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Adverse Childhood Experiences and Blood Pressure in Women in the United States: A Systematic Review

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Abstract

Introduction: Elevated blood pressure is a leading contributor to adverse cardiovascular outcomes. Some studies suggest there is an association between adverse childhood experiences (ACEs) and subsequent elevated blood pressure in adulthood. The literature specific to ACEs and blood pressure in women has not been synthesized; thus the purpose of this systematic review was to examine what is known about the association between ACEs and blood pressure in women living in the United States.

Methods: In collaboration with a medical librarian, a systematic search of the literature published between January 1998 and December 2019 was conducted. Original, peer-reviewed publications were identified from PubMed, CINAHL, and PsycINFO databases. Studies were excluded if they (1) were conducted outside the United States, (2) measured acute stress or adult stressors, or (3) measured childhood- or pregnancy-related outcomes.

Results: Of 1740 articles, 12 publications met criteria for inclusion in this study, 8 of which were from cohort studies. Racial and ethnic diversity was limited, with half of the articles in this review consisting of samples that were majority white. Of the studies that used a self-reported history of hypertension, 60% obtained significant associations with ACEs, compared with only 30% of the studies that had objective blood pressure data. ACEs were associated with lower blood pressure in 3 studies.

Discussion: More research is needed to elucidate the relationship between ACEs and elevated blood pressure. Inconsistencies in the findings may be related to the measurement of blood pressure, assessment of ACEs, and population characteristics. Future studies should incorporate

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CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

diverse population-representative samples with consideration for sex- or race-specific stressors such as pregnancy or racism and their potential influence on blood pressure. Health care providers may consider the history of ACEs as part of screening for cardiovascular risk factors among female patients, especially younger women presenting with elevated blood pressure.

Keywords

blood pressure; childhood abuse; health disparities; hypertension; preventive care; primary care; sexual abuse; trauma

Cardiovascular disease (CVD) is the number one cause of death in the United States and currently accounts for approximately 1 of every 3 deaths.[1] The elimination of hypertension alone would reduce cardiovascular mortality by almost 40% among women, compared with 30% in men,[1] which suggests that hypertension is a more potent risk factor for CVD death in women. Sex-specific risk factors, such as blood pressure disorders associated with pregnancy,[2,3] the abrupt rise in risk of hypertension associated with the menopausal transition, and estrogen-specific effects related to acute and chronic stress, may contribute to the difference between men and women in mortality associated with hypertension.[3,4] Hypertension is a key modifiable risk factor for CVD, as well as for cerebrovascular, renal, and metabolic diseases,[1,3,5] so the health behaviors and other lifestyle factors that contribute to hypertension have been well studied. Additional research is needed, however, to identify further factors that may contribute to hypertension in order to support ongoing efforts to prevent CVD and to promote cardiovascular health.

Important determinants of adult health occur during infancy and childhood. Research into the physical health consequences of childhood adversity was spurred by the 1998 landmark study conducted in collaboration with the Centers for Disease Control and Prevention.[6] This study tested the idea that adversities often coexist and may significantly affect adult physical health.[6] The authors grouped 7 forms of adverse childhood experiences (ACEs) into 2 broad categories: child maltreatment, such as physical, sexual, and emotional abuse, and family dysfunction consisting of witnessing partner violence against the mother or living with a family member with mental illness or substance abuse issues or who was formerly incarcerated.[6] The findings showed that the health consequences of ACEs rise in direct proportion to the degree of exposure.[6,7] For example, experiencing 4 or more ACEs was associated with up to a 2-fold increase in adult risk for ischemic heart disease.[6,7] A recent meta-analysis reported that the association of ACEs with CVD is on par with other psychosocial risks such as social isolation.[8] However, the relationship linking ACEs with diabetes and metabolic syndrome, 2 important cardiovascular risk factors, is less clear.[8,9]

The cardiovascular health sequelae of early life stress may differ for women compared with men. Several population-representative studies have found that girls experience more childhood adversity than their male counterparts.[10-12] Of the 3.7 million referrals made in 2011 for abuse and neglect, the Centers for Disease Control and Prevention estimated that 681,000 children were victims of child maltreatment, with higher rates of victimization among girls.[13] Also, rates of parental substance abuse and mental illness are increasing, further contributing to the prevalence of ACEs.[14] Research suggests that women may be

more susceptible to acute, mental stress–induced coronary syndromes, such as mental stress–induced myocardial ischemia,[15] but the sex-specific consequences of chronic stress that begin early in life are still unclear.[8,16] In several studies, findings suggest that cardiovascular risk associated with ACEs may be stratified by sex, with women having worse outcomes,[15,17-19] yet systematic reviews of risk factors for CVD have not always included hypertension,[20] and to our knowledge, there is not a systematic review focused exclusively on the sex-specific effects of ACEs on elevated blood pressure. A 2018 meta-analysis noted a lack of research investigating the associations of between ACEs and CVD stratified by sex and identified this as a priority area for future research.[8] The authors of the meta-analysis focused on clinical outcomes (eg, hypertension), excluding studies with blood pressure as the outcome variable.[8] Given the strong association between hypertension and CVD in women, the rise in cardiovascular mortality among women,[21] and the stagnation in reducing cardiovascular deaths in young women,[22] the study of a potential risk factor such as ACEs is warranted.

Recent research has made discoveries about the transgenerational transmission of stress in utero,[16,23] and there is a growing interest in screening for ACEs in clinical care,[24] so understanding ACE-related cardiovascular health consequences is important for clinicians and researchers alike. Although ACE-related cardiovascular consequences may be similar across geographies, this assumption has not been validated cross-culturally or transnationally. On the contrary, there are clear cultural and geographic differences in the definition of ACEs (eg, what constitutes neglect or parental mental illness), the types of exposures (eg, neighborhood violence vs violence from civil war), and how health and social services access may mitigate the effects of ACEs on cardiovascular health. Thus, this systematic review will focus only on the US context. The aim of this systematic review was to synthesize the literature to answer the question, “Is there an association between adverse childhood experiences and blood pressure in women living in the United States?” Specifically, we aimed to (1) map the relationship between ACEs and blood pressure in women, (2) identify gaps in the sources and data, and (3) delineate priorities for additional studies of the relationship between ACEs and hypertension.

METHODS

To identify studies, PubMed, CINAHL, and PsycINFO were searched to ensure wide coverage of the medical, nursing, psychological, and allied health literature. Research published prior to the 1998 landmark ACE study was excluded.[6] Over the course of multiple consultations with a medical research librarian, a search strategy was developed by modifying and building on previous strategies designed to capture ACE literature in systematic reviews.[9,25] The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist guided the reporting of the methods, and the PRISMA flowchart is included to enhance replicability (Figure 1).

The initial search terms included *adverse childhood experiences, life change events, early life stress, ACEs*, and *toxic stress* (see Supporting Information: Table S1). In addition, using the Boolean connector OR, key categories (eg, *child maltreatment* and *household dysfunction*), classically grouped under the heading of ACEs, based on the initial ACE study

were added.[6] In each search, subject headings such as Medical Subject Headings (MeSH) in PubMed were identified to ensure that all relevant articles were retrieved. Next, the MeSH headings for hypertension and blood pressure were used to search for articles. The adversity and blood pressure searches were combined using the Boolean connector AND. Lastly, the search was restricted to articles that (1) included female human participants, (2) were written in English, and (3) were published in peer-reviewed journals with full data presented (ie, meeting abstracts were excluded).

After removing duplicates, articles were screened by title and abstract by 2 independent reviewers. At this stage, all studies with an all-male study population or participants younger than 18 years were excluded, as well as articles that focused on outcomes unrelated to cardiovascular health such as oncology, protocols, and pharmaceutical trials. In addition, research related to pregnancy was excluded because the physiologic changes of pregnancy may lower or elevate blood pressure; thus that body of research should be reviewed separately from research literature on nonpregnant women. Our initial review retained articles only if the outcome was related to cardiovascular health (eg, hypertension, diabetes) because blood pressure is often assessed as part of studies focused on other aspects of cardiovascular health. In addition, articles that measured adverse experiences that occurred in adulthood or measured acute, perceived, or racial stress were excluded.

The search strategy produced 1740 articles. After duplicates were removed, 1407 articles remained. The title and abstract screening omitted all but 80 articles. The full text articles were evaluated independently by at least 2 authors against the exclusion criteria. At this point, research conducted on populations outside of the United States and studies not meeting the other inclusion criteria were excluded. Eleven articles were retained, and a 12th article identified in a review of the bibliographies of the included articles was added. The overall concordance rate between reviewers in the initial title and abstract screening and full text review was 87% to 91%. Inconsistencies were discussed, and consensus was reached between reviewers.

Independent reviewers extracted the following data in the review matrix: first author, year of publication, name of cohort (if applicable), sample size, percent female, racial composition, measurement of ACEs, subjective versus objective measurement of blood pressure, and results related to our research question.

Inclusion criteria stated, participants and setting described, ACE measurement valid and reliable, An 11-item quality assessment adapted from the Joanna Briggs criteria for cross-sectional and cohort studies was completed (see Supporting Information: Table S2). Some of the quality metrics evaluated included the following: the inclusion criteria were clearly stated, confounding factors were identified and addressed, the handling of missing data was described, and risk of bias was discussed. Additional quality measures relevant to this review, such as consideration of potential confounders related to blood pressure, were also included in the quality assessment. All articles that met the inclusion criteria were included in the synthesis regardless of quality rating.

RESULTS

Table 1 provides an overview of the characteristics of the 12 articles included in this review. Eight of the 12 articles analyzed data from large cohort studies such as the National Survey of Midlife Development in the United States and the Nurses' Health Study II.[29,33] Because multiple articles were published from the National Longitudinal Study of Adolescent to Adult Health (Add Health)[27,28,36] only 5 different cohort samples are represented. Two of the studies in this systematic review were longitudinal and provided opportunities to study the influence of childhood adversity on blood pressure trajectories.[31,35] The number of participants in each study ranged from 213 to more than 69,000. In 6 of the articles, the mean age was less than 40 years. Participants comprised white adults in more than 55% of studies, with 3 exceptions.[26,30,35]

None of the articles met all quality metrics, but 5 articles met 10 of the 11 metrics (see Supporting Information: Table S2).[28,31,32,35,36] The oldest articles, published in 1999 and 2004, met the fewest number of quality metrics, 3 and 4, respectively.[10,30] The following 4 quality assessments were the most common: (1) limited description of participants and setting, (2) failure to address prior diagnosis of hypertension and medication use, (3) failure to address missing data, and (4) failure to include strategies to address confounding.

Assessment of ACEs

Most studies in this review focused on child maltreatment, which is 1 of the 2 broad categories of ACEs examined in the 1998 landmark study of ACEs.[6] Child maltreatment was commonly defined as neglect and/or emotional, physical, or sexual abuse.[10,28,30,32,33,36] Three studies included a broader representation of traumatic events in childhood by using questionnaires modeled on the original 1998 ACE study or by using the Childhood Trauma Questionnaire.[29,31,35] All but 2 articles used retrospective reporting of adversity. One exception was a study using substantiated cases of maltreatment found in judicial records from 1967 through 1971.[32] In the second exception, researchers analyzed data from the Add Health prospective cohort using 2 questions about violence exposure from the first wave when participants were adolescents.[27]

Assessment of Blood Pressure

Five articles assessed hypertension by self-report of prior hypertension diagnosis, whereas 7 articles measured blood pressure objectively (Table 1). Most articles with self-reported data on hypertension identified a positive association between ACEs with hypertension,[10,30,33] whereas only two[27,36] of the 7 studies with objective blood pressure measurements found the same positive association. Researchers used various strategies to manage data from participants who were taking medication to treat hypertension. The most common approach was to include use of antihypertensives or prior diagnosis as a covariate.[27,32,35] Another approach was to exclude participants with a prior diagnosis of hypertension. In a prospective study of 2739 young adults, Lehman et al assessed the relationship between variables related to ACEs to changes in blood pressure. This study obtained objective measurements of blood pressure over time and excluded participants using antihypertensive medications initially, but the 6% who started hypertension medication during the 10 years of follow-up blood pressure

assessments were included in the analysis.[31] A study that used data from the Add Health cohort of 12,420 young adults excluded participants taking antihypertensives in the 4 weeks prior to the blood pressure assessment but conducted a sensitivity analysis including those participants.[28]

Relationship Between ACEs and Hypertension

Half of the studies in this review found a significant positive association between ACEs and elevated blood pressure in women.[10,27,30,33,35,36] Four found a positive association between childhood sexual abuse and hypertension in women.[10,30,33,36] In one of the most racially homogenous samples, recruited from attendees of a conference on the health of Black women, there was a weak positive linear correlation between sexual abuse during childhood and self-reported diagnosis of hypertension (r=0.29; P<.05).[30] In 3 cohort studies, researchers also found a positive relationship between sexual abuse and hypertension.[10,33,36] Using data from Add Health[36] and the National Comorbidity Survey,[10] a history of childhood sexual abuse was associated with hypertension in women but not in men.

Ford and Browning analyzed data from Add Health exploring exposure to violence in childhood and adolescence.[27] Results demonstrated that women who were victims of violence as an adolescent (eg, being stabbed or shot) had 72% higher odds of hypertension (adjusted odds ratio [aOR], 1.72; 95% CI, 1.04-2.84) compared with women who were not victimized in this way. In this study, women who witnessed violence as an adolescent had lower odds of hypertension (aOR, 0.67; 95% CI, 0.39-1.16), but this was not statistically significant.[27] Other studies reported similar unexpected findings. A national cohort study of 12,420 young adults, half of whom were female, found a lower prevalence of hypertension in women who experienced physical abuse (aOR, 0.81; 95% CI, 0.64-1.01) or had social services involvement (aOR, 0.78; 95% CI, 0.50-1.22), but again the difference was not statistically significant.[36] In a smaller sample of 213 adults from the greater Pittsburgh area, family conflict and emotional neglect were associated with lower systolic and diastolic blood pressure among women but not among men.[34]

Effect of the Severity of ACE Exposure

Some investigators analyzed data based on the frequency or severity of ACE exposure.—A study of more than 68,000 women, most of whom were white registered nurses, examined both exposure to abuse and severity of the abuse.[33] Riley and colleagues reported a dose-response relationship in risk for hypertension at all levels of abuse severity, ranging from a 4% risk at the least exposure (hazard ratio [HR], 1.04; 95% CI, 0.99-1.08) to a 59% higher risk for women who experienced the most severe abuse (HR, 1.59; 95% CI, 1.42-1.78).[33] These findings were not consistent across all studies. Gooding et al (2014) used data from Add Health to study the relationship between blood pressure and child maltreatment, specifically in those with frequent exposure to maltreatment.[28] They measured blood pressure objectively and found no association of frequent abuse and hypertension in women or men.[28] These findings are more consistent with those from the National Survey of Midlife Development in the US cohort study of predominantly middle aged, well-educated, white Americans in which the effect of a cumulative adversity score on hypertension was greater in men than in women, although both had very small effect sizes (Somers' d < 0.2).[29]

A regional cohort study of 394 participants examined the association of cumulative ACE exposure, measured by the total number of ACEs, on longitudinal blood pressure trajectories. Participants in the Georgia Stress and Heart Study who experienced multiple ACEs in childhood had a steeper rise in blood pressure that was detectable after the age of 30 years.[35] An examination of blood pressure recorded over a 10-year period found that at age 38 years, participants with 4 or more ACEs had systolic and diastolic blood pressure measurements that were higher compared with their counterparts having no exposure to adversities (9.3 mm Hg systolic and 7.6 mm Hg diastolic, respectively); this relationship did not differ significantly by sex or race.[35] Only one article in this review included confirmed cases of neglect and matched controls. In this prospective examination of data collected in the Midwest from almost 700 cases and controls, investigators did not detect a direct relationship with hypertension, and there were no findings to suggest that this relationship differed by sex.[32]

Behavioral Risk Factors Associated with ACEs and Cardiovascular Outcomes

Behavioral factors are an essential consideration for any cardiovascular-related outcome, and 67% of the articles in this review included established cardiovascular risk behaviors such as tobacco use, physical activity, or body mass index as covariates. In the Georgia Stress and Heart Study, including health behaviors in the model had almost no effect on the relationship between ACEs and systolic blood pressure trajectories over time.[35] Three other studies reported similar findings.[8,31,36] In 2 of these studies, including behavioral covariates shifted results to statistical nonsignificance, although there was minimal change in odds ratios.[10,36] For example, Goodwin and Stein used data from the National Comorbidity Study to examine if child abuse was associated with physical health. They found that sexual abuse was associated with 60% higher odds of hypertension (aOR, 1.60; 95% CI, 1.00-2.60) after adjusting for demographics, which was attenuated to 40% higher odds of hypertension (aOR, 1.40; 95% CI, 0.80-2.30) after adjusting for alcohol and substance use behaviors.[10]

Including measures of emotional health as covariates was also common.[10,27,28,31,36] Lehman and colleagues explored hypothesized pathways linking blood pressure, ACEs, and emotionality operationalized as depression, anxiety, anger and hostility, in an analysis of 2738 young adults in the Coronary Artery Risk Development in Young Adults (CARDIA) prospective study.[31] They found that ACEs were related to negative emotions, which in turn predicted blood pressure; however, in models testing specific sex differences, the link from emotional regulation to health behavior was not significant for women.[31]

Measures of childhood economic position, such as the educational level of parents and parental occupations, were also commonly included covariates.[27,28,31,35] Su et al (2015) identified strong collinearity between ACEs and childhood socioeconomic status; however, further analysis determined that the 2 are linked but not redundant.[35] In their sample of almost 400 young adults under the age of 40 years, half of the participants who reported abuse and a third of participants who reported high ACE exposure were from medium- or high-earning families. Whereas a traditional ACE score had no direct effect on blood pressure, when childhood socioeconomic status was included as part of the ACE cumulative score, there was a significant interaction of this expanded ACE score and age on systolic and

diastolic blood pressure, suggesting that ACEs and childhood socioeconomic status are not capturing the same risk elements.[35]

DISCUSSION

The findings of this systematic review indicate that the relationship between ACEs and subsequent hypertension remains unclear. The studies had notable differences in study outcomes, measurement of blood pressure, assessment of ACEs, and population characteristics. Of the various ACEs assessed, childhood sexual abuse was the most consistently associated with elevated blood pressure.[12,30,33,36] These findings are similar to conclusions from other systematic reviews, which found inconclusive or weak support for a relationship between ACEs and diabetes[8,9,20] and stronger support for ACEs and coronary and ischemic heart disease.[8,20]

Studies that used a self-reported history of hypertension were more likely to find a significant association with ACEs.[12,30,33] Although the specificity of self-report of hypertension is among the highest of all diseases,[37,38] especially among women,[39] it is less precise than objective blood pressure data. Self-report bias may explain the higher prevalence of positive significant results in studies using self-reported data and support future research relying on objective blood pressure data. Furthermore, objective measurements of blood pressure allow researchers to evaluate nuances related to the stage of hypertension and to changes in blood pressure over time.

Statistical accounting for prior diagnosis of hypertension or current use of antihypertensive medication use is a relevant consideration for this area of research. Although there are no standard guidelines, there are generally 3 approaches: (1) excluding participants with prior diagnosis or current medication use, (2) controlling for medication use or prior diagnosis in the statistical analyses, and (3) manually assigning participants with either prior hypertension diagnosis or current antihypertensive use to the hypertensive group.[40,41] Excluding participants using medication reduces power and precision and may introduce selection bias from the risk of removing participants who have had more interaction with the health care system because of higher acuity. One study of partner violence in adolescence and young adulthood used a different approach by adding a constant to the blood pressure values based on the estimated blood pressure reduction of a single dose of antihypertensive medication.[42] This approach is possibly the least used but has been recommended for a robust analysis.[40,41] A full discussion of the statistical ramifications is beyond the scope of this article; therefore, the interested reader is referred to the work of Tobin and colleagues.[41] To enhance the quality of future studies and to clarify the relationship of ACEs and blood pressure among women, researchers should prioritize research using objective blood pressure data and should account for confounders such as medication use.

Several studies in this review did not identify a direct relationship between ACEs and a single blood pressure measurement. Moreover, 3 cross-sectional analyses reported that higher ACE scores were associated with having lower, not higher, blood pressure.[27,34,36] This enigmatic finding should be interrogated further to explore hypotheses such as (1) the differential relationship of the sympathetic nervous system and blood pressure among

women versus men[43] and (2) the role of estrogen receptors in the brain on the sympathetic nervous system.[4]

Notably, there were important findings about the association between ACEs and the trajectory of blood pressure over time. Two of the studies found a steeper rise in blood pressure occurring around the third decade of life,[31,35] with one study identifying a steeper slope only among Black women.[31] These findings contrast with the often-depicted clinical picture of hypertension and CVD as an illness of the middle aged, which may not hold true for women who experienced childhood adversity. Black women have among the highest prevalence of hypertension in the world,[1,3] and few studies have explored the potential role of ACEs on this health disparity. Findings from longitudinal studies suggest that experiencing ACEs may be associated with earlier deterioration in health, consistent with the weathering hypothesis.[44,45] Simply stated, stressors, especially cumulative stress, may exert more wear and tear on the physical health of young women. For example, young adulthood is a period of life often characterized by the stress of establishing a career, forming an intimate partnership, and raising a family.[46] Future research could explore other stressors pertinent to this developmental stage that may contribute to the concerning blood pressure trajectory among some young women.

Sex-specific factors such as pregnancy complications and postpartum weight retention are important considerations for hypertension in women, especially during the childbearing years.[2,3] Blood pressure disorders associated with pregnancy, such as preeclampsia, are more prevalent in Black women,[2,3] and some studies have linked various stressors with hypertensive disorders of pregnancy.[47,48] Future research should pursue an understanding of how ACEs may contribute to blood pressure changes in the childbearing years. Our review found one study that consisted entirely of mothers of young children,[26] but there was no consideration of potential confounding from unresolved hypertensive disorders of pregnancy. As the body of evidence supporting the developmental origins of health and disease continues to expand, an understanding of the relationship between childhood adversity and blood pressure in young women could provide transgenerational health benefits, improve the health of all women, and reduce racial and ethnic cardiovascular health disparities in the next generation.[16,23]

A common critique of ACE research concerns the use of retrospective versus prospective reports of adversity. In one of the prospective ACE measures in this review, data on physical neglect were based on court records from the 1960s,[32] yet cultural and temporal norms about the definition of neglect may have changed over time. A more lenient definition of neglect, combined with a known underrepresentation of neglect in government records, could lead to an underestimation of the effects of neglect on blood pressure.[13,49] Cultural norms, biases on the part of medical or legal teams, and emotional well-being have the potential to influence reports of ACEs.[50,51] These factors should be considered in future ACE research. Overall, child maltreatment was well represented in the literature, with less attention paid to other types of ACEs.

Parental substance abuse and incarceration were not well represented, although both may be on the rise because of the opioid crisis.[52] Substance abuse is cited in at least a third of cases

in which children are removed from the home by child protective services.[49] In addition, although we know that ACEs and health outcomes are dose dependent, only a few studies in this review analyzed ACEs based on cumulative ACE exposure. Insufficient attention to a wide variety of ACEs may obscure important relationships related to cardiovascular health. We observed that several studies retrieved in our search were related to discrimination, which raises questions about whether forms of adversity that were not part of the 1998 ACE study may be relevant to the study of ACEs and blood pressure among women across the life span and in populations with a disparate prevalence of hypertension. Finkelor and colleagues found that adolescents identified other forms of relevant adversity according to their developmental stage.[53] Their analysis found that expanding the definition of ACEs resulted in the addition of stressors that were more predictive of poor health than the original ACEs. For example, the effects of substance abuse in the household on emotional health was attenuated when adversities like peer victimization (eg, bullying) were examined.[53]

Implications for Future Practice and Research

Inconsistent findings in this review of the literature preclude concluding that there is a consistent link between ACEs and hypertension in adult female patients. However, 50% of studies reviewed showed a positive association. The findings suggest that women's health care providers should be aware of the potential that ACEs may influence blood pressure in adulthood. Screening for ACEs among young adult women presenting with elevated blood pressure may be warranted and could identify a need for focused behavioral health interventions.

This review highlighted several gaps in the literature. First, despite a thorough search strategy, only 12 articles were identified with sex-stratified analyses, and of these, only 5 further stratified the analysis by race and sex. More research is needed to accurately determine the relationship between ACEs and blood pressure not only among women but also within racial and ethnic subpopulations that may be at greater risk. Future research should explore the earlier and steeper rise in blood pressure among some women by focusing on young adulthood and the stressors occurring at this developmental stage that may amplify effects of ACEs on cardiovascular health. Likewise, additional research incorporating measures of stress related to discrimination and sex-specific variables, like pregnancy, is needed to determine how these factors may influence the impact of early life stress on adult health.

Equally important is the need to shift beyond identifying the stressors to testing hypotheses surrounding factors that may be protective for cardiovascular health and may contribute to resiliency. Some of this work has begun,[54-56] but it has been primarily focused on early childhood,[56] so research with diverse populations and studies focused on other sensitive periods, such as adolescence,[54,57] is needed. The first goal of research efforts should be ACE prevention, and early intervention should be a close priority; however, even the best efforts will not achieve 100% penetration, so clinicians and public health professionals must be prepared to intervene beyond the early childhood years. Also, given that Black women are disproportionately affected by hypertension, research is needed to explore (1) how the intersectionality of identities (ie, being Black and female) may affect blood pressure and (2)

ways in which future interventions might be tailored to address this risk. Preliminary research, such as focus groups with the intended populations, may provide the best guidance for identifying key characteristics and variables for designing tailored interventions.[58]

Although the searched included 3 of the most widely used research databases and multiple consultations with a research librarian, there may be articles that were inadvertently missed. Until 2019, there was not a common subject identifier (MeSH term) in the research databases, making it more challenging to search the literature in this area comprehensively. Other limitations include the inconsistent measurement of ACEs, a shortage of studies that consider the cumulative impact of multiple ACEs, and reduced generalizability because of a lack of racial and ethnic diversity in some studies.

CONCLUSION

In this systematic review, the need for additional research to determine the relationship between ACEs and subsequent hypertension in women was identified. Moreover, scant literature that considers the cumulative impact of stress, particularly of race- and sex-specific stressors, was identified. Future studies should address these gaps to (1) facilitate continued interventions at the individual, community, and societal levels; (2) prevent CVD; and (3) promote optimal health for women and their offspring.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Quick Points

- Adverse childhood experiences (ACEs) were positively associated with elevated blood pressure in 6 of the 12 articles reviewed.
- Observed differences in the association of ACEs and blood pressure may be related to self-reported history of hypertension versus objective measurement of blood pressure, the different categories of ACEs assessed, and population characteristics.
- More research is needed to explore the relationship between ACEs and blood pressure among racial and ethnic subpopulations with a higher prevalence of hypertension.
- Health care providers should be aware of the potential for adversity across the life course to influence blood pressure in adulthood.

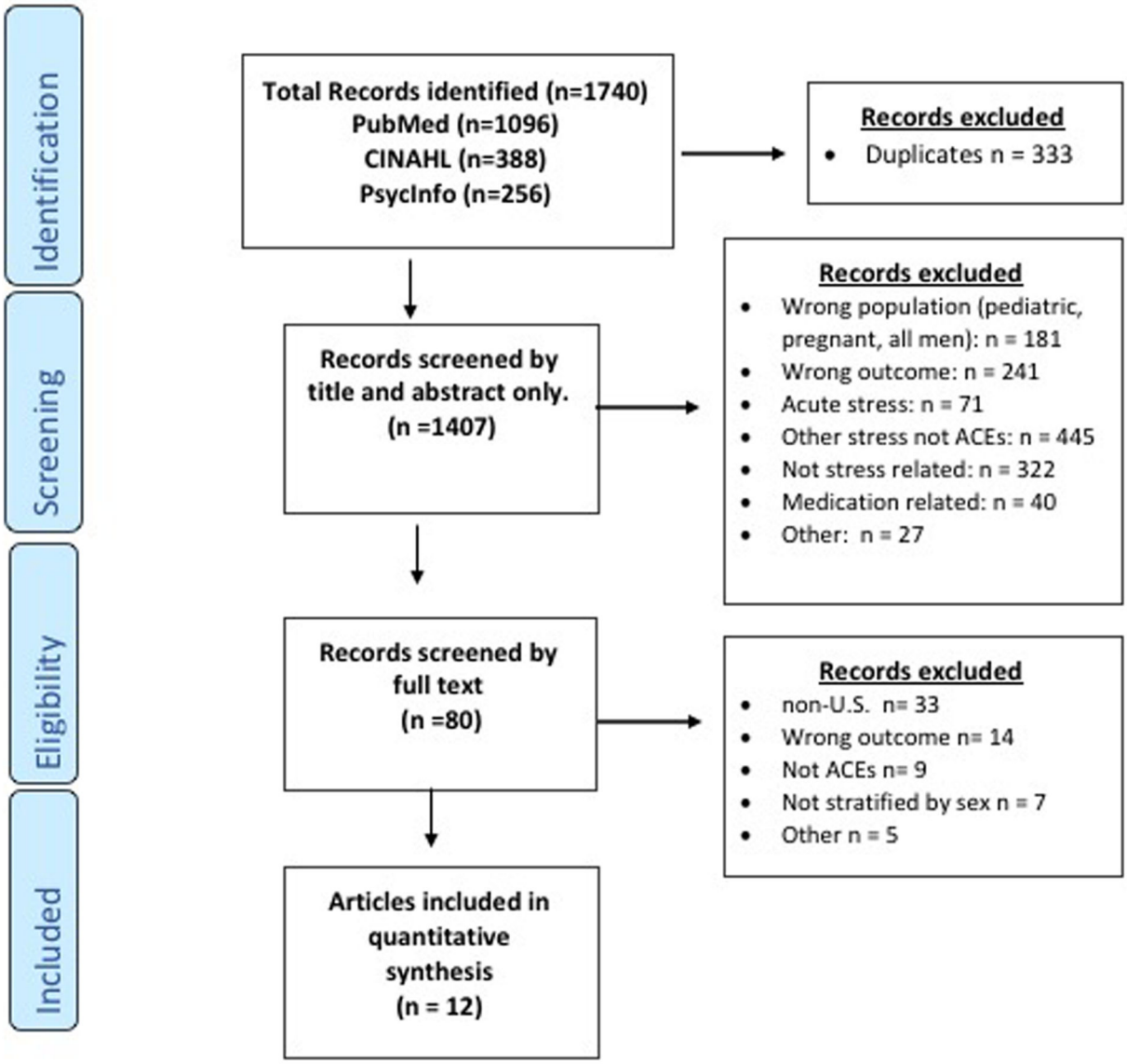

Figure 1.
PRISMA Flow Diagram of Identification of Articles
Abbreviation: ACE, adverse childhood experience.

Table 1.

Overview of Studies Examining Adverse Childhood Experiences and Elevated Blood Pressure Among Women in the United States

Author(Year)	Type of Study	Sample Size (N)	Assessment of BP or HTN Status	No. of Quality Metrics Met[a]	Adjusted for Confounders	Key Results
Cubbin et al[26] (2019)	Cross-sectional analysis of data from California GROW study	2409	Subjective	8	Demographics	No association of ACEs with HTN.
Ford and Browning [27](2014)	Cross-sectional analysis of data from the Add Health prospective cohort study	7971	Objective	8	Health behaviors, mental health	Women who were victims of violence before age 16 had increased odds of HTN (aOR, 1.75; 95% CI, 1.07–2.86), but witnessing violence before age 16 was not associated with HTN (aOR, 0.67; 95% CI, 0.39–1.15).
Gooding et al[28] (2014) *b*	Cross-sectional analysis of data from the Add Health prospective cohort study	12,420	Objective	10	Demographics, health behaviors, mental health	No significant association between SBP and frequent emotional (β, 0.35; 95% CI, −0.39, 1.10), physical (*β*, −0.78; 95% CI, −2.06, 0.50), or sexual (*β*, −0.69; 95% CI, −1.82, 0.45) childhood abuse. The results for DBP and HTN were similar with no significant findings.
Goodwin and Stein [10] (2004)	Cross-sectional analysis of data from the National Comorbidity Survey	5877	Subjective	4	Demographics, health behaviors, mental health	Sexual abuse was positively associated with HTN in women (aOR, 1.6; 95% CI, 1.0–2.6).
Kuhlman et al[29] (2018)	Cross-sectional analysis of data from the MIDUS cohort study	4036	Subjective	5	Demographics, age when adversity occurred	The effect size for cumulative adversity and HTN was small (d < 0.05), not clinically significant.
Lawson et al[30] (1999)	Correlational analysis	323	Subjective	3	None	Childhood sexual abuse correlated with HTN (r = .29; *P* < .05).
Lehman et al[31] (2009)	Longitudinal analysis of data from the CARDIA cohort study	2739	Objective	10	Demographics, health behaviors, mental health	Structural equation modeling showed no direct effects of ACEs on initial BP or on BP change. Black women had higher BP and steeper rise in BP over time, but the pathways between ACEs and BP were similar for all race-sex subgroups.
Nikulina and Widom[32] (2014)	Case-control	675cases,667 controls	Objective	10	Demographics, health behaviors, BP medication	No direct effect of neglect on HTN (aOR, 1.07; 95% CI, 0.73–1.56) was observed.
Riley et al[33] (2010)s	Cross-sectional analysis of data from the Nurses' Health Study II	64,733	Subjective	8	Demographics, health behaviors, family history, OCP	Severe physical abuse (HR, 1.27; 95% CI, 1.17–1.38) and forced sexual activity (HR, 1.47; 95% CI, 1.33–1.62) were associated with significant increased riskofHTN.
Schreier et al[34] (2019)	Cross-sectional analysis of data from the Pittsburgh Common Cold Project	213	Objective	9	Demographics, health behaviors, mental health, contraceptive medication	Adversity was associated with significantly lower SBP (β, −0.26; SE, .09; *P* = .01) and DBP (β, −0.15; SE, .07; P = .02) among women but not among
Su et al[35] (2015)	Longitudinal analysis of data from the Georgia Stress and Heart Study	394	Objective	10	Demographics, health behaviors, BP medication	Higher ACE score associated with a steeper rise in SBP (*β*, 0.0005; SE, .0002; *P*= .03) and DBP (*β*, 0.0004; SE, .0002; *P* = .02) after age 30. No effect modification by

Author(Year)	Type of Study	Sample Size (N)	Assessment of BP or HTN Status	No. of Quality Metrics Met[a]	Adjusted for Confounders	Key Results
Suglia et al[36] (2014)	Cross-sectional analysis of data from the Add Health prospective cohort study	11,384	Objective	10	Demographics, health behaviors, mental health	Women, but not men, who experienced childhood sexual abuse had higher prevalence of HTN (PR, 1.35; 95% CI, 0.92–1.96), but this was not statistically significant. Physical abuse and neglect in childhood were not associated with higher prevalence ofHTN.

Abbreviations: ACE, adverse childhood experience; Add Health, National Longitudinal Study of Adolescent to Adult Health; aOR, adjusted odds ratio; BP, blood pressure; CARDIA, Coronary Artery Risk Development in Young Adults; DBP, diastolic blood pressure; GROW, Geographic Research on Wellbeing; HR, hazard ratio; HTN, hypertension; MIDUS, National Survey of Midlife Development in the United States; OCP, XXXX; PR, prevalence ratio; SBP, systolicbloodpressure.

[a]Eleven quality metrics were assessed. See Supporting Information: Table S2 for additional details.

[b]Data reported by Gooding et al (2014) include men and women. No effect modification by sex was found, but only data for the combined male and female sample were provided.