The Association between Sexual Violence and Cardiovascular Disease: An Analysis using Data from the 2017 Alaska Behavioral Risk Factor Surveillance System

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Abstract

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Cardiovascular diseases represent a significant portion of deaths among women in the United States. Research has suggested that abuse and violence may be risk factors for cardiovascular diseases. Nearly 1 in 3 women in the United States have experienced some form of sexual violence in their lifetime, with Native Alaskan women experiencing a significantly greater burden than the national average. The objective of this study was to examine the association between sexual violence and cardiovascular disease, and whether this association is modified by race. Data were obtained from the 2017 Alaska Behavioral Risk Factor Surveillance System. The study population (N=1,049) was restricted to female respondents age 45-80 years who provided data on sexual violence, cardiovascular disease, and the covariates included in the models. Poisson regression was used to estimate unadjusted and adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs). To assess effect modification by race, data were stratified by

race (White and Native Alaskan) and PRs (and 95% CIs) were calculated. Interaction models were fit to assess statistical significance of the interaction. A lifetime history of sexual violence was associated with a 71% greater prevalence of cardiovascular disease (adjusted PR 1.71 95% CI 1.61-1.81). The association between sexual violence and cardiovascular disease was significantly stronger among Native Alaskan women (adjusted PR 14.1, 95% CI 9.59-20.7) compared with the association among White women (adjusted PR 1.62, 95% CI 1.52-1.72) (P-value for interaction < 0.05). Female residents of Alaska, particularly Native Alaskan women, who have experienced sexual violence have a greater burden of cardiovascular disease than non-exposed female residents. Survivors of sexual violence have unique healthcare needs, which should include prevention and treatment of cardiovascular diseases.

Introduction

Cardiovascular diseases, including coronary heart disease and myocardial infarction, impact 1 in 16 women age 20 and older and account for approximately 1 in 4 adult female deaths in the United States.[1] The risk factors for cardiovascular diseases have not been fully characterized, particularly among women.[2,3] While there are substantial gender differences in the risk factors and symptomology of cardiovascular diseases,[4] underrepresentation of female subjects in studies assessing risk factors of cardiovascular diseases has contributed to a significant gap in the understanding of cardiovascular diseases pathogenesis and manifestation among women. Recent research has identified the role of stressful or traumatic life events in increasing an individual's risk of cardiovascular diseases. A 2017 prospective cohort study of 28,583 subjects of any gender estimated that each additional stressful life event, including death or serious illness/ injury of a close family member or friend, divorce or separation, incarceration of a close family member or friend, crime victimization, and loss of income, is associated with a 15% increased odds of incident cardiovascular disease.[5] Albeit not specifically included in this study, sexual violence is a traumatic life event that disproportionately impacts the female population.[6,7]

Sexual violence is a major public health issue in the United States. Sexual violence refers to sexual or intimate encounters where consent is not present or freely given.[8] A survivor is an individual who has experienced any form of unwanted sexual activity.[9] It is estimated that nearly 1 in 3 women in the United States have experienced some form of sexual violence involving physical contact throughout their lifetime.[10]

Sexual violence has been linked to a number of poor health outcomes, including chronic pelvic pain, cervical cancer, and poor obstetrical outcomes.[11–16] While there is a lack of research

assessing the relationship between sexual violence and cardiovascular disease, recent evidence has suggested an association between domestic violence and poor cardiovascular health.[12,17–19] In a 2020 study of 90,778 women, those who had been exposed to domestic abuse were at a 31% greater risk of cardiovascular diseases than non-exposed women.[17] However, more research is needed to understand the disproportionate burden of cardiovascular disease among survivors of sexual violence, particularly among understudied populations and populations who are disproportionately affected by sexual violence. In Alaska, approximately 45% of female residents have experienced some form of sexual violence in their lifetime (95% CI: 38.0-51.3%).[6] Among Native Alaskan women, it is estimated that 56.1% have experienced sexual violence in their lifetime.[20] From current available estimates, this population experiences the greatest burden of sexual violence of any population in the United States.[6,10,20] Despite the significant burden of violence on the female population of Alaska, there is a lack of research assessing the relationship between sexual violence and health outcomes among this population.

The purpose of this study was to assess if there is an additional burden of cardiovascular disease among female residents in Alaska with lifetime exposure to sexual violence and to assess if this association is modified by race (White or Native Alaskan). Study findings can contribute to a better understanding of non-genetic risk factors for cardiovascular diseases and the relationship between sexual violence and adverse health outcomes. This research is particularly important for supplementing the knowledge of Alaska healthcare providers on the unique healthcare needs of survivors of sexual violence.

Methods

Study Design and Setting

This is a cross-sectional study conducted using data from the 2017 Alaska Behavioral Risk Factor Surveillance System (BRFSS). BRFSS is a national telephone survey that collects self-reported prevalence data on risk behaviors (smoking, alcohol consumption, etc.), life events that may influence health outcomes (adverse childhood events, intimate partner violence, sexual violence), and health outcomes[21]. Each state has a state-added module that supplements the main BRFSS questionnaire. In Alaska, sexual violence exposure was measured in the 2017 state-added module.

Study Population

The study population for the current analyses included 45-80 year old female-identifying respondents to the 2017 Alaska BRFSS questionnaire who provided data on sexual violence exposure and coronary heart disease or history of myocardial infarction. Analyses were restricted to females age 45 and older in order to better satisfy the assumption that all subjects in the study population are at reasonable risk of coronary heart disease or myocardial infarction. Younger women are at a significantly lower risk of adverse cardiovascular health outcomes and have risk factor profiles (e.g. genetics) that are significantly different from the general population. A total of 3,203 residents of Alaska responded to the 2017 BRFSS survey. Exclusion criteria and resulting sample sizes for the unadjusted, age-adjusted, and multivariate adjusted models are summarized in Figure 1. After restricting to female residents over age 45 and excluding respondents with missing data on sexual violence exposure (12.2%, n = 146). and cardiovascular disease (0.4%, n = 6)., the analytic study population used for the crude and age-adjusted models was 1,049.

The Institutional Review Board (IRB) of the University of Washington recognizes BRFSS as a publicly available, de-identified data source, and thus does not constitute as human subjects research.[22]

Data Collection

The exposure was unwanted sexual activity throughout the life course. Lifetime exposure to unwanted sexual activity was measured in a state-added module of the 2017 Alaska BRFSS using the following question:

> *Has anyone ever made you take part in any sexual activity when you really did not want to—including touch that made you uncomfortable?*

Respondents could answer *yes, no, I don't know/ not sure,* or refuse to answer. If respondents answered "No" to the above question, they were classified as non-exposed. Respondents that answered "Yes" to the above question were classified as exposed. If respondents answered, "I don't know", "unsure", or refused to answer, they were grouped with missing data and excluded from the analysis.

The outcome of interest was self-reported cardiovascular disease, including coronary heart disease and myocardial infarction. Coronary heart disease was ascertained in the primary BRFSS questionnaire with the following question:

> *Has a doctor, nurse, or other health professional ever told you that you had angina or coronary heart disease?*

Myocardial infarction, also known as a "heart attack", was ascertained in the primary BRFSS questionnaire with the following question:

> *Has a doctor, nurse, or other health professional ever told you that you had a heart attack also called a myocardial infarction?*

Respondents could answer yes, no, I don't know/not sure, or refuse to answer. Respondents who answered "I don't know", "Not sure", or refused to answer were grouped with missing data and excluded from the analysis. If respondents answered "Yes" to either of the questions above, they were classified as cases. Respondents who answered "No" to both questions were classified as controls.

A covariate was included in the multivariate as a confounder if it was determined to be associated with sexual violence exposure, associated with cardiovascular disease, and not believed to be on the causal pathway. Marital status, age, education, health insurance coverage, and race were included in the final models. Marital status was grouped into three categories: single, married or in a domestic partnership, and formerly married. Age was a continuous variable. Education was a categorical variable with four groups: less than high school, high school graduate or GED, some college or technical school, and college graduate. Health insurance coverage was a binary variable indicting current health insurance coverage of any type. Race was coded into three groups: White, Native Alaskan/ Indigenous, and Other. Body mass index in BRFSS was grouped into five categories: underweight (<18.5), normal (18.5-24.9), overweight (25.0-29.9), and obese (29.9<). In this study, the underweight and normal categories were merged for adjustment to create four categorical groups due to sufficient respondents classified as underweight. Smoking was coded into a binary variable from separate questions on the BRFSS inquiring about smoking status. The two groups were 100+ cigarettes in their lifetime or current smoker and <100 cigarettes in their lifetime or never smoker.

Statistical Analysis

Survey weighting was used for all analyses. BRFSS provides sampling weights that account for non-response and different probabilities of selection due to sampling design.[23–25]

Poisson regression was used to calculate unadjusted and adjusted prevalence ratios (PRs) and 95% confidence intervals (CIs) to estimate the association of lifetime unwanted sexual activity with cardiovascular disease. Four models were constructed in total: unadjusted, age-adjusted, multivariate-adjusted, and multivariate-adjusted with potential mediators. The multivariate-adjusted model included age, marital status, education, health insurance coverage, and race as confounders. Body mass index and smoking were potential mediators in the relationship between sexual violence and cardiovascular disease. A separate multivariate model was fitted that adjusted for these variables as well.

In order to assess effect modification by race, data were stratified by race (White and Alaskan Native). The association between unwanted sexual activity and cardiovascular disease was assessed within the strata groups. Adjusted interaction models that included all variables (described above) as well as interaction terms for unwanted sexual activity and race were constructed to assess the statistical significance of the multiplicative interaction of race and unwanted sexual activity.

A significance level of 0.05 was used to conclude statistically significant relationships. All analysis was completed in R Version 1.2.1335.

Results

A comparison of selected characteristics of female respondents age 45 and older who have experienced lifetime unwanted sexual activity (n = 301) to those without lifetime unwanted sexual activity (n = 749) is shown in **Table 1**. Respondents with a lifetime history of unwanted sexual activity tended to be younger on average, were more likely to never have been married, were more likely to have smoked 100+ cigarettes in their lifetime or be current smokers, and tended to have higher BMI. Respondents with lifetime exposure to sexual violence were also less

likely to have had a medical check-up in the past year (59.8 vs 67.8%, respectively, p-value < 0.05).

The prevalence of cardiovascular disease among respondents with a lifetime history of unwanted sexual activity (5.7%) was 34% greater than the prevalence of cardiovascular disease among respondents without a lifetime history of unwanted sexual activity (4.2%) (**Table 2**). The prevalence of cardiovascular disease among women with lifetime unwanted sexual activity was 80% and 71% higher than it is among women without lifetime unwanted sexual activity in age-adjusted (age-adjusted PR 1.80, 95% CI 1.70-1.91) and multivariate-adjusted models (adjusted PR 1.71, 95% CI 1.61-1.81), respectively. The associations were attenuated but remained statistically significant after adjusting for smoking cigarettes and body mass index, which were considered possible mediators (adjusted PR 1.42, 95% CI 1.34-1.51).

The observed association of history of lifetime unwanted sexual activity and cardiovascular disease was stronger among Native Alaskan women, compared with similar association among Whites across all models (**Table 3**). In adjusted models, among Native Alaskan women, there was a 14.1-fold greater prevalence of cardiovascular disease among women exposed to lifetime unwanted sexual activity compared to non-exposed women (adjusted PR 14.1, 95% CI 9.59-20.7). Similar association among White women was weaker (adjusted PR 1.62, 95% CI 1.52-1.72). After additionally adjusting for potential mediators smoking cigarettes and body mass index, the association was attenuated but remained statistically significant among Native Alaskan women (Native Alaskan-specific adjusted PR 5.49, 95% CI 3.63-8.29). The multiplicative interaction for all adjusted models was statistically significant (P-value < 0.05).

Discussion

In the current study, we found a 71% greater prevalence of cardiovascular disease among female respondents to the Alaska BRFSS who reported lifetime exposure to sexual violence, compared to female respondents without exposure to sexual violence. The association between lifetime exposure to sexual violence and cardiovascular disease was significantly stronger among Native Alaskan women. Among Native Alaskan women, those with lifetime exposure to unwanted sexual activity had 14.1 times greater prevalence of cardiovascular disease compared to women without lifetime exposure. A similar but weaker association was observed among White women.

To our knowledge, this is the first study to assess the relationship between unwanted sexual activity throughout the life course and cardiovascular diseases among adult women. Other studies have assessed the effect of domestic abuse or childhood forced sex or sexual abuse and cardiovascular events in adulthood.[19,26,2717] Consistent with our findings, a retrospective study by Rich-Edwards et al. of 66,798 female nurses estimated a 1.56 times greater risk of incident cardiovascular events among adult study participants (adjusted HR 1.56, 95% CI 1.23-1.99). However, after the study adjusted for adult lifestyle and medical risk factors, the association between forced sex during childhood and cardiovascular disease no longer remained significant (adjusted HR 1.25, 95% CI 0.98-1.60). Many of the adult lifestyle and medical risk factor variables included in the Rich-Edwards et al. study model possibly occurred after forced sex during childhood (i.e. adult body mass index, parity, oral contraceptive use, menopausal status).[28] As these variables may operate as mediators, rather than confounders, we chose not to include those variables in our models. We included two potential mediators, smoking cigarettes and body mass index, in our final adjusted model which resulted in an attenuated, yet statistically significant, result (Table 2).[29] However, it is possible smoking cigarettes and body mass index at

time of survey preceded exposure to lifetime unwanted sexual activity and these variables could plausibly be adjusted for.

A recent retrospective cohort study of 18,547 women (mean age 36.9 years) assessed the relationship between domestic abuse during adulthood and cardiovascular disease. After adjusting for age, body mass index, sex, smoking cigarettes, diabetes status, lipid-lowering drug use, hypertension, and Townsend deprivation score at baseline, the study estimated a IRR of 1.31 (95% CI 1.11-1.55) of cardiovascular disease among women with exposure to domestic violence in adulthood, compared to non-exposed women.[17] Similar to the prior study assessing forced sex during childhood and cardiovascular disease, the study adjusted for variables that may operate as mediators in the relationship between domestic abuse and cardiovascular disease, possibly attenuating the true estimate. Despite these differences between previous studies and the current study, the majority of results indicate a positive associations between sexual violence and cardiovascular outcomes.[17,19,26,27,30–32]

The mechanisms by which sexual violence may be related to adverse cardiovascular outcomes are unclear. One possibility is mediation by poor mental health (such as depression, generalized anxiety, and post-traumatic stress disorder) and/or risk behaviors (e.g. alcohol consumption, smoking cigarettes, and binge eating disorders) resulting from exposure to sexual violence.[29,31,33] In the current study, after adjusting for smoking cigarettes and body mass index, the association between unwanted sexual activity and cardiovascular disease was attenuated, indicating this possibility. The fact the association remained significant indicates that there may be other factors mediating the association. Research has suggested traumatic or stressful life events can lead to epigenetic changes (e.g. DNA methylation or acetylation) in an individual's genome and immune system dysregulation, which have implications on cardiovascular health.[34–

[37] A third possibility is uncontrolled confounding, e.g. third variables associated with sexual violence and cardiovascular disease that are not on the causal pathway and not included in the present models.

There are several contributions of the present study to existing literature. To our knowledge, it is the first study to assess lifetime unwanted sexual activity as the primary exposure for cardiovascular diseases. Previous studies have assessed childhood sexual abuse and domestic abuse.[17,32] Second, the focus on female residents of Alaska provides valuable and pertinent information for clinicians practicing in Alaska and state public health professionals. Finally, this is the first study to assess the relationship between sexual violence and cardiovascular diseases among Native Alaskan/ Indigenous women specifically.

While the present study adds critical new information to the available literature, there are important limitations to address. BRFSS is a survey without follow-up. We are unable to ascertain from the data available if the unwanted sexual activity or activities occurred prior to diagnosis of coronary heart disease or occurrence of myocardial infarction. Restricting to women age 45 and older mitigates this concern given sexual violence impacts younger women more frequently and coronary heart disease and myocardial infarction tend to common among older women.[29,38] Another important limitation of this study is the ascertainment of the exposure and outcome status in the BRFSS dataset. Respondents are asked via telephone about lifetime exposure to unwanted sexual activity. Without a guaranteed private setting, verbal ascertainment of sensitive information, such as sexual violence history, could be subject to misclassification. Respondents are asked to self-report cardiovascular disease. Risk of misclassification is higher in self-reported surveys compared to studies using clinical records.[39]

Findings of the current study have important public health and clinical implications in Alaska. This study frames sexual violence as a substantial public health issue with implications on life course health, including cardiovascular health. The results highlight the need for interventions to prevent sexual violence and to reduce risk of cardiovascular disease among survivors of sexual violence, as well as other adverse health outcomes. Recent research on the effect of positive childhood experiences (PCEs) on the relationship between adverse childhood experiences (ACEs) and adverse health outcomes may help inform potential interventions to improve cardiovascular health among survivors of sexual violence.[22] ACEs are potentially traumatic events during childhood (0-17 years) that are risk factors for adverse health outcomes, including heart disease.[19,26,27] Recent research has suggested positive childhood experiences (PCEs) could be powerful counterbalances against the impact of ACEs on health outcomes. A study from 2019 reported a 72% reduction in odds of depression and/or poor mental health among adults reporting 6-7 PCEs compared to those reporting 1-2 PCEs after accounting for ACEs.[22] Albeit preliminary, this research suggests interventions to mediate the association between sexual violence and cardiovascular disease should focus on fostering positive experiences and resilience. Training primary care providers and community health aides in trauma-informed care practices tailored to survivors of sexual violence may serve as a positive experience for survivors and help to encourage preventive steps against cardiovascular disease. Given the strength of the association between unwanted sexual activity and cardiovascular disease among Native Alaskan women, culturally-appropriate interventions should be considered. Approaches should involve community partners from Native Alaskan communities and community health aides.

Conclusion

The present study findings support a strong association between lifetime exposure to sexual violence and cardiovascular disease among female residents of Alaska, particularly among Native Alaskan women. To our knowledge, this is the first study to demonstrate an association between lifetime sexual violence and adult cardiovascular disease, as well as the first to assess this association among Native Alaskan women specifically. Future research should include prospective studies to better understand the temporality of this relationship, studies specifically structured to evaluate potential mechanisms for these associations, and quasi-experimental studies to assess possible interventions to reduce cardiovascular disease prevalence among survivors of sexual violence. Clinicians practicing in Alaska should heighten their attention to managing cardiovascular disease risk factors among survivors of sexual violence. Violence screening programs and trauma-informed care training for clinicians would be of particular importance.

Table 1: Selected Characteristics of 2017 Alaska BRFSS Female Respondents by Lifetime Exposure to Unwanted Sexual Activity

			Lifetime Unwanted Sexual Activity			
	Total (n = 1049)		Yes (n = 301)		No (n = 748)	
Characteristics	N	weighted %	N	weighted %	N	weighted %
Age (mean, sd)	62.7 (9.3)		60.8 (8.3)		63.5 (9.5)	
Education Level						
High school/ GED or less	273	25.3	77	23.0	196	26.2
Some college/ technical school	337	42.0	95	40.6	242	42.5
College/ technical school	430	32.0	128	35.1	302	30.8
Health Insurance						
Yes	992	93.8	282	92.3	710	94.3
No	55	5.9	18	7.7	37	5.2
Marital Status						
Married/ Unmarried Couple	598	62.0	170	63.1	428	61.7
Divorced/ Separated/ Widowed	380	29.3	104	27.1	276	30.2
Never Married	62	8.3	24	9.3	38	7.9
Smoking						
>100 cigarettes in lifetime or current smoker	448	42.6	152	51.5	296	39.2
Never Smoked/ <100 cigarettes in lifetime	595	56.3	149	48.5	446	59.2
Body mass index						
Underweight/ Normal (< 25)	335	30.4	90	26.0	245	32.1
Overweight (25.0-29.0)	314	29.3	86	31.3	229	28.5
Obese (> 30.0)	363	36.6	119	40.5	244	35.1
Race/ Ethnicity						
White	823	73.3	248	85.1	575	68.9
Alaskan Native/ Indigenous	143	12.3	30	7.6	113	14.0
Other	83	14.4	23	7.2	60	17.1
Length of time since last check-up						
< 1 year ago	680	65.6	185	59.8	494	67.8
1-2 years ago	156	17.0	55	21.1	101	15.5
3+ years ago	188	17.4	56	19.1	132	16.7

PR: Prevalence Ratio, CI: Confidence Interval, SD: Standard Deviation.
*Includes female respondents age 45-80 who provided data on lifetime unwanted sexual activity.
**Weighted proportions adjusted for non-response and selection bias.

Table 2: Relationship between Unwanted Sexual Activity and Cardiovascular Outcomes Among Female Respondents of the 2017 Alaska BRFSS, Aged 45-80

				Unadjusted		Age-Adjusted		Multivariate-Adjusted 1*		Multivariate-Adjusted 2**	
		Cases	Controls	PR	(95% CI)	PR	(95% CI)	PR	(95% CI)	PR	(95% CI)
Cardiovascular Disease	Non-Exposed	48	700	1.00	-	1.00	-	1.00	-	1.00	-
	Exposed	28	273	1.34	(1.27, 1.42)	1.80	(1.70, 1.91)	1.71	(1.61, 1.81)	1.42	(1.34, 1.51)

PR: Prevalence Ratio.
CI: Confidence Interval.
*Adjusted for age, health insurance coverage, education, marital status, and race.
** Adjusted for age, health insurance coverage, education, marital status, race, smoking cigarettes, and body mass index.

Table 3: Relationship between Unwanted Sexual Activity and Cardiovascular Outcomes Among Female Respondents of the 2017 Alaska BRFSS, Aged 45-80, Stratified by Race

		Unadjusted			Age-Adjusted			Multivariate-Adjusted 1*			Multivariate-Adjusted 2**		
		N	PR	(95% CI)	N	PR	(95% CI)	N	PR	(95% CI)	N	PR	(95% CI)
Cardiovascular Disease	White	824	1.15	(1.08, 1.22)	824	1.54	(1.45, 1.63)	809	1.62	(1.52, 1.72)	782	1.29	(1.21, 1.38)
	Native Alaskan	143	4.04	(2.88, 5.66)	143	13.2	(9.08, 19.2)	142	14.1	(9.59, 20.7)	133	5.49	(3.63, 8.29)

*Adjusted for age, marital status, education, and health insurance coverage.

**Adjusted for age, marital status, education, health insurance coverage, smoking cigarettes, and body mass index.

P-value for interaction between race and unwanted sexual activity **<0.05**

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Supplemental Table 1: Sensitivity Analysis Stratifying Outcome

		Unadjusted			Age-Adjusted			Multivariate-Adjusted 1*		
		N	PR	(95% CI)	N	PR	(95% CI)	N	PR	(95% CI)
Myocardial Infarction	White	824	1.37	(1.27, 1.47)	824	1.78	(1.65, 1.92)	806	1.62	(1.50, 1.75)
	Native Alaskan	144	2.35	(1.48, 3.73)	144	6.24	(3.72, 10.5)	141	5.69	(3.25, 9.96)
Coronary Heart Disease	White	824	1.25	(1.16, 1.36)	824	1.72	(1.59, 1.86)	806	1.68	(1.55, 1.82)
	Native Alaskan	143	3.09	(2.02, 4.71)	143	7.98	(4.96, 12.8)	140	6.60	(4.06, 10.7)

*Adjusted for age, health insurance coverage, education, marital status, and race.

Figure 1: Inclusion Criteria and Sample Sizes for Models