Association of Baseline Depressive Symptoms with Prevalent and Incident Pre-Hypertension and Hypertension in Postmenopausal Hispanic Women: Results from the Women’s Health Initiative

Ruth E. Zambrana1, Lenny López2*, Gniesha Y. Dinwiddie3, Roberta M. Ray4, Charles B. Eaton5, Lawrence S. Phillips6, Sylvia Wassertheil-Smoller7

1 Department of Women’s Studies, Consortium on Race, Gender and Ethnicity, University of Maryland, College Park, Maryland, United States of America, 2 Division of Hospital Medicine, University of California, San Francisco, California, United States of America, 3 African American Studies Department, University of Maryland, College Park, Maryland, United States of America, 4 Fred Hutchinson Cancer Research Center, Seattle, Washington, United States of America, 5 Family Medicine & Epidemiology, Alpert Medical School, Brown University, Providence, Rhode Island, United States of America, 6 Division of Endocrinology and Metabolism, Emory University School of Medicine, Atlanta, Georgia, United States of America, 7 Department of Epidemiology & Population Health, Albert Einstein College of Medicine, Bronx, New York, United States of America

* Lenny.lopez@ucsf.edu

Abstract

Background
Depression and depressive symptoms are risk factors for hypertension (HTN) and cardiovascular disease (CVD). Hispanic women have higher rates of depressive symptoms compared to other racial/ethnic groups yet few studies have investigated its association with incident prehypertension and hypertension among postmenopausal Hispanic women. This study aims to assess if an association exists between baseline depression and incident hypertension at 3 years follow-up among postmenopausal Hispanic women.

Methods
Prospective cohort study, Women’s Health Initiative (WHI), included 4,680 Hispanic women who participated in the observational and clinical trial studies at baseline and at third-year follow-up. Baseline current depressive symptoms and past depression history were measured as well as important correlates of depression—social support, optimism, life events and caregiving. Multinomial logistic regression was used to estimate prevalent and incident prehypertension and hypertension in relation to depressive symptoms.

Results
Prevalence of current baseline depression ranged from 26% to 28% by hypertension category and education moderated these rates. In age-adjusted models, women with
depression were more likely to be hypertensive (OR = 1.25; 95% CI 1.04–1.51), although results were attenuated when adjusting for covariates. Depression at baseline in normotensive Hispanic women was associated with incident hypertension at year 3 follow-up (OR = 1.74; 95% CI 1.10–2.74) after adjustment for insurance and behavioral factors. However, further adjustment for clinical covariates attenuated the association. Analyses of psychosocial variables correlated with depression but did not alter findings. Low rates of antidepressant medication usage were also reported.

Conclusions
In the largest longitudinal study to date of older Hispanic women which included physiologic, behavioral and psychosocial moderators of depression, there was no association between baseline depressive symptoms and prevalent nor incident pre-hypertension and hypertension. We found low rates of antidepressant medication usage among Hispanic women suggesting a possible point for clinical intervention.

Trial Registration
Clinicaltrials.gov NCT00000611

Introduction
Investigators over the last two decades have produced an increasing body of knowledge on racial/ethnic hypertension disparities [1–4] and hypothesized that depression plays a mediating role in elevated blood pressure among adult women. [5–10] Depression and depressive symptoms are risk factors for hypertension (HTN) and cardiovascular disease (CVD). However, the pathophysiologic mechanisms linking depressive symptoms to cardiovascular outcome has yet to be understood among Hispanic women. [11–14] Depression and anxiety are more common in women than men, increase with age, and menopause doubles the risk of hypertension even after adjusting for factors such as age and body mass index. [5,15] Several hypotheses have been proposed to explain this relationship: (1) Hypertension may be a mechanism through which depressive symptoms influence CVD pathogenesis; [7] (2) depression may contribute to hypertension, or conversely (3) women who are hypertensive may exhibit higher rates of depression. [15] Hispanic women (specifically of Puerto Rican and Mexican ancestry) across the life course have lower-income, less education, lower perceptions of social support that contribute to higher rates of depression and depressive symptoms compared to non-Hispanic White and other Hispanic subgroups. [16–19] A paucity of research exists that investigates the association between incident prehypertension and hypertension with depression among postmenopausal Hispanic women, and few include multiple psychosocial stressors, or use a longitudinal study design. [6]

Women’s response to life stressors play a role in the higher rates of depression. High rates of depression for Hispanic women include daily stressors such as living in low-resourced neighborhoods, and low social support with high levels of caregiving. [16,20,21] Hispanic women are more likely to experience stressful life events, less likely to receive mental health services, least likely to receive psychiatric medication during treatment, [16,22, 23] and are less likely to be aware of their HTN; receive treatment and or have their HTN controlled compared to other racial/ethnic women. [24] Comprehensive reviews of the role of psychosocial factors, namely
low levels of social support, [25] stressful life events, low optimism, depression, and increased rates of caregiving responsibilities, [8,26–31] provide convincing evidence of their link with higher levels of systolic blood pressure. [6,14] Although social support has been shown to reduce stress, improve adherence to medication, and buffer disease severity and depression, [32,33] increased caregiving responsibilities of family members and a pessimistic attitude play a significant role in predicting hypertensive risk. [34,35] These psychosocial predictors of depression have not been included in most prior epidemiologic studies. The contribution of this study is its ability to assess known psychosocial correlates of depression that have a significant association with depression and hypertension. We seek to assess if an association exists between baseline depression and incident hypertension at 3 years follow-up among postmenopausal Hispanic women.

Methods

The Women’s Health Initiative (WHI) is a large, multiethnic, 40-center study funded by the National Heart, Lung, and Blood Institute (NHLBI) that focuses on strategies for preventing heart disease, breast and colorectal cancer, and osteoporotic fractures in postmenopausal women. The total sample includes 161,808 women aged 50–79 years. Self-reported race/ethnicity includes 82.5% non-Hispanic White; 9.0% Black or African American; 4.0% Hispanic, predominantly Mexican American; 2.6% Asian or Pacific Islander; and 1.5% other. For the analyses, we include 4,680 Hispanic women who participated in the WHI observational and clinical trial studies at baseline (1994–1998) and at third-year follow-up and for whom blood pressure was measured at baseline and year 3. Data were collected during a baseline screening visit and during a third year visit; the data included physical measurements and questionnaires related to medical history, family history, and behavioral factors. A full description of the WHI study is presented elsewhere. [36,37] The dependent variables were prehypertension and hypertension analyzed in separate models. Blood pressure was measured at the first screening clinic visit by certified staff with the use of standardized procedures and instruments; it was measured in the right arm with a mercury sphygmomanometer after the participant was seated and had rested for 5 minutes. [36] The cuff, was inflated to 30 mm Hg above palpated systolic blood pressure (SBP). SBP was defined as the pressure level at which the first of two Korotkoff sounds occurred in appropriate rhythm and diastolic blood pressure (DBP) was the phase V Korotkoff value. The average of 2 blood pressure readings obtained at least 30 seconds apart, was used for analysis. Hypertension was defined in women who reported that they were told by a doctor they had high blood pressure, and/or those who were prescribed medications for hypertension, and/or those whose systolic blood pressure was \( \geq 140 \) mm Hg, and/or those whose diastolic blood pressure was \( \geq 90 \) mm Hg. [1] Participants with prehypertension were those women whose systolic/diastolic blood pressure was \( 120-139/80-89 \) mm Hg with no self-report of medication prescribed for hypertension as defined by the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7). [38] Participants with normal blood pressure had systolic/diastolic blood pressure \(< 120/80 \) mm Hg and no self-report of medication for hypertension.

At baseline, participants completed a psychosocial questionnaire using 6-items from the Center for Epidemiological Studies Depression Scale (CES-D) scale to assess depressive symptoms in the past week and two items from the Diagnostic Interview Schedule (DIS) regarding a history of depressive symptoms in the past year. [19,39,40] Women were asked in the CES-D to report how often, in the past week, they had felt depressed; had restless sleep; enjoyed life; had crying spells; felt sad; and felt that people disliked them. Items were scored as: rarely or none of the time (\(< 1 \) day); some or a little of the time (1–2 days); occasionally or a moderate
amount of time (3–4 days); and most or all of the time (5–7 days). The 2 items derived from the DIS asked: "‘In the past year, have you had 2 weeks or more during which you felt sad, blue, or depressed, or lost pleasure in things that you usually cared about or enjoyed?’; ‘Have you had 2 years or more in your life when you felt depressed or sad most days, even if you felt okay sometimes?’; and ‘If yes, have you felt depressed or sad much of the time in the past year?’"

Based on prior research, [9,19,41] we constructed three measures of depression. The CES-D items measured current depressive symptoms at baseline and were scored from 0 to 3, with a score of 0 indicating the participant never or rarely experienced the depressive symptoms and a score of 3 indicating the symptom was experienced most or all of the time. A summary measure of current depressive symptoms at baseline summed the responses to the CES-D and categorized a score of 5 or higher (of a possible total 18) as indicative of symptoms of depression. In a second measure, we combined the DIS items, so that a woman who responded ‘yes’ to both questions was considered to have a prior history of depression. We constructed a third measure that included items from the CES-D and DIS and a logistic regression algorithm [39] was used to compute the Burnam score indicating probability of depression. The Burnam score ranges from 0 to 0.99 with a score higher than 0.06 defining high depressive symptomatology. [19] This threshold score is not itself a measure of clinically diagnosed depression but is well correlated with clinical depression. [41] We coded antidepressant use at baseline (yes/no) from a detailed medication inventory at that visit.

Our assessment of psychosocial factors included four validated scales that measured stressful life events, social support, optimism, and caregiving responsibilities. An index of stressful life events was created with 11 items, derived from the Alameda County Epidemiologic Study, [42] and modified for the Beta Blocker Heart Attack Trial. [43] A summary score (range: 0–33) was computed as the count of the number of events weighted by the participant’s appraisal of stress attributed to each event with higher scores indicating a greater number of stressful events. The stress-weighted number of life events was divided into four categories of events (0, 1–2, 3–4, 5–33). Social support was assessed using 9 items from the Medical Outcomes Study questionnaire. [44] Participants ranked on a 5-point scale how often emotional, affection, and tangible and positive interaction support domains were available. The total summary score ranged from 9 to 45, where a higher score indicated more social support. For analysis, we recoded the scores as lower (9 to 33), medium (34 to 40), and higher levels of support (41 to 45). Optimism was measured using the Life Orientation Test-Revised (LOT-R) six item scale. [45] Responses were coded on a 5-point scale, and categorized as low (6–23), medium (24, 25), and high (26–30). Caregiving responsibility was based on a two-part item derived from the Cardiovascular Health Survey (none/less than once a week, 1–2 times per week, >3 times per week). [46]

All participants provided written informed consent. Institutional review board approval was obtained from each of the participating study centers and from the Fred Hutchinson Cancer Research Center, which currently serves as the IRB of record for the WHI.

Analyses

All statistical analyses were performed using SAS System for Windows version 9.3 (SAS Institute, Cary, NC). Descriptive analyses evaluated the unadjusted baseline associations of hypertension status (normotensive, prehypertensive, or hypertensive) by demographic, clinical, behavioral, and psychosocial characteristics of the participants, and the three depression measures. For our main analysis, we dichotomized continuous Burnam scores at the standard threshold of 0.06 to identify women experiencing symptoms consistent with depressive disorders or probability of depression, including major depression and dysthymia [1,19,47]
We used multinomial logistic regression models to evaluate: hypertension status at baseline in relation to each of three measures of depression, adjusted for the effects of other explanatory variables and potential confounders included in each model; and the association of incident prehypertension and hypertension at year 3 with the probability of depression, using baseline Burnam score in multivariable models. Associations were presented as odds ratios (OR) and 95% confidence intervals (95% CI).

A set of baseline covariates was selected a priori to adjust for potential confounding. These included age at enrollment (50–64, 65–79); level of education (less than high school, high school degree/GED/vocational or training school, some college, and college graduate or above); personal medical history of cholesterol levels requiring pills, treated diabetes, and history of CVD; BMI (<25 kg/m², 25 to <30 kg/m², ≥30 kg/m²); family history of adult diabetes, stroke or myocardial infarction (computed as the sum of conditions reported, scores ranging from 0 to 3); health insurance coverage (yes/no); smoking status (never smoked/past smoker, current smoker; physical activity assessed in metabolic equivalent of task (MET)-hours per week (0 to <3.0, 3.0 to <11.75, ≥11.75); alcohol intake (nondrinker/past drinker, <7 drinks per week); and antidepressant use (yes/no). In addition, we separately evaluated the effects of four self-reported psychosocial measurements: stressful life events, social support, optimism and caregiving responsibilities.

Results

The mean age at baseline of participants by hypertension status was: normotensive: 58.3 years (SD 6.17), prehypertensive: 60.2 years (SD 6.7) and hypertensive: 62.3 years (SD 6.8). Prevalence of prehypertension and hypertension at baseline was lower in participants with some college education or higher compared to those with a lower education attainment (Table 1). Women enrolled in WHI at an older age, those with insurance, a BMI ≥30, taking high cholesterol and diabetes medications, a family and/or personal history of cardiovascular disease were more likely to have prehypertension or hypertension at baseline. Most participants were never or past smokers and were slightly more likely to have prehypertension or hypertension. However, women who had <7 drinks per week were less likely to have prehypertension or hypertension. Participants with ≥2 episodes of moderate-strenuous physical activity ≥20 minutes or ≥11.75 MET/hr/week were less likely to have prehypertension or hypertension. Of 4,680 Hispanic women, 26% met current depression criteria and 19% had a history of depression at baseline. About 12% reported both current depression and history of depression. There were no differences in baseline history of depression, current depressive status, or use of antidepressants at baseline across hypertension categories. Finally, there were no differences across measures of stressful life events, social support, optimism and caregiving by hypertension status.

After adjustment for the full set of demographic and clinical variables, we observed a modest association between a history of depression and prehypertension at baseline (OR 1.27, 95% CI: 1.01, 1.61). Age-adjusted multinominal models found an association between baseline depression (measured by shortened CES-D/DIS (score ≥ 0.06) and baseline hypertension (OR 1.25, 95% CI: 1.04, 1.51) (Table 2).

A similar association between history of depression and baseline hypertension was observed (OR 1.23, 95% CI: 1.02, 1.49). These findings were attenuated to the null in fully adjusted models. No associations were found between baseline hypertension status and measures of stressful life events, social support, optimism and caregiving (not shown), nor with baseline depression and incident prehypertension at year 3. Incident hypertension at year 3 was associated with baseline depression after adjustment for demographic characteristics (age, education), health
| **Education** | **Normotensive (N = 1564)** | **Prehypertensive (N = 1581)** | **Hypertensive (N = 1535)** |
|--------------|-----------------------------|-------------------------------|-----------------------------|
| Less than high school | 306 20.0 | 393 25.3 | 434 28.7 |
| High school diploma or GED, vocational or training school | 437 28.5 | 450 28.9 | 444 29.4 |
| Some college or associate degree | 400 26.1 | 394 25.3 | 344 22.8 |
| College graduate and above | 390 25.4 | 319 20.5 | 289 19.1 |
| **Age at WHI enrollment** | | | |
| 50–64 | 1293 82.7 | 1161 73.4 | 942 61.4 |
| 65–79 | 271 17.3 | 420 26.6 | 593 38.6 |
| **Body-mass index (kg/m2), baseline** | | | |
| <25 | 551 35.5 | 348 22.2 | 273 18.0 |
| 25 - <30 | 632 40.7 | 631 40.2 | 549 36.3 |
| ≥ 30 | 368 23.7 | 592 37.7 | 691 45.7 |
| **Family history of diabetes, stroke, MI (number of conditions)** | | | |
| 0 | 474 30.7 | 458 29.3 | 354 23.6 |
| 1 | 552 35.8 | 570 36.4 | 538 35.8 |
| 2 | 375 24.3 | 390 24.9 | 449 29.9 |
| 3 | 141 9.1 | 146 9.3 | 162 10.8 |
| **History of high cholesterol requiring pills** | | | |
| No | 1282 89.5 | 1262 86.4 | 1150 79.9 |
| Yes | 150 10.5 | 198 13.6 | 290 20.1 |
| **Treated diabetes (pills or shots)** | | | |
| No | 1503 96.2 | 1501 94.9 | 1378 89.9 |
| Yes | 59 3.8 | 80 5.1 | 155 10.1 |
| **History of cardiovascular disease** | | | |
| No | 1338 91.5 | 1340 90.1 | 1181 79.6 |
| Yes | 125 8.5 | 147 9.9 | 276 18.9 |
| **Insurance Status** | | | |
| Public only (Medicare/Medicaid) | 112 7.5 | 169 11.2 | 217 14.9 |
| Private only | 871 58.6 | 777 51.7 | 677 46.6 |
| Public/Private combination | 107 7.2 | 156 10.4 | 230 15.8 |
| Military/VA sponsored and/or other | 127 8.5 | 106 7.0 | 112 7.7 |
| No insurance | 269 18.1 | 296 19.7 | 216 14.9 |
| **Smoking status** | | | |
| Never smoked, past smoker | 1408 91.5 | 1467 93.9 | 1429 94.3 |
| Current smoker | 131 8.5 | 96 6.1 | 87 5.7 |
| **Moderate-strenuous physical activity > = 20 min** | | | |
| No activity/some activity | 920 61.8 | 995 66.2 | 1022 69.3 |
| 2 or more episodes per week | 568 38.2 | 509 33.8 | 452 30.7 |
| **Total energy expenditure/week, MET-hours** | | | |
| 0–<3.0 | 493 33.1 | 548 36.4 | 545 37.0 |
| 3.0–<11.75 | 468 31.5 | 455 30.3 | 507 34.4 |
| ≥ 11.75 | 527 35.4 | 501 33.3 | 422 28.6 |
| **Alcohol intake** | | | |
| Non-drinker | 240 15.6 | 297 19.1 | 333 22.1 |
| Past drinker | 329 21.4 | 351 22.5 | 379 25.1 |
| <7 drinks per week | 893 58.0 | 826 53.0 | 735 48.7 |
| 7+ drinks per week | 78 5.1 | 84 5.4 | 63 4.2 |
| **History of depression** | | | |
| No | 1221 82.0 | 1201 79.4 | 1164 79.6 |
| Yes | 268 18.0 | 312 20.6 | 298 20.4 |
| **Currently depressed at baseline** | | | |
| No | 1077 73.7 | 1076 72.4 | 1024 71.6 |
| Yes | 384 26.3 | 410 27.6 | 406 28.4 |
| **Taking antidepressants at baseline** | | | |
| No | 1469 93.9 | 1497 94.7 | 1423 92.7 |
| Yes | 95 6.1 | 84 5.3 | 112 7.3 |
| **Depression (shortened CES-D/DIS score > = 0.06)** | | | |
| No | 1166 80.8 | 1173 80.8 | 1098 78.3 |
| Yes | 277 19.2 | 278 19.2 | 305 21.7 |
care insurance, and behavioral factors (OR 1.74, 95% CI: 1.10, 2.74), but the association was attenuated after further adjustment for clinical factors such as body mass index (BMI) (OR = 1.53; 95% CI 0.95–2.46) (Table 3).

While the psychosocial variables of social support, optimism and stressful life events were not found to be associated with baseline hypertension, they were associated with depression

Table 1. (Continued)

| Variable (0–3 scoring, accounting for intensity of experience), baseline | No. | % | No. | % | No. | % |
|---|---|---|---|---|---|---|
| Caregiving frequency, baseline | None, < 1 time per week | 1004 | 65.4 | 1010 | 65.0 | 971 | 64.7 |
| | 1–2 times per week | 235 | 15.3 | 222 | 14.3 | 236 | 15.7 |
| | 3+ times per week | 297 | 19.3 | 323 | 20.8 | 293 | 19.5 |
| Life event construct | None | 269 | 18.2 | 252 | 17.0 | 251 | 17.8 |
| | 1–2 | 287 | 19.5 | 300 | 20.2 | 287 | 20.3 |
| | 3–4 | 299 | 20.3 | 334 | 22.5 | 348 | 24.6 |
| | 5+ | 619 | 42.0 | 599 | 40.3 | 528 | 37.3 |
| Social Support Construct, baseline | 9–33 (low) | 609 | 40.9 | 607 | 40.3 | 618 | 43.1 |
| | 34–40 | 458 | 30.8 | 437 | 29.0 | 432 | 30.1 |
| | 41+ (high) | 421 | 28.3 | 461 | 30.6 | 385 | 28.8 |
| Optimism construct, baseline | <24 (low) | 919 | 62.6 | 942 | 63.5 | 951 | 66.9 |
| | 24–25 | 253 | 17.2 | 274 | 18.5 | 232 | 16.3 |
| | > ≥ 26 (high) | 296 | 20.2 | 268 | 18.1 | 238 | 16.7 |

For each characteristic, the numbers of women may sum to less than the total due to missing data.

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Table 2. Associations of Depression with Baseline Prehypertension and Hypertension.

| Variable | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| Normotensive (N = 1564) | Prehypertensive (N = 1581) | Hypertensive (N = 1535) |
| (shortened CES-D/DIS score > = 0.06) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Depression | 1.03 (0.85, 1.24) | 1.01 (0.84, 1.22) | 1.02 (0.84, 1.24) | 1.00 (0.81, 1.23) | 1.01 (0.79, 1.29) |
| Currently depressed at baseline | 1.09 (0.93, 1.29) | 1.04 (0.88, 1.24) | 1.05 (0.89, 1.25) | 1.00 (0.83, 1.21) | 1.02 (0.82, 1.26) |
| History of depression | 1.21 (1.01, 1.46) | 1.18 (0.98, 1.41) | 1.19 (0.99, 1.44) | 1.20 (0.98, 1.48) | 1.27 (1.01, 1.61) |

Hypertension

| Variable | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| (shortened CES-D/DIS score > = 0.06) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Depression | 1.25 (1.04, 1.51) | 1.19 (0.99, 1.44) | 1.17 (0.96, 1.42) | 1.08 (0.87, 1.34) | 1.07 (0.83, 1.38) |
| Currently depressed at baseline | 1.17 (0.99, 1.39) | 1.08 (0.91, 1.28) | 1.06 (0.89, 1.26) | 0.92 (0.76, 1.12) | 0.90 (0.72, 1.14) |
| History of depression | 1.23 (1.02, 1.49) | 1.16 (0.96, 1.40) | 1.13 (0.93, 1.38) | 1.05 (0.84, 1.31) | 1.08 (0.84, 1.39) |

Model 1: Age Adjusted
Model 2: Age + Education Level
Model 3: Model 2 + Antidepressant Use
Model 4: Model 3 + Behavior variables: (smoking status, total energy expenditure/week, alcohol intake) + insurance + Clinical variables: (BMI; family history of diabetes, stroke, or MI; high cholesterol requiring pills; treated diabetes; history of CVD)
Model 5: Model 4 + caregiving, stressful life events, social support and optimism

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and therefore could be effect modifiers on the relationship of depression with prehypertension and hypertension ($p < .001$). We therefore stratified our results by social support, optimism, and stress life events and evaluated the association of depression on incident prehypertension and hypertension. Stratified analyses by social support, optimism, and stress life events and the association of depression on incident prehypertension and hypertension demonstrated no effect modification by these factors.

**Discussion**

Our analyses reveal that Hispanic women have high levels of baseline depression relative to other Hispanic cohorts, and education moderates these depression rates. In this study, baseline depression and history of depression were not associated with incident prehypertension or hypertension. However, psychosocial variables (life events, social support and optimism) were associated with baseline depression in unadjusted analyses. This is the first study to include additional psychosocial variables in analyses of hypertension risk and these psychosocial variables have been observed to be associated with depression among urban, racial/ethnic and poor women, and with cardiovascular events. Among Hispanics, high rates of depression compared to other racial/ethnic groups nationally are associated with history of CVD, and increasing number of CVD risk factors that strongly correlate with psychosocial stressors and socioeconomic status.

Hispanic women across the life course have consistently demonstrated high rates of depression (ranges from 22.3% to 43.1%) that are associated with increased hypertension risk. We observed only modest associations of depression at baseline and incident hypertension in 3-year follow-up. Our findings are consistent with prior longitudinal studies which have found mixed associations between baseline depressive symptoms and incident hypertension. The Whitehall II cohort and CARDIA demonstrated a positive association while the Multi-Ethnic Study of Atherosclerosis (MESA) cohort found small associations between baseline depressive symptoms and increases in blood pressure but no statistically significant association with incident hypertension. Although our study is unique by focusing only on Hispanics, it is unknown if the differences in our findings could be attributable to differences in age distributions in other population cohorts, follow-up time, depression measure used, or possibly socio-ethnic differences in the experience and reporting of depression.

The psychosocial variables considered shed some light on the complex yet indirect moderating role that these factors may exert on hypertension risk and confirm the findings of other studies. One study of 2,564 Mexican Americans aged 65 or older showed an association between high positive emotion and lower blood pressure among older Mexican Americans.
In contrast, pessimism heightens risk for self-reported, treated and incident hypertension, and significant interactions are reported between pessimism, socioeconomic status (SES) and hypertension. In our study, the majority of respondents who reported low rates of social support (61–63%) also had the highest rates of current depression and history of depression at baseline suggesting that social support may not be able to “buffer” stress from adverse life events.

A recent study of 15,864 Hispanics confirms the association of depression with education level and Hispanic subgroup with higher rates observed for those with less than a high school education among those aged 45–64 similar to our study. Another study of Hispanic women (<high school) found that 11% reported at least one major depressive disorder in the past 12 months while 12% rated their mental health status as fair or poor. In our study about one-third of women with less than a high school education reported a history of (24.5%) and current depression (35.3%) compared to respondents who are college graduates or above (19.8% and 14.5% respectively). Unadjusted analyses confirm that education was inversely associated with depression with a significant decrease in rates of depression as education increases. These high rates of depression may be due to differences in awareness and reporting of depressive symptoms that are influenced by higher educational attainment and income, and higher rates of health care insurance coverage that may increase use of mental health services and psychotropic medications. Alternatively Hispanic women’s higher prevalence of depression may reflect more exposure to stressful workplace events, discrimination and living in unsafe neighborhood contexts.

In our study, higher levels of current depression at baseline were associated with lower levels of antidepressant use (7%) and lack of health insurance (15%). Moreover, Hispanic patients may have their medications less intensified than other racial/ethnic groups.

Our study has several limitations. The Hispanic sample is predominantly of Mexican-origin and these data may not be representative of other Hispanic subgroups. All women were postmenopausal and our findings cannot be generalized to younger reproductive age women. This cohort were healthier at baseline than women of this age in the U.S. population, as indicated by lower baseline prevalence of diabetes, hypertension, CVD, high cholesterol levels that required medication, and cigarette use. Education levels were higher among WHI participants and fewer women reported no leisure-time physical activity compared to other cohorts with Hispanics. These demographic and health findings may be attributed to the voluntary recruitment strategy that was used in the WHI studies. Although we accounted for traditional CVD risk factors in multivariable regression models, we were unable to include all possible confounders thus preventing any causal conclusions about incident hypertension. Additionally, we did not include use of medication in management of prehypertension or initial drug therapy with compelling indications as suggested by the JNC7 report. Notwithstanding these limitations, our longitudinal study is the largest study to date of older Hispanic women which included physiologic, behavioral and psychosocial moderators of depression.

Future studies need to be mindful of evaluating psychosocial factors such as social support to assess its moderating effect by SES and to parse out SES by nativity and ethnic background/ancestry to disentangle effects of depression on hypertension, as Hispanic women report less control over their lives and experience more negative life events than men and majority groups. Yet, questions remain regarding what are the direct and indirect effects of psychosocial variables on hypertension development, management and control for Hispanic populations. Primary prevention is an important goal in the detection and management of HTN among Hispanic populations and differences by nativity, geographic region and Hispanic subgroup are significant moderators of hypertension. We found low rates of antidepressant medication usage that confirms other studies suggesting an additional clinical intervention...
to improve the higher rates of depressive symptoms among Hispanic women. [17] Further analyses that included psychosocial variables correlated with depression did not alter findings suggesting the complex role these factors may exert on cardiovascular health. Elucidating the complex pathways of depression’s effect on hypertension may lead to appropriately tailored interventions among Hispanic women.

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Author Contributions

Conceived and designed the experiments: RZ LL GD. Performed the experiments: RR. Analyzed the data: RZ LL RR. Wrote the paper: RZ LL RR GD LP CE SWS.

References

1. Wassertheil-Smoller S, Anderson G, Psaty B, Black H, Manson J, Wong N et al. Hypertension and Its Treatment in Postmenopausal Women: Baseline Data from the Women’s Health Initiative. Hypertension. 2000; 36(5):780–789. PMID: 11082143

2. Cooper-DeHoff R, Zhou Q, Gaxiola E, Cangiano J, Garcia-Barreto D, Handberg E et al. Influence of Hispanic Ethnicity on Blood Pressure Control and Cardiovascular Outcomes in Women with CAD and Hypertension: Findings from INVEST. Journal of Women’s Health. 2007; 16(5):632–640. PMID: 17627399

3. Daviglus M, Talavera G, Avilés-Santa M, Allison M, Cai J, Criqui M et al. Prevalence of Major Cardiovascular Risk Factors and Cardiovascular Diseases Among Hispanic/Latino Individuals of Diverse Backgrounds in the United States. JAMA. 2012; 308(17):1775. doi: 10.1001/jama.2012.14517 PMID: 23117778

4. Zambrana R, Lopez L, Dinwiddie G, Ray R, Phillips L, Trevisan M et al. Prevalence and Incident Prehypertension and Hypertension in Postmenopausal Hispanic Women: Results from the Women’s Health Initiative. American Journal of Hypertension. 2014; 27(3):372–381. doi: 10.1093/ajh/hpt279 PMID: 24460867

5. Barton M, Meyer M. Postmenopausal Hypertension: Mechanisms and Therapy. Hypertension. 2009; 54(1):11–18. doi: 10.1161/HYPERTENSIONAHA.108.120022 PMID: 19470884

6. Low C, Thurston R, Matthews K. Psychosocial Factors in the Development of Heart Disease in Women: Current Research and Future Directions. Psychosomatic Medicine. 2010; 72(9):842–854. doi: 10.1097/PSY.0b013e3181e6934f PMID: 20841557

7. Shah M, Zonderman A, Waldstein S. Sex and Age Differences in the Relation of Depressive Symptoms With Blood Pressure. American Journal of Hypertension. 2013; 26(12):1413–1420. doi: 10.1093/ajh/hpt135 PMID: 23969543

8. Read J, Gorman B. Racial/Ethnic Differences in Hypertension and Depression among U.S. Adult Women. Ethnicity & Disease. 2007; 17:389–396.

9. Kim C, McGorray S, Bartholomew B, Marsh M, Dicken T, Wassertheil-Smoller S et al. Depressive Symptoms and Heart Rate Variability in Postmenopausal Women. Arch Intern Med. 2005; 165 (11):1239. PMID: 15956002

10. Bromberger J, Hartlow S, Avis N, Kravitz H, Cordal A. Racial/Ethnic Differences in the Prevalence of Depressive Symptoms Among Middle-Aged Women: The Study of Women’s Health Across the Nation (SWAN). Am J Public Health. 2004; 94(8):1378–1385. PMID: 15284047

11. Licht C, de Geus E, Seldennijk A, van Hout H, Zitman F, van Dyck R et al. Depression Is Associated With Decreased Blood Pressure, but Antidepressant Use Increases the Risk for Hypertension. Hypertension. 2009; 53(4):631–638. doi: 10.1161/HYPERTENSIONAHA.108.126698 PMID: 19237679
Association of Depression & Hypertension in Hispanic Women

12. Matthews K. Blood Pressure Reactivity to Psychological Stress Predicts Hypertension in the CARDIA Study. Circulation. 2004; 110(1):74–78. PMID: 15210592

13. Scuteri A. Depression and cardiovascular risk: does blood pressure play a role?. Journal of Hypertension. 2008; 26(9):1738–1739. doi: 10.1097/HJH.0b013e32830dfff7 PMID: 18698205

14. Rutledge T, Hogan B. A Quantitative Review of Prospective Evidence Linking Psychological Factors With Hypertension Development. Psychosomatic Medicine. 2002; 64(5):756–766. PMID: 12271106

15. Lima R, Wofford M, Reckelhoff J. Hypertension in Postmenopausal Women. Curr Hypertens Rep. 2012; 14(3):254–260. doi: 10.1007/s11906-012-0260-0 PMID: 22427070

16. Alegria M, Mulvaney-Day N, Torres M, Polo A, Cao Z, Canino G. Prevalence of Psychiatric Disorders Across Latino Subgroups in the United States. Am J Public Health. 2007; 97(1):68–75. PMID: 17138910

17. Wassertheil-Smoller S, Arredondo E, Cai J, Castaneda S, Choca J, Gallo L et al. Depression, anxiety, antidepressant use, and cardiovascular disease among Hispanic men and women of different national backgrounds: results from the Hispanic Community Health Study/Study of Latinos. Annals of Epidemiology. 2014; 24(11):822–830. doi: 10.1016/j.annepidem.2014.09.003 PMID: 25439033

18. Swenson C, Baster J, Shetterly SM, Scarbro SL, Hamman RF. Depressive Symptoms in Hispanic and Non-Hispanic White Rural Elderly The San Luis Valley Health and Aging Study. American Journal of Epidemiology. 2000; 152(11):1048–1055. PMID: 11117614

19. Wassertheil-Smoller S, Shumaker S, Ockene J, Talavera G, Greenland P, Cochrane B et al. Depression and Cardiovascular Sequae in Postmenopausal Women. Arch Intern Med. 2004; 164(3):289. PMID: 14769624

20. Zambrana R, Thornton Dill B. Disparities in Latina Health: An Intersectional Analysis. Race, Class, Gender and Health. 1st ed. San Francisco: Jossey-Bass; 2006. p. 192–227.

21. Acevedo-Garcia D, Lochner K, Osypuk T, Subramanian S. Future Directions in Residential Segregation and Health Research: A Multilevel Approach. Am J Public Health. 2003; 93(2):215–221. PMID: 12554572

22. Ai A, Appel H, Huang B, Lee K. Overall Health and Healthcare Utilization Among Latino American Women in the United States. Journal of Women's Health. 2012; 21(8):878–885. doi: 10.1089/jwh.2011.3431 PMID: 22747245

23. Henry J. Kaiser Foundation. Women's Health Care Chartbook: Key Findings from the Kaiser Women's Health Survey. Washington, DC: Henry J. Kaiser Foundation; 2011.

24. Vital Signs: Awareness and Treatment of Uncontrolled Hypertension Among Adults—United States, 2003–2010 [Internet]. Cdc.gov. 2016. Available: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6135a3.htm. Accessed 23 March 2016.

25. Räikkönen K, Matthews K, Kuller L. Trajectory of psychological risk and incident hypertension in mid-aged women. Hypertension [Internet]. 2001; 38:798–802. Available: http://hyper.ahajournals.org/content/38/4/798.short. PMID: 11641289

26. Kaplan M, Nunes A. The psychosocial determinants of hypertension. Nutrition, Metabolism and Cardiovascular Diseases. 2003; 13(1):52–59. PMID: 12772438

27. Bosworth H, Bartash R, Olsen M, Steffens D. The association of psychosocial factors and depression with hypertension among older adults. Int J Geriat Psychiatry. 2003; 18(12):1142–1148.

28. Stern S, Dhandha R, Hazuda H. Helplessness predicts the development of hypertension in older Mexican and European Americans. Journal of Psychosomatic Research. 2009; 67(4):333–337. doi: 10.1016/j.jpsychores.2009.04.007 PMID: 19773026

29. Din-Dzietham R, Nembhard W, Collins R, Davis S. Perceived stress following race-based discrimination at work is associated with hypertension in African Americans. The metro Atlanta heart disease study, 1999–2001. Social Science & Medicine. 2004; 58(3):449–461.

30. Conway F, Magai C, Springer C, Jones S. Optimism and pessimism as predictors of physical and psychological health among grandmothers raising their grandchildren. Journal of Research in Personality. 2008; 42(5):1352–1357.

31. Wulsin L, Singal B. Do Depressive Symptoms Increase the Risk for the Onset of Coronary Disease? A Systematic Quantitative Review. Psychosomatic Medicine. 2003; 65(2):201–210. PMID: 12651987

32. Alferi S, Carver C, Antoni M, Weiss S, Durán R. An exploratory study of social support, distress, and life disruption among low-income Hispanic women under treatment for early stage breast cancer. Health Psychology. 2001; 20(1):41–46. PMID: 11199065

33. DiMatteo M. Social Support and Patient Adherence to Medical Treatment: A Meta-Analysis. Health Psychology. 2004; 23(2):207–218. PMID: 15008666
34. Lee S, Colditz G, Berkman L, Kawachi I. Caregiving to Children and Grandchildren and Risk of Coronary Heart Disease in Women. Am J Public Health. 2003; 93(11):1939–1944. PMID: 14600070

35. Shaw W, Patterson T, Semple S,Dimsdale J, Ziegler M, Grant I. Emotional expressiveness, hostility and blood pressure in a longitudinal cohort of Alzheimer caregivers. Journal of Psychosomatic Research. 2003; 54(4):293–302. PMID: 12670605

36. Anderson G, Manson J, Wallace R, Lund B, Hall D, Davis S et al. Implementation of the women's health initiative study design. Annals of Epidemiology. 2003; 13(9):S5–S17. PMID: 14575938

37. Women’s Health Initiative Study Group. Design of the Women's Health Initiative Clinical Trial and Observational Study. Controlled Clinical Trials. 1998; 19(1):61–109. PMID: 9492970

38. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 Report. JAMA. 2003; 289(19):2560–2571. doi: 10.1001/jama.289.19.2560 PMID: 12748199

39. Burnam M, Wells K, Leake B, Landsverk J. Development of a Brief Screening Instrument for Detecting Depressive Disorders on JSTOR [Internet]. Jstor.org. 1988. Available: http://www.jstor.org/stable/3765462. Accessed 23 March 2016.

40. Melchior L, Huba G, Brown V, Reback C. A Short Depression Index for Women. Educational and Psychological Measurement. 1993; 53(4):1117–1125.

41. Bertone-Johnson E, Powers S, Spangler L, Larson J, Michael Y, Millen A et al. Vitamin D Supplementation and Depression in the Women's Health Initiative Calcium and Vitamin D Trial. American Journal of Epidemiology. 2012; 176(1):1–13. doi: 10.1093/aje/kwr482 PMID: 22573431

42. Berkman L, Syme S. Social networks, host resistance, and mortality: a nine-year follow-up study of Alameda County residents. American Journal of Epidemiology [Internet]. 1979; 109(2):186–204. Available: http://aje.oxfordjournals.org/content/109/2/186.short. Accessed 23 March 2016. PMID: 4259585

43. Ruberman W, Weinblatt E, Goldberg J, Chaudhary B. Psychosocial Influences on Mortality after Myocardial Infarction. New England Journal of Medicine. 1984; 311(9):552–559. PMID: 6749228

44. Sherbourne C, Stewart A. The MOS social support survey. Social Science & Medicine. 1991; 32(6):705–714.

45. Scheier M, Carver C. Optimism, coping, and health: Assessment and implications of generalized outcome expectancies. Health Psychology. 1985; 4(3):219–247. PMID: 4029106

46. Brown L, Potter J, Foster B. Caregiver Burden Should Be Evaluated During Geriatric Assessment. Journal of the American Geriatrics Society. 2001; 49(7):948–953. PMID: 11527487

47. Gonzalez H, Haan M, Hinton L. Acculturation and the Prevalence of Depression in Older Mexican Americans: Baseline Results of the Sacramento Area Latino Study on Aging. Journal of the American Geriatrics Society. 2001; 49(7):948–953. PMID: 11527487

48. Doornbos M, Zandee G, DeGroot J, De Maagd-Rodriguez M. Using Community-Based Participatory Research to Explore Social Determinants of Women's Mental Health and Barriers to Help-Seeking in Three Urban, Ethnically Diverse, Impoverished, and Underserved Communities. Archives of Psychiatric Nursing. 2013; 27(6):278–286. doi: 10.1016/j.apnu.2013.09.001 PMID: 24238007

49. Handberg E, Eastwood J, Eteiba W, Johnson B, Krantz D, Thompson D et al. Clinical implications of the Women's Ischemia Syndrome Evaluation: inter-relationships between symptoms, psychosocial factors and cardiovascular outcomes. Women's Health. 2013; 9(5):479–490. doi: 10.2217/whe.13.50 PMID: 24007253

50. Davidson K, Jonas B, Dixon K, Markovitz J. Do Depression Symptoms Predict Early Hypertension Incidence in Young Adults in the CARDIA Study?. Arch Intern Med. 2000; 160(10):1495. PMID: 10826464

51. Ostir G, Berges I, Markides K, Ottenbacher K. Hypertension in Older Adults and the Role of Positive Emotions. Psychosomatic Medicine. 2006; 68(5):727–733. PMID: 17012526
56. Jonas B, Lando J. Negative Affect as a Prospective Risk Factor for Hypertension. Psychosomatic Medicine. 2000; 62(2):188–196. PMID: 10772396

57. Grewen K, Girdler S, West S, Bragdon E, Costello N, Light K. Stable Pessimistic Attributions Interact with Socioeconomic Status to Influence Blood Pressure and Vulnerability to Hypertension. Journal of Women's Health & Gender-Based Medicine. 2000; 9(8):905–915.

58. Bell C, Thorpe R, LaVeist T. Race/Ethnicity and Hypertension: The Role of Social Support. American Journal of Hypertension. 2010; 23(5):534–540. doi: 10.1038/ajh.2010.28 PMID: 20186126

59. World Health Organization. The world health report. Mental health: new understanding, new hope. 2001. Geneva: World Health Organization; 2001.

60. Hicken M, Lee H, Morenoff J, House J, Williams D. Racial/Ethnic Disparities in Hypertension Prevalence: Reconsidering the Role of Chronic Stress. Am J Public Health. 2014; 104(1):117–123. doi: 10.2105/AJPH.2013.301395 PMID: 24228644

61. Williams D, Mohammed S, Leavell J, Collins C. Race, socioeconomic status, and health: Complexities, ongoing challenges, and research opportunities. Annals of the New York Academy of Sciences. 2010; 1186(1):69–101.

62. Mujahid M, Roux A, Cooper R, Shea S, Williams D. Neighborhood Stressors and Race/Ethnic Differences in Hypertension Prevalence (The Multi-Ethnic Study of Atherosclerosis). American Journal of Hypertension. 2011; 24(2):187–193. doi: 10.1038/ajh.2010.200 PMID: 20847728

63. Hicks L, Shaykevich S, Bates D, Ayanian J. Determinants of racial/ethnic differences in blood pressure management among hypertensive patients. BMC Cardiovasc Disord. 2005; 5(1):16. PMID: 15972095

64. Howard B, Kuller L, Langer R, Manson JE, Allen C, Assaf A et al. Risk of Cardiovascular Disease by Hysterectomy Status, With and Without Oophorectomy: The Women's Health Initiative Observational Study. Circulation. 2005; 111(12):1462–1470. PMID: 15781742

65. Dinwiddie G, Zambrana R, Garza M. Exploring Risk Factors in Latino Cardiovascular Disease: The Role of Education, Nativity, and Gender. Am J Public Health. 2014; 104(9):1742–1750. doi: 10.2105/AJPH.2013.301280 PMID: 24028268

66. Sorlie P, Allison M, Aviles-Santa M, Cai J, Daviglus M, Howard A et al. Prevalence of Hypertension, Awareness, Treatment, and Control in the Hispanic Community Health Study/Study of Latinos. American Journal of Hypertension. 2014; 27(6):793–800. doi: 10.1093/ajh/hpu003 PMID: 24627442