A Population-Based Study of Cardiovascular Disease Risk in Sexual-Minority Women

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Cardiovascular disease (CVD) is the leading cause of death for women in the United States and has a mortality rate for women 10 times greater than that of breast cancer.[1] Although there has been a significant reduction in CVD mortality rates in recent years, the decline in CVD deaths has been significantly smaller for women than for men.[2] The leading modifiable risk factors for CVD include smoking, physical inactivity, obesity, elevated lipid levels, and diabetes.[3] With the exception of smoking, women have a greater prevalence of these risk factors than men.[2]

Subgroups of women may be at greater risk for CVD relative to all women. Sexual minority women (SMW; i.e., women who identify a sexual orientation other than heterosexual or who engage in same-sex sexual behavior) may be one such group because, in part, of increased prevalence of certain CVD risk factors. A growing line of research indicates that SMW are more likely to smoke are than heterosexual women.[4,5] In a systematic review of 42 studies from 1987 to 2007, Lee et al. found that SMW were 1.5 to 2 times more likely to smoke than their heterosexual counterparts.[6] Moreover, being overweight (body mass index [BMI; defined as weight in kilograms divided by the square of height in meters] = 25–29.9 kg/m^2) or obese (BMI ≥ 30 kg/m^2) may also contribute to increased CVD risk among SMW.[3] Previous studies have found that SMW have a higher prevalence of being overweight or obese than their heterosexual counterparts.[4,7–11] For instance, using the National Family Growth Survey, Boehmer et al. found that SMW (defined as lesbian-identified women) were more than twice as likely to be overweight or obese than heterosexual women.[8] In addition, SMW have higher rates of heavy alcohol and drug use,[12] which are both independent risk factors for CVD.[13,14] With the increased prevalence of these CVD risk factors among SMW, there is reason to believe that disparities in CVD may exist for SMW.

Objectives. We sought to determine if sexual-minority women were at greater risk for cardiovascular disease (CVD) than their heterosexual counterparts.

Methods. We aggregated data from the 2001–2008 National Health and Nutrition Examination Surveys to examine differences in CVD risk between heterosexual and sexual-minority women by using the Framingham General CVD Risk Score to calculate a ratio of vascular and chronological age. We also examined differences in the prevalence of various CVD risk factors.

Results. Sexual-minority women were more likely to be current or former smokers, to report a history of drug use, to report risky drinking, and to report a family history of CVD. On average, sexual-minority women were 13.9% (95% confidence interval [CI] = 8.5%, 19.3%) older in vascular terms than their chronological age, which was 5.7% (95% CI = 1.5%, 9.8%) greater than that of their heterosexual counterparts. Family history of CVD and history of drug use were unrelated to increased CVD risk, and this risk was not fully explained by either risky drinking or smoking.

Conclusions. Sexual-minority women are at increased risk for CVD compared with heterosexual women. (*Am J Public Health.* 2013;103:1845–1850. doi:10.2105/AJPH.2013.301258)

The recent Institute of Medicine report on the health of lesbian, gay, bisexual, and transgender people noted a paucity of research concerning CVD among sexual minorities in general.[12] Of the few studies conducted, the majority have focused on increased risk of CVD among HIV-infected individuals and among transgender individuals who utilize masculinizing hormones. To date, only a few population-based studies have examined the relationship between sexual minority status and the prevalence of CVD among women. In a study of 4135 women participating in the 1999 Los Angeles County Health Survey, Diamant and Wold found that, even after they adjusted for demographic characteristics, BMI, and current smoking status, self-identified lesbian and bisexual women were significantly more likely to report a diagnosis of heart disease than were their heterosexual counterparts.[15] Conversely, Cochran and Mays found no differences in self-reported heart disease between SMW and heterosexual women in the California Quality of Life Survey.[16] Conron et al. also found no difference in self-reports of cardiovascular

disease between SMW and their heterosexual counterparts when analyzing aggregated 2001–2008 data from the Massachusetts Behavioral Risk Factor Surveillance Survey; however, self-identified lesbians and bisexuals were more likely to report multiple risks for CVD.[4] The reason for these contradictory results is unclear, but it may be the result of differences in age or the geographic distribution of the samples.

The purpose of the current study was to compare the risk for CVD between SMW and heterosexual women by using national population-based health surveillance data. After pooling data from the National Health and Nutrition Examination Survey (NHANES) from 2001 to 2008, we calculated estimates of vascular age for a sample of heterosexual and sexual minority women by utilizing the multivariable Framingham General CVD risk score.[17] Vascular age, which can be conceptualized as the age of a person's heart and vascular system given his or her individual set of CVD risk factors, is a more useful metric than absolute CVD risk in younger to middle-aged populations because it provides an estimate of

CVD risk relative to an individual's chronological age.[18] In the present study, we calculated the ratio of participants' vascular and chronological age as a measure of CVD risk and compared it by sexual minority status. In addition, we compared differences in individual CVD predictor variables across sexual minority status to investigate the primary drivers of CVD risk in this population.

METHODS

We utilized publicly available data from the NHANES, pooled from 2001 to 2008. The NHANES is a nationally representative cross-sectional survey of US adults and children that assesses health and nutritional status by using in-home interviews and physical examinations. In 1999, the NHANES became a continuous program in which approximately 5000 new persons are surveyed each year, and data reports are generated every 2 years. This design is advantageous for studying small population groups, as data can be combined across years to provide adequate sample size. In 2001, questions about participant sexual orientation were added to the sexual behavior interview, and these data were reported in the public-use data set for all participants aged 20 to 59 years from 2001 to 2006 and for all participants aged 20 to 69 in 2007 to 2008. Survey response rates for the NHANES-examined sample ranged from 75% to 80% for the 8-year period.[19] More detailed information regarding the NHANES design and sampling strategies are described elsewhere.[20–23]

From 2001 to 2008, 6179 women aged 20 to 69 years completed the sexual behavior survey. For the present study, we excluded 149 (2.4%) because they either refused to answer the sexual orientation question or provided a "not sure" or "don't know" response. We excluded another 237 women (3.8%) because of preexisting cardiovascular disease (self-reported congestive heart failure, coronary heart disease, angina, heart attack, or stroke), resulting in a final analytic sample of 5793 women.

Measures

Sexual minority status. The NHANES contains measures of both sexual orientation and sexual behavior. Sexual orientation was assessed of all participants with the question:

Do you think of yourself as . . . heterosexual or straight (that is, sexually attracted only to men); homosexual or lesbian (that is, sexually attracted only to women); bisexual (that is, sexually attracted to men and women); something else; or you're not sure?

Sexual behavior was assessed in participants who indicated ever having had engaged in sexual intercourse by asking participants to provide the total number of their lifetime same-sex and opposite-sex sexual partners. For the present study, we defined sexual-minority women (SMW) as women who either self-identified as lesbian, bisexual, or something else, or who reported having had at least 1 lifetime same-sex sexual partner.

Cardiovascular disease risk. We assessed CVD risk by using the Framingham General CVD risk score. The Framingham score is a sex-specific, multivariable, risk factor algorithm that utilizes several established CVD risk factors to predict both the absolute 10-year likelihood of developing a first CVD event as well as an estimate of vascular age.[17] Vascular age is defined as the chronological age of a person with the same predicted CVD risk if he or she has risk factor levels in the normal range. As such, vascular and chronological age will be equal when a person has a normal risk factor profile, and the ratio of his or her vascular and chronological age will be equal to 1. For example, the vascular age of a 40-year-old female smoker with untreated systolic blood pressure between 140 and 149 millimeters of mercury is 55, and the ratio of her vascular to chronological age is 1.375. This ratio indicates that her vascular system is 37.5% older than would be expected with her chronological age. As age is a primary driver of CVD risk, the use of vascular age is a more appropriate measure of CVD risk in younger to middle-aged populations, as it is rare for persons in this age group to exhibit increased absolute risk whether they have multiple CVD risk factors.[18]

The risk factors included in the Framingham algorithm are age, sex, high-density lipoprotein (HDL) and total cholesterol level, systolic blood pressure, antihypertensive medication use, diabetes, and current smoking status. We considered a woman to have a normal risk factor profile if she did not currently smoke, was nondiabetic, had a total cholesterol level less than 160 milligrams per deciliter, had a

HDL cholesterol level of 45 milligrams per deciliter or greater, and had an untreated systolic blood pressure of 120 to 129 millimeters of mercury. We classified women as current smokers if they answered either "some days" or "every day" to the question "Do you now smoke cigarettes?" and we considered women diabetic if they answered "yes" to the question "Other than during pregnancy, have you ever been told by a doctor or health professional that you have diabetes or sugar diabetes?"

Additional covariates. In addition to the variables that comprise the Framingham risk score, we assessed participants' family history of early CVD, BMI, education, annual household income, race/ethnicity, history of hard drug use, and alcohol use. We considered participants to have a family history of premature CVD if they answered "yes" to the question

Including living and deceased, were any of your close biological, that is, blood relatives, including father, mother, sisters or brothers, ever told by a health professional that they had a heart attack or angina before the age of 50?

We recoded participants' current BMI into 3 categories based on National Institutes of Health guidelines: less than 25 kg/m^2 (normal or underweight), 25 kg/m^2 to 29.9 kg/m^2 (overweight), and 30 kg/m^2 or more (obese).[24] We recoded education into 4 categories (< high school, high school, some college, ≥ college graduate) and recoded income into 5 categories (< $25 000, $25 000 to $34 999, $35 000 to $44 999, $45 000 to $54 999, and ≥ $55 000). We retained the original NHANES race/ethnicity categories (non-Hispanic White, non-Hispanic Black, Mexican American, other Hispanic, other race—including multiracial).

We considered participants to have a history of hard drug use if they answered "yes" to the question "Have you ever used cocaine, including crack or freebase, or other street drugs? Do not include marijuana." if surveyed in the years 2001–2004, or if they answered "yes" to the question "Have you ever used cocaine, crack cocaine, heroin, or methamphetamine?" if surveyed in the years 2005–2008. We classified participants into 3 categories of alcohol users (risky drinkers, social drinkers, infrequent drinkers) based on the National Institute on Alcohol Abuse and Alcoholism criteria for risky drinking.[25] We classified participants as risky drinkers if, during

the past 12 months, they indicated having on average either 4 or more drinks per day or more than 7 drinks per week, or they indicated at least 1 occasion where they drank 5 or more drinks in a day. Participants were classified as social drinkers if they indicated having had 12 or more alcoholic beverages in their lifetime, but did not meet any of the 3 criteria for risky drinking. Participants were classified as infrequent drinkers if they indicated they had not had at least 12 drinks in their lifetime. Lifelong abstention was not directly assessed in the survey.

Statistical Analyses

We analyzed data by using SAS version 9.3 (SAS Institute, Cary, NC), incorporating both the design information and weights as specified in the NHANES Analytic and Reporting Guidelines.[26] We compared demographic characteristics and individual CVD risk factors by sexual minority status by using the χ^2 test for proportions and the student t test for continuous variables. We used linear regression to examine whether the ratio of vascular to chronological age varied by sexual minority status. We used multivariate linear regression to adjust for differences on demographic characteristics and other covariates that were not incorporated into the Framingham calculation. We did not consider BMI as a possible adjustment variable, as it is both highly correlated with dyslipidemia, hypertension, and diabetes, and is used as a proxy for lipid levels in the Framingham score when laboratory information is unavailable.[3,17]

We considered variables candidates for adjustment if they exhibited a statistically significant difference by sexual minority status at the $\alpha = 0.10$ level. We used a 10% change in the parameter estimate for sexual minority status as the final criterion for determining which variables to retain as covariates in the final model. In addition, we conducted a sensitivity analysis to examine the extent to which using a narrower definition of sexual minority women affected the study's results. This narrower definition included only those women who self-identified as "lesbian," "bisexual," or "something else."

RESULTS

Table 1 provides a summary of demographic characteristics and individual CVD risk

TABLE 1—Demographic Characteristics and Cardiovascular Risk Factors of Female NHANES Participants From 2001 to 2008 by Sexual Minority Status: United States

Variable	Heterosexual Women (n = 5356), % or Mean (SE)	Sexual Minority Women[a] (n = 437), % or Mean (SE)	P
Demographic characteristics			
Age, y			<.001
20–29	36.2	49.2	
30–39	27.2	27.4	
40–49	27.3	18.2	
50–59	9.4	5.3	
Race			.13
Non-Hispanic White	69.8	73.4	
Non-Hispanic Black	12.0	13.2	
Mexican American	8.0	5.1	
Other Hispanic	4.9	3.5	
Other (including multiracial)	5.3	4.8	
Education			.23
< high school	13.7	15.5	
High school	22.7	20.0	
Some college	34.7	39.5	
≥ college graduate	28.8	25.0	
Annual household income, $			.15
< 25 000	25.6	32.1	
25 000–34 999	13.8	14.9	
35 000–44 999	12.6	11.6	
45 000–54 999	13.0	12.3	
≥ 55 000	35.0	29.1	
CVD risk factors			
Smoking status			<.001
Smoker	22.7	38.0	
Former smoker	17.7	26.4	
Nonsmoker	59.6	35.6	
Diabetes: yes	5.3	6.4	
Antihypertensive medication: yes	14.7	11.6	
Family history of CVD: yes	8.7	12.2	
Body mass index, kg/m^2	28.3 (0.18)	29.1 (0.54)	.18
BMI category			.29
Normal/underweight (< 25 kg/m^2)	55.2	51.5	
Overweight (25–29.9 kg/m^2)	19.1	18.5	
Obese (≥ 30 kg/m^2)	25.7	30.0	
Total cholesterol, mg/dL	198.5 (0.80)	192.0 (2.50)	.01
HDL cholesterol, mg/dL	58.3 (0.37)	57.0 (0.99)	.2
Systolic blood pressure, mm Hg	116.1 (0.30)	115.5 (0.85)	.47
History of drug use (excluding marijuana): yes	28.1	46.4	
Alcohol use[b]			<.001
Risky drinker	23.7	46.9	
Social drinker	62.6	47.2	
Infrequent drinker	13.7	5.8	

Note. BMI = body mass index; CVD = cardiovascular disease; NHANES = National Health and Nutrition Examination Survey.
[a]Included women who identified as "lesbian," "bisexual," or "something else" and straight-identified women with at least 1 lifetime same-sex sexual partner.
[b]Based on the National Institute on Alcohol Abuse and Alcoholism criteria for risky drinking.[25]

factors by sexual minority status. Of the 5793 women in the sample, 8.2% were classified as SMW and 91.8% were classified as straight or heterosexual. Of the 8.2% of SMW, 1.3% identified as "lesbian," 2.6% identified as "bisexual," 0.4% identified as "something else," and 3.9% were women who self-identified as "straight" but reported 1 or more lifetime same-sex sexual partners. A majority (65.8%) of the SMW who self-identified as "straight" reported only 1 lifetime same-sex sexual partner.

The SMW were more likely to be younger in terms of chronological age than heterosexual women ($P < .001$), but were similar with regard to all other demographic characteristics. In addition, SMW were more likely to be current smokers (38.0% vs 22.7%) or former smokers (26.4% vs 17.7%), were more likely to have a history of hard drug use (46.4% vs 28.1%), were more likely to be risky drinkers (46.9% vs 23.7%), were more likely to have a family history of premature CVD (12.2% vs 8.7%), and were more likely to have lower total cholesterol (192.0 mg/dL vs 198.5 mg/dL). Although a significantly ($P < .001$) greater percentage of SMW reported binge drinking in the past 12 months compared with heterosexual women (39.9% vs 20.0%), there was not a significant difference in the percentage of risky drinkers who reported binge drinking by sexual minority status. Moreover, there were no statistically significant differences by sexual minority status with regard to diabetes status, HDL cholesterol, systolic blood pressure, use of antihypertensive medication, mean BMI, or the percentage of participants who could be considered overweight or obese.

The mean ratio of vascular to chronological age for the entire sample was 1.087, indicating that, on average, participants' vascular age was 8.7% greater than their chronological age. All subsequent ratios will be expressed as percentages to aid in interpretation. Regression analysis revealed a statistically significant difference in this percentage by sexual minority status. The SMW were on average 13.9% (95% confidence interval [CI] = 8.5%, 19.3%) older in vascular terms than their chronological age, which was 5.7% (95% CI = 1.5%, 9.8%) greater than that of their heterosexual counterparts.

Three variables emerged as potential candidates for adjustment in the bivariate analysis: family history of premature CVD, history of

hard drug use, and alcohol use. Both family history of premature CVD and history of hard drug use failed to achieve statistical significance in a multivariate analysis, and neither appreciably changed the parameter estimate for sexual minority status (0.9% and 4.0%, respectively, well under the required 10% change). Thus, we excluded them from further consideration. Alcohol use was statistically significant in the multivariate analysis ($P < .001$ for risky drinkers and $P = .002$ for infrequent drinkers) and produced a 17.5% change in the parameter estimate for sexual minority status; thus, we retained it as an adjustment variable. After adjustment for alcohol use, the effect of sexual minority status on CVD risk decreased from 5.7% to 4.7% (95% CI = 0.5%, 9.0%), but retained statistical significance.

When we performed a sensitivity analysis narrowing the definition of sexual minority status to only those who self-identified as "lesbian," "bisexual," or "something else," the unadjusted difference in the ratio of vascular to chronological age between sexual minority and heterosexual women increased from 5.7% to 7.5% (95% CI = 2.4%, 12.6%). As with the broader definition of sexual minority status, this ratio declined after adjustment for alcohol use from 7.5% to 6.4% (95% CI = 1.4%, 11.4%), but retained statistical significance. Table 2 provides a summary of these findings.

Because of the significantly higher prevalence of both current and former smoking among the SMW in our sample, we were

interested in determining if smoking status was responsible for their increased CVD risk. To make this determination, we recalculated vascular age for all participants leaving smoking status out of the Framingham calculation, and then reran our multivariate regression models adjusting for both smoking status and alcohol use. The results of this analysis indicated that, even after we accounted for smoking status and alcohol use, SWM were 3.6% (95% CI = 0.0%, 7.3%) older in vascular terms than their heterosexual counterparts when we used the broad definition of sexual minority status, and 5.1% (95% CI = 0.2%, 10.0%) older in vascular terms when we used the narrow definition of sexual minority status. Table 3 provides a summary of the unadjusted and adjusted analyses with this modified version of the Framingham Score.

DISCUSSION

The results of the current study suggest that SMW are at increased risk of CVD compared with their heterosexual counterparts. On average, SMW in our study had vascular systems that were 5.7% older than those of their heterosexual counterparts, and 13.9% older than would be expected with their chronological age. This disparity in vascular age increased to 7.5% when the definition of sexual minority status was restricted only to those who self-identified as "lesbian," "bisexual," or "something else." Neither family history of premature CVD nor history of heavy drug

TABLE 2—Ratios of Vascular to Chronological Age by Sexual Minority Definition, Female NHANES Participants From 2001 to 2008: United States

	Heterosexual Women	Sexual Minority Women	Difference (95% CI)
Broad definition[a]			
Unadjusted	1.082	1.139	0.057 (0.015, 0.098)
Adjusted[b]	1.063	1.111	0.047 (0.005, 0.090)
Narrow definition[c]			
Unadjusted	1.084	1.159	0.075 (0.024, 0.126)
Adjusted[b]	1.064	1.128	0.064 (0.014, 0.114)

Note. CI = confidence interval; NHANES = National Health and Nutrition Examination Survey.
[a]Included women who identified as "lesbian," "bisexual," or "something else" and straight-identified women with at least 1 lifetime same-sex sexual partner.
[b]Adjusted for alcohol use.
[c]Included only women who identified as "lesbian," "bisexual," or "something else."

TABLE 3—Ratios of Modified Vascular to Chronological Age by Sexual Minority Definition, Female NHANES Participants From 2001 to 2008: United States

	Heterosexual Women	Sexual Minority Women	Difference (95% CI)
Broad definition[a]			
Unadjusted	1.040	1.078	0.038 (0.002, 0.074)
Adjusted[b]	1.023	1.059	0.036 (0.000, 0.073)
Narrow definition[c]			
Unadjusted	1.041	1.097	0.056 (0.006, 0.105)
Adjusted[b]	1.023	1.075	0.051 (0.002, 0.101)

Note. CI = confidence interval; NHANES = National Health and Nutrition Examination Survey. We performed modification by removing smoking status from the Framingham General Cardiovascular Disease Risk Score.
[a]Included women who identified as "lesbian," "bisexual," or "something else" and straight-identified women with at least 1 lifetime same-sex sexual partner.
[b]Adjusted for alcohol use and smoking status.
[c]Included only women who identified as "lesbian," "bisexual," or "something else."

use accounted for this disparity; however, alcohol use did slightly attenuate this difference.

Because of the established link between smoking and CVD and the significantly higher rates of current and former smoking among the SMW in our sample, we conducted an additional analysis to determine if smoking accounted for SMW's increased CVD risk. Our results indicated that increased CVD risk persisted, even after we adjusted for both smoking status and alcohol use. As such, our findings suggest that sexual minority status may confer additional CVD risk beyond that of smoking and excessive alcohol use.

It is of interest to note that, when we narrowed the definition of SMW to include only those who expressed a nonheterosexual identity, the disparity in CVD risk increased. This finding suggests that disparities in CVD risk are driven more by nonheterosexual identity than by ever engaging in same-sex sexual behavior. This finding is consistent with Meyer's theory of minority stress in which individuals who identify as sexual minority experience chronic, additive, and unique stress stemming from living in social conditions characterized by prejudice and discrimination for sexual minority–identified people.[27] Individuals who identify as nonheterosexual may experience increased or unique types of stress compared with those who identify as heterosexual but engage in same-sex sexual behaviors. This stress may result in biological

processes that confer increased CVD risk (e.g., inflammatory processes resulting from increased allostatic load), or it may precipitate negative coping behaviors (e.g., smoking, excessive alcohol use, drug abuse) that increase CVD risk.[28,29] Our findings provide support for both of these processes, and future research should specifically examine how each process may uniquely contribute to increased CVD among sexual minorities.

The increased prevalence of smoking, risky alcohol use, and history of hard drug use among the SMW in our sample was consistent with that in most previous research. However, contrary to other studies of SWM, we did not find a statistically significant difference between SMW and heterosexual women with regard to either mean BMI or the percentage of women classified as overweight or obese. One possible explanation for this finding is that SMW in our study were significantly younger than their heterosexual counterparts, and previous research indicates that lesbian and bisexual women are more likely to experience adverse weight gain trajectories throughout adulthood.[30] This age difference may also account for the significantly lower total cholesterol levels among the SMW in our study, as cholesterol levels tend to increase with age.[31]

Strengths of this study include the use of a national population-based sample, the use of a validated multirisk algorithm to measure CVD risk, and the use of both identity and behavior measures to operationalize sexual

minority status. Limitations include a lack of sexual behavior data for older participants and a relatively small sample of SMW. As such, we were unable to examine differences in CVD risk either within SMW or by sexual minority status and race, educational level, income, or smoking characteristics. In addition, heterosexual women and SMW may differ with regard to CVD risk factors that are not included in the Framingham CVD risk calculation (e.g., parity). Such differences may influence the disparity in CVD risk between these groups and should be explored in future research.

To our knowledge, this is the first study of its kind to examine differences in CVD risk between SMW and heterosexual women by using both a national population-based sample and a multivariable CVD risk algorithm. Our findings indicate that SMW are at greater risk for CVD than their heterosexual counterparts, but future work is needed to fully understand the causes of this increased risk. In addition, the large disparities in smoking, risky drinking, and history of hard drug use we found in this study reinforce the need for culturally competent interventions to reduce substance use in this population in addition to addressing other CVD risk factors. ■

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Contributors

G. W. Farmer and J. M. Jabson originated the study idea and wrote the initial draft of the article. G. W. Farmer completed the analyses. D. J. Bowen and K. K. Bucholz supervised the analyses and helped with interpretation of the findings. All authors edited drafts of the article. G. W. Farmer had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Human Participant Protection

The Saint Louis University institutional review board reviewed this study and determined that it did not meet the criteria of human participant research.

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