






ORIGINAL RESEARCH

Sexual Violence and Risk of Hypertension in Women in the Nurses' Health Study II: A 7-Year Prospective Analysis

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BACKGROUND: Hypertension is a prevalent condition in women and an important modifiable risk factor for cardiovascular disease. Despite women's experiences of sexual violence being common, no prospective studies have examined lifetime sexual assault and workplace sexual harassment in relationship to hypertension in large civilian samples with extended follow-up. Here, we examined whether these experiences were prospectively associated with greater risk of developing hypertension over 7 years.

METHODS AND RESULTS: Data are from a substudy of the Nurses' Health Study II and include women free of hypertension at the time of sexual assault and workplace sexual harassment assessment in 2008 (n=33 127). Hypertension was defined as self-reported doctor diagnosis or initiating antihypertensive medication use, assessed biennially through 2015. We performed Cox proportional hazards regression models to predict time to developing hypertension associated with sexual violence exposure, adjusting for relevant covariates. Over follow-up, 7096 women developed hypertension. Sexual assault and workplace sexual harassment were prevalent (23% and 12%, respectively; 6% of women experienced both). Compared with women with no exposure, women who experienced both sexual assault and workplace sexual harassment had the highest risk of developing hypertension (hazard ratio [HR], 1.21; 95% CI, 1.09–1.35), followed by women who experienced workplace sexual harassment (HR, 1.15; 95% CI, 1.05–1.25) and then by women who experienced sexual assault (HR, 1.11; 95% CI, 1.03–1.19), after adjusting for relevant covariates.

CONCLUSIONS: Sexual assault and workplace sexual harassment are prospectively associated with greater risk of hypertension. Reducing such violence is important in its own right and may also improve women's cardiovascular health.

Key Words: cardiovascular ■ hypertension ■ Nurses' Health Study ■ sexual assault ■ sexual harassment ■ sexual violence

Hypertension is a prevalent condition in women and an important modifiable risk factor for cardiovascular disease (CVD), the leading cause of death.^{1,2} Sexual violence, including sexual assault and verbal or physical harassment, is common among women.^{3,4} Evidence is emerging that sexual violence may be an important risk factor, not only for mental health problems, but also for multiple physical health problems,

including CVD.^{3,5–12} Most studies examining sexual violence in relationship to cardiovascular health have focused specifically on intimate partner violence^{13–19} or abuse in childhood^{20–25} which, although important, do not capture the full scope of women's experiences of sexual violence. For example, sexual assault occurs within and outside of established partnerships, and sexual harassment takes place in work settings, and

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CLINICAL PERSPECTIVE

What Is New?

- In this longitudinal study of midlife women, sexual assault and workplace sexual harassment were prospectively associated with greater risk of developing hypertension over a 7-year follow-up period.
- Women who experienced both sexual assault and workplace sexual harassment had the highest risk of hypertension.

What Are the Clinical Implications?

- Sexual violence may represent a risk factor for cardiovascular disease in women via increased risk of hypertension.
- Reducing sexual violence against women may provide an important strategy for improving women's lifetime cardiovascular health.

Nonstandard Abbreviations and Acronyms

NHS II Nurses' Health Study II

may or may not involve physical contact.^{3,4} Prevalence estimates of sexual assault and workplace sexual harassment range from 13% to 44% and up to 80%, respectively,^{4,6,7,26–30} which are likely underestimates of the true prevalences.⁴ Given the high reported prevalences of these exposures, further investigations into their relationship with risk of developing hypertension is important for early identification of modifiable factors that influence women's cardiovascular health.

A small number of studies have examined the relationship between sexual assault or workplace sexual harassment and hypertension. However, to the best of our knowledge, no prospective studies have examined lifetime sexual assault and workplace sexual harassment with cardiovascular outcomes in large civilian samples with extended follow-up times. Some prior studies have found that history of sexual assault or workplace sexual harassment were associated with a greater likelihood of hypertension in women.^{7,8,31,32} These studies did not investigate potential joint effects of sexual assault and workplace sexual harassment and used cross-sectional designs, with many studies also using samples of female veterans.^{7,8,31–36} Another limitation of these prior studies is that they did not account for other traumatic experiences in the absence of sexual violence, such as accidents, disasters, or unexpected death of a loved one, that are also common and have been linked to adverse mental and physical health.^{37–40}

Here, we address these limitations of prior work by investigating whether history of sexual assault and/or workplace sexual harassment was prospectively associated with greater risk of developing hypertension over 7 years in the NHS II (Nurses' Health Study II), a sample of civilian women aged 43 to 64 years at the start of follow-up. Given distress often follows sexual violence and other trauma⁴⁰ and has previously been associated with increased risk of hypertension in this cohort,⁴¹ we accounted for psychological distress in sensitivity analyses. Overall, we hypothesized that women with a history of sexual assault and/or workplace sexual harassment (versus no trauma exposure) would have a higher likelihood of developing hypertension over time.

METHODS

Data Availability

Data are from the NHS II and are not publicly available but may be made available upon request to the Channing Division of Network Medicine at the Brigham and Women's Hospital. Further information including the procedures to obtain and access data from the Nurses' Health Studies is described at <https://www.nurseshealthstudy.org/researchers>.

Sample

NHS II is an ongoing cohort study of US women, which enrolled 116 429 nurses aged 24 to 42 years in 1989. An extensive range of sociodemographic, medical, and behavioral variables have been measured in this cohort, primarily via biennial questionnaires. The study protocol was approved by the institutional review boards of the Brigham and Women's Hospital and the Harvard T.H. Chan School of Public Health, and the institutional review boards allowed participants' completion of questionnaires to be considered as implied consent. A substudy was conducted in 2008, measuring sexual violence and other trauma exposure as well as posttraumatic stress disorder (PTSD) and depression symptoms, and other factors among a subset of women (n=54 703). The protocol for this substudy has been published.⁴² We excluded women who reported a previous diagnosis of hypertension or use of antihypertensive medication before start of follow-up in 2008 (n=21 370). An additional 91 women were removed because of history of cardiovascular/cerebrovascular disease (eg, self-reported myocardial infarction or stroke; reports confirmed by medical records, by death information, or self-corroborated by the participant) and 115 women were lost to follow-up for biennial questionnaires between becoming eligible for the substudy and the start of the present follow-up. Our main analytic sample therefore consisted of 33 127 women.

Measures

Sexual Violence

Lifetime history of sexual violence was assessed in 2008 using 2 of the 16 items from the modified Brief Trauma Questionnaire.^{43,44} Women indicated whether they had ever experienced workplace sexual harassment (“Ever experienced sexual harassment at work that was either physical or verbal?”) and/or sexual assault in any domain (“Ever been made or pressured into having some type of unwanted sexual contact? Note: By sexual contact we mean any contact between someone else and your private parts or between you and someone else’s private parts.”). The remaining 14 items as well as free-text responses were used to classify whether women were exposed to other traumas (eg, accidents, disasters, unexpected death of a loved one) or if they were unexposed to trauma.

We derived 3 exposure measures. For analyses of sexual assault, we characterized women as having a history of: sexual assault, other trauma only (ie, other trauma(s), but not sexual assault), or no trauma (reference). For analyses of workplace sexual harassment, women were characterized as having a history of: workplace sexual harassment, other trauma only (ie, other trauma(s), but not workplace sexual harassment), or no trauma (reference). Our third exposure was a combined measure categorized as: both sexual assault and workplace sexual harassment, either sexual assault or workplace sexual harassment, other trauma only (ie, other trauma(s) but not sexual assault or workplace sexual harassment), or no trauma (reference).

Hypertension

Women reported whether they had physician-diagnosed high blood pressure at enrollment in 1989 and biennially thereafter. Self-report measures of high blood pressure have previously been validated in this cohort.^{45,46} For each questionnaire after 1989, women who reported high blood pressure also reported whether they were diagnosed before, during, or since the 2-year interval following the previous biennial questionnaire. We estimated high blood pressure to have onset at the mid-point of response options.

Antihypertensive medication use was also assessed via biennial questionnaires. In 1989 and 1993, women were asked to report the medications they were currently regularly using. For each subsequent biennial questionnaire, women were asked about medications regularly used within the past 2 years. We created a binary measure for antihypertensive medication that indicated use of any of the following: thiazide diuretics (measured biennially from 1989–2015 apart from in 1991), calcium channel blockers (measured biennially from 2001–2015), beta-blockers (measured

in 1989 and biennially from 2001–2015), angiotensin-converting enzyme inhibitors (measured biennially from 2001–2015), angiotensin receptor blockers (measured biennially from 2005–2015), loop diuretics (Furosemide (Lasix); measured in 1989 and then biennially between 2001–2015), potassium (measured biennially from 2003–2015 apart from in 2007), or “other” antihypertensive medications (measured in 1989 and biennially from 1993–2015). We considered the onset date of antihypertensive medication use to be 12 months before women first reported use of any of these medications.

We defined incident hypertension as the first report of physician-diagnosed high blood pressure or first report of antihypertensive medication use. To reduce concerns about potential reverse causation, only cases occurring after start of follow-up in 2008 were included.

Covariates

We accounted for an extensive range of sociodemographic, childhood and family factors, and adult health behaviors and conditions which could be considered confounders and/or mediators of the association between sexual violence and hypertension. Time-invariant covariates were reported in 1989 (apart from parental education, reported in 2005) and included: race and ethnicity (coded as non-Hispanic White, Black, Hispanic, Asian, other racial or ethnic groups); maximum parental education at the participant’s birth (high school or less, some college, 4+ years of college); maternal and paternal history of hypertension; and somatotype at age 5 (based on a somatogram scale to estimate childhood adiposity where participants selected 1 of 9 pictograms of body size, truncated at pictogram 5 and above).^{47,48} Time-varying factors were updated at each available cycle (every 2 or 4 years) and included: physical activity (<3, 3–<9, 9–<18, 18–<27, 27+ metabolic equivalent h/wk; queried in 2009 and 2013); alcohol use (0, 1–<5, 5–<10, 10–<20, 20+ grams/day; assessed in 2007, 2011, and 2015); smoking status (non-smokers, former smokers, or current smokers of 1–14, 15–24, or 25+ cigarettes/day; measured in 2009, 2011, 2013, 2015); diet quality based on Alternative Healthy Eating Index⁴⁹ and excluding alcohol use (measured in 2007, 2011, 2015); adult body mass index (BMI) in kg/m² (derived using self-reported height in inches and weight in pounds from 2009, 2011, 2013, and 2015).⁵⁰

Additional covariates included psychological distress. PTSD was based on self-reported lifetime diagnosis by a health professional in 2008. Depression was measured in 2008 using the 10-item Centers for Epidemiologic Study Depression Scale with a score of ≥ 10 considered probable depression.^{51,52}

All covariates were missing <5% at start of follow-up except alcohol use and diet quality, which were missing

≈6%. For time-varying factors, responses were carried forward one cycle if missing over follow-up. For values still missing, a missing indicator was used for categorical variables (race and ethnicity [1.4% missing], parental education [4.2% missing], somatotype at age 5 [1.7% missing], physical activity [4.6% missing], smoking status [0.1% missing], alcohol use [6.3% missing], diet quality [6.3% missing], and depression [0.9% missing]) and mean imputed within our analytic sample for continuous measures (BMI and diet quality; missing 3.8% and 6.3%, respectively).

Statistical Analysis

We first calculated the prevalence of sexual assault and workplace sexual harassment in our sample. We then assessed the distribution of covariates by sexual assault and harassment status. The prospective association of our measures of sexual violence with incident hypertension was estimated with Cox proportional regression models (computing hazard ratios (HR) and 95% CI). The reference group for all analyses was women with no trauma. The follow-up period started in 2008 with return of the questionnaire assessing sexual violence and extended through to the 2015 questionnaire (return dates, 2015–2017). Women contributed person-time from start of follow-up until onset of hypertension or censoring ($n=1095$). Women were censored at end of follow-up, their last questionnaire return date (if they did not return the 2015 questionnaire), onset of cardiovascular/cerebrovascular disease (self-reported myocardial infarction or stroke; reports confirmed by medical records, by death information, or self-corroborated by the participant), or death.

We conducted separate sets of analyses for each of our 3 exposures categorizations (sexual assault, workplace sexual harassment, combined sexual assault and workplace sexual harassment), increasingly adjusted for the same covariates. For model 1, we included adjustment for age. Model 2 was additionally adjusted for race and ethnicity, childhood and family factors (parental education, somatotype at age 5, maternal and paternal hypertension). For model 3, we further adjusted for adult health behaviors and conditions (BMI, alcohol use, smoking status, physical activity, and diet quality), which may be mediators of associations. We verified that the proportional hazards assumption was satisfied for mean age at start of follow-up (younger than 53 years versus 53 years or older) and follow-up period (pre- versus post-2011) using likelihood ratio tests.

To examine the role of psychological distress, which likely lies on the pathway between sexual violence and hypertension, we included a model that adjusted for PTSD and depression in addition to model 2 or 3 covariates in sensitivity analysis. All analyses were performed using SAS software Version 9.4 (SAS Institute Inc) and an alpha value of 0.05 was used to determine significance.

RESULTS

Sexual assault and workplace sexual harassment were common, with lifetime prevalence of 23% and 12%, respectively; 6% of women had experienced both. The mean age at start of follow-up was 53.1 (SD=4.6) years, and our sample consisted of mainly non-Hispanic White women (95%). Over follow-up, 7096 women (21%) reported developing hypertension. Table 1 presents the distribution of covariates at the start of follow-up for our combined exposure capturing both sexual assault and workplace sexual harassment. Tables S1 and S2 present the distribution of covariates at the start of follow-up for sexual assault and workplace sexual harassment exposures, respectively.

Results for Cox proportional regression models are shown in Table 2. Compared with women with no trauma, women who experienced sexual assault had a higher risk of developing hypertension. Women who experienced workplace sexual harassment also had higher risk of developing hypertension compared with those with no trauma. We found the highest risk of developing hypertension in women who experienced both sexual assault and workplace sexual harassment. All estimates attenuated after additionally adjusting for adult health behaviors and conditions in model 3 although history of having both sexual assault and workplace sexual harassment, and history of workplace sexual harassment, each remained clearly associated with increased risk of developing hypertension. Across analyses, history of other traumas was not consistently associated with increased risk of hypertension.

In sensitivity analyses adjusting for psychological distress (PTSD and depression) as well as sociodemographic, childhood and family factors, results remained similar to our main findings (HR, 1.09; 95% CI, 1.01–1.17 for sexual assault; HR, 1.12; 95% CI, 1.03–1.22 for workplace sexual harassment; HR, 1.18; 95% CI, 1.06–1.31 for both sexual assault and workplace sexual harassment) (Table S3). Results were somewhat attenuated, similar to our main findings, when additionally adjusting for psychological distress, in addition to adult health behaviors and conditions (ie, model 3 covariates) (Table S3).

DISCUSSION

We found that women who had experienced sexual violence had an increased risk of developing hypertension over a 7-year follow-up period. Women who experienced both sexual assault and workplace sexual harassment had the highest risk of hypertension.⁹ Sexual violence was common in our sample; 23% of women reported experiencing sexual assault and 12% reported workplace sexual harassment during their

Table 1. Age-Standardized Characteristics by Sexual Violence Among 33 127 Women in the Nurses' Health Study II at Start of Follow-Up in 2008

| | Sexual assault and harassment | | | |
|--|-------------------------------|--------------------------|--|---|
| | No trauma (n=6617) | Other trauma* (n=16 668) | Either sexual assault or harassment (n=7862) | Both sexual assault and harassment (n=1980) |
| Sociodemographic factors | | | | |
| Age (y) [†] | 53.0 (4.7) | 53.1 (4.7) | 53.1 (4.6) | 53.3 (4.4) |
| Race or ethnicity | | | | |
| Non-Hispanic White, %(n) | 95.2 (6200) | 95.6 (15 702) | 95.1 (7390) | 95.1 (1860) |
| Black, %(n) | 0.5 (35) | 0.5 (83) | 0.7 (55) | 1.1 (22) |
| Other race or ethnicity [‡] , %(n) | 4.3 (280) | 3.9 (636) | 4.2 (327) | 3.8 (75) |
| Childhood and family factors | | | | |
| Parental education | | | | |
| High school or less, %(n) | 49.3 (3126) | 49.7 (7938) | 48.2 (3621) | 49.0 (926) |
| Some college, %(n) | 24.4 (1551) | 24.6 (3926) | 25.5 (1919) | 24.1 (454) |
| 4+ years of college, %(n) | 26.3 (1670) | 25.8 (4119) | 26.3 (1976) | 26.9 (508) |
| Highest somatotype at age 5 [§] , %(n) | 5.6 (362) | 5.8 (949) | 6.5 (500) | 6.4 (125) |
| Maternal hypertension, %(n) | 25.6 (1696) | 24.9 (4154) | 25.4 (1998) | 24.8 (492) |
| Paternal hypertension, %(n) | 26.1 (1728) | 27.0 (4504) | 27.8 (2182) | 25.9 (512) |
| Adult health behaviors and conditions | | | | |
| Body mass index (kg/m ²) | 25.7 (5.2) | 25.9 (5.2) | 26.1 (5.3) | 26.1 (5.3) |
| Diet quality score | 57.3 (12.1) | 57.9 (12.1) | 58.9 (12.2) | 59.5 (12.3) |
| Physical activity (MET-h/wk) [¶] | 26.7 (31.8) | 27.0 (30.4) | 26.9 (31) | 28.7 (34.3) |
| Current smoker, %(n) | 4.5 (298) | 4.8 (805) | 6.7 (525) | 7.0 (139) |
| Alcohol use (g/d) [¶] | 6.6 (9.7) | 6.5 (9.6) | 7.2 (10.7) | 7.3 (11.1) |
| Psychological distress | | | | |
| Posttraumatic stress disorder, % (n) | 0.0 (0) | 2.3 (376) | 5.5 (432) | 11.2 (222) |
| Depression, % (n) | 10.7 (696) | 15.4 (2554) | 23.1 (1809) | 31.6 (622) |

Sexual harassment refers to workplace sexual harassment. Values are means (standard deviations) for continuous variables; percentages (n) for categorical variables, and are standardized to the age distribution of the study population. Values of polytomous variables may not sum to 100% because of rounding or missing (all missing <5% except alcohol use and diet quality which were ≈6%). g/d indicates grams per day; kg/m², kilogram per (meter squared); and MET-h/wk, metabolic equivalent task hours per week.

*Other trauma indicates women with other trauma(s) but not workplace sexual harassment or sexual assault.

[†]Value is not age adjusted.

[‡]Other race or ethnicities include Hispanic, Asian, and other ethnicities and are presented as 1 category here for brevity.

[§]Only certain categories for somatotype at age 5 and smoking status are presented here for brevity. Highest somatotype refers to the highest category of somatotype responses.

^{||}Diet quality and body mass index are presented before mean imputation. Diet quality was based on the Alternative Healthy Eating Index. A higher diet quality score indicates a higher quality diet.

[¶]Continuous variables for physical activity and alcohol use are presented here for brevity.

lifetime (within the range of prior reports),^{4,6,7,26–29} Ours is the first study, of which we are aware, to prospectively examine the relationships of sexual assault and workplace sexual harassment with incident hypertension in a large civilian sample of women. A limited number of previous studies have examined these traumas in relationship to hypertension using cross-sectional designs.^{7,8,31–35} As hypertension is a major risk factor for CVD^{53,54} the present findings highlight the importance of considering these measures of sexual violence for women's cardiovascular health.

The observed associations of our sexual violence measures with hypertension appeared independent of sociodemographic factors. Associations attenuated

when including adjustment for adult health behaviors and BMI across all exposures but particularly for sexual assault, whereas a substantive association between workplace sexual harassment and increased risk of hypertension remained evident. Interestingly, we did not see associations between history of other traumas and risk of hypertension, suggesting that increased hypertension risk does not follow any trauma exposure and may be related to trauma type, frequency, and/or severity. Our finding that experiencing both sexual assault and workplace sexual harassment showed the highest risk of hypertension underscores the potential compounding effects of multiple sexual violence exposures on health.^{9,20} Moreover, the risk for hypertension

Table 2. Cox Proportional Hazards Estimates for the Association Between Sexual Violence and Hypertension (Incident Hypertension or Initiation of Antihypertensive Medication Use) Among 33 127 Women in NHS II for Follow-Up Between 2008 to 2015

| | Model 1 | | | Model 2 | | Model 3 | |
|--|-----------------------------|------------------|---------|------------------|---------|------------------|---------|
| N=7096 events among 249 467 person-years | | | | | | | |
| | n for cases/ person-year | HR (95% CI) | P value | HR (95% CI) | P value | HR (95% CI) | P value |
| Sexual assault | | | | | | | |
| No trauma | 1349/50354 | 1.00 (Reference) | | 1.00 (Reference) | | 1.00 (Reference) | |
| Other (non-sexual assault) trauma | 4008/141709 | 1.05 (0.98–1.11) | 0.16 | 1.05 (0.98–1.11) | 0.16 | 1.03 (0.97–1.10) | 0.31 |
| Sexual assault | 1739/57717 | 1.11 (1.03–1.19) | 0.005 | 1.11 (1.03–1.19) | 0.004 | 1.06 (0.99–1.14) | 0.12 |
| Sexual harassment | | | | | | | |
| No trauma | 1349/50354 | 1.00 (Reference) | | 1.00 (Reference) | | 1.00 (Reference) | |
| Other (non-sexual harassment) trauma | 4799/168993 | 1.05 (0.99–1.11) | 0.12 | 1.05 (0.99–1.12) | 0.12 | 1.03 (0.97–1.09) | 0.40 |
| Sexual harassment | 948/30433 | 1.15 (1.06–1.25) | 0.001 | 1.15 (1.05–1.25) | 0.001 | 1.12 (1.03–1.22) | 0.01 |
| Sexual assault and harassment | | | | | | | |
| No trauma | 1349/50354 | 1.00 (Reference) | | 1.00 (Reference) | | 1.00 (Reference) | |
| Other trauma | 3539/125874 | 1.04 (0.98–1.11) | 0.23 | 1.04 (0.98–1.11) | 0.22 | 1.03 (0.96–1.09) | 0.40 |
| Sexual assault or harassment | 1729/58953 | 1.08 (1.01–1.16) | 0.03 | 1.08 (1.00–1.16) | 0.04 | 1.04 (0.97–1.12) | 0.30 |
| Sexual assault and harassment | 479/14598 | 1.20 (1.08–1.34) | 0.001 | 1.21 (1.09–1.35) | 0.0003 | 1.17 (1.05–1.30) | 0.004 |

Sexual harassment refers to workplace sexual harassment. Age (in months) and follow-up wave were stratified. Covariates were time-updated apart from race and ethnicity, parental education, somatotype at age 5 years, maternal and paternal hypertension. HR indicates hazard ratio.

Model 1: adjusted for age.

Model 2: Model 1 plus adjustment for race and ethnicity, parental education, somatotype at age 5, maternal and paternal hypertension.

Model 3: Model 2 plus adjustment for body mass index, alcohol use, smoking status, physical activity, diet quality.

associated with sexual violence while less in magnitude than that for obesity,⁵⁵ is similar in magnitude to that found in other studies for sexual abuse as a child or adolescent²⁰ and sleep duration,⁵⁶ and greater than the risk linked with environmental pollutants (particulate matter, road proximity),⁵⁷ risk factors which have received more attention in the literature.

Experiences of sexual violence have been linked to increased likelihood of psychological distress.^{26,40} Psychological health has been linked with CVD risk⁵⁸ and, in previous work, we have shown that psychological distress following trauma is more strongly associated with hypertension risk, than trauma alone.^{41,59} It is therefore likely that psychological distress lies on the sexual violence-hypertension pathway. In the present study, we found that the association between history of sexual violence and hypertension was only slightly attenuated by adjustment for psychological distress (lifetime PTSD and current depression) at start of follow-up although the precise time sequence of trauma and distress was not available.

Potential Pathways

Stress can affect health directly through biological mechanisms, or indirectly through behavior.⁶⁰

Psychological distress can impact blood pressure through a variety of mechanisms, including excess activation of the hypothalamic-pituitary-adrenal axis and sympathetic nervous system, and poorer endothelial function.^{60,61} Although we did not find strong support for a psychological distress pathway, our study could not test for mediation by distress because of limited information on timing, and as we also did not include biological pathways of distress, these remain a possible mechanism for our findings.

Adult health behaviors and BMI may lie on the pathway between sexual violence and hypertension and prior work has shown that women with versus without history of sexual violence were more likely to smoke and be obese.³² These health factors have also previously been associated with increased likelihood of hypertension.^{62,63} In line with this, our results attenuated when including adjustment for adult health behaviors and BMI, with the greatest attenuation seen for sexual assault. A previous study in this cohort found that BMI explained some of the association between child/adolescent sexual abuse and adult hypertension.²⁰ Therefore, secondary to reducing sexual violence against women, screening victims for modifiable health behaviors and BMI may help to reduce the likelihood of hypertension.

Strengths and Limitations

This study had numerous strengths. Compared with prior research conducted in veteran populations^{8,33,64} the current study's use of data from civilian women increases the generalizability of findings. Additionally, we used a prospective design with 7 years of follow-up and included an extensive range of possible covariates in analyses. Furthermore, using women with no trauma exposure as our reference group allowed us to account for other traumatic experiences in the absence of sexual violence that have previously been linked to adverse health outcomes.^{37–40} This study also examined multiple types of sexual violence, allowing for the consideration of their combined relationship to hypertension.

There are also at least 5 limitations that should be considered. First, sexual violence was assessed retrospectively at one timepoint and may therefore be subject to recall bias, although any underreporting would likely bias results towards the null. Hypertension was also self-reported, allowing for potential misclassification. However, reporting of high blood pressure has been validated in this sample with medical record diagnoses and objective measures.^{45,46} Second, our sample was composed of women who did not have hypertension before start of follow-up in 2008, remained in the cohort and were responsive to questionnaires. Our study therefore investigates the risk of hypertension in midlife and this may have introduced potential survivor bias. A prior report of hypertension prevalence in women aged 40 to 59 was 50%, and 74% in women aged ≥ 60 years.⁶⁵ Third, women in this sample were majority non-Hispanic White and were selected via a professional career in health care, and as a result findings may not generalize to women in the general population.^{66,67} Fourth, the timing and severity of sexual assault and workplace sexual harassment were not captured here and it is therefore difficult to disentangle more specifically the relationships and pathways between these, other traumas, psychological distress and hypertension. Future studies, in addition to capturing more detail on women's experiences of sexual violence, should examine whether psychological distress mediates the relation of sexual violence and hypertension using measures with information on timing. Fifth, performing mean imputation for BMI and diet quality may have introduced bias through decreased standard errors and/or attenuating results towards the null; mean imputation is also not appropriate if missing data are not missing completely at random. However, the missing rate for covariates was low and therefore any bias is likely to be minimal; additionally mean imputation is computationally efficient and easily interpretable. Lastly, this was an observational study and the possibility of unmeasured confounding bias remains.

CONCLUSIONS

Sexual assault and workplace sexual harassment are common experiences amongst women. The present study highlights the importance of investigating sexual violence, including in the workplace, in women's health research. These results suggest that sexual assault and workplace sexual harassment are prospectively associated with greater risk of hypertension, which may place women at risk for future CVD.

Reducing such violence against women is important in its own right and may also provide an important strategy for improving women's lifetime cardiovascular health.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Tables S1–S3

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Supplemental Material

Table S1. Age-standardized characteristics by sexual assault among 33,127 women in the Nurses' Health Study II at start of follow-up in 2008.

| | Sexual assault | | |
|---|------------------------|--|-----------------------------|
| | No trauma (n=6,617) | Other (non-sexual assault) trauma (n=18,765) | Sexual assault (n=7,745) |
| Sociodemographic factors | | | |
| Age (years) [§] | 53 (4.7) | 53.1 (4.7) | 53.1 (4.5) |
| Race/ethnicity | | | |
| Non-Hispanic white, %(n) | 95.2 (6,200) | 95.7 (17,692) | 94.9 (7,265) |
| Black, %(n) | 0.5 (35) | 0.5 (93) | 0.8 (64) |
| Other race/ethnicity*, %(n) | 4.3 (280) | 3.8 (706) | 4.3 (330) |
| Childhood and family factors | | | |
| Parental education | | | |
| High school or less, %(n) | 49.3 (3,126) | 49.3 (8,872) | 48.8 (3,612) |
| Some college, %(n) | 24.4 (1,551) | 24.8 (4,467) | 24.7 (1,830) |
| 4+ years of college, %(n) | 26.3 (1,670) | 25.9 (4,652) | 26.4 (1,954) |
| Highest somatotype at age 5 [¶] , %(n) | 5.6 (362) | 5.9 (1,081) | 6.4 (490) |
| Maternal hypertension, %(n) | 25.6 (1,696) | 25.0 (4,699) | 25.0 (1,938) |
| Paternal hypertension, %(n) | 26.1 (1,728) | 27.3 (5,118) | 26.7 (2,070) |
| Adult health behaviors and conditions | | | |
| Body mass index [‡] (kg/m ²) | 25.7 (5.2) | 25.8 (5.2) | 26.1 (5.4) |
| Diet quality score [‡] | 57.3 (12.1) | 58 (12.1) | 58.9 (12.2) |
| Physical activity ^{††} (MET-hrs/wk) | 26.7 (31.8) | 27.1 (30.6) | 27.2 (32.1) |
| Current smoker, %(n) | 4.5 (298) | 5.0 (931) | 6.9 (535) |
| Alcohol use ^{††} (g/d) | 6.6 (9.7) | 6.6 (9.7) | 7.2 (10.9) |
| Psychological distress | | | |
| Posttraumatic stress disorder, %(n) | 0.0 (0) | 2.4 (450) | 7.4 (576) |
| Depression, %(n) | 10.7 (696) | 16.1 (2,996) | 25.9 (1,994) |

Note: Values are means (standard deviations) for continuous variables; percentages (n's) for categorical variables, and are standardized to the age distribution of the study population. Values of polytomous variables may not sum to 100% due to rounding or missing. Abbreviations: MET-hrs/wk: metabolic equivalent task hours per week; kg/m²: kilogram per (meter squared); g/d: grams per day.

[§]Value is not age adjusted.

*Other race/ethnicities include Hispanic, Asian and other ethnicities and are presented as one category here for brevity.

[¶]Only certain categories for somatotype at age 5 and smoking status are presented here for brevity. Highest somatotype refers to the highest category of somatotype responses.

‡Diet quality and body mass index are presented before mean imputation. Diet quality was based on the Alternative Healthy Eating Index. A higher diet quality score indicates a higher quality diet.

††Continuous variables for physical activity and alcohol use are presented here for brevity.

Table S2. Age-standardized characteristics by workplace sexual harassment among 33,127 women in the Nurses' Health Study II at start of follow-up in 2008.

| | Sexual harassment | | |
|---|------------------------|--|-----------------------------------|
| | No trauma (n=6,617) | Other (non-sexual harassment) trauma (n=22,433) | Sexual harassment (n=4,077) |
| Sociodemographic factors | | | |
| Age (years) [§] | 53 (4.7) | 53.1 (4.7) | 53.3 (4.5) |
| Race/ethnicity | | | |
| Non-Hispanic white, %(n) | 95.2 (6,200) | 95.4 (21,105) | 95.5 (3,848) |
| Black, %(n) | 0.5 (35) | 0.6 (129) | 0.8 (32) |
| Other race/ethnicity*, %(n) | 4.3 (280) | 4.0 (889) | 3.7 (148) |
| Childhood and family factors | | | |
| Parental education | | | |
| High school or less, %(n) | 49.3 (3,126) | 49.5 (10,646) | 47.7 (1,859) |
| Some college, %(n) | 24.4 (1,551) | 24.7 (5,298) | 25.7 (1,000) |
| 4+ years of college, %(n) | 26.3 (1,670) | 25.8 (5,547) | 26.6 (1,036) |
| Highest somatotype at age 5 [¶] , %(n) | 5.6 (362) | 6.0 (1,324) | 6.4 (257) |
| Maternal hypertension, %(n) | 25.6 (1,696) | 24.9 (5,597) | 25.4 (1,037) |
| Paternal hypertension, %(n) | 26.1 (1,728) | 27.0 (6,060) | 28.0 (1,141) |
| Adult health behaviors and conditions | | | |
| Body mass index [‡] (kg/m ²) | 25.7 (5.2) | 25.9 (5.3) | 25.9 (5.2) |
| Diet quality score [‡] | 57.3 (12.1) | 58.1 (12.1) | 59.4 (12.3) |
| Physical activity ^{††} (MET-hrs/wk) | 26.7 (31.8) | 26.9 (30.6) | 28.7 (33.2) |
| Current smoker, %(n) | 4.5 (298) | 5.3 (1197) | 6.6 (269) |
| Alcohol use ^{††} (g/d) | 6.6 (9.7) | 6.7 (9.9) | 7.3 (10.8) |
| Psychological distress | | | |
| Posttraumatic stress disorder, %(n) | 0.0 (0) | 3.3 (734) | 7.4 (303) |
| Depression, %(n) | 10.7 (696) | 17.6 (3,921) | 26.7 (1,085) |

Note: Sexual harassment refers to workplace sexual harassment. Values are means (standard deviations) for continuous variables; percentages (n's) for categorical variables, and are standardized to the age distribution of the study population. Values of polytomous variables may not sum to 100% due to rounding or missing. Abbreviations: MET-hrs/wk: metabolic equivalent task hours per week; kg/m²: kilogram per (meter squared); g/d: grams per day.

[§]Value is not age adjusted.

*Other race/ethnicities include Hispanic, Asian and other ethnicities and are presented as one category here for brevity.

[¶]Only certain categories for somatotype at age 5 and smoking status are presented here for brevity. Highest somatotype refers to the highest category of somatotype responses.

[‡]Diet quality and body mass index are presented before mean imputation. Diet quality was based on the Alternative Healthy Eating Index. A higher diet quality score indicates a higher quality diet.

^{††}Continuous variables for physical activity and alcohol use are presented here for brevity.

Table S3. Cox proportional hazards estimates for the association between sexual violence and hypertension (incident hypertension or initiation of antihypertensive medication use) among 33,127 women in NHS II for follow-up between 2008-2015. Sensitivity analysis additionally adjusting for PTSD and depression.

| | | Model 2 + PTSD and depression | | Model 3 + PTSD and depression | |
|--|---------------------------|-------------------------------|---------|-------------------------------|---------|
| | n for cases / person-year | HR (95% CI) | p-value | HR (95% CI) | p-value |
| <i>N=7,096 events among 249,467 person-years</i> | | | | | |
| Sexual Assault | | | | | |
| No Trauma | 1349/50354 | 1.00 (Reference) | | | |
| Other (non-sexual assault) trauma | 4008/141709 | 1.04 (0.98, 1.11) | 0.23 | 1.03 (0.97, 1.10) | 0.34 |
| Sexual assault | 1739/57717 | 1.09 (1.01, 1.17) | 0.02 | 1.05 (0.978, 1.13) | 0.17 |
| Sexual Harassment | | | | | |
| No Trauma | 1349/50354 | 1.00 (Reference) | | | |
| Other (non-sexual harassment) trauma | 4799/168993 | 1.04 (0.98, 1.11) | 0.20 | 1.02 (0.96, 1.09) | 0.45 |
| Sexual harassment | 948/30433 | 1.12 (1.03, 1.22) | 0.01 | 1.11 (1.02, 1.21) | 0.01 |
| Sexual Assault and Harassment | | | | | |
| No Trauma | 1349/50354 | 1.00 (Reference) | | | |
| Other trauma | 3539/125874 | 1.04 (0.97, 1.10) | 0.29 | 1.03 (0.96, 1.09) | 0.43 |
| Sexual assault or harassment | 1729/58953 | 1.06 (0.99, 1.14) | 0.09 | 1.03 (0.96, 1.11) | 0.36 |
| Sexual assault and harassment | 479/14598 | 1.18 (1.06, 1.31) | 0.002 | 1.16 (1.04, 1.29) | 0.01 |

Note: Sexual harassment refers to workplace sexual harassment. Age (in months) and follow-up wave were stratified.

Model 2: adjusted for age, race/ethnicity, parental education, somatotype at age 5, maternal and paternal hypertension, PTSD and depression.

Model 3: Model 2 plus adjustment for BMI, alcohol use, smoking status, physical activity, diet quality, PTSD and depression.