24] found that same-sex cohabiting women had higher mortality rates to opposite sex cohabiting women for these diseases (HR 1.37 (95%CI 1.22 to 1.54) and HR 2.10 (95%CI 1.74 to 2.53) respectively) but that same-sex married women had similar mortality rates to opposite sex married women (HR 1.32 (95%CI 0.75 to 2.33) and HR 0.85 (95%CI 0.36 to 2.05) respectively) . The sample sizes were larger for same-sex cohabiting women (n=207 and n=111) than same sex married women (n=12 and n=5) and no conclusions can be drawn from the same sex married women data as sample sizes were too small.

Numerical prevalence results are presented in Table 2 (asthma), Web Appendix Table 3 (CVD), Web Appendix Table 4 (hypertension), and Web Appendix Table 5 (diabetes mellitus). They demonstrate that the way these rates were reported varied across the studies, for example some studies presented results for SMW compared to heterosexual women whereas others presented results separately for lesbians and for bisexual women. Percentages of women with conditions varied across the studies, most notably hypertension which varied from 14.7%[21] to 65.3%[17] in heterosexual women. Most studies presented AORs as well as the adjusted or unadjusted percentages but fewer gave measures of spread such as 95% CIs or standard errors (SEs). One study[26] presented results for heart disease and stroke separately and found no difference in rates between any of the groups (see

Web Appendix Table 3). One study[30] presented results for chronic obstructive pulmonary disease which found higher rates in bisexual women compared to heterosexual women but not for lesbians (prevalence in lesbians 6.0% (95%CI 3.2 to 11.0), bisexual women 13.6% (95%CI 6.9 to 25.2), heterosexual women 6.4% (95%CI 5.9 to 6.8).

Meta-analysis

There were sufficient studies (i.e. n>4) presenting results for CVD, hypertension, asthma and diabetes (any type) in lesbians and in bisexual women for meta-analyses to be conducted.

Meta-analyses of unadjusted prevalence (see figure 1, Web Figure 2a, 2b, 3a, 3b, 4a, 4b) showed no difference in CVD (lesbian OR=0.94 (95%CI 0.73 to 1.21) and bisexual women OR=0.90 (95%CI 0.54 to 1.51)) but lower prevalence of hypertension (lesbian OR=0.82 (95%CI 0.72 to 0.94) and bisexual women OR=0.64 (95%CI 0.49 to 0.85). There was higher prevalence of asthma (lesbians OR=1.47 (95%CI 1.32 to 1.63) and bisexual women OR=1.97 (95%CI 1.71 to 2.26) and combined for all SMW OR=1.68 (95%CI 1.52 to 1.85). For diabetes mellitus there was no difference in prevalence between lesbians and heterosexual women but lower prevalence in bisexual women (OR=0.86 (95%CI 0.65 to 1.12) and OR=0.70 (95%CI 0.54 to 0.91)).

Meta-analyses of adjusted odds ratios (all adjusted for age) showed increased rates of asthma in lesbians and in bisexual women compared to heterosexual women (ORs = 1.44 (95%CI 1.27 to 1.64) I^2=0% and 1.64 (95%CI 1.41 to 1.89) I^2=0%). They showed no differences for lesbians or bisexual women compared to heterosexual women for CVD (ORs = 1.34 (95%CI 0.97 to 1.85) I^2=45% and 1.08 (95%CI 0.80 to 1.47) I^2=0%), for hypertension (ORs = 0.98 (95%CI 0.86 to 1.14) I^2=0% and 1.08 (95%CI 0.86 to 1.35) I^2=39%), and for diabetes mellitus (ORs = 1.11 (95%CI 0.91 to 1.36) I^2=0% and 1.01 (95%CI 0.75 to 1.36) I^2=51%).

Discussion

Summary of main findings

Results from a single large study reporting mortality rates[24] showed that there was no difference in cardiovascular or respiratory tract disease mortality rates in same-sex married compared to opposite sex married women, but higher mortality rates in same-sex cohabiting women compared to opposite sex cohabiting women.

Meta-analyses of adjusted odds ratios of disease prevalence showed no differences in CVD, hypertension or diabetes mellitus prevalence, but a higher prevalence of asthma in SMW compared to heterosexual women.

Discussion of main findings

A key finding was the higher prevalence, from the adjusted odds ratio meta-analysis, of asthma in lesbians and bisexual women. Asthma is caused by a mixture of genetic and environmental factors. Higher rates are associated with anxiety but it is not known if asthma causes psychological problems or if psychological problems lead to asthma[33]. Nevertheless, studies have shown higher rates of mental health problems including anxiety in SMW [34,35]. Asthma is also more common amongst those who are economically disadvantaged, and a consistent finding in studies included in the systematic review was that SMW had below average incomes[15-17,21,29]. Asthma is also more common amongst current or former smokers. Several included studies showed higher rates of smoking or tobacco use amongst SMW[15,16,19-21,23,25,26,28]. However, only one of the studies reporting asthma prevalence clearly controlled for smoking behaviour[15].

The finding of lower hypertension prevalence and no difference in the adjusted odds ratio meta-analysis in lesbians and bisexual women was unexpected. Higher rates of hypertension are associated with lack of exercise and obesity. Several of the included studies demonstrated higher rates of obesity [15-18,20-22,25,26] and a recent systematic review on obesity in SMW [36] also found consistently higher rates of obesity amongst SMW compared to heterosexual women. However, the rates of physical exercise in SMW is less clear. Two of the included studies showed higher rates of physical activity or exercise in lesbians and bisexual women compared to heterosexual women[16,28] whilst four showed no differences[20,22,25,26]. Hypertension is also associated with mental health difficulties, particularly depression[37], and there are higher rates of depression in SMW [34,35].

No difference in rates of diabetes mellitus were found in the meta-analysis of adjusted odds ratios, but in the unadjusted prevalence meta-analysis higher rates were found in bisexual women but not lesbians. It is unclear as to why this would occur. Risk factors for type II diabetes mellitus include hypertension, overweight/obesity, physical inactivity and unhealthy diet. Evidence on the first three are discussed above, however there is much less information available about diet. Dilley et al 2010[19] reported that the proportion eating insufficient fruits and vegetables was higher in bisexual women than lesbians and heterosexual women but Garland-Forshee et al 2014[25] showed no differences between lesbians, bisexual and heterosexual women in the proportion who met US CDC recommendations on fruit and vegetable intake.

Three of the included studies calculated that lesbians and bisexual women were at higher risk of CVD[18,21,31]. Farmer et el (2013)[21] and Clark et al (2015)[31] calculated risk scores using the Framingham General CVD Risk Score and both calculated that SMW had higher CVD risk scores. Farmer et al (2013)[21] calculated that SMW were 13.9% (95%CI 8.55 to 19.3%) older in vascular terms than their chronological age, and that this was 5.7% (95%CI 1.5% to 9.8%) greater than heterosexual women. Clark et al (2015)[31] found that average 30 year CVD risk was raised in all sexual minority groups of women, significantly so in mostly heterosexual and mostly homosexual women. Conron et al (2010)[18] also calculated CVD risk, using presence of obesity and smoking plus one other risk factor including lack of moderate physical activity, lifetime diabetes mellitus, hypertension and high cholesterol. They estimated that lesbians and bisexual women were at higher risk of CVD than heterosexual women.

It is known that there are higher rates of several CVD risk factors in SMW, including overweight/obesity, diabetes mellitus, tobacco use (all discussed above) high cholesterol and harmful use of alcohol (discussed below). Hence the finding of no difference in CVD rates was surprising. Also, since the systematic review found higher rates of asthma, if this was due to higher rates of smoking, it would be expected that there would be correspondingly higher rates of CVD.

Several of the included studies reported higher rates of harmful alcohol use in lesbians and bisexual women compared to heterosexuals[16,19-21,23,25,26]. Several also reported cholesterol levels - one found lower cholesterol levels in lesbians and bisexual women[20] but most found no significant differences[19,23,25]. Matthews et al, 2014[28] found that twice as many lesbians and bisexual women than heterosexual women were not having their cholesterol checked (32.5% vs 13.8%), but the implications of this are unclear.

Strengths and weaknesses of the study

The strengths of the current systematic review include extensive searches from a number of different sources, a minor weakness is that the searches were conducted to December 2016 and more studies may have been published since then. We used a wide definition of SMW to include

identity, behaviour and partnership. It is acknowledged that these are different concepts and women can identify as lesbian or bisexual without being sexually active or being in a partnership. Also some women identify as lesbian whilst having sex with men and some women identify as heterosexual whilst having sex with women. Most of the studies also used self-report for the physical conditions, and this may result in responder bias, but it is unclear why responder bias might be stronger in SMW than heterosexual respondents. Also, almost all of the included studies were conducted in USA, so results may not be generalizable to other countries. Also, it is known that SMW have less insurance coverage and poorer access to healthcare in USA[38]. The precise questions on health used in the BRFSS questionnaires asked whether the respondent had been 'told by a health care professional' that they had had the named condition. If SMW have less access to healthcare, it could be assumed that fewer would have been told they had one of the conditions investigated here. So it is possible that all of the rates may have been underestimated, and the increased rates of asthma may be even higher than found here. In the reported results, prevalence of physical conditions were weighted to better reflect the underlying population in some of the included studies but not in others. Where the sexual minority samples were younger than the heterosexual population with which they were compared, it might be expected that the lack of weighting by age would result in underestimation of the difference in prevalence of physical health conditions, particularly CVD, hypertension and diabetes mellitus where prevalence rises by age. There were insufficient studies to be able to conduct meaningful subgroup analyses by whether or not the study had controlled for age. Furthermore, two of the studies[16,23] were unclear as to whether they weighted the reported prevalence or whether the reported weighting factors referred to the adjusted odds ratios that they also report. Some of the studies weighted by factors such as education and income which may also impact on the estimated prevalence of physical conditions. Some important factors were often not controlled for, e.g. for asthma, it would be usual to include smoking rates, which differ between SMW and heterosexual female populations. A further major limitation is that almost all of the prevalence research was from USA so it currently unclear if the findings are generalizable to other countries.

In the meta-analyses, considerable efforts were made to avoid double counting of participants from different studies when entering data and hence some studies were excluded for one or more reported outcomes[19,23,31,32]. Random effects models were used because of clinical heterogeneity of the study samples. The heterogeneity between studies in the weightings that were used for the prevalence estimates in the unadjusted meta-analyses may have introduced some bias from this loss of information about differences between the two groups. Hence there may be some inconsistency between the AORs reported in the results tables and the ORs used in the meta-analysis. The meta-analyses of AORs mitigates some of these effects, and all AORs used were adjusted for age. However, in both types of meta-analyses, there was heterogeneity in outcome measures (e.g. one study measured hypertension, six using self-report hypertension and one study using hypertensive medication use), although we do not expect that this impacted on the observed differences between groups, our main outcome of interest.

Strengths and weaknesses in relation to previous research

The previous systematic reviews[12,13] found fewer studies and did not conduct meta-analyses so did not quantify the physical health disparities they had found. For CVD prevalence Eliason (2014)[12] included seven studies, of which four were published before 2010, and for hypertension it included 12 studies, of which four were published before 2010. For asthma it included 13 studies, four of which were published before 2010. Some relevant results from included studies were not described, and the study by Garland-Forshee et al 2014[24] was omitted. Eliason (2014)[12] concluded that asthma

was more common in SMW, but no differences were consistently found in the other chronic physical conditions she investigated, including diabetes, hypertension and CVD. Simoni et al (2016)[13] had a very brief summary of results. For CVD it found one study, for hypertension one study and for asthma four studies. All of these were included in the systematic review by Eliason (2015)[12]. Simoni et al (2016)[13] found evidence of disparities in the one included study reporting CVD[22] and in asthma, but that evidence was lacking in diabetes and hypertension. There is also little information on the prevalence of these conditions in men according to sexual orientation and no relevant systematic reviews[10].

Implications for clinicians and policy-makers

If there are higher rates of asthma in lesbians and bisexual women, this might have implications for health service delivery, particularly in primary care. Urwin and Whittaker (2016)[39] published an evaluation of the English General Practice Patient Survey (n=2,807,320 in total, 1,556,909 women) looking at inequalities of GP use by sexual orientation for various conditions. They found that lesbians but not bisexual women were less likely to visit the GP than heterosexual women in the previous 3 months for asthma or long-term chest problem (adjusted OR=0.84 (95%CI 0.71 to 0.98 and OR=0.85 (95%CI 0.69 to 1.04)). So it is likely that SMW, particularly in the UK and possibly elsewhere, are not accessing services despite ill-health. A recent systematic review found that sexual minority populations generally have difficulties with access to health services for a variety of reasons including communication difficulties, internalized homophobia, prejudicial conduct adopted by health professionals, breach of confidentiality during consultations and institutional homophobia [40]. Combined with the evidence shown in this systematic review, this suggests potentially considerable latent demand for primary care services amongst SMW and that there may be particular issues for lesbians accessing primary health care services for asthma. This evidence contributes to a bigger picture about inequality for SMW in a wide range of aspects[5,8].

This systematic review highlights the need for better routine data collection on sexual minority women as much of the current research has small sample sizes and based on countries with significantly different healthcare access and social norms around sexual identity. The introduction of an NHS information standard on sexual orientation in April 2017[41] will start to introduce routine data capture across hospital episode statistics and disease registries, alongside training across the NHS to support staff having positive conversations about sexual orientation, which will build over time a much clearer picture of the health inequalities in this group and potentially help to reduce them.

Implications for research

This rigorously conducted systematic review has reported some important new findings on health inequalities in SMW that are hard to explain. Further research would be useful on these health inequalities, including their causes. This would be supported by the routine collection of sexual identity measures in population-level epidemiological studies, and the results published. Robust multi-level modelling (including sexual identity) should be conducted with large databases and cohort studies. For asthma, results from large cohort studies, controlled for risk factors such as smoking and overweight/obesity would be useful to further examine these findings. Regarding hypertension and CVD, the findings are also unexpected so investigation into potential causes would be very useful, such as possible differences in hormone levels, or other environmental, social, physiological, psychological or genetic factors that might be contributing to these results.

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Tables and figures, with web appendix

Table 1. Characteristics of included studies.

Table 2. Prevalence of asthma by sexual orientation

Figure 1. Subgroup meta-analysis of asthma in lesbians, bisexual women and SMW

WEB APPENDIX

Web Supplement 1. – Search strategies

Web Table 1. Participant baseline characteristics

Web Table 2. CASP quality assessment results

Web Table 3. Prevalence of cardiovascular disease or CVD symptoms by sexual orientation

Web Table 4. Prevalence of hypertension or hypertensive medication use by sexual orientation

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Web Figure 1. PRISMA flow diagram

Web Figure 2a. CVD in lesbians

Web Figure 2b, CVD in bisexual women

Web Figure 3a. Hypertension in lesbians

Web Figure 3b. Hypertension in bisexual women

Web Figure 4a. Diabetes mellitus in lesbians

Web Figure 4b. Diabetes mellitus in bisexual women

Table 1. Characteristics of included studies

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
Mortality studies							
Frisch (2013)	National demographic data from Danish Civil Registration System, including mortality data	Population, marriage, living in same sex or opposite sex cohabitation for at least 1 year between 1982 and 2011, Denmark	Cohabitation record, marriage record (same sex marriage from 1989, (NB 75.6% same sex cohabiting women were same sex married)	Opposite sex cohabitation, marriage	National demographic data collection	Mortality	Population cohort Supported by – not reported (NR)
Surveys based on multi-state Behavioral Risk Factor Surveillance System (BRFSS)							
Blosnich (2013)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults in partnerships. All states, USA	Various similar in the 10 states with response options heterosexual or straight; homosexual, gay or lesbian; bisexual; other; and opposite or same sex partner.	Opposite sex partnered women	Behavioral Risk Factor Surveillance System (BRFSS) for all US States 2004.	Current asthma, lifetime asthma	Population survey. Supported by a National Research Service award
Blosnich (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. Alaska, Arizona, California, Maine, Massachusetts, Montana, New Mexico, North	Various similar in the 10 states with response options heterosexual or straight; homosexual, gay or lesbian; bisexual; other.	Heterosexual women	Behavioral Risk Factor Surveillance System (BRFSS) for 10 States 2010.	CVD symptoms, asthma, diabetes	Population survey. Supported by National Research Service awards.

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
		Dakota, Washington, Wisconsin, USA					
Surveys based on single state Behavioral Risk Factor Surveillance System (BRFSS)							
Conron (2010)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English, Spanish or Portuguese speaking non-institutionalised adults. Massachusetts, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women	Massachusetts Behavioral Risk Factor Surveillance System (BRFSS) 2001-8.	Heart disease, diabetes, asthma	Population survey. Supported by Massachusetts Department of Public Health HIV/AIDS Bureau and Ford Foundation
Garland-Forshee (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults, Oregon, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D other? (D answers excluded)	Heterosexual women	Oregon Behavioral Risk Factor Surveillance System 2005-8	Cardiovascular disease, hypertension, diabetes, asthma	Population survey. Supported by Center for Disease Control grants.
Matthews (2014)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. North Carolina, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D other? (D answers excluded)	Heterosexual women	North Carolina Behavioral Risk Factor Surveillance System 2011	Angina or heart disease, hypertension, diabetes, asthma	Population survey. Supported by National Institute for Mental Health grant.
Dilley (2010)	Telephone-based (landline) random digit dialled	English or Spanish speaking non-institutionali	A heterosexual or straight, B homosexu	Heterosexual women	Washington State Behavioral Risk Factor Surveillanc	Diabetes, hypertension, (asthma),	Population survey. Supported by Washington

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
and	interview. Had ever been told by a health professional that they had (a named condition)	sed adults. Washington, USA	al, gay or lesbian, C bisexual or D something else? (D answers excluded)		e System (BRFSS) 2003-6.		State Tobacco Prevention and Control Program and BRFSS
Fredriksen-Goldsen (2012) and	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults. Washington, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women	Washington State Behavioral Risk Factor Surveillance System (BRFSS) 2003-9.	Asthma	Population survey. Supported by NIH and National Institute on Aging grants
Fredriksen-Goldsen (2013)	Telephone-based (landline) random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	English or Spanish speaking non-institutionalised adults aged over 50. Washington, USA	A heterosexual or straight, B homosexual, gay or lesbian, C bisexual or D something else? (D answers excluded)	Heterosexual women aged over 50	Washington State Behavioral Risk Factor Surveillance System (BRFSS) 2003-10.	Cardiovascular disease (asthma, diabetes, hypertension),	Population survey. Supported by National Institute on Aging grant
Studies based on other US national or state surveys							
Jackson (2016) and Ward (2015)	In-person interviews using cluster-based probability sampling. Had ever been told by a health professional that they had (a named	Non-institutionalised adults. USA	Straight (not lesbian or gay); gay or lesbian; bisexual; something else? (something else answers excluded)	Straight women	National Health Interview Survey 2013-14	Diabetes, heart disease (CHD or any other kind of heart disease, angina pectoris or a myocardial infarction), stroke, hypertension Asthma	Population survey Supported by several grants including from Harvard Catalyst and NIH

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	condition), or diagnosed by a doctor (CVD)					(Ward)	
Kann (2016)	School questionnaire - based survey, nationally representative data. Had ever been told by a doctor or nurse that they had asthma	Students in grades 9–12 (aged 14-18) attending high schools, USA	Which of the following best describes you? "heterosexual (straight)," "gay or lesbian," "bisexual," or "not sure." AND During your life, with whom have you had sexual contact? "I have never had sexual contact," "females," "males," and "females and males."	Heterosexual female students AND Sexual contact with males.	Youth Risk Behavior Surveillance System (YRBSS)	Lifetime asthma	Population survey Supported by Center for Disease Control and Prevention
Boehmer (2014) and	Telephone-based random digit dialled interview. Had ever been told by a health professional that they had (a named condition)	Adults aged over 20 with telephone and living in California	Identified as heterosexual; gay or lesbian; bisexual (excluded celibate and non-sexual responses)	Heterosexual women	California Health Interview Survey 2001-7	Heart disease, hypertension, hypertensive medication, diabetes, asthma	Population survey. Supported by – NR
Wallace	Telephone-based	Lesbian and bisexual	NR	Heterosexual	California Health	(Heart disease,	Population survey.

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
(2011)	survey. Question NR	women aged 50-70		women aged 50-70	Interview Surveys 2003-7	hypertension, diabetes,)	Supported by California Wellness Foundation
Farmer (2013)	In-home survey. Had ever been told by a health professional that they had diabetes or sugar diabetes, responded yes to currently taking anti-hypertensives	Adults aged 20-69 who completed the sexual behaviour survey. National, USA	Do you think of yourself as heterosexual or straight (attracted only to men); homosexual or lesbian (sexually attracted only to women); bisexual (sexually attracted to men and women); something else or not sure.	Heterosexual women	National Health and Nutrition Examination Survey (NHANES) 2001-8	Diabetes, anti-hypertensive medication	National population survey Supported by National Institute for Drug Abuse and National Institute on Alcohol Use and Alcoholism grants.
Studies based on single waves of cohort studies							
Everett (2013) and Clark (2015)	Interviewer collected Hypertension results (Everett) and diabetes from fasting blood glucose sample, non-fasting glucose sample, HbA1c or self-report health provider diagnosis	Follow up 10-15 years after, from sample recruited originally through schools. National, USA	100% heterosexual (straight); mostly heterosexual (straight) but somewhat attracted to people of your own sex; bisexual – attracted to males and females equally; mostly homosexu	100% heterosexual women	Wave IV of National Longitudinal Study of Adolescent Health 2007-8	Everett 2013 - Hypertension of >140 SBP and >90 DBP. Clarke 2015 - Diabetes (and antihypertensive medication)	National population cohort Supported by Eunice Shriver National Institute of Child Health and Human Development grant. (Everett 2013) and National Center for Advancing translational sciences

First author (year)	Survey method, Exposure	Population, setting, country	Sexual orientation/ behaviour question	Comparison	Recruitment, data collection	Outcomes of interest*	Study design, funding
	or use of anti-diabetic medication in previous 4 weeks (Clarke 2015)		al (gay) but somewhat attracted to people of the opposite sex; 100% homosexual (gay).				grant. (Clarke 2015)
McNair (2011)	Self-completion questionnaire. Had been diagnosed or treated for a range of illnesses over the previous 3 years	Original sample aged 18-23 selected randomly from database of Medicare Australia	Exclusively heterosexual, mainly heterosexual, bisexual, mainly homosexual (lesbian)	Exclusively heterosexual women	Third survey of the young cohort of women in the Australian Longitudinal Study on Women's Health 2003	Asthma,	National population cohort Supported by Lesbian Health Fund, USA

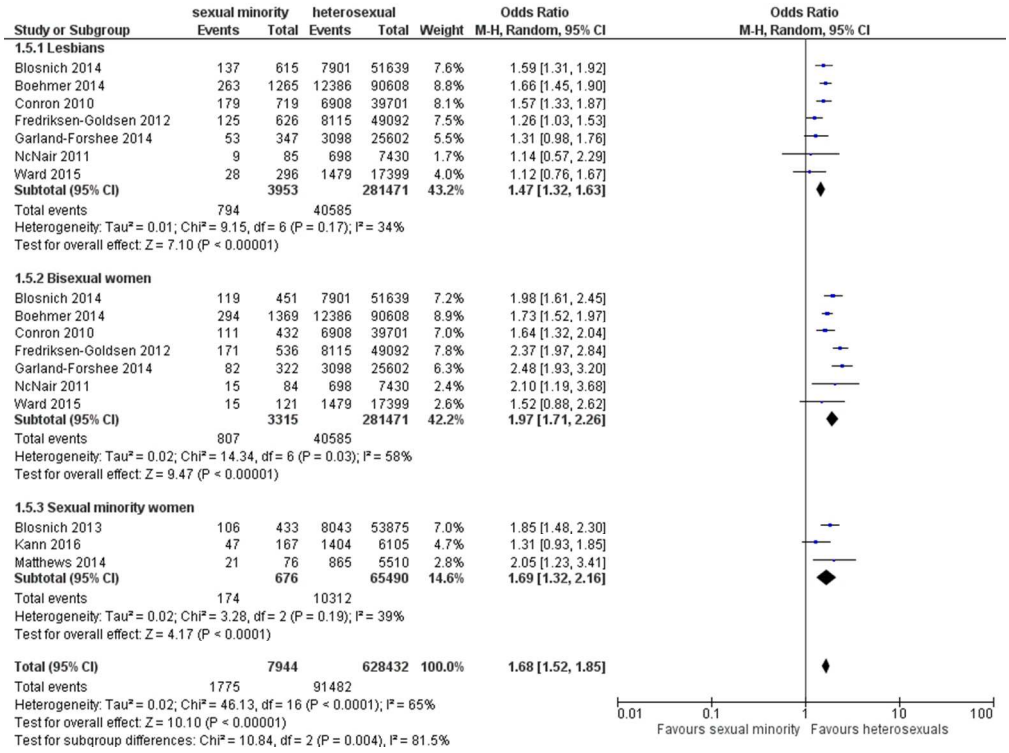
* outcomes in brackets were reported in included study texts but not used in the systematic review due to elimination of duplicate reporting.

Table 2. Prevalence of asthma by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	15.3%# (SE 0.003)	22.2%# (SE 0.03)	1.50 (1.04 to 2.16)*	26.4%# (SE 0.04)	1.68 (1.07 to 2.63)*		
Blosnich 2013 (lifetime diagnosis)	14.6%# (NR)					26.1%# (NR)	1.72 (1.11 to 2.65)*
Blosnich 2013 (current diagnosis)	9.5% (NR)					21.4% (NR)	2.09 (1.30 to 3.36)*
Boehmer 2014£	13.7% (SE 0.16)	20.8% (SE 1.70)	1.41 (1.14 to 1.73)*	21.5% (SE 1.76)	1.52 (1.24 to 1.87)*	NR	NR
Conron 2010&	17.4%# (SE 0.3)	24.9%# (SE 2.3)	1.68 (1.32 to 2.14)	25.7%# (SE 3.1)	1.58 (1.15 to 2.18)	NR	NR
Fredriksen-Goldsen 2012&	16.5%#	19.9%#	1.23 (NR)	31.9%#	2.17 (NR)*	NR	NR
Garland-Forshee 2014&	12.1%# (11.5 to 12.7)	15.4%# (10.8 to 21.7)	1.2 (0.8 to 1.9)	25.6%# (18.6 to 34.2)	2.4 (1.5 to 3.6)*	NR	NR
Kann 2016 by sexual identity	23.0%# (21.1 to 24.9)	NR	NR	NR	NR	28.3%# (24.4 to 32.6)	NR
Kann 2016 by sexual behaviour	25.8%# (23.5 to 28.2)	NR	NR	NR	NR	31.4%# (26.9 to 36.4)	NR
Matthews 2014	15.7%#	NR	NR	NR	NR	27.7%#	1.94 (0.96 to 3.92)
McNair 2011£	9.4%	10.4%	NR	18.0%*	NR	NR	NR
Ward 2015 (current diagnosis)	8.5% (7.9 to 9.0)	9.5% (6.2 to 14.4)	1.11 (0.70 to 1.76)	12.4% (7.3 to 20.4)	1.53 (0.87 to 2.70)	NR	NR

* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Figure 1. Meta-analysis of asthma in lesbians and in bisexual women



Subgroup meta-analysis of asthma in lesbians, bisexual women and SMW

Title: A systematic review and meta-analysis of diabetes mellitus, cardiovascular and respiratory condition epidemiology in sexual minority women.

Authors: Catherine Meads[1], Adam Martin[2], Jeffrey Grierson[1], Justin Varney[3]

WEB APPENDIX

Web supplement 1. Search strategy for Medline, Embase, PsycInfo and CAB Abstracts. Dec 2016, Medline April 2015

Web Table 1. Participant baseline characteristics

Web Table 2. Critical Appraisal Skills Programme (CASP) quality assessment results

Web Table 3. Prevalence of cardiovascular disease or CVD symptoms by sexual orientation

Web Table 4. Prevalence of hypertension or hypertensive medication use by sexual orientation

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Web Figure 1. PRISMA flow diagram

Web Figure 2a. CVD in lesbians

Web Figure 2b, CVD in bisexual women

Web Figure 3a. Hypertension in lesbians

Web Figure 3b. Hypertension in bisexual women

Web Figure 4a. Diabetes mellitus in lesbians

Web Figure 4b. Diabetes mellitus in bisexual women

Web Supplement 1. – Search strategy for Medline, Embase, PsycInfo and CAB Abstracts. December 2016

Database: Ovid MEDLINE(R) 1948 to Present (including In-Process & Other Non-Indexed Citations)

Search Strategy:

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1 lesbian.mp. or Homosexuality, Female/ (5704)
2 Bisexuality/ or bisexual women.mp. (4142)
3 wsw.mp. (120)
4 WSMW.mp. (5)
5 sexual orientation.mp. or Sexual Behavior/ (56050)
6 sexual identity.mp. (1251)
7 queer.mp. or Homosexuality/ (13250)
8 1 or 2 or 3 or 4 or 5 or 6 or 7 (70952)
9 limit 8 to yr="2015 -Current" (4625)
10 limit 9 to female (3011)
11 Great Britain/ or UK.mp. (276229)
12 10 and 11 (62)

SEARCH QUERY - EMBASE

(('homosexual female':ab,ti or 'bisexual female':ab,ti or 'women who have sex with women':ab,ti and [2015-2016]/py) or ('homosexual female'/exp or 'homosexual female') or 'bisexual female' or 'women who have sex with women' or wsw or wsmw) and (2015:py or 2016:py or 2017:py)) and 'united kingdom'

Database: PsycINFO <1967 to November Week 1 2016>

Search Strategy:

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1 exp Lesbianism/ or exp Sexual Orientation/ or exp Homosexuality/ or exp Bisexuality/ or lesbian$.mp. (30632)
2 bisexual women.mp. (613)
3 wsw.mp. (46)
4 wsmw.mp. (2)
5 sexual identity.mp. (3150)
6 queer.mp. (3030)
7 1 or 2 or 3 or 4 or 5 or 6 (32610)
8 limit 7 to (human and yr="2015 -Current") (3331)
9 limit 8 to female (1815)
10 Great britain.mp. (2848)
11 united kingdom.mp. (8990)

12 uk.mp. (30316)
13 british.mp. (20760)
14 gb.mp. (241)
15 english.mp. (118463)
16 scottish.mp. (2638)
17 welsh.mp. (1111)
18 irish.mp. (3268)
19 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (177759)
20 9 and 19 (57)

Database: CAB Abstracts <1973 to 2016 Week 44>

Search Strategy:

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1 exp Lesbianism/ or exp Sexual Orientation/ or exp Homosexuality/ or exp Bisexuality/ or lesbian$.mp. (2168)
2 bisexual women.mp. (25)
3 wsw.mp. (100)
4 wsmw.mp. (1)
5 sexual identity.mp. (113)
6 queer.mp. (104)
7 1 or 2 or 3 or 4 or 5 or 6 (2365)
8 limit 7 to (human and yr="2015 -Current") [Limit not valid in CAB Abstracts; records were retained] (412)
9 limit 8 to female [Limit not valid in CAB Abstracts; records were retained] (412)
10 Great britain.mp. (34833)
11 united kingdom.mp. (152174)
12 uk.mp. (170127)
13 british.mp. (188436)
14 gb.mp. (8148)
15 english.mp. (41160)
16 scottish.mp. (5784)
17 welsh.mp. (3198)
18 irish.mp. (15558)
19 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 (252567)
20 9 and 19 (10)

Database: OVID Medline April 2015

1 Exp Homosexuality, Female/
2 wsw.tw
3 lesbian*.tw
4 gay.tw
5 LGBT*.tw
6 homosexual*.tw
7 Exp Bisexuality/
8 bisexual*.tw
9 pan?sexual*.tw
10 queer*.tw
11 “sexual orientation”.tw
12 “sexual preference*”
13 ”sexual minorit*”.tw
14 “same sex”.tw
15 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14

Web Table 1. Participant baseline characteristics

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
Blosnich (2014)	51,639	Mean 47.3 (SE 0.16)	61.4% white, 3.6% black, 26.3% Hispanic	615 lesbians, 451 bisexual women	Mean 43.1 (SE 1.33) lesbians, 35.1 (SE 1.41) bisexual women	70.8% white, 4.3% black, 15.9% Hispanic lesbians, 61.1% white, 5.5% black, 24.0% Hispanic bisexual women	SMW younger, fewer partnered, lesbians more educated, more employed, bisexual women less educated, fewer employed, less income.	Age race/ethnicity, education, income	Age race/ethnicity, education, income (only conducted where bivariate analyses p<0.05)
Blosnich (2013)	53,875 opposite sex partnered	Mean 33.0 (SE 0.06)	67.5% white	433 same-sex partnered	Mean 32.7 (SE 0.69)	72.6% white	Same sex partnered lower income,	Education, income, race/ethnicity, overweight, smoking	'weighted to account for sampling design'
Boehmer (2014)	90,608	Mean 43.0 (SE 0.03)	50.1% white, 6.5% black, 13.0% Asian 24.6% Hispanic	1,265 lesbians, 1,369 bisexual women	Mean 42.4 (SE 0.47) lesbians, 36.3 (SE 0.53) bisexual women	68.5% white, 7.4% black, 4.9% Asian 11.8% Hispanic lesbians, 57.6% white, 10.0% Asian 7.0% black, 16.9% Hispanic bisexual women	SMW younger, more white, more educated, more US born, lesbians more income, bisexual women less income, fewer with health insurance	Unadjusted prevalence reported	Age, race/ethnicity, education, household income, nativity
Conron (2010)	39,701	35.2% aged 18-33	83.2% white, 4.1% black, 2.6% Asian, 8.9% Hispanic	719 lesbian, 432 bisexual women	30.4% lesbians, 65.1% bisexual women aged 18-33	87.2% white, 4.5% black, 1.2% Asian, lesbian, 5.7% Hispanic	Lesbians more educated	Age, gender	Age, gender, education, income

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
						78.9% white, 4.7% black, 5.7% Asian, 9.3% Hispanic bisexual women			
Dilley (2010)	47,505	Mean 46.3	85.6% white, 1.8% black, 3.6% Asian, 7.1% Hispanic	589 lesbian, 561 bisexual women	Mean 40.0 lesbian, 32.9 bisexual women.	85.5% white, 1.6% black, 3.1% Asian, 7.2% Hispanic	More higher education in lesbians, less in bisexual women. Lesbians and bisexuals lower income.	Assumed that unadjusted prevalence reported	Sexual orientation, age, education
Everett (2013) and	6,072	Mean 28.7 (whole sample)	NR	138 gay/mostly gay 1345 bisexual/ mostly heterosexual,	NR	NR	NR	Possibly unadjusted prevalence reported	N/A
Clarke (2015)	5713	Mean 28.8 (95%CI 28.6 to 29.1)	67.7% white	71 homosexual, 60 mostly homosexual, 154 bisexual, 1089 mostly heterosexual	Mean (95%CI) 28.9 (28.3 to 29.5), homosexual, 28.4 (27.8 to 29.0) mostly homosexual, 28.3 (27.9 to 28.6) bisexual, 28.5 (28.2 to 28.7) mostly heterosexual	White 64.1% homosexual, 73.2% mostly homosexual, 69.4% bisexual, 77.5% mostly heterosexual	NR	See above	N/A

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
Farmer (2013)	5,356	36.2% aged 20-29	69.8% white, 12.0% black, 12.9% Hispanic	437 SMW	49.2% aged 20-29	73.4% white, 13.2% black, 8.6% Hispanic	SMW younger	Possibly unadjusted prevalence reported	N/A
Fredriksen-Goldsen (2012)	49,092	Mean 46.6 (SE 0.12)	83.7% white	626 lesbians, 536 bisexual women	Mean 42.9 (SE 0.81) lesbian, 32.7 (SE 0.85) bisexual women	85.4% white lesbian, 78.2% white bisexual women.	SMW younger, fewer partnered, lesbians less education, bisexual women lower income	Age	Age, education, income
Fredriksen-Goldsen (2013)	57,466	Mean 63.8 (SD 0.06)	91.8% white	562 lesbians, 291 bisexual women	Mean 58.6 (SD 0.37)	90.3% white	SMW more employed, fewer partnered, fewer less educated	Unclear weighting factors	Age, education, income
Frisch (2013)	61,993,266	Aged 18+	NR	655,941 same sex cohabiting	Aged 18+	NR	NR	(Mortality estimate - by age)	N/A
Garland-Forshee (2014)	25,602	28.8% aged 18-34	86.7% white	347 lesbians, 322 bisexual women	26.9% lesbian, 62.3% bisexual women aged 18-34	81.6% lesbians, 85.8% bisexual women white	SMW less likely to be partnered, more education, more urban residence, Lesbians more employed, Bisexual women younger, less income	Unclear weighting factors	Age, education, relationship status, rural or urban residency
Jackson (2016)	37,185	NR	68.3% white, 12.3%	525 lesbians, 353 bisexual women	NR	71.4% white, 12.7% black,	Lesbians more educated, fewer	Age, ethnicity, educational attainment,	Age race/ethnicity, education,

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
			black, 12.9% Hispanic			12.5% Hispanic lesbian 73.5% white, 16.0% black, 7.2% Hispanic bisexual women	partnered, bisexual women less income	annual household income, occupational class, health status, region of residence	income, occupational class, health status, region of residence
Ward (2015)	17,399	NR	NR	296 lesbians, 121 bisexual women	NR	NR	NR	As Jackson 2016 above	Age, race/ethnicity, education, income, marriage status, employment, health insurance status, region of residence
Kann (2016) identity	6,105	NR	NR	167 lesbian, 734 bisexual women	NR	NR	NR	Sex, race/ ethnicity and grade	N/A
Kann (2016) behaviour	3,054	NR	NR	173 lesbians, 572 bisexual women	NR	NR	NR	Sex, race/ ethnicity and grade	N/A
Matthews (2014)	6,110	25.7% aged 18-34	71.3% white, 20.7% black, 5.2% Hispanic	86 SMW	40.6% aged 18-34	77.7% white, 14.1% black, 1.7% Hispanic	SMW younger, more likely to use mobile phones	Survey design	Age
McNair (2011)	8,083	25-30	NR	99 lesbians, 100 bisexual women	25-30	NR	SMW lower income, less likely to be partnered, fewer with	Unclear weighting factors	N/A

	Number of hetero-sexual women	Age	Ethnicity	Number of lesbians/bisexual/SMW	Age	Ethnicity	Demographic imbalances compared to heterosexual women.	Prevalence estimates weighted by:	Adjusted odds ratios weighted by:
							children, more urban residence, Lesbians more educated, bisexual women less educated,		

Web Table 2. Critical Appraisal Skills Programme (CASP) quality assessment results

Study	1	2	3	4	5a	5b	6a	6b	9	10	11
Blosnich (2014)	Y	Y	Y	N	n	CT	N/A	N/A	Y	Y	Y
Blosnich (2013)	Y	Y	CT	N	N	CT	N/A	N/A	Y	Y	Y
Boehmer (2014)	Y	Y	Y	N	CT	N	N/A	N/A	Y	Y	Y
Clarke (2015)	Y	Y	Y	Y	N	CT	N/A	N/A	Y	Y	Y
Conron (2010)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Dilley (2010)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Everett (2013)	Y	Y	Y	Y	N	CT	N/A	N/A	Y	Y	Y
Farmer (2013)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Fredriksen-Goldsen (2012)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Fredriksen-Goldsen (2013)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Frisch (2013)	Y	Y	CT	Y	N	CT	CT	Y	Y	Y	N/A
Garland-Forshee (2014)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Jackson (2016)	Y	Y	Y	N	N	Y	N/A	N/A	Y	Y	Y

Study	1	2	3	4	5a	5b	6a	6b	9	10	11
Kann (2016)	Y	Y	Y	N	N	Y	N/A	N/A	Y	Y	Y
Matthews (2014)	Y	Y	Y	N	CT	CT	N/A	N/A	Y	Y	Y
McNair (2011)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y
Ward (2015)	Y	Y	Y	N	N	CT	N/A	N/A	Y	Y	Y

The checklist questions were 1. Did the study address a clearly focused issue? 2. Was the cohort recruited in an acceptable way? 3. Was the exposure accurately measured to minimise bias? 4. Was the outcome accurately measured to minimise bias? 5a. Have the authors identified all important confounding factors? 5b) Have they taken account of the confounding factors in the design and/or analysis? 6a. Was the follow up of subjects complete enough? 6b. Was the follow up of subjects long enough? 9. Do you believe the results? 10. Can the results be applied to the local population? 11. Do the results of this study fit with other available evidence?

Web Table 3. Prevalence of CVD by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	5.8%# (SE 0.002)	5.0%# (SE 0.002)	NR	7.0%# (SE 0.024)	NR	NR	NR
Boehmer 2014£	4.9% (SE 0.11)	5.8% (SE 1.30)	1.46 (0.92 to 2.34)	3.8% (SE 0.75)	1.14 (0.75 to 1.72)	NR	NR
Conron 2010&	1.3%# (SE 0.1)	1.8%# (SE 0.6)	1.92 (0.95 to 3.87)	3.3%# (SE 2.2)	2.24 (0.53 to 9.43)	NR	NR
Fredriksen-Goldsen 2013&	10.7%#	NR	NR	NR	NR	10.5%#	1.37 (1.00 to 1.86)*
Garland-Forshee 2014&	6.2%# (5.8 to 6.6)	4.0%# (2.1 to 7.5)	1.0 (0.5 to 1.9)	1.8%# (0.6 to 6.0)	0.7 (0.2 to 2.9)	NR	NR
Jackson 2016 (heart disease)	10.8%	9.9%	0.91 (0.61 to1.35)	7.2%	0.73 (0.40 to 1.35)	NR	NR
Jackson 2016 (stroke)	3.2%	5.8%	1.96 (1.14 to 3.39)*	3.4%	1.68 (0.71 to 3.97)	NR	NR
Matthews 2014	4.1%	NR	NR	NR	NR	0.4%	0.19 (0.04 to 0.87)

* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Table 4. Prevalence of hypertension (or hypertensive medication use) by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Boehmer 2014	21.2% (SE 0.19)	19.0% (SE 1.81)	0.99 (0.77 to 1.26)	17.6% (SE 1.70)	1.21 (0.95 to 1.53)	NR	NR
Boehmer 2014 (medication use)	65.3% (SE 0.47)	66.0% (SE 4.29)	1.57 (0.90 to 2.75)	45.0% (SE 4.69)	0.74 (0.44 to 1.24)	NR	NR
Dilley 2010	22.7% (22.1 to 23.4)	14.7% (9.8 to 21.4)	1.0 (0.6 to 1.7)	17.0% (12.2 to 23.1)	1.6 (1.1 to 2.5)*	NR	NR
Everett 2013&	12.2%# (SE 0.65)	10.3%# (SE 3.21)	NR	11.4%# (SE 1.19)	NR	NR	NR
Farmer 2013£ (medication use)	14.7%	NR	NR	NR	NR	11.6%	Not statistically significant
Garland-Forshee 2014	25.6%# (24.3 to 26.8)	22.9%# (13.8 to 35.7)	1.2 (0.6 to 2.4)	12.4%# (7.5 to 19.9)	0.9 (0.5 to 1.7)	NR	NR
Jackson 2016	35.5%	32.2%	0.91 (0.74 to 1.12)	32.1%	0.96 (0.71 to 1.31)	NR	NR
Matthews 2014	33.2%	NR	NR	NR	NR	22.0%	1.00 (0.43 to 2.33)

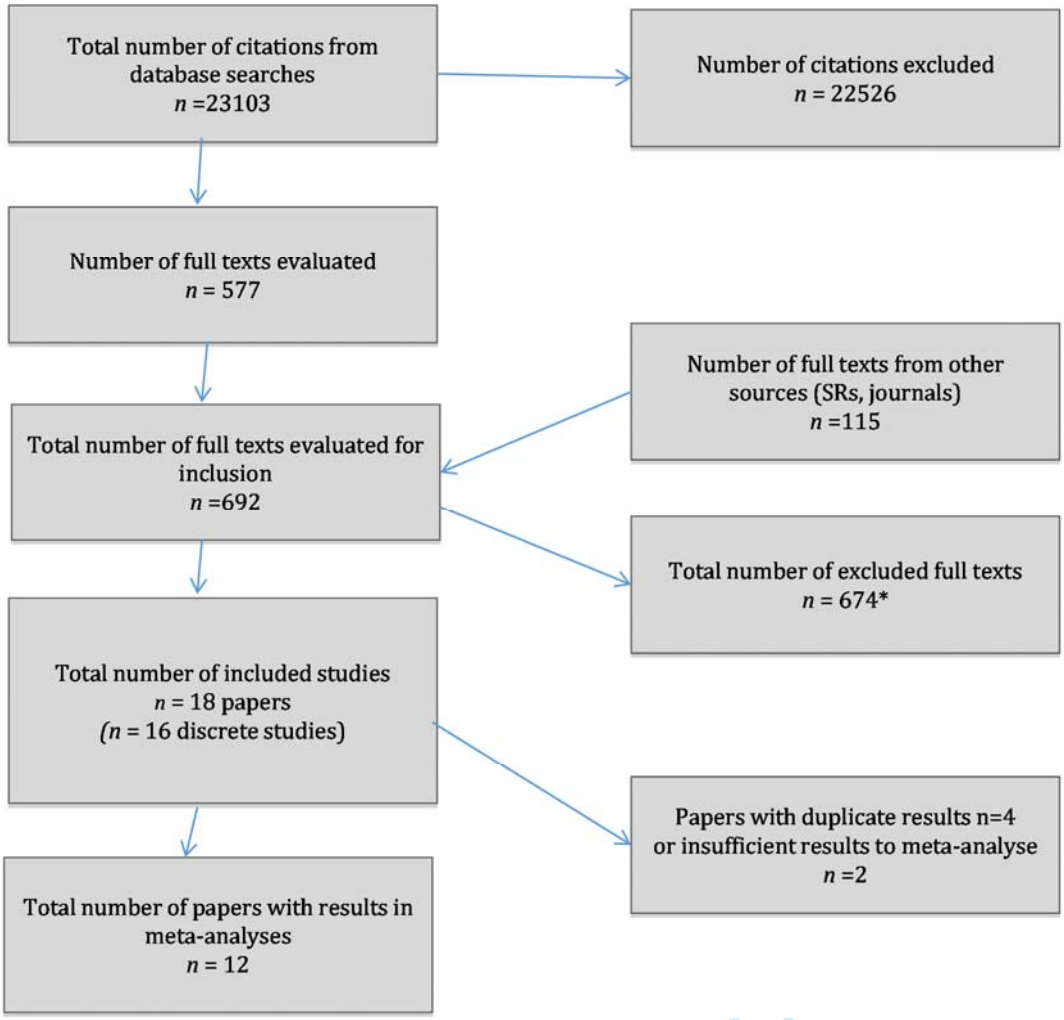
* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Table 5. Prevalence of any type of diabetes mellitus by sexual orientation

Study name	Heterosexual	Lesbian	AOR (95%CI)	Bisexual	AOR (95%CI)	SMW	AOR (95%CI)
Blosnich 2014&	10.2%# (SE 0.002)	6.8%# (SE 0.016)	NR	6.1%# (SE 0.016)	0.75 (0.44 to 1.29)	NR	NR
Boehmer 2014£	5.7% (SE 0.12)	4.6% (SE 0.74)	1.07 (0.76 to 1.50)	4.2%	1.10 (0.79 to 1.55)	NR	NR
Clark 2015	6.0%	1.9%	NR	6.8%	NR	7.2%	NR
Conron 2010	3.9% (SE 0.1)	3.8% (SE 0.9)	1.23 (0.74 to 2.06)	3.9% (SE 1.1)	1.04 (0.62 to 1.76)	NR	NR
Dilley 2010	6.3% (6.0 to 6.5)	5.1% (3.3 to 7.7)	1.3 (0.8 to 2.0)	5.8% (3.8 to 8.8)	1.8 (1.1 to 2.8)*	NR	NR
Farmer 2013	5.3%	NR	NR	NR	NR	6.4%	Not statistically significant
Garland-Forshee 2014	6.5% (6.1 to 6.8)	10.8% (4.1 to 26.0)	2.2 (0.6 to 7.8)	2.4% (1.2 to 5.0)	0.8 (0.4 to 1.6)	NR	NR
Jackson 2016	10.7%	7.7%	0.88 (0.58 to 1.34)	7.1%	0.63 (0.33 to 1.20)	NR	NR
Matthews 2014	11.3%#	NR	NR	NR	NR	4.3%#	0.55 (0.17 to 1.82)

* - statistically significant to p<0.05 or less, # - weighted percentages, & - calculated from weighted percentages, £ - calculated from unweighted percentages, RR – relative risk.

Web Figure 1. PRISMA flow diagram

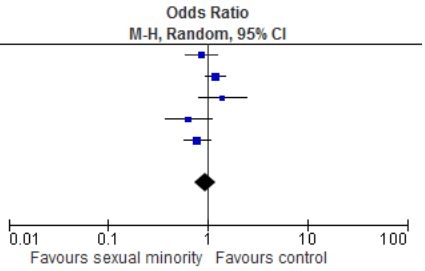


* Reasons for 674 full text exclusions: case studies = 7, diagnostic studies = 8, experimental studies = 8, in children only = 7, no comparison with heterosexual women = 1, no relevant numerical outcomes = 94, pilot studies = 2, qualitative studies = 123, results in men and women combined only = 124, reviews/editorials = 74, surveys on wrong topic = 226.

Web Figure 2a. CVD in lesbians

Study or Subgroup	Sexual minority Events	Total	Heterosexual Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Blosnich 2014	31	615	2995	51639	21.0%	0.86 [0.60, 1.24]
Boehmer 2014	73	1265	4440	90608	28.0%	1.19 [0.94, 1.51]
Conron 2010	13	719	516	39701	13.3%	1.40 [0.80, 2.44]
Garland-Forshee 2014	14	347	1587	25602	13.9%	0.64 [0.37, 1.09]
Jackson 2016	44	525	3905	37185	23.8%	0.78 [0.57, 1.06]
Total (95% CI)		**3471**		**244735**	**100.0%**	**0.94 [0.73, 1.21]**
Total events	175		13443			

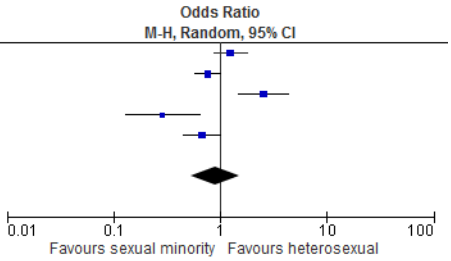
Heterogeneity: Tau² = 0.04; Chi² = 9.23, df = 4 (P = 0.06); I² = 57%
Test for overall effect: Z = 0.47 (P = 0.64)



Web Figure 2b, CVD in bisexual women

Study or Subgroup	Sexual minority Events	Total	Heterosexual Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Blosnich 2014	32	451	2995	51639	21.7%	1.24 [0.86, 1.78]
Boehmer 2014	52	1369	4440	90608	22.7%	0.77 [0.58, 1.01]
Conron 2010	14	432	516	39701	19.2%	2.54 [1.48, 4.36]
Garland-Forshee 2014	6	322	1587	25602	15.2%	0.29 [0.13, 0.65]
Jackson 2016	26	353	3905	37185	21.2%	0.68 [0.45, 1.01]
Total (95% CI)		**2927**		**244735**	**100.0%**	**0.90 [0.54, 1.51]**
Total events	130		13443			

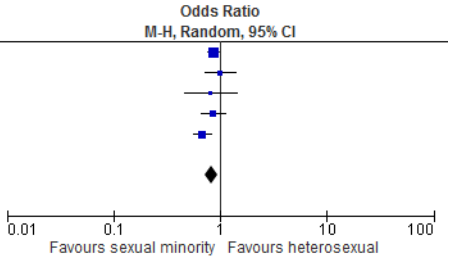
Heterogeneity: Tau² = 0.29; Chi² = 29.32, df = 4 (P < 0.00001); I² = 86%
Test for overall effect: Z = 0.40 (P = 0.69)



Web Figure 3a. Hypertension in lesbians

Study or Subgroup	Sexual minority Events	Total	Heterosexual Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Boehmer 2014	240	1265	19209	90608	37.9%	0.87 [0.76, 1.00]
Dilley 2010	42	185	5216	22979	11.6%	1.00 [0.71, 1.41]
Everett 2013	14	138	741	6072	5.0%	0.81 [0.46, 1.42]
Garland-Forshee 2014	79	347	6554	25602	19.0%	0.86 [0.67, 1.10]
Jackson 2016	134	525	12491	37185	26.5%	0.68 [0.56, 0.83]
Total (95% CI)		**2460**		**182446**	**100.0%**	**0.82 [0.72, 0.94]**
Total events	509		44211			

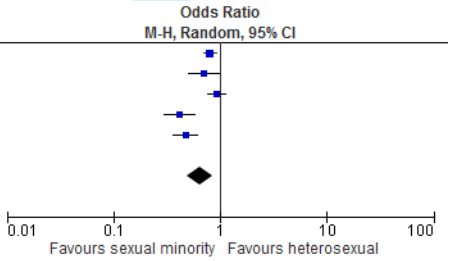
Heterogeneity: Tau² = 0.01; Chi² = 5.66, df = 4 (P = 0.23); I² = 29%
Test for overall effect: Z = 2.97 (P = 0.003)



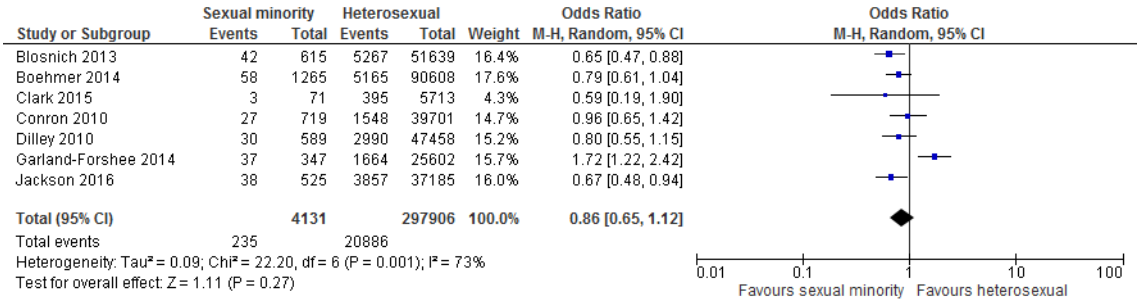
Web Figure 3b. Hypertension in bisexual women

Study or Subgroup	Sexual minority Events	Total	Heterosexual Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Boehmer 2014	241	1369	19209	90608	22.6%	0.79 [0.69, 0.91]
Dilley 2010	45	265	5216	22979	18.1%	0.70 [0.50, 0.96]
Everett 2013	153	1345	741	6072	21.7%	0.92 [0.77, 1.11]
Garland-Forshee 2014	40	322	6554	25602	17.9%	0.41 [0.30, 0.57]
Jackson 2016	68	353	12491	37185	19.7%	0.47 [0.36, 0.62]
Total (95% CI)		**3654**		**182446**	**100.0%**	**0.64 [0.49, 0.85]**
Total events	547		44211			

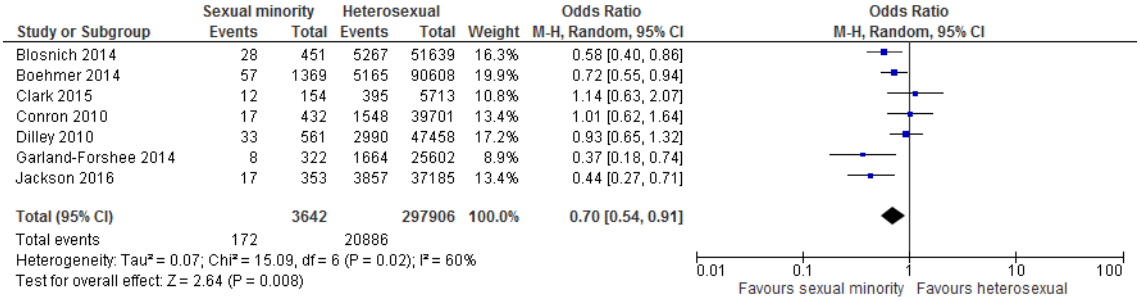
Heterogeneity: Tau² = 0.08; Chi² = 29.59, df = 4 (P < 0.00001); I² = 86%
Test for overall effect: Z = 3.11 (P = 0.002)



Web Figure 4a. Diabetes mellitus in lesbians



Web Figure 4b. Diabetes mellitus in bisexual women



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4,5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	5
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	5
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5,32
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	15-19
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	27
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	5-7, 20, 29-31
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	21,33,34
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	See 5
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	7
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	8,9
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	9,10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	1

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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