UPSTREAM FACTORS: THE ASSOCIATION BETWEEN COUNTY INTERGENERATIONAL DEPRIVATION, STATE INCOME INEQUALITY, STATE MINIMUM WAGE AND HYPERTENSION AMONG YOUNG ADULTS

by

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ABSTRACT

ANNE N. MBUGUA. Upstream Factors: The Association Between County Intergenerational Deprivation, State Income Inequality, State Minimum Wage and Hypertension among Young Adults. (Under the direction of DR. LARISSA BRUNNER HUBER)

While hypertension is largely preventable, its rates have been increasing in young adults. Hypertension is associated with substantial costs to the US health care system and therefore a public health burden. In recent times, there has been a shift in focus toward the role of upstream factors and how they influence the risk of hypertension. The primary objective of this dissertation was to evaluate whether upstream social factors, namely, county intergenerational deprivation, state income inequality and state minimum wage are associated with hypertension in young adults. The secondary objective was to assess whether race-ethnicity and geographical region were effect modifiers of these associations. To address these two objectives, three separate studies were done. Paper 1 examined the association between county intergenerational deprivation and hypertension among young adults, 18-39 years, using the 2009 and 2011 Behavioral Risk Factor Surveillance System (BRFSS), 1996-2012 Opportunity Insights database, 2008-2012 American Community Survey (ACS), and 2010 County Health Rankings and Roadmaps (CHR&R) data. Paper 2 examined the associations between state income inequality and hypertension in young adults, 18-39 years, using the 2019 BRFSS and 2015-2019 ACS data. Last, paper 3 assessed the association between state minimum wage and hypertension among young adults 18-39 years with a high school education or less. Taken together, findings indicated that within the young adult hypertension literature, county intergenerational deprivation may be a more salient upstream factor than state income inequality and state minimum wage. Also, findings suggested that race-ethnicity and geographical region were effect modifiers of the

exposure-disease associations. Additional population-based studies are necessary to confirm findings.

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DEDICATION

For my daughters, Xoeii and Zara---Believe in yourself, pursue purpose and never give up! I love you!

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CHAPTER 1. INTRODUCTION

Cardiovascular disease (CVD) or heart disease remains the number one cause of death in the United States.[1] Hypertension or high blood pressure (HBP) is the leading modifiable risk factor for heart disease and stroke.[2,3] CVD accounted for 690,882 deaths in the United States in 2020, making it the leading cause of death.[4]

Hypertension affects approximately half (46%) of the US adult population.[5] About one fifth (22.4%) of the US young adult population (that is, aged 18-39 years old) has hypertension.[6] Although hypertension is more common in older adults, young adults are not immune to the disease or its effects. Previous studies demonstrate that exposure to suboptimal blood pressure in young adulthood is linked to an increased risk of CVD events and end-organ damage later in life.[7,8] Moreover, early onset hypertension (<55 years) has been robustly linked to hypertension in the subsequent offspring.[9]

Regarding race-ethnicity, non-Hispanic Black individuals in the US have among the highest prevalence rates of hypertension in the world and are therefore disproportionately impacted.[10] Recent 2013 to 2016 National Health and Nutrition Examination Survey (NHANES) data show that young non-Hispanic Black adults (30.7%) have the highest prevalence of hypertension, followed by non-Hispanic White (21.9%) and Mexican-Americans (21.9%).[11] Reviews of literature characterize hypertension in non-Hispanic Black individuals as highly aggressive and thus difficult to treat in comparison to other racial groups.[12,13] As such, non-Hispanic Black individuals experience exceeding morbidity and mortality from hypertension-related conditions like stroke, heart failure and end-stage renal disease.[12,13] To illustrate, the 2020 age-adjusted death rate attributed to hypertension (per 100,000) was higher in non-Hispanic Black males (54.1) and non-Hispanic Black females (37.8) compared to non-Hispanic White males (23.0), Hispanic males (21.8) and non-Hispanic White females (18.6).[10]

Geographically, the Southeastern US generally has the highest age-standardized prevalence of hypertension, with 2017 rates ranging from ~32.0% to 38.0%.[14,15] Loop and colleagues found that non-Hispanic Black individuals in the west Southeast and non-Hispanic White individuals in the central Southeast contributed most to the high prevalence observed.[16]

The financial implications of having hypertension for an individual are substantial. Data from MEPS for years 2011 through 2014 where hypertension was the primary diagnosis, show annual costs varied between $3,914 for those without comorbidities to $13,920 for those with comorbidities.[17] US projections show that by 2035, the total direct and indirect costs of hypertension could possibly increase to about $220 billion.[10] These cost projections are concerning and indicate that the US will face a considerable public health burden. In relation to reducing the burden of cost, one of Healthy People 2030 goals is to reduce the proportion of adults with hypertension.[18] In line with this goal, a considerable effort must be taken to identify the modifiable risk factors associated with hypertension in young adults.

Decades of research have made substantial advances in understanding the factors associated with hypertension. Nonetheless, in an effort to understand what shapes health, the national debate on health outcomes tends to revolve around the individual responsibility for health behavior and clinical care; the role of social and economic factors, and the physical environment are usually missing in this debate.[19] While the former are important factors, they only explain about 50% of health outcomes.[19] Conversely, the social and economic factors are arguably more important as they comprise the social determinants of health.[19]

In recent times, there has been a renewed motivation to pursue health equity given the long-standing disparities in health.[20] Likewise, there has been a need to examine the role of upstream factors or “the root causes” in shaping the downstream determinants of health. One

such root cause is systemic racism. Systemic racism is built on the ideology of a dominant race and a racial hierarchy. The system works by unfairly allocating opportunities, risks and societal resources to non-dominant races considered inferior.[21,22] Systemic racism interacts with other societal structures such as education, economic, labor market, housing, legal and lending institutions (to create structural racism), and influences health by differentially allocating opportunities and risks.[21,23,24] A notable mechanism of structural racism has been through racial residential segregation and the concentrated poverty it has created.[25–27] The experience of poverty in turn, may affect an individual/communities in a variety of ways such as, a monetary sense that is, deprivation through income, a capability sense particularly in terms of limited freedoms to pursue opportunities, or by social exclusion from networks and other facets of life.[28,29]. The poverty in turn limits prospects for intergenerational mobility of income by determining access to quality educational and employment opportunities in Black communities.[21,30] The combination of limited employment opportunities, low minimum wages, and preemptive laws blocking minimum wage increases at local levels,[31] further exacerbates the disadvantage. Moreover, low wages have been identified as contributing to the rising income inequality;[32] and while not conclusive, increasing income inequality has also been hypothesized to limit upward mobility.[33] Thus, the extent to which these upstream social factors, namely intergenerational mobility or what we refer to as intergenerational deprivation, income inequality and minimum wage, influence the likelihood of hypertension in young adults is the focus of this dissertation. These social factors may undermine cardiovascular health by acting through the social positions of persons—and depending on one's socioeconomic status, create differential vulnerability or exposure to various conditions.[34] These conditions in turn may be biological, behavioral, the social environment, or physical environment.[35]

The first factor, intergenerational deprivation is also referred to as equality of opportunity, economic opportunity or intergenerational mobility in the literature. It is used to judge the extent to which the US lives up to its ideal of making the American Dream accessible, where one's chances of success are not dependent on one's birth circumstances.[36,37] Fairly recently, the issue gained traction in public and political discourse over concerns of a "fading American Dream" prompting President Obama to describe it as the "defining challenge of our time".[38] One study found that, compared to other advanced economies, the US lags behind in mobility, with low income children having twice the likelihood of climbing to the top of the income ladder in Canada compared to the US.[39] Interestingly, the variation in chances of upward mobility are even more pronounced within the US with different geographical regions offering different levels of opportunity based on where a child grows up.[40] Of concern is that mobility levels have fallen from 90% for children born in the 1940 birth cohort to 50% for those in the 1980 birth cohort.[41] The falling mobility levels may mean that for young adults in the labor market today, their chances of upward mobility largely depend on the incomes of their parents as opposed to merit. How these declining mobility levels would impact young adult health is largely the motivating factor of interest.

In particular, the literature on whether intergenerational deprivation is associated with health has grown a little in the last few years due to the availability of high resolution data.[42–46] But to date, there is still a shortage of evidence with only two known studies[43,47] examining the association between intergenerational deprivation and hypertension. A plausible theoretical link between the two (that is, intergenerational deprivation and hypertension) is that lack of opportunity disincentivizes individuals against investing in health capital and this in turn may

lead to lower health stock.[48] Moreover, when individuals lose hope, they are likely to invest in unhealthy behaviors which are damaging to general health.[49]

The second issue that has gained prominence in policy and political circles is income inequality. The recent sharp rise in income inequality in the US has been well acknowledged.[50–52] A brief history indicates that the years from the end of World War II until the 1970s were years of ample economic growth that was shared broadly by all income groups.[53] Although there was a considerable gap in incomes between the top, middle and bottom of the income ladder, it stayed this way during this time period.[53] However, starting in the late 1970s, income growth slowed and the income gap widened. Stone et al. noted that middle and lower income households experienced a sudden slowing down, whereas households with top incomes continued to experience robust growth. This accumulation of income by those at the top of the income distribution was last seen during the 1920s.[53] Recent statistics point to the period between 2016 and 2017 as one that saw a growth in income for all groups at the rate of 4.5%. Nonetheless, the bottom 99% of incomes grew by 2.9% while the top 1% of incomes saw a faster growth by 10.8%.[50] In addition, concerns over income inequality also suggest geographic differences. A comparison of the top 1% and the bottom 99% in 2015, revealed that eight states had gaps in income that were wider than the national gap.[54] These include New York, Florida, Connecticut, Nevada, Wyoming, Massachusetts, California, Illinois and the District of Columbia. In terms of region, the Northeast and West had gaps that were wider than the national gap.[54] Similarly, considerable heterogeneity exists in income inequality conditional on the racial-ethnic composition. One study found that from 1970-2016, Asian individuals had the widest gap in income inequality followed by Black while White and Hispanic had the smallest gap.[55] This

sharp difference in income between the top and bottom warrants the investigation of whether income inequality is associated with health.

Even though the decade long debate between income inequality and health appeared to have been settled,[56,57] a recent increase in literature[58–63] re-visiting the issue as rates of inequality have steadily risen, indicates that the evidence may be inconclusive. Of interest is the relationship between income inequality and hypertension.[58,59] Given that income inequality has been at an all-time high,[50] there has been a dearth of recent studies linking income inequality to hypertension. In particular, samples focusing on young adults are sparse, even though psychosocial factors like stress have an established association with hypertension.[64–67]

The third issue is minimum wage, and the debate has remained a hotly contested subject among policymakers and economists.[68–70] According to pre-pandemic data from the US Bureau of Labor Statistics, workers paid at or below the federal minimum wage of $7.25 per hour comprised 2.1% of all hourly workers or about 1.7 million workers. The workers were likely to be young and less than half (47.1%) were of ages 16-24 and an additional 20.4% were ages 25-34 years. Additionally, more were female and the majority were located in the Southern region of the US.[71] An inquiry into the history of minimum wage reveals that, when adjusted for inflation, minimum wages have remained at the same level they were since the 1980s.[72] It is alarming to note that the last time wages peaked was in 1968 when they were $8.68 (in 2016 dollars) compared to the 2009 hike of $7.25- an amount that has lost its purchasing power to inflation by 9.6%.[73]

Despite the attention that minimum wage occupies in policy debates, (e.g., the recent increase in the federal minimum wage for federal workers) studies linking minimum wage to health outcomes are still in early development, but are growing rapidly as reflected in a review of

literature.[74] To date, there are a few known studies that have examined the wage and hypertension relationship.[75–80] Leigh and Du investigated low wages in general[78] while Narain and Zimmerman's study[79] evaluated state-level minimum wage increases and effect on hypertension on 21-64 year olds. Buszkiewicz et al. examined the association between state minimum wage and hypertension in a sample of 25-64 year olds that included less skilled and highly skilled workers.[76,77] While these studies have made notable contributions to the literature, the evidence observed thus far has been mixed.[75–77,79,80] To date, no other known study has examined the link between state-level minimum wage and hypertension in a subpopulation that is young and with a high school education or less.

To fill the aforementioned gaps in knowledge, the overarching objective of this dissertation is to examine the associations between upstream social factors (namely, county intergenerational deprivation, state income inequality, and state minimum wage) and hypertension in young adults.

Significance of the Study

This study aims to contribute to health services research by highlighting the influence of upstream social factors on the health and wellbeing of individual young adults (that is, cardiovascular health). A social epidemiological perspective is applied to health services research in understanding how contextual or upstream factors influence hypertension. In this way, findings from the study may assist in developing appropriate interventions that alleviate the current burden on the health care system.

Broadly, this dissertation aims to broaden our understanding on how county intergenerational deprivation, low state minimum wages and high state income inequality may harm cardiovascular health in young adulthood. Specifically, potential associations between

county intergenerational deprivation and hypertension using individual level data, will help fill a knowledge gap in the literature. Furthermore, findings on the differential associations by race-ethnicity in the county intergenerational-deprivation-hypertension may be important in explaining the long-standing disparities in hypertension rooted in structural racism. Therefore, these findings could be used by local policy makers to invest in appropriate opportunity structures that break the poverty cycle and promote upward mobility. On the other hand, the heterogenous findings by race-ethnicity in the state income inequality and hypertension and state minimum wage and hypertension associations, would be useful to researchers seeking to further understand the contextual effects of both factors.

Methodologically, this dissertation aims to contribute to the debates as well as address the gaps in the minimum wage, income inequality and hypertension literature, by applying the new 2017 American Heart Association blood pressure thresholds. Furthermore, the study extends the current minimum wage-hypertension literature by using an understudied sample that is more likely to earn a minimum wage: that is, younger, more diverse and with a high school education or less. Finally, findings from the county intergenerational deprivation and hypertension study that lay out the mechanisms of structural racism as a root cause, may be helpful in reconfiguring the Commission on Social Determinants of Health (CSDH) framework.

Research Questions and Hypothesis

The purpose of this dissertation was to examine the association between upstream social factors (that is, county intergenerational deprivation, state income inequality and state minimum wage) and hypertension in young adults. The specific research questions were answered using three papers and are listed below:

1) Is county intergenerational deprivation associated with hypertension among young adults aged 18-39? Does geographical region and race-ethnicity modify the association between county intergenerational deprivation and hypertension?

H1: Increasing county intergenerational deprivation is associated with a decreased likelihood of hypertension.

H2: The association between county intergenerational deprivation and hypertension differs by geographical region and race-ethnicity.

2) Is there an association between state income inequality and hypertension in young adults aged 18-39? Does race-ethnicity modify the income inequality-hypertension association?

H1: Increasing state income inequality is associated with an increased likelihood of hypertension.

H2: The income inequality-hypertension association differs by race-ethnicity.

3) Is there an association between state minimum wage and hypertension in young adults 18-39 years with a high school education or less? Does geographical region and race-ethnicity modify the state minimum wage-hypertension association?

H1: Low state minimum wage is associated with an increased likelihood of hypertension.

H2: The state minimum wage-hypertension association differs by geographical region and race-ethnicity.

Conceptual Framework: Commission on Social Determinants of Health (CSDH) Framework

This dissertation was guided through the lens of the World Health Organization's Commission on Social Determinants of Health (CSDH) framework. The CSDH conceptual framework was selected because it primarily views health as a fundamental social right and therefore attainment of health equity is its ultimate goal.[81] The framework further emphasizes the role of structural social factors in influencing health outcomes. More importantly, the framework is clear in its distinction between the social determinants of health and social triggers influencing the distribution of these causes.[81]

The CSDH framework is composed of three major components (see **figure 1**). These are: 1) the socioeconomic and political context, 2) structural determinants and socioeconomic position, and 3) the intermediary determinants. First, the socioeconomic and political context is composed of societal systems that create and preserve social hierarchies.[81] Systems within the context have been conceptualized as having a "historical past, a present and a future trajectory".[82] They include the political institutions, educational system, housing, the health system, the labor market, the welfare state and cultural and societal values.[81]

Second, the structural determinants and socioeconomic position are composed of the socioeconomic political context, and the mechanisms in society that generate social stratification to create socioeconomic positions.[81] Socioeconomic positions are then categorized based on income, education, occupation, race-ethnicity, gender, and sexuality.[81] Fundamentally, the socioeconomic position is the entry point in the model where differential access to societal-level resources (like employment opportunities, education, and material) occurs.[34] To add, in Phelan and Link's work, access to resources is conceptualized as comprising of knowledge, prestige,

money, and power.[83] Thus, depending on which group has access to these scarce resources, then that group is able to avoid risk to disease and its consequences.[83]

The third component, is the intermediary determinants or what is commonly referred to as the "social determinants of health". In the causal pathway of disease, socioeconomic position influences health directly through intermediary determinants such as: material circumstances and living environments, social-environment or psychosocial circumstances (e.g. stressful living, lack of social support) and behavioral and biological factors.[35,81]

The CSDH framework also includes the health care system as a social determinant in dealing with differential exposure and vulnerability through the provision of equitable access to care.[81] Finally, the framework includes social capital as a determinant that shapes population health. Social capital is defined as "features of social organization, such as networks norms and social trust, that facilitate coordination and cooperation for mutual benefit".[84]

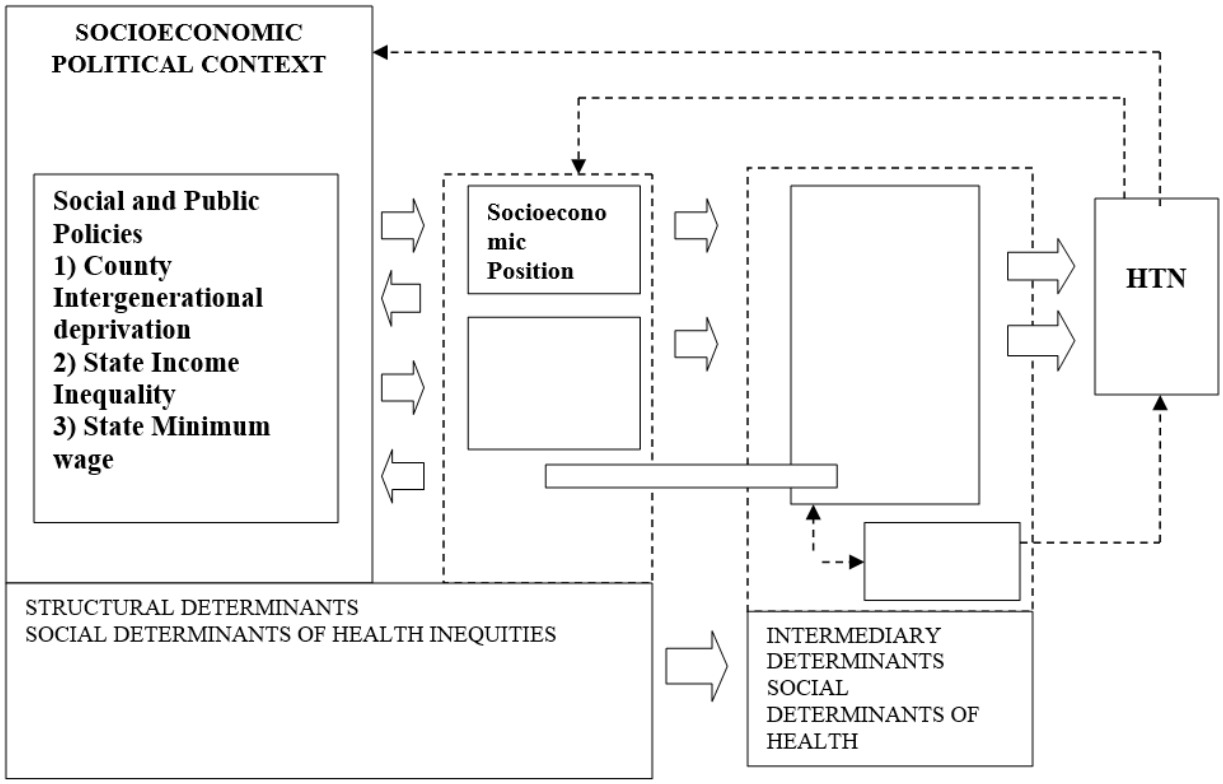

Figure 1. Conceptual framework illustrating the relationships between county intergenerational deprivation, state income inequality, and state minimum wage and hypertension using the Commission for Social Determinants of Health (CSDH) Framework

Biological Mechanisms

The proposed mechanisms under which county intergenerational deprivation, state income inequality and state minimum wage influence the risk of hypertension are outlined in the following approaches. Under the CSDH framework, intergenerational deprivation is thought to influence health via the limited prospects for mobility in income. Limited prospects for upward income mobility may compromise health, especially for the disadvantaged, through exposure to diminished hope.[85] Diminished hope may in turn increase the likelihood of engaging in unhealthy behaviors such as unhealthy eating habits, no physical activity, smoking and alcohol consumption.[85] These unhealthy behaviors are known risk factors of hypertension.

Alternatively, for individuals on the lower end of the income distribution, limited prospects for mobility may further exacerbate chronic stress. Previous research has demonstrated that the lower the social status of an individual, the lower the capability to have control over life and the more the cumulative stress.[86,87] Exposure to chronic stress is a psychosocial factor known to directly increase the risk of hypertension.[67,88] The stress may also influence the risk of hypertension through an indirect pathway such as engaging in a negative health behavior.[89]

Income inequality is also thought to influence health through psychosocial processes as documented in Wilkinson's relative income hypothesis. Under the relative income hypothesis, relative income is more important than absolute income in developed countries.[90] The argument is that, in more unequal societies, status is more prominent and consumption choices are made based on what other people in the social hierarchy consume.[91–93] Thus, greater income inequality is more likely to intensify status competition and in turn heighten status anxiety.[92] Those with the lowest social status, that is, those at the bottom of the income rank, are most likely to feel intense shame and inferiority.[92–94] Earlier studies by Brunner and Marmot demonstrate that increased status anxiety has been linked to chronic stress.[95,96] Recurrent exposure to prolonged chronic stress impairs the neuroendocrine systems controlling the "flight or fight" response thus leading to increases in heart rate, cardiac output and high blood pressure.[96] Previous studies have linked anxiety and chronic stress with hypertension.[88,89,97] On the other hand, individuals could also engage in unhealthy behavior as a coping mechanism to chronic stress, which in turn could increase risk of hypertension.

On the other hand, income inequality is thought to influence health through the neo-material hypothesis or social disinvestment.[98] Social disinvestment simply reflects less investments in human capital and social resources (e.g. public infrastructure such as health

services, good schools, parks, safe housing) that promote health in the disadvantaged.[81] Previous studies have established that factors such as the built environment may influence the risk of hypertension.[99–101] The built environment thus may be a stressor or it might constrain or encourage health behavior such as engaging in physical activity, diet or alcohol consumption.

State minimum wage may influence health primarily via income. Income in this instance represents access to conditions or material goods that individuals can afford to promote good health. Individuals earning a minimum wage may experience financial hardship,[102] which in turn may influence the type of residential environment they can afford. Deprived neighborhoods are sources of stress[99] which when perceived by the brain as such, initiate a physiologic response. Over time, when these systems are over-activated they may become impaired leading to hypertension development.[103] Living in deprived neighborhoods may also be suggestive of exposure to insufficient nutritional resources. The exposure may lead to consumption of increased sodium and eventually hypertension.[99]

On the other hand, minimum wage workers may be exposed to job strain. Job strain is characterized by working conditions that are high demand and low control.[104] Previous studies show evidence of a relationship between job strain and hypertension.[105,106]

Literature Review

Hypertension in the United States

Hypertension (also referred to as systemic arterial hypertension) is identified by continuously high blood pressure in the body's main arteries.[107] There are two types of hypertension. One is primary or essential hypertension, where the exact cause is unknown while the other is secondary, indicating it can be traced to a known condition, e.g. renal artery stenosis or primary aldosteronism.[107] Primary hypertension is the focus of this dissertation.

The main risk factors of hypertension fall into two broad categories: modifiable and non-modifiable. Modifiable risk factors can be controlled and include environmental or lifestyle influences such as overweight and obesity, high sodium consumption, low potassium intake, high consumption of alcohol, tobacco usage and physical inactivity.[17,108,109] Similarly having conditions such as diabetes mellitus, chronic kidney disease, sleep apnea,[109] gestational hypertension and preeclampsia increase the risk of hypertension.[17] Moreover, lower socioeconomic status as measured by indicators such as education, income and occupation have been linked to a higher risk of hypertension development.[17]

Non-modifiable risk factors associated with the development of hypertension include advancing age, gender, black race-ethnicity, and genetics/family history. Aging contributes to arterial stiffness through a gradual loss of arterial elasticity resulting in an increase in systolic blood pressure.[110] Gender differences in hypertension are such that men have a higher prevalence than women prior to age 50. However, after age 50, women have a higher prevalence of hypertension than men.[111] Studies have found that hypertension in non-Hispanic Black individuals is typically more severe[112], develops earlier in life, and prevalence is consistently higher than in White individuals.[108,113] The current prevalence of hypertension in non-Hispanic

Black males and non-Hispanic Black females is about 57.5% and 58.4%, respectively. In comparison, the current prevalence in non-Hispanic White males and non-Hispanic White females is 48.9% and 42.6%, respectively.[10] Although several genes associated with the development of hypertension have been identified, these genes have been noted to account for only 3.5% of the variability in blood pressure.[107,114] Relatedly, although it has been known that individuals with a family history of hypertension are at an increased risk of developing hypertension, recent research has quantified this risk across multiple generations. For example, Niiranen et al. suggest that exposure to parental and grandparental early-onset hypertension (< age 55 years) increases the risk of hypertension by two folds, [Parental risk OR=2.10 (95% CI, 1.66–2.67), $P < 0.001$] and 33% [Grandparental risk OR=1.33 (95% CI, 1.12–1.58), $P < 0.01$] in children and grandchildren, respectively.[115] More importantly, studies have observed that the interaction of a positive family history and environmental risk factors strongly increase an individual's risk of hypertension development.[17,108]

Hypertension is responsible for a considerable burden on the US health care system. The 2017 National Hospital Ambulatory Medical Care Survey reported that hypertension was one of the most common chronic conditions observed at emergency department visits (EDs). Nearly 25.2% of the total portion of ED visits were attributed to hypertension,[116] and hence very costly at $131 billion in annual hypertension-related health care expenditures.[117]

In addition, mortality from hypertension has been notable. Data from the National Vital Statistics in 2020 indicate that the age-adjusted death rate attributable to hypertension was 29.0 deaths per 100,000 population.[10] Given the substantial loss of life associated with hypertension, one study demonstrated that the eradication of hypertension in adults aged 45-79 years could decrease CVD deaths by nearly 38.0% and 30.4% in females and males, respectively.[118]

In recent years the general adult population has experienced an increase in the prevalence of hypertension from 32.0% in 2011-2014[114] to 46.7% in 2017-2020.[10] A similar pattern was noted in young adults. Data from the NHANES 2017-2018, indicate that the current prevalence is 22.4% in adults aged 18-39 years.[6] This prevalence is considerably higher than the prevalence of 7.5% based on data from the NHANES 2015-2016.[119]

Although young adults with hypertension have had improved coverage as a result of the Affordable Care Act,[120] they have also been burdened by poor awareness and low control compared to older adults.[121] Management of hypertension in young adults has also been challenging.[122–124] With the lower blood pressure threshold in place, ≥130/80mmHg, research has to understand how upstream social factors may heighten the risk of hypertension in young adults and more importantly in Black individuals.

A close examination of the recent young adult hypertension literature reveals several key themes. These are organized according to: 1) Risk factors of hypertension, 2) non-Hispanic Black individuals as a high risk population, 3) Effects of hypertension, and 4) Management of hypertension.

Studies of Risk Factors of Hypertension

There is a growing need to understand factors influencing hypertension in young adults. The rationale behind this is to develop interventions that will prevent, or manage hypertension in this critical period of life. Of the risk factors identified in the literature, race has been a prominent issue. This is particularly the case with non-Hispanic Black individuals bearing a disproportionately high burden of the risk in terms of incidence,[125] early developmental age,[125,126] and cumulative lifetime burden.[127] For instance, recent data suggest that by age 55 (middle age), non-Hispanic Black men (75.5%) and women (75.7%) had the highest cumulative

incidence of hypertension. In comparison, the cumulative incidences for non-Hispanic White men and White women were 54.5% and 40.0%, respectively.[125] Similarly, the cumulative lifetime burden of hypertension (tracked from ages 20-85 years) for non-Hispanic Black men (86.1%) and non-Hispanic Black women (85.7%) was higher but comparable to the proportion observed in non-Hispanic White men (83.8%) and only 69.3% for non-Hispanic White women.[127] Furthermore, the data suggests that non-Hispanic Black men and women develop hypertension at younger ages when contrasted with non-Hispanic White men and women.[125] For example, Thomas and colleagues found that the age at which 30% of non-Hispanic Black men, non-Hispanic Black women, non-Hispanic White men and non-Hispanic White women were hypertensive stood at 35 years, 39 years, 44 years and 53 years, respectively.[125]

Ultimately, irrespective of baseline blood pressure, non-Hispanic Black individuals still have a higher adjusted risk of developing hypertension that is 1.5 to 2 times that of non-Hispanic White individuals.[125] The higher risk in non-Hispanic Black individuals is observed even when blood pressure levels are <110/70 mm Hg and the participants have an approximate mean age of 24 years at baseline.[125] Given that blood pressure limits are below normal, the authors hypothesized that the increased risk may be attributed to the upkeep of health behaviors, and not higher blood pressure levels originating in childhood.[125]

Beyond race, location-based factors such as area-level residential segregation and census tract violent crime have also been examined in the recent literature. Although studies examining these location-based factors have been fewer, they nonetheless indicate that they have an influence on hypertension in young adulthood.[128,129] For example, exposure to neighborhood segregation in young black adults increased the odds of systolic blood pressure by 16%, and though small, the increase was statistically significant.[128] Additionally, the exposure associated

with moving out of a segregated neighborhood was associated with reductions in systolic blood pressure greater than 1mm Hg.[128] On the other hand, studies including the overall adult population seem to indicate there are mixed findings regarding the association between residential segregation and hypertension.[130–132] For instance, one recent study of individuals older than 18 years assessed the association between neighborhood racial isolation (a measure of residential segregation) and hypertension in Durham, North Carolina, and found that an increase in racial isolation was associated with modestly increased odds of hypertension among non-Hispanic Black and non-Hispanic White adults.[130] Contrarily, an older study examining the association between segregation and hypertension among foreign- and US-born Black individuals in New York City, reported that segregation was associated with 46% decreased odds of hypertension only among older (65+ years), foreign-born Black individuals residing in highly segregated areas relative to low segregated areas. Contrarily, no association was found between residing in highly segregated areas relative to low segregated ones, among US-born Black individuals.[132] While these findings are important, they may have limited generalizations to young adult populations.

Other studies examining young adults and their risk of hypertension development can be broadly categorized as mostly focusing on biological/clinical risk factors. These factors include, pulse wave velocity, preterm birth, antidepressant use, parental history of hypertension, serum uric acid and body mass index. First, having a preterm birth as opposed to term birth was observed to increase the risk of systolic hypertension.[133] Also, elevated pulse wave velocity, a marker of arterial stiffness, increased the progression of systolic and diastolic hypertension.[134] In the same study, pulse wave velocity was observed to be a significant predictor of incident hypertension.[134] In addition, the use of antidepressant medications increased the risk of

hypertension in a sample of young adults.[135] Finally, having a parental history of hypertension, higher serum uric acid levels, and higher body mass index were observed to increase the risk of incident hypertension.[125]

The last category of studies includes behavioral factors such as diet and binge drinking which have been found to influence the risk of hypertension development. For instance, having a higher Dietary Approaches to Stop Hypertension (DASH) diet adherence in young adults was associated with a lower risk of hypertension.[125] Alternatively, binge drinking was observed to increase the risk of elevated systolic blood pressure even after adjustment for physical activity and dietary influences in a cross-sectional study.[136]

Studies addressing non-Hispanic Black Individuals as a High Risk Population

In addressing why non-Hispanic Black individuals compared to non-Hispanic White individuals are generally a high risk group, environmental influences like the Southern diet have been found to explain some of the racial/ethnic differences.[137] In the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study, the Southern dietary pattern accounted for 51.6% (95% CI, 18.8% to 84.4%) of the excess risk associated with hypertension in non-Hispanic Black men and 29.2% (95% CI, 13.4% to 44.9%) of the excess risk in non-Hispanic Black women.[137] The same study also indicated that low education, as measured by a high school education or less, seemed to explain about 12.3% of the excess hypertension risk among non-Hispanic Black men.[137] However, the study examined older adults with a mean age of about 60 years and thus findings may not be generalizable to younger adults. In Thomas et al.'s cohort study of young adults, a higher DASH diet score was associated with a reduction in odds of incident hypertension in non-Hispanic Black (9%) and White (15%) individuals.[125] Thus,

interventions in young adulthood aimed at improving adherence to the DASH diet in Black individuals may help lower their risk of hypertension.

Also, a recent review of literature identified genetic influences, comorbid conditions like obesity, and psychosocial factors like perceived stress and racism as some determinants that could explain the racial differences.[12] A slightly divergent finding appeared to indicate that genetic influences, as in the case of a parental history of hypertension, may not fully explain the racial differences. For instance, in Thomas et al.'s study, having a parental history of hypertension significantly increased the likelihood of incident hypertension similarly in both Black (24%) and White adults (24%).[125]

While some factors highlighted why non-Hispanic Black individuals are a high-risk group, some factors were found to be protective of hypertension incidence in non-Hispanic Black individuals. For instance, in the Jackson Heart Study, compared to non-Hispanic Black individuals with ≤1 ideal component, those who maintained 2, 3, 4, 5 and 6 components had a lower incidence of hypertension.[138] The ideal components are a group of cardiovascular health measures emphasizing behavioral factors (cigarette smoking, diet, physical activity and BMI) and biological factors (blood pressure, fasting glucose and total cholesterol).[138] Although the Jackson's Heart Study has some young adults, majority of the participants are in their middle ages (average age 49.0 years) and therefore some limitations exist with generalizing findings to young adult populations.

Studies with Effects of Hypertension

It is understood that exposure to suboptimal blood pressure in young adulthood increases the risk of later life cardiovascular events and target end-organ damage. Prior studies have found that as blood pressure increases so does the risk of a CVD outcome and target organ

damage.[7,8,139–143] For example, in Yano et al.'s study, compared to young adults who maintained normal blood pressure in young adulthood (that is, through age 40), having elevated, stage 1, and stage 2 hypertension, was associated with an increased risk of CVD events ranging from 1.67 (95% CI, 1.01-2.77), 1.75 (95% CI, 1.22-2.53), and 3.49 (95% CI, 2.42-5.05), respectively.[142] In Kishi et al.'s 25 year follow-up study, cumulative exposure to high blood pressure from young adulthood through middle age was linked to diastolic and systolic left ventricular dysfunction during middle age.[7] More importantly, one recent study in young adults found that early onset hypertension (<35 years) was associated with about twice the odds of left ventricular hypertrophy, coronary calcification and left ventricular diastolic dysfunction.[143] In the study, the end-organ damage was observed at midlife and adults with an onset at ≥45 years of age did not have the same damage. The finding that not only cumulative blood pressure, but also early onset hypertension has adverse consequences as early as middle adulthood, highlights the importance of maintaining ideal blood pressure in young adulthood.

Studies with Management of Hypertension

In the young adult literature, management of hypertension has gravitated toward the use of antihypertensive medications[144] and lifestyle approaches to control blood pressure.[145,146] Current national guidelines recommend that when stage 1 hypertension occurs, (that is, SBP, 130–139 or DBP, 80–89 mm Hg,) pharmacological treatment should be initiated. Treatment should occur if patients have atherosclerotic cardiovascular disease, a 10 year cardiovascular risk estimate that is greater than 10%, or if diabetes mellitus or chronic kidney disease are present.[147] However, it is generally agreed that most young adults have a relatively low cardiovascular risk[142,147] and thus current guidelines may oversimplify this risk.

Additionally, there is disagreement over intensive treatment of blood pressure in young adults using the currently established lower threshold of ≥130/80mmHg.[148,149] The basis for the disagreement is in the underrepresentation of young adults in clinical trials that established the guidelines that is, the Systolic Blood Pressure Intervention Trial (SPRINT). The sample for the SPRINT trial was mostly made of adults who were older than 50 and high risk.[148]

Despite the use of antihypertensive therapies, studies have observed a residual risk of a CVD event or end-organ damage as blood pressure increases. The observed residual risk exists regardless of whether hypertension is controlled or not.[140,150] This observation implies that blood pressure medication may not undo the damage caused to the heart or vasculature as a result of sustaining high blood pressure over time.[151]

Thus, primordial prevention, in the form of eliminating distal factors associated with the disease, is a goal that ought to be pursued. Doing so will avoid the potential damage both to individuals and society that hypertension causes.

Summary

The literature regarding young adults and hypertension is growing. However, emphasis has been placed on identifying biological and or clinical risk factors. While current studies have made important contributions to the literature on hypertension in young adults, gaps in knowledge exist with regard to associations between upstream social factors and hypertension in this population.

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CHAPTER 2: ASSOCIATION BETWEEN COUNTY INTERGENERATIONAL DEPRIVATION AND HYPERTENSION (PAPER 1)

Abstract

Introduction: Although hypertension is a major modifiable risk factor of cardiovascular disease, its prevalence has been increasing in young adults. Evidence seems to indicate that the location a child grows up could determine their future economic outcomes and health. This study evaluated the association between county intergenerational deprivation and hypertension in young adults and whether race-ethnicity and geographical region modified this association.

Methods: We used the 2009 and 2011 Behavioral Risk Factor Surveillance System (BRFSS), 1996-2012 Opportunity Insights database, 2008-2012 American Community Survey (ACS), and 2010 County Health Rankings and Roadmaps (CHR&R) (n=129,881). Absolute upward mobility was obtained from the Opportunity Insights dataset while hypertension was self-reported by BRFSS participants. Weighted multilevel logistic regression was used to obtain odds ratios and 95% confidence intervals. Stratified analyses assessed whether race-ethnicity and geographical region modified the county intergenerational deprivation-hypertension association.

Results: A 5.31 unit increase in absolute upward mobility, equivalent to a change between the 10^{th} and 50^{th} percentile, or South to Northeast, was associated with decreased odds of hypertension (aOR: 0.74; 95% CI: 0.62-0.89). Race-ethnicity modified the county intergenerational-deprivation-hypertension association. Among non-Hispanic White young adults, absolute upward mobility was not associated with odds of hypertension (aOR: 1.04; 95% CI: 0.97-1.12). Conversely, among Hispanic, non-Hispanic Black and 'Other' young adults, a 5.31 unit increase in absolute upward mobility was associated with increased odds of hypertension (aOR: 1.08; 95% CI: 0.91-1.28; aOR: 1.13; 95% CI: 0.95-1.34; aOR: 1.12; 95% CI: 0.89-1.42, respectively). Geographical region modified the association between county

intergenerational deprivation and hypertension. Among young adults living in the South, Midwest, and Northeast, a 5.31 unit increase in absolute upward mobility was associated with statistically significant decreased odds of hypertension (aOR: 0.61; 95% CI: 0.44-0.84; aOR: 0.41; 95% CI: 0.29-0.59; aOR: 0.12; 95% CI: 0.07-0.21, respectively).

Conclusion: County intergenerational deprivation was associated with hypertension. Interventions that are designed to increase opportunity structures at the local level would be beneficial.

Introduction

Hypertension is the most influential risk factor in the development of cardiovascular disease (CVD) in comparison to other modifiable risk factors such as dyslipidemia, smoking and diabetes.[1] According to data from the National Health and Nutrition Examination Survey (NHANES), the rates of hypertension have increased among young adults aged 18-39 years.[2,3] The prevalence of hypertension in this age group has increased from 7.5% in 2015-2016 to 22.4% in 2017-2018.[2,3] Studies also show that non-Hispanic Black individuals not only have higher rates of hypertension than other racial-ethnic groups, but also develop hypertension at an earlier age.[4–6] Hypertension is associated with a substantial economic burden on the United States (US). Recent data on health care utilization indicates that hypertension accounted for 56.8 million physician office visits and 1.0 million visits to the emergency department, with hypertension listed as the primary diagnosis.[7] Furthermore, recent data from 2018 to 2019 shows that the estimated direct and indirect cost of hypertension was $52.2 billion.[6]

The traditional risk factors of hypertension are male sex, black race-ethnicity, increasing age, obesity, physical inactivity, consuming unhealthy diets and low socioeconomic status.[6] In addition to these risk factors, there has been a renewed interest in addressing research agendas that pursue health equity in order to address the fundamental root causes of racial-ethnic health disparities.[8–11] One such factor is structural racism and its manifestations. Structural racism refers to the policies and processes in institutions or societal structures that perpetuate racism, that is, having a dominant race.[10] These policies and processes are embedded in economic, housing, law and educational institutions and are used to facilitate the unfair allocation of opportunities, risks and resources that influence health.[10] One manifestation of structural racism is in limited prospects for income mobility across generations.[9] The idea of limited economic mobility is at odds with the notion of equality of opportunity in the US, that is, that an

individual's birth circumstances should not determine her/his economic fate in life.[12–14] The limited prospects for upward mobility are a policy concern especially for children from disadvantaged families.[12] In this paper, we use the term intergenerational deprivation to refer to this concept of limited economic mobility.

There have been concerns over declines in the prospects for upward mobility in the US.[14,15] Studies reveal that upward mobility levels have fallen from 90% to 40% for children born in the 1940 and 1980 birth cohorts, respectively.[16] In addition, there is substantial evidence of racial-ethnic and geographical differences in the prospects for upward mobility. In one study, Hispanic individuals had similar upward mobility rates as White individuals, while Asian individuals had much higher mobility rates than White individuals. In contrast, Indian and Black American individuals were documented to have the lowest rates of upward mobility and the largest rates of downward mobility compared to White individuals.[17] Spatially, cities such as Salt Lake City, Pittsburgh and San Jose were observed to have the largest rates of upward mobility while Charlotte, Atlanta, and Raleigh, were shown to have the lowest upward mobility rates.[15] The consequences of lack of upward mobility in some locations implies that those from disadvantaged backgrounds remain in persistent poverty. Interestingly, areas with lower mobility rates have been characterized by racial residential segregation, poor school quality as indicated by lower test scores and higher dropout rates as well as a broken social structure.[15] While these characteristics are correlations, the study findings are largely consistent with the findings of previous studies. These studies have identified racial residential segregation, a manifestation of structurally racist policies, as the main mechanism that has concentrated poverty in Black communities, determined access to local schools and employment opportunities and thus, limited upward mobility.[9,10,18–20] Living in environments with limited prospects for upward mobility

diminishes hope[21] since socioeconomic status remains unchanged,[10] and thus can intensify chronic stress for individuals on the lower end of the income distribution. Prior studies have established a direct association between chronic stress and hypertension.[22,23]

In addition, the concentration of poverty in segregated communities contributes to a disadvantaged social environment as characterized by higher crime and violence;[10,24] and disinvestments in poverty-stricken communities gives rise to disadvantaged physical environments (e.g., poor neighborhood quality and poor housing).[25] Environments with disadvantaged social environments are sources of chronic stress[10,24] and are unlikely to support positive health behaviors.[10] Residence in disadvantaged social environments and physical environments have been linked to an increased risk of hypertension.[26,27]

With regard to the literature, studies assessing the association between intergenerational deprivation and hypertension have had inconsistent findings. Some literature has argued that increased mobility across generations is not related to the risk of hypertension.[28–30] Contrarily, other studies have found that increased upward mobility is associated with an increased likelihood of hypertension,[31] while others indicate that increased upward mobility is associated with a decreased risk of hypertension.[29,31–34] Still, other studies have found that lack of upward mobility is associated with an increased risk of hypertension.[28] While prior studies have made notable contributions, only one study has focused on young adults age 18 years;[33] the rest have mainly focused on the overall adult population with ages varying between 20-95 years.[28–32] Also, studies have relied on self-reported data to measure upward mobility and thus have been prone to misclassification of the exposure.[28–33] Furthermore, current knowledge on non-Hispanic Black individuals has been limited to a community setting and thus is not generalizable to the broader US context.[31] Also, some studies have occurred in international contexts and thus have had

limited generalizability to the US context;[28,29,32,33] and have used aggregate data and thus are prone to the ecological fallacy.[34] Therefore, this study addressed the gaps in the literature using a racially and ethnically diverse, population-based sample of young adults, 18-39 years to 1) assess the association between county intergenerational deprivation and hypertension and 2) evaluate whether race-ethnicity and geographical region modifies the county intergenerational deprivation-hypertension association. This study may help local community leaders and researchers understand how fundamental causes of health disparities rooted in structurally racist policies influence cardiovascular health by affecting a location's upward mobility.

Methods

Study design and population

This cross-sectional study used publicly accessible data from the 2009 and 2011 Behavioral Risk Factor Surveillance System (BRFSS), 1996-2012 Opportunity Insights database, 2008-2012 American Community Survey (ACS), and 2010 County Health Rankings and Roadmaps (CHR&R). The BRFSS is a state-based survey that monitors the risk factors, preventive health behaviors and chronic diseases in noninstitutionalized adults (aged ≥18 years) residing in the US.[35] Data collection in the BRFSS is via computer-assisted telephone interviewing. Interviews are conducted monthly and approximately 400,000 adults are interviewed annually.[35,36]

There is a difference between the BRFSS 2009 and 2011 survey cycles. The 2009 survey cycle only collected data from landline telephones but changed its methodology to include cell phone data in 2011. As such, there are differences in the weighting methodologies. The 2009 survey cycle used the post-stratification method while the 2011 survey cycle used the raking method.[37] Raking has been more advantageous than poststratification since it enables the

insertion of more demographic and telephone ownership variables.[37] Therefore, the estimates produced have reduced bias and are more representative of the target population.[38] In addition, the inclusion of cell-phone respondents to the 2011 dataset has been useful in ensuring the inclusion of previously underrepresented racial-ethnic minorities as well as lower income respondents.[37] The median call response rates for all the states and the District of Columbia in 2009 was 52.48% and the range was between 37.90% to 66.85%.[39] Likewise, the median call response rate for 2011 was 49.72% and the range was from 33.77% to 64.14%.[40]

The rationale for using the BRFSS datasets is because they contain the individual level data on the outcome (that is, hypertension) and several key covariates. While the hypertension question is asked every odd year, data from 2009 and 2011 were selected because they provide the most recent year where the county of the respondents is reported since the BRFSS stopped collecting county data in 2012.

The 1996-2012 intergenerational estimates were obtained from the Opportunity Insights Database.[41] This dataset was created by Chetty and colleagues and contains the first measure of mobility statistics created for the United States.[15] Chetty and colleagues created county intergenerational mobility estimates using mean income from 2010-2012 income tax returns for approximately 10 million children in the 1980-1982 birth cohort. These 10 million children made up the core sample of their study. Their rationale for limiting the analysis to the 10 million children was based on several factors. First, all individuals had to have a valid social security number or individual tax identification number. Second, all individuals had to have US citizenship as of 2013 in order to exclude immigrants who likely came to the US as adults and thus without parent income. Third, for parents who filed income tax returns, their mean income between 1996-2000 had to be a stringently positive value. Fourth, since 1996 was the base year

for the data, the portion of children linked to parents began dropping substantially before the 1980 birth cohort and children began leaving the household starting at age 17. Consequently, a decision was made to limit analysis to children in 1980 or later.[15] Chetty and colleagues linked the data from the children to the parents' mean income between 1996-2000.[15] They then assigned each child a county based on the zip code listed on the parent's income tax return when the child was first claimed as a dependent. This assigned county thus represents the area where the child grew up (approximate age of children is 15 years). It is noted that average pre-tax income is used for both parents and children in generating mobility statistics.[15]

The ACS is a monthly survey administered by the Census Bureau to approximately 3.5 million addresses in the 50 states, District of Columbia and Puerto Rico.[42] The purpose of the ACS is to provide timely, annual data on characteristics of the US population on a wide array of topics such as demographic, economic, education, social and housing characteristics.[42] The 2008-2009 ACS data were used to obtain poverty estimates at the county level.[43] We selected the 5-year estimates because they offer more precise and stable estimates over the 1-year estimates, especially in subnational geographies such as counties, where samples are usually smaller.[44]

The CHR&R is a project of the University of Wisconsin Population Health Institute and the Robert Wood Johnson Foundation. The purpose of the CHR&R data is to provide evidence of factors influencing health outcomes across counties in the 50 states.[45] We used the 2010 CHR&R data to extract the county high school graduation rates. CHR&R sourced the high school graduation data from the National Center for Education Statistics, spanning years 2005-2006 and 2007-2008. The high school graduation rate was used to determine the averaged freshman graduation rate (that is, the students in the ninth grade cohort that graduated in four years) and spanned years 2005-2006 and 2007-2008.[46,47]

For this study, the 2009 and 2011 BRFSS, 1996-2012 Opportunity Insights data, 2008-2012 ACS, and the 2010 County Health Rankings education level were linked via the county Federal Information Processing Standard (FIPS) code. For the purpose of analysis, we excluded persons who 1) were from Guam, Puerto Rico, Virgin Islands (n=3,955), 2) were not 18 to 39 years of age (n=752,811), 3) provided incomplete information on hypertension while completing the BRFSS survey (n=2,315) or only reported hypertension during pregnancy (n=7,092) and 4) were missing information on key covariates such as marital status (n=630), smoking status (n=854), physical activity (n=5,199), body mass index (n=9,606), alcohol consumption (n=5,153), diabetes (n=701), race-ethnicity (n=900), chronic stress (n=1,475), and county code (n=19,372). The final sample size for the study was 129,881.

Primary Outcome Variable

The outcome variable was hypertension. Respondents were classified as having hypertension if they self-reported that a health care professional told them they had hypertension.

Main Exposure Variable

The key exposure variable was county absolute upward mobility. This measure denotes the average income rank at the county level attained by children born to parents in the 25th percentile (that is, the lowest quartile) of the national income distribution.[15,34,48] Each respondent in the BRFSS was assigned an absolute upward mobility measure from the 1996-2012 Opportunity Insights dataset based on their county of residence. This measure ranges from 1-100 with higher values denoting higher mobility in the respective counties.[34] Similar to previous studies, county absolute upward mobility was operationalized as a continuous variable.[34,48]

Other Covariates

Variables that could potentially confound the association between intergenerational deprivation and hypertension were included based on the extant literature. These variables were measured at the individual and county level. Individual level variables self-reported by participants included sociodemographic variables such as age (18-29, 30-39), sex (male, female), and marital status ((married, previously married, never married) and behavioral variables including alcohol consumption (number of alcoholic beverages consumed per week (no drinks at all, moderate [1-14 beverages /week for men and 1-7 beverages /week for women], and heavy [>14 beverages /week for men and >7 beverages /week for women]), smoking status (current, previous, non-smoker), physical activity (yes, no) and chronic stress ((≥14 days/month, <14 days/month). We defined chronic stress as the number of days mental health was not good in the preceding 30 days. Physical activity was defined as engagement in any physical activities or exercise that included running, and other activities other than one's job in the preceding 30 days. Other individual level risk factors included BMI (<18.5, 18.5-24.9, 25.0-29.9, ≥30.0 kg/m^2) and diabetes (yes, no). Race-ethnicity and geographical region were evaluated as potential effect modifiers of the exposure-disease association. The classifications for race-ethnicity considered for this analysis included: non-Hispanic White, non-Hispanic Black, Hispanic and Other. For geographical region, the classifications considered included: Northeast, Midwest, South, and West.

The county level characteristics included were poverty and high school graduation rates. We defined poverty rate as the poverty status in the preceding 12 months. The poverty rate was calculated by dividing the total number of people below poverty by the population for whom poverty status is determined, multiplied by 100.[49] Poverty status in the ACS is determined by

comparing it to yearly pretax income and poverty thresholds; the poverty thresholds are in turn based on family size.[49,50] We defined the high school graduation rate as the averaged freshman graduation rate (that is, students in the ninth grade cohort that graduated in four years).[46,47]

Statistical Analysis

Frequencies, proportions and means were used to report the characteristics of the analytical sample. Unadjusted odds ratio and 95% confidence intervals between all the independent variables and hypertension were assessed using marginal logistic regression adjusted for survey weights. Given that the participants in the study were nested in counties, we used a 2-level weighted multilevel logistic regression to investigate the county intergenerational deprivation and hypertension association whilst controlling for confounders. We first estimated a null model and subsequently calculated the variance partition coefficient (VPC). The VPC quantified the proportion of variation in hypertension at the county level. Next, we added absolute upward mobility (model 2). In order to be consistent with the literature, we modeled our exposure as a 5.31 unit increase in absolute upward mobility, which is roughly the difference between an observation in the 10th versus the 50th percentile in our mobility distribution, or equivalent to movement from the South to the Northeast.[34] Last, we added all the individual level and county level covariates to the full model (model 3). Additionally, stratified analyses were conducted to assess whether race-ethnicity and geographical region modified the county intergenerational deprivation-hypertension association. However, our race-ethnicity stratified model failed to run with county as a random effect because of very few observations in various counties. Instead, we used logistic regression adjusted for survey weights and specified the geographical region variable as a fixed effect.

We also conducted a mediation analysis to evaluate whether chronic stress and poverty rate mediated the association between county intergenerational deprivation and hypertension. The mediation analysis followed the traditional four steps for establishing mediation.[51] All the final models were assessed for multicollinearity using the variance inflation factor (VIF). The independent variables in the models yielded VIF values of less than 3, thus indicating no multicollinearity.[52] We weighted all analyses to account for the complex sampling design utilized by the BRFSS. Significance tests were set at alpha < 0.05. Analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

Results

Among the sample, 13.84% had hypertension (**Table 1.1**). Approximately half were younger than age 30 years and nearly 30% of the total sample were minorities (Hispanic and non-Hispanic Black). In addition, the mean of absolute upward mobility was 41.84. In the unadjusted model, non-Hispanic Black young adults had increased odds of hypertension (OR: 1.54; 95% CI: 1.41-1.68), while Hispanic and 'Other' had decreased odds of hypertension compared to non-Hispanic White young adults (OR: 0.83; 95% CI: 0.75-0.92 and OR: 0.94; 95% CI: 0.83-1.06, respectively; **Table 2.1**). In addition, females had decreased odds of hypertension compared to males (OR: 0.57; 95% CI: 0.54-0.61). A 5.31 unit increase in absolute upward mobility, that is, equivalent to movement in residence from 10th to the 50th percentile, or South to the Northeast, was associated with decreased odds of hypertension (OR: 0.89; 95% CI: 0.86-0.93), and this association was statistically significant.

After adjusting for age, sex, marital status, smoking status, alcohol consumption, physical activity, body mass index, diabetes, chronic stress, county poverty rate, and county high school graduation rate, the magnitude of the association between absolute upward mobility and

hypertension increased in magnitude (OR: 0.74; 95% CI: 0.62-0.89; **Table 3.1**), and this association remained statistically significant.

In stratified analyses, the county intergenerational-deprivation-hypertension association differed among race-ethnicity groups. Among non-Hispanic White young adults, a 5.31 unit increase in absolute upward mobility was not associated with odds of hypertension (OR: 1.04; 95% CI: 0.97-1.12; **Table 4.1**). However, among Hispanic, non-Hispanic Black and 'Other' young adults, a 5.31 unit increase in absolute upward mobility was associated with increased odds of hypertension; however, these findings were not statistically significant (OR: 1.08; 95% CI: 0.91-1.28; OR: 1.13; 95% CI: 0.95-1.34; OR: 1.12; 95% CI: 0.89-1.42, respectively). Thus, race-ethnicity modified the county intergenerational deprivation-hypertension association. In stratified analyses, geographical region modified the association between county intergenerational deprivation and hypertension. Specifically, among young adults residing in the West, a 5.31 unit increase in absolute upward mobility was associated with 11% increased odds of hypertension (OR: 1.11; 95% CI: 0.77-1.59; **Table 5.1**); however, this association was not statistically significant. Conversely, among young adults residing in the South, Midwest, and Northeast, a 5.31 unit increase in absolute upward mobility was associated with statistically significant decreased odds of hypertension (OR: 0.61; 95% CI: 0.44-0.84; OR: 0.41; 95% CI: 0.29-0.59; OR: 0.12; 95% CI: 0.07-0.21, respectively).

Results for step 1, 2, 3, and 4 of the mediation analyses are shown on **Table 6.1**. Absolute upward mobility did not predict hypertension (OR: 0.98; 95% CI: 0.97-0.99). The potential mediator, chronic stress, was associated with a two-fold increase in odds of hypertension (OR: 2.09; 95% CI: 1.94-2.26). The model controlling for chronic stress failed to support the hypothesis that chronic stress mediated the association between absolute upward

mobility and hypertension. Similarly, results for step 1, 2, 3, and 4 of the mediation analyses for poverty rate are shown on **Table 7.1**. Absolute upward mobility did not predict hypertension (OR: 0.98; 95% CI: 0.97-0.99). The potential mediator, poverty rate, was not associated with odds of hypertension (OR: 1.02; 95% CI: 1.01-1.02), and the model controlling for poverty rate failed to support the hypothesis that poverty rate mediated the association between absolute upward mobility and hypertension.

Discussion

In this study, we found that an increase in absolute upward mobility was associated with decreased odds of hypertension, after adjustment for confounders in the overall sample. In the first stratified analysis, race-ethnicity modified the county intergenerational-deprivation-hypertension association. Specifically, among non-Hispanic White young adults, absolute upward mobility was not associated with odds of hypertension. Contrarily, among Hispanic, non-Hispanic Black and 'Other' young adults, absolute upward mobility was associated with increased odds of hypertension. In the second stratified analysis, geographical region modified the association between county intergenerational deprivation and hypertension. Notably, among young adults residing in the West, an increase in absolute upward mobility was associated with increased odds of hypertension. However, among young adults residing in the South, Midwest and Northeast, an increase in absolute upward mobility was associated with decreased odds of hypertension.

Studies of county intergenerational deprivation and hypertension have had contradictory findings.[28–34] However, the results of our overall study are consistent with other studies that show that an increase in upward mobility is associated with a decreased likelihood of hypertension.[31–34] For instance, in an ecological study of n=1,477 US counties examining the association

between economic opportunity and hypertension, a 1 standard deviation (SD) increase in opportunity, approximately the difference in movement from the 10th to 50th percentile of their opportunity distribution, or between a county in the South and Northeast, was associated with a 2.8% decrease in hypertension rates. The opportunity measure in the ecological study, was similar to ours, and was based on the county-average rank (1-100) that was attained by individuals born to parents in the lowest income quartile of the national income distribution.[34] An additional cohort study of Black adults in the Jackson Heart Study (n=4,751 adults; aged 21-95 years) assessed the association between upward mobility and incident hypertension.[31] In their results, compared to participants with no upward mobility, that is, low childhood socioeconomic status (SES) to low adult SES, those with upward mobility (low childhood SES to high adult SES) had a 21% decreased risk of hypertension. Their study's mobility measure was based on the mother's education and the participant-reported adult education. Taken together, there is evidence across multiple study designs and samples that upward mobility is associated with decreased odds/risk of hypertension.

The association of increased upward mobility with decreased odds of hypertension in our overall findings may suggest hope[21] was bolstered due to the SES change. According to Snyder and colleagues, the hope process requires an interplay of two related components: a sense of successful goal-directed determination (agency) and a sense of planning to meet individual goal (pathways).[21] Thus, the increased prospect for upward mobility may have ignited hope, and in turn increased the likelihood of engaging in positive health behaviors that lower the risk of hypertension. Thus, the reduced odds of hypertension are plausible. Alternatively, an SES increase may have helped increase individual social status and in turn strengthened an

individual's capacity for control over their life. In turn, this strengthened capacity for control may have a protective effect on chronic stress,[53] a known risk factor of hypertension.[54]

To our knowledge, no known current studies have examined whether race-ethnicity modifies the county intergenerational deprivation-hypertension association. However, one study did evaluate the association between upward mobility and cardiovascular disease (CVD) related outcomes and found that upward mobility (versus consistently disadvantaged) was associated with an increased risk of CVD among White males, but had no association among Black or Latino individuals.[55] These findings are inconsistent with our results that indicated no association between county intergenerational deprivation and hypertension among non-Hispanic White participants; and increased odds among Hispanic, non-Hispanic Black and 'Other' participants. Thus, a plausible explanation for the increased odds of hypertension in racial-ethnic minorities may be because the gains in SES may not have been sufficient to overcome the exposure to the effects of racial residential segregation[55] such as concentrated poverty, and the accompanying social disadvantage such as neighborhood quality and the social disorder.[10,25] Residence in deprived neighborhoods is a psychosocial stressor that does not support positive health behavior[10] and is associated with increased odds of hypertension in young adults.[56]

We also noted differences in the county intergenerational-deprivation-hypertension association by geographical region. In particular, odds of hypertension were increased among participants residing in the West, but decreased among participants residing in the South, Midwest and Northeast. To our knowledge, researchers have not previously evaluated whether the county intergenerational-deprivation-hypertensions association differs by geographical region. However, given that residential segregation is more pronounced in the South and there was a reduction in odds of hypertension, our results indicate that poverty and the subsequent

limitations on education play an important role in influencing the likelihood of hypertension. We did not anticipate that the county intergenerational-deprivation-hypertension association would be elevated for participants residing in the West since there is less residential segregation compared to the South.[15,57] Thus, the differential vulnerability in odds of hypertension across the geographical regions could be due to regional-level factors, and hence warrants additional research.

Strengths and Limitations

There were several strengths and limitations in the study. First, there is a possibility that our results may be subject to migration bias where healthier individuals tend to move to higher opportunity localities. However, another study[48] of 147,000 young adults who participated in the 2009-2012 BRFSS, did not find that there was an association between county economic opportunity and migration and thus, this type of bias should not a be a concern. Also, our study was cross-sectional and therefore we could not make causal inferences on the associations observed. In addition, measurement of hypertension, was self-reported. While it is possible that some participants may have misreported reported this information, previous investigations have reported that using self-reported hypertension measures produces the same result as actual measurement of blood pressure.[3,58] In any case, if nondifferential misclassification of the outcome was present it would likely bias results towards the null. Furthermore, while there were concerns of low response rates in the BRFSS, the introduction of raking as a weighting methodology in BRFSS 2011 aided in the adjustment for non-response bias.[59] Additionally, our usage of the 2011 dataset was beneficial as it helped ensure the inclusion of cell-phone only[37] participants which likely includes racial-ethnic minorities as well as lower income participants.

Finally, there may be residual confounding given that our study was limited to the variables available in the study datasets.

In spite of the limitations, our study has several strengths. The study was able to extend the literature by connecting individual-level data on health outcomes to mobility measures and assess the underlying ways opportunity is linked to hypertension. Also, our use of administrative tax records to measure incomes for both parents and children was more objective than other measures used to assess intergenerational deprivation and thus nondifferential misclassification of the exposure was unlikely. Furthermore, our study was able to examine effect modification by geographical region and race-ethnicity; the geographical region analysis has not been examined by other studies and therefore provides useful information for future studies. Conversely, the heterogenous results in race-ethnicity were helpful in understanding how increases in SES for young adult minorities interact with structural factors to shape hypertension outcomes. Finally, the BRFSS offered large samples and hence results may be generalizable to similar non-institutionalized young adults between the ages of 18-39 years.

In conclusion, we found evidence of a statistically significant association between county intergenerational deprivation and hypertension in our overall sample. We also found that the county intergenerational-deprivation-hypertension association varies by race-ethnicity and geographical region. In addition, the study expanded our understanding of how structural factors such as intergenerational deprivation are manifestations of structurally racist policies, and the mechanisms by which they create inequities in odds of reporting hypertension at the individual level. Interventions aimed at increasing opportunity structures at the local level should consider investing in factors such as mixed income housing since it has the ability to de-concentrate poverty[11] as well as school quality.

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Table 1.1 Individual and state characteristics of young adults in BRFSS 2009 and 2011

Variables	HTN n= 15,786 (Weighted %)	No HTN n=114,095 (Weighted %)
Individual level		
Age		
18-29	4,488 (4.61)	46,092 (47.24)
30-39	11,298 (7.17)	68,003 (40.99)
Sex		
Male	8,456 (7.61)	46,647 (45.06)
Female	7,330 (4.16)	67,448 (43.16)
Marital Status		
Married	7,662 (5.00)	59,883 (37.23)
Previously married	2,239 (1.28)	10,202 (5.59)
Never married	5,885 (5.50)	44,010 (45.40)
Smoking Status		
Current	4,535 (3.67)	23,990 (19.44)
Previous	2,907 (2.03)	17,799 (12.15)
Non-smoker	8,344 (6.08)	72,306 (56.64)
Alcohol Consumption		
No drinks at all	6,861 (4.77)	4,6343 (36.37)
Moderate	7,693 (5.97)	6,0379 (45.49)
Heavy	1,232 (1.04)	7,373 (6.36)
Physical activity		
Yes	11,949 (9.03)	92,442 (71.40)
No	3,837 (2.75)	21,653 (16.83)
Body Mass Index (kg/m^2)		
<18.5	125 (0.11)	2,670 (2.39)
18.5-24.9	2,910 (2.33)	49,382 (38.87)
25.0-29.9	4,880 (3.70)	36,770 (28.33)
≥30.0	7,871 (5.64)	25,273 (18.63)
Diabetes		
Yes	1,654 (1.13)	3,590 (2.32)
No	14,132 (10.65)	11,0505 (85.90)
Days Mental health not good		
<14 Days/month	12,464 (9.43)	101,744 (78.82)
≥14 Days/month	3,322 (2.35)	12,351 (9.40)
Race-ethnicity		
Non-Hispanic White	10,547 (7.15)	81,455 (54.78)
Non-Hispanic Black	2,446 (1.96)	10,305 (9.77)
Hispanic	1,562 (1.77)	13,341 (16.36)
Other	1,231 (0.90)	8,994 (7.30)
Geographical Region		
Midwest	3,648 (2.68)	28,298 (20.46)
North	2,815 (1.78)	21,984 (13.90)

Table 1.1 Individual and state characteristics of young adults in BRFSS 2009 and 2011 (Continued)

Variables	**HTN n= 15,786 (Weighted %)**	**No HTN n=114,095 (Weighted %)**
North	2,815 (1.78)	21,984 (13.90)
South	5,708 (4.73)	33,719 (32.05)
West	3,615 (2.60)	30,094 (21.81)
County level		
	Mean (95% Confidence Interval)	
Absolute Upward Mobility	41.84 (41.81- 41.87)	
Poverty Rate	14.82 (14.77- 14.86)	
High School Graduation Rate	74.98 (74.89- 75.06)	

Table 2.1 Unadjusted odds ratios (OR) and 95% confidence intervals (CI) of the association between sociodemographic characteristics, county intergenerational deprivation and other county level characteristics and hypertension

Variables	OR (95% CI)
Individual level	
Age	
18-29	1.00
30-39	1.79 (1.68-1.91)
Sex	
Male	1.00
Female	0.57 (0.54-0.61)
Marital Status	
Married	1.00
Previously married	1.70 (1.55-1.88)
Never married	0.90 (0.85-0.96)
Smoking Status	
Current	1.76 (1.64-1.89)
Previous	1.56 (1.44-1.69)
Non-smoker	1.00
Alcohol Consumption	
No drinks at all	1.00
Moderate	1.00 (0.94-1.07)
Heavy	1.25 (1.11-1.40)
Physical activity	
Yes	1.00
No	1.29 (1.20-1.39)
Body Mass Index (kg/m^2)	
<18.5	0.79 (0.59-1.05)
18.5-24.9	1.00
25.0-29.9	2.18 (2.00-2.34)
≥30.0	5.06 (4.65-5.50)
Diabetes	
Yes	3.93 (3.50-4.40)
No	1.00
Days mental health not good	
<14 Days/month	1.00
≥14 Days/month	2.09 (1.94-2.26)
Race-ethnicity	
Non-Hispanic White	1.00
Non-Hispanic Black	1.54 (1.41-1.68)
Hispanic	0.83 (0.75-0.92)
Other	0.94 (0.83-1.06)
Geographical Region	
Midwest	1.03 (0.93-1.13)

Table 2.1 Unadjusted odds ratios (OR) and 95% confidence intervals (CI) of the association between sociodemographic characteristics, county intergenerational deprivation and other county level characteristics and hypertension (Continued)

Variables	**OR (95% CI)**
Northeast	1.00
South	1.16 (1.05-1.27)
West	0.93 (0.84-1.03)
County level	
Absolute Upward Mobility	0.89 (0.86-0.93)
Poverty Rate	1.02 (1.01-1.02)
High School Graduation Rate	0.99 (0.99-1.00)

Table 3.1 Multivariable multilevel logistic regression of the association between county intergenerational deprivation and hypertension in young adults

Variables	Null Model	Model 1 OR (95% CI)	Full model OR (95% CI)
Individual level			
Age			
18-29			1.00
30-39			1.61 (1.61-1.61)
Sex			
Male			1.00
Female			0.52 (0.52-0.52)
Marital Status			
Married			1.00
Previously married			1.52 (1.52-1.52)
Never married			1.22 (1.22-1.22)
Smoking Status			
Current			1.40 (1.40-1.40)
Previous			1.23 (1.23-1.23)
Non-smoker			1.00
Alcohol Consumption			
No drinks at all			1.00
Moderate			0.99 (0.98-0.99)
Heavy			1.20 (1.19-1.20)
Physical activity			
Yes			1.00
No			1.05 (1.05-1.06)
Body Mass Index (kg/m^2)			
<18.5			0.82 (0.81-0.83)
18.5-24.9			1.00
25.0-29.9			1.89 (1.88-1.89)
≥30.0			4.35 (4.34-4.35)
Diabetes			
Yes			3.27 (3.26-3.28)
No			1.00
Days mental health not good			
<14 Days/month			1.00
≥14 Days/month			1.82 (1.81-1.82)
County Level			
Absolute Upward Mobility		0.73 (0.63-0.85)	0.74 (0.62-0.89)
Poverty Rate			1.03 (1.00-1.05)
High School Graduation Rate			1.01 (0.99-1.02)
Fixed effect Intercept	-3.157 (0.065)	-0.630 (0.597)	-2.812 (0.842)

Table 3.1 Multivariable multilevel logistic regression of the association between county intergenerational deprivation and hypertension in young adults (Continued)

Variables	**Null Model**	**Model 1 OR (95% CI)**	**Full model OR (95% CI)**
Random Effects			
Intercept	8.938 (0.333)	8.892 (0.333)	8.626 (0.319)
VPC (%)	73.09	72.99	72.39
Model Fit Statistics			
-2 Log Likelihood	46186053	46186032	41458605
AIC	46186057	46186038	41458643
N	129,881	129,881	129,881

Abbreviations: VPC, Variance partition coefficient; AIC, Akaike's information criterion

Table 4.1 Adjusted odds ratios* (OR) and 95% confidence intervals (CIs) of the county intergenerational deprivation-Hypertension association stratified by race-ethnicity

	Race-Ethnicity			
	NH-White	NH-Black	Hispanic	Other
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Absolute Upward Mobility[∞†]	1.04 (0.97-1.12)	1.13 (0.95-1.34)	1.08 (0.91-1.28)	1.12 (0.89-1.42)

Abbreviations: NH, Non-Hispanic.
∞A 5.31-unit increase in absolute upward mobility from the mean.
[†]Mean of absolute upward mobility: NH White 42.18; NH Black 39.07; Hispanic 42.24; Other 42.34.
*Adjusted for age, sex, marital status, geographical region, smoking status, alcohol consumption, physical activity, body mass index, diabetes, chronic stress, poverty rate and high school graduation rate.

Table 5.1 Adjusted odds ratios* (OR) and 95% confidence intervals (CIs) of the county intergenerational deprivation-Hypertension association stratified by Geographical Region

	Geographical Region			
	South **OR (95% CI)**	West **OR (95% CI)**	Northeast **OR (95% CI)**	Midwest **OR (95% CI)**
Absolute Upward Mobility∞ †	0.61(0.44-0.84)	1.11(0.77-1.59)	0.12(0.07-0.21)	0.41(0.29-0.59)

Abbreviations: NH, Non-Hispanic.

∞ A 5.31-unit increase in absolute upward mobility from the mean.

† Mean of absolute upward mobility: South 39.98; West 43.15; Northeast 44.20; Midwest 41.82.

*Adjusted for age, sex, marital status, smoking status, alcohol consumption, physical activity, body mass index, diabetes, chronic stress, poverty rate and high school graduation rate.

Table 6.1 Degree to which chronic stress mediates association between county intergenerational deprivation and hypertension

	Hypertension
Logistic regression	**OR (95% CI)**
Absolute upward mobility predicting hypertension	0.98 (0.97-0.99)
Absolute upward mobility predicting chronic stress	1.02 (1.01-1.03)
Chronic stress predicting hypertension	2.09 (1.94-2.26)
Absolute upward mobility predicting hypertension, controlling chronic stress	0.98 (0.97-0.99)

Table 7.1 Degree to which poverty rate mediates association between county intergenerational deprivation and hypertension

	Hypertension
Logistic regression	**OR (95% CI)**
Absolute upward mobility predicting hypertension	0.98 (0.97-0.99)
Absolute upward mobility predicting poverty rate	0.49 (0.49-0.50)
Poverty rate predicting hypertension	1.02 (1.01-1.02)
Absolute upward mobility predicting hypertension, controlling poverty rate	0.99 (0.98-1.00)

CHAPTER 3: ASSOCIATION BETWEEN STATE INCOME INEQUALITY AND HYPERTENSION (PAPER 2)

Abstract

Introduction: Hypertension has increased in young adults and its prevention is a priority. Income inequality exacerbates health disparities between social classes; however, few studies have examined the association between income inequality and hypertension. This study examined the association between state income inequality and hypertension in young adults and evaluated whether race-ethnicity modified the association.

Methods: We used 2019 Behavioral Risk Factor Surveillance System (BRFSS) and 2015-2019 American Community Survey (ACS) data (n=72,792). State-level Gini coefficient was obtained from the ACS data while hypertension was self-reported by BRFSS participants. Weighted logistic regression was used to obtain odds ratios and 95% confidence intervals. Stratified analysis was used to assess whether race-ethnicity modified the state income inequality-hypertension association.

Results: There was no association between living in states in the medium or highest Gini tertiles and hypertension (aOR 1.03, 95% CI: 0.95-1.12 and aOR 1.04, 95% CI: 0.96-1.13, respectively). However, race-ethnicity modified the income inequality-hypertension association. Among non-Hispanic White and non-Hispanic black young adults, those living in the highest Gini tertile had increased odds of hypertension versus those living in the lowest Gini tertile (aOR 1.17, 95% CI: 1.06-1.30 and aOR 1.14, 95% CI: 0.87-1.49, respectively). Among Hispanic and 'other' young adults, living in the highest Gini tertile was associated with decreased odds of hypertension.

Conclusion: Income inequality affected hypertension likelihood in some young adult subpopulations based on race-ethnicity. Since income inequality is an upstream risk factor that

exacerbates existing health differences, even small reductions may help lessen its impact. Additional studies are needed to confirm the findings.

Introduction

Cardiovascular disease (CVD) remains the leading cause of death in the United States (US).[1] The leading modifiable risk factor for CVD and stroke is hypertension.[2] In recent years, the young adult population aged 18-39 years has experienced an increase in the prevalence of hypertension from 7.5% in 2015-2016 to 22.4% in 2017-2018.[3,4] The diagnosis of hypertension is associated with serious complications and is a huge economic burden to individuals and the US. Studies have indicated that exposure to suboptimal blood pressure in young adulthood is associated with an increased risk of CVD events later in life.[5] Economically, projections show that by 2035, the total direct and indirect costs of hypertension could possibly increase to about $220 billion.[6] Thus, reducing this enormous burden on public health is a priority.

A number of risk factors for hypertension have been established, including increasing age, black race-ethnicity, male sex, physical inactivity, poor diet, excessive alcohol intake, smoking, overweight/obesity, low income and low education.[2,7] One potential risk factor that is less understood is income inequality. The recent sharp rise in income inequality has been well acknowledged.[8] Recent statistics point to the period between 2016 and 2017 as one that saw a growth in income for all groups at the rate of 4.5%. Nonetheless, the bottom 99% incomes grew by 2.9% while the top 1% incomes saw a faster growth by 10.8%.[8] This sharp difference in income between the top and bottom warrants the investigation of whether income inequality is associated with health, particularly since greater income inequality has been known to exacerbate health disparities by highlighting the larger distances between social classes in society.[9]

Despite this knowledge, no known studies have evaluated the association between income inequality and hypertension only in young adults. Previous studies have focused on the overall adult population with ages ranging from 18-99 years,[10–12] have had inadequate

representation of racial-ethnic minorities,[11,12] and were conducted prior to the change in the 2017 hypertension guidelines.[10–12] Furthermore, individual income is viewed as a marker of social class or position and thus adjusting for its effects, as observed in prior studies,[10,11] could amount to over-controlling for the effects of class differentiation.[13] Lastly, results have been inconsistent with some studies finding no association[11] and others demonstrating that greater income inequality increases the risk of hypertension.[11,12] To address these methodological concerns and the gaps in the literature, this study used a racially diverse, population-based sample of young adults, 18-39 years to assess the relationship between state-level income inequality and hypertension (as defined by current guidelines) and to examine whether race-ethnicity modified the income inequality-hypertension association. This research will therefore broaden our understanding of upstream research risk factors and how they may influence the cardiovascular health of young adults, as well as contribute to the policy debate on how income inequality influences health.

Methods

Study design and population

This cross-sectional study used data from the 2019 Behavioral Risk Factor Surveillance System (BRFSS) and 2015-2019 American Community Survey (ACS). Since the study used publicly available, de-identified data, approval from our assigned Institutional Review Board was not needed. The BRFSS is an ongoing state-based survey that collects uniform data on risk factors, chronic health conditions and preventive health practices in noninstitutionalized adults (aged ≥18 years) living in the US.[14] State health departments collect data monthly through interviews with technical assistance provided by the CDC.[14] Interviews are conducted over landline and cellular phones and approximately 400,000 adults are interviewed each year.[15]

The BRFSS began incorporating cell phone data in their survey in 2011 and subsequently changed their weighting methodology from the post stratification method to iterative proportional fitting or raking.[14,15] Thus the 2019 survey employed raking, the new weighting methodology, which enables the BRFSS to collect samples that mirror the states' sociodemographic characteristics.[14] Given the use of the complex sampling techniques, it is recommended that analysis of data incorporate stratification and weighting.[15] The median call response rates for all the states and the District of Columbia in 2019 was 49.4% and ranged from 37.3% to 73.1%.[16] In 2019 New Jersey did not collect enough data and thus was not included in the 2019 combined dataset.[14]

The ACS is administered by the Census Bureau and it is an ongoing series of surveys conducted monthly in the US and Puerto Rico.[17] The ACS provides data on the economic, social, demographic and housing characteristics of the US population.[17] Each year, a sample of approximately 3.5 million addresses across all US counties in all 50 states, the District of Columbia and Puerto Rico is selected for interviews.[17] The sample is drawn from two separate sources, one consisting of residents in housing unit addresses and the other consisting of residents of group quarters facilities.[17] Data in the ACS are currently collected via three methods: internet, mailed paper questionnaires, and personal visits for nonrespondents.[18] Prior to late 2017, phone interviews had also been used to contact nonrespondents.[18] Eligibility in the survey is based on whether the resident of a sampled housing unit is a current resident or intends to live at the address for more than two months at the time of survey administration.[19] The response rates for the 2019 ACS data were 86.0% and 90.9% for the housing units and group quarters, respectively.[17] In the current investigation, the 2015-2019 ACS 5-year estimates were used because they provided the Gini index of income inequality averaged over 60 months.

For this study, the BRFSS 2019 dataset was linked to 2015-2019 ACS data by the state FIPS code. The 5-year ACS estimates were selected because they are based on a larger sample size and therefore provide increased statistical reliability over the 2019 1-year estimates.[20] For this analysis, we excluded individuals from Guam and Puerto Rico (n=2,141). We further excluded individuals who were not 18 to 39 years of age (n=321,822), did not provide complete information on hypertension while completing the BRFSS survey (n=1,572), or who only reported having hypertension during pregnancy (n=3,072). Additionally, we excluded individuals who were missing key covariates such as health insurance (n=830), marital status (n=555), smoking status (n=1,705), alcohol consumption (n=2,412), chronic stress (n=990), physical activity (n=608), BMI (n=8,543), diabetes (n=103) and race-ethnicity (n=847). Thus, data on 72,792 individuals was included in this analysis.

Primary Outcome Variable

Hypertension was the outcome variable. Participants self-reported whether a doctor, nurse or other health professional told them they had high blood pressure during their interviews. Individuals who indicated they had hypertension were considered to have the outcome.

Main Exposure Variable

State income inequality was measured by the state-level Gini coefficient. It ranges from 0 to 1 with 0 denoting perfect equality where all income is equally subdivided in the population, and 1 denoting perfect inequality where all the income belongs to one group.[21] Each participant in the BRFSS was assigned a Gini coefficient from the 5-year ACS dataset based on their state of residence. Similar to other studies, state income inequality was coded into tertiles based on the distribution of the Gini coefficients[21,22]: Lowest (Gini 0.427-0.454), Medium (Gini 0.455-0.474), and Highest (Gini 0.475-0.527).

Other Covariates

Variables that could potentially confound the association between income inequality and hypertension were included based on a review of the relevant literature.[10–12,23–25] All were individual-level and self-reported. Sociodemographic variables that were included are age (18-29, 30-39), sex (male, female), highest level of education (not a high school graduate, high school graduate, some college, college graduate), whether the participant has health insurance (yes, no), and marital status (married, previously married, never married). Behavioral variables included smoking status (current, previous, never smoked) and alcohol consumption which was defined as the number of alcoholic beverages consumed per week (no drinks at all, moderate [1-14 beverages /week for men and 1-7 beverages /week for women], and heavy [>14 beverages /week for men and >7 beverages /week for women]). Additional behavioral variables included chronic stress (≥14 days/month, <14 days/month) and physical activity (yes, no). Chronic stress was defined as the number of days mental health was not good in the previous 30 days. Physical activity was defined as participation in any physical activities or exercise inclusive of running, other than activities for one's job in the previous 30 days. Other risk factors included BMI (<18.5, 18.5-24.9, 25.0-29.9, ≥30.0 kg/m^2) and diabetes (yes, no). Race-ethnicity was self-reported and considered a potential effect modifier of the exposure-disease relationship. The categories that were considered for this analysis included: non-Hispanic White, non-Hispanic Black, Hispanic and Other.

Statistical Analysis

Frequencies and proportions were used to describe characteristics of the analytic sample. Unadjusted odds ratio and 95% confidence intervals between all the independent variables and hypertension were calculated using logistic regression. Multivariate logistic regression was used to investigate the association between state income inequality and hypertension while controlling

for confounders. Confounders were retained in the final model if they changed the magnitude of the OR by at least 10%.[26] To assess whether race-ethnicity was an effect modifier of the state income inequality-hypertension association, a stratified analysis was also conducted.

To determine whether chronic stress mediated the relationship between state income inequality and hypertension, a four-step approach traditionally used to test for mediation was followed [27]: (1) the risk factor (that is, state income inequality) should predict the outcome (that is hypertension); (2) the risk factor should predict the mediator (that is, chronic stress); (3) the mediator should be significantly associated with the outcome; (4) the effect of the risk factor (that is, state income inequality) on the outcome (that is, hypertension) should be attenuated when the mediator (that is, chronic stress) is statistically controlled.

Multicollinearity was assessed using the variance inflation factor (VIF) in the final models. The predictors in the models yielded VIF values of less than 3, indicating no multicollinearity.[28] All analyses were weighted to account for the complex sampling design utilized by the BRFSS. Significance tests were set at alpha < 0.05. All statistical analyses were conducted with SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

Results

Majority of the participants were younger than 30 years (53.9%), non-Hispanic White (56.7%), never married (58.8%) and had at least some college education (61.3%; **Table 1.2**). The mean, median and interquartile range of the Gini coefficient across the states was 0.475, 0.478, and 0.464-0.484, respectively. The proportion of the sample reporting hypertension was nearly 13.8%.

In unadjusted models, non-Hispanic Black young adults had 26% increased odds of reporting hypertension compared to non-Hispanic White (OR 1.26, 95% CI: 1.12-1.40; **Table**

2.2). In contrast, Hispanic young adults had 19% decreased odds of reporting hypertension (OR 0.81, 95% CI: 0.73-0.91) while those of other race-ethnicity had 32% decreased odds of reporting hypertension (OR 0.68, 95% CI: 0.59-0.77). Participants aged 30-39 were 1.95 times more likely to report hypertension compared to those aged 18-29 (OR 1.95, 95% CI: 1.81-2.10). Females had reduced odds of reporting hypertension compared to males (OR 0.57, 95% CI: 0.53-0.62). Living in states in the medium Gini or highest Gini tertiles was not associated with odds of reporting hypertension compared to living in states in the lowest Gini tertile (OR 1.04, 95% CI: 0.97-1.13 and OR 1.00, 95% CI: 0.93-1.09, respectively).

After adjusting for confounders, the association between state income inequality and hypertension for participants in the medium and highest Gini tertiles remained largely the same (OR 1.03, 95% CI: 0.95-1.12 and OR 1.04, 95% CI: 0.96-1.13, respectively; **Table 3.2**). Race-ethnicity was an effect modifier of the state income inequality and hypertension association. Among Non-Hispanic White young adults, those living in the highest Gini tertile had statistically significant odds of reporting hypertension compared to those living in the lowest Gini tertile (OR 1.17, 95% CI: 1.06-1.30) while there was no association for those living in the medium tertile (OR 1.04, 95% CI: 0.95-1.14). Among non-Hispanic Black young adults, those in the medium and highest Gini tertiles had similar increased odds of hypertension (OR 1.15, 95% CI: 0.87-1.51 and OR 1.14, 95% CI: 0.87-1.49, respectively). Conversely, among Hispanic young adults, those living in the medium and highest Gini tertiles had decreased odds of reporting hypertension (OR 0.95, 95% CI: 0.74-1.23; OR 0.89, 95% CI: 0.70-1.13, respectively) in comparison to those living in the lowest Gini tertile. Findings were similar among 'other' young adults living in the medium (OR 0.93, 95% CI: 0.71-1.23) and highest (OR 0.76, 95% CI: 0.56-1.01; **Table 4.2**) Gini tertiles.

Results for steps 1, 2, 3 and 4 of the mediation analysis are displayed in **Table 5.2**. State income inequality did not predict hypertension (Medium Gini OR 1.04, 95% CI: 0.97-1.13; Highest Gini OR 1.00, 95% CI: 0.93-1.09). The potential mediator, chronic stress, was associated with 86% increased odds of hypertension (OR 1.86, 95% CI: 1.71-2.02). However, the model controlling for chronic stress failed to support the hypothesis that chronic stress mediated the association between state income inequality and hypertension.

Discussion

In this population-based study, we found no association between state income inequality and hypertension in young adults after adjustment for confounders. However, our stratified analysis indicated that race-ethnicity was an effect modifier of the state income inequality-hypertension association. Specifically, among non-Hispanic White and non-Hispanic Black young adults, living in the highest Gini tertile was associated with increased odds of reporting hypertension compared to those in the lowest Gini tertile; however, this finding was only statistically significant among non-Hispanic White young adults. Among other racial-ethnic groups, high income inequality was associated with decreased odds of hypertension.

As previously mentioned, studies of income inequality and hypertension have had inconsistent findings. However, the main findings of our study are consistent with a previous prospective cohort study (n=34,445) of individuals aged 18 and over 90 years, that used data from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC)[11] which also found that state income inequality was not associated with hypertension.

To our knowledge, no previous studies evaluated whether race-ethnicity is an effect modifier of the income inequality-hypertension association. Income inequality is thought to influence health through psychosocial processes. Thus, a possible explanation for the observed

associations may be that certain racial-ethnic subgroups are more susceptible to the effects of income inequality because they are more likely to experience intense status competition.[9,13,29] In addition, certain subgroups may be more likely to experience chronic stress which impairs the neuroendocrine system and may increase the odds of hypertension.[30]

Strengths and Limitations

This study had several limitations. First, this study was cross-sectional and therefore we could not make causal inferences on the associations observed. Further, income data from the ACS used to measure the Gini coefficient of income inequality is usually top-coded for very high incomes. As such, the Gini index likely understates the income inequality in a state. Also, measurement of the outcome, hypertension, was self-reported and it is possible that some respondents may have misreported this information. However, prior studies have established that measurement of hypertension using self-report yields similar results to actual measurement of blood pressure.[3,31] In any event, nondifferential misclassification of the exposure or outcome would likely bias results towards the null. Finally, there may be residual confounding due to unmeasured variables given that this study was restricted to the variables available in the study's datasets.

There were a number of strengths in the study. Selection bias was likely minimized in the ACS when measuring income inequality due to the high survey response rates, and the use of BRFSS data provided a large sample compared to many previous studies. This study used the most recent hypertension guidelines when defining hypertension and considered a young, racially diverse population. Thus, results from this study may be generalizable to similar non-institutionalized young adults in the US.

In conclusion, this study contributed to the policy debate on income inequality, by demonstrating that inequality harms cardiovascular health by increasing the likelihood of hypertension in young adult subpopulations based on race-ethnicity. In relation to public health implications, since young adulthood is an important developmental period, efforts to reduce early-onset hypertension should continue. Since income inequality is an upstream risk factor that works by exacerbating existing health differences, even small reductions may help lessen its impact on existing health differences. As such state policymakers should consider strategies that enhance the economic productivity of the state while also lessening the widening gaps within the income distribution. Additional studies using alternative measures of income inequality, longer lag times and with racially diverse populations are needed to confirm the findings.

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Table 1.2 Individual and state characteristics of young adults in BRFSS 2019

Variables	HTN n=10,033 Weighted (%)	No HTN n=62,759 Weighted (%)
Individual level		
Age		
18-29	3,440 (4.97)	32,163 (48.94)
30-39	6,593 (7.62)	30,596 (38.47)
Sex		
Male	6,517 (8.13)	32,106 (44.67)
Female	3,516 (4.46)	30,653 (42.74)
Education		
Less than High school graduate	728 (1.48)	3,319 (7.96)
High school	2,981 (3.98)	16,733 (25.24)
Some college	3,086 (4.13)	19,216 (30.16)
College graduate	3,238 (2.99)	23,491 (24.05)
Health insurance		
Yes	8,498 (10.42)	53,301 (72.48)
No	1,535 (2.17)	9,458 (14.93)
Marital Status		
Married	3,804 (4.44)	23,653 (30.17)
Previously married	1,262 (1.35)	4,540 (5.20)
Never married	4,967 (6.79)	34,566 (52.03)
Smoking Status		
Current	2,497 (3.12)	10,055 (13.18)
Previous	2,130 (2.56)	9,657 (12.43)
Non-smoker	5,406 (6.91)	43,047 (61.80)
Alcohol Consumption		
No drinks at all	3,817 (4.70)	24,017 (35.07)
Moderate	1,691 (2.16)	10,402 (14.77)
Heavy	4,525 (5.72)	28,340 (37.57)
Physical activity		
Yes	7,696 (9.61)	50,707 (69.82)
No	2,337 (2.98)	12,052 (17.59)
Body Mass Index (kg/m^2)		
<18.5	121 (0.14)	1,582 (2.57)
18.5-24.9	1,968 (2.67)	2,5751 (36.8
25.0-29.9	2,934 (3.74)	19,994 (27.51)
≥30.0	5,010 (6.04)	15,432 (20.56)
Diabetes		
Yes	943 (1.18)	1,682 (2.25)
No	9,090 (11.41)	61,077 (85.17)
Days Mental health not good		
<14 Days/month	7,393 (9.23)	52,658 (73.09)
≥14 Days/month	2,640 (3.36)	10,101 (14.33)

Table 1.2 Individual and state characteristics of young adults in BRFSS 2019 (Continued)

Variables	HTN n=10,033 Weighted (%)	No HTN n=62,759 Weighted (%)
Race-ethnicity		
Non-Hispanic White	6,794 (7.44)	42,440 (49.22)
Non-Hispanic Black	1,075 (1.89)	4,948 (9.94)
Hispanic	1,166 (2.28)	8,773 (18.58)
Other	998 (0.99)	6,598 (9.67)
State level		
Gini coefficient of Income Inequality		
Lowest tertile (Gini=0.427-0.454)	3,158 (1.67)	21,273 (11.75)
Medium tertile (Gini=0.455-0.474)	3,307 (3.78)	20,605 (25.52)
Highest tertile (Gini=0.475-0.527)	3,568 (7.14)	20,881 (50.14)

Table 2.2 Unadjusted odds ratios (OR) and 95% confidence intervals (CI) of the association between sociodemographic characteristics and state income inequality and hypertension

Variables	OR (95% CI)
Age	
18-29	1.00
30-39	1.95 (1.81-2.10)
Sex	
Male	1.00
Female	0.57 (0.53-0.62)
Education	
Less than High school graduate	1.50 (1.30-1.72)
High school	1.27 (1.16-1.39)
Some college	1.10 (1.01-1.20)
College graduate	1.00
Health insurance	
Yes	1.00
No	1.01 (0.92-1.12)
Marital Status	
Married	1.00
Previously married	1.77 (1.56-2.00)
Never married	0.89 (0.82-0.96)
Smoking Status	
Current	2.12 (1.93-2.31)
Previous	1.85 (1.68-2.03)
Non-smoker	1.00
Alcohol Consumption	
No drinks at all	1.00
Moderate	1.09 (0.98-1.22)
Heavy	1.14 (1.05-1.23)
Physical activity	
Yes	1.00
No	1.23 (1.13-1.34)
Body Mass Index (kg/m^2)	
<18.5	0.75 (0.53-1.06)
18.5-24.9	1.00
25.0-29.9	1.87 (1.69-2.08)
≥30.0	4.05 (3.68-4.45)
Diabetes	
Yes	3.93 (3.42-4.52)
No	1.00
Days mental health not good	
<14 Days/month	1.00
≥14 Days/month	1.86 (1.71-2.02)
Race-ethnicity	
Non-Hispanic White	1.00

Table 2.2 Unadjusted odds ratios (OR) and 95% confidence intervals (CI) of the association between sociodemographic characteristics and state income inequality and hypertension (Continued)

Variables	**OR (95% CI)**
Non-Hispanic Black	1.26 (1.12-1.40)
Hispanic	0.81 (0.73-0.91)
Other	0.68 (0.59-0.77)
State level	
Gini coefficient of Income Inequality	
Lowest tertile (Gini=0.427-0.454)	1.00
Medium tertile (Gini=0.455-0.474)	1.04 (0.97-1.13)
Highest tertile (Gini=0.475-0.527)	1.00 (0.93-1.09)

Table 3.2 Adjusted odds ratios* (OR) and 95% confidence intervals (CIs) of State Income inequality and Hypertension

	Hypertension
	OR (95% CI)
Gini Coefficient of Income Inequality	
Lowest tertile (Gini=0.427-0.454)	1.00 (Referent)
Medium tertile (Gini=0.455-0.474)	1.03 (0.95-1.12)
Highest tertile (Gini=0.475-0.527)	1.04 (0.96-1.13)

*Adjusted for age, sex, education, health insurance, marital status, smoking status, alcohol consumption, physical activity, Body Mass Index, diabetes, chronic stress.

Table 4.2 Adjusted odds ratios* (OR) and 95% confidence intervals (CIs) of the State income inequality-Hypertension association stratified by race-ethnicity

	Race-Ethnicity			
	NH-White **OR (95% CI)**	NH-Black **OR (95% CI)**	Hispanic **OR (95% CI)**	Other **OR (95% CI)**
Gini coefficient of Income Inequality				
Lowest tertile (Gini=0.427-0.454)	1.00	1.00	1.00	1.00
Medium tertile (Gini=0.455-0.474)	1.04 (0.95-1.14)	1.15 (0.87-1.51)	0.95 (0.74-1.23)	0.93 (0.71-1.23)
Highest tertile (Gini=0.475-0.527)	1.17 (1.06-1.30)	1.14 (0.87-1.49)	0.89 (0.70-1.13)	0.76 (0.56-1.01)

Abbreviations: NH, Non-Hispanic.
*Adjusted for age, sex, education, health insurance, marital status, smoking status, alcohol consumption, physical activity, Body Mass Index, diabetes and chronic stress.

Table 5.2 Degree to which chronic stress mediates association between state income inequality and hypertension

	Hypertension
Logistic regression	**OR (95% CI)**
State income inequality predicting hypertension	
Medium tertile (Gini=0.455-0.474)	1.04 (0.97-1.13)
Highest tertile (Gini=0.475-0.527)	1.00 (0.93-1.09)
State income inequality predicting chronic stress	
Medium tertile (Gini=0.455-0.474)	0.89 (0.83-0.95)
Highest tertile (Gini=0.475-0.527)	1.03 (0.95-1.10)
Chronic stress predicting hypertension	1.86 (1.71-2.02)
State income inequality predicting hypertension, controlling chronic stress	
Medium tertile (Gini=0.455-0.474)	1.03 (0.95-1.11)
Highest tertile (Gini=0.475-0.527)	1.01 (0.93-1.09)

CHAPTER 4: ASSOCIATION BETWEEN STATE MINIMUM WAGE AND HYPERTENSION (PAPER 3)

Abstract

Introduction: Hypertension rates in young adults have increased, and early onset hypertension is associated with serious complications. Recent literature suggests a possible association between state minimum wage and hypertension. Young adults make up a larger proportion of the minimum wage workforce and low wages are risk factors of hypertension; thus, this is an important population to consider. This study examined the association between state minimum wage and hypertension in young adults and assessed whether race-ethnicity and geographical region modified the association.

Methods: We used the 2019 Behavioral Risk Factor Surveillance System (BRFSS) and 2019 University of Kentucky Center for Poverty Research's (UKCPR) Data (n=18,463). State minimum wage was obtained from the UKCPR data while hypertension was self-reported by BRFSS participants. Weighted multilevel logistic regression was used to obtain odds ratios and 95% confidence intervals. Stratified analyses assessed whether race-ethnicity and geographical region modified the state minimum wage-hypertension association.

Results: There was no association between state minimum wage and hypertension (aOR 1.11; 95% CI: 0.97-1.28). However, race-ethnicity modified the state minimum wage-hypertension association (Breslow Day Test of Homogeneity: $p<0.0001$). Among 'other' and Hispanic young adults, those living in states below the minimum wage rate had increased (aOR 1.21; 95% CI: 0.34-4.36) and decreased odds (aOR 0.77; 95% CI: 0.33-1.79) of hypertension versus those in states below the minimum wage rate. Among non-Hispanic White or non-Hispanic Black young adults, living in states below the minimum wage rate versus living in states above the minimum wage rate was not associated with hypertension (aOR 1.02; 95% CI: 0.75-1.38; aOR 1.03; 95%

CI: 0.20-5.41, respectively). Geographical region was not an effect modifier of the association (Breslow Day Test of Homogeneity: p=0.06).

Conclusion: State policy makers should consider strengthening their safety nets in order to alleviate the financial hardship of their minimum wage labor force.

Introduction

Hypertension is a well-known risk factor for coronary heart disease, heart failure and stroke.[1] In recent years, young adults between the ages of 18-39 years, have had an increased prevalence of hypertension from 7.5% in 2015-2016 to 22.4% in 2017-2018.[2,3] There is compelling evidence suggesting that hypertension at an early age is associated with unfavorable complications. Specifically, early onset hypertension (that is, hypertension diagnosed at less than 35 years of age) is associated with increased odds of target end-organ damage such as left ventricular hypertrophy, coronary calcification and left ventricular diastolic dysfunction.[4] Furthermore, these target end-organ complications are known to increase the risk of cardiovascular events;[5–7]therefore, one of the Healthy People 2030 goals is to reduce the proportion of adults with hypertension.[8] The well-known risk factors of hypertension include increasing age, having a family history of hypertension, Black race-ethnicity, male sex and engaging in negative health behaviors such as consuming high sodium and low potassium foods, consuming too much alcohol, physical inactivity and smoking.[9] In addition to these risk factors, there are also a number of social factors associated with hypertension, such as living in highly segregated areas, exposure to high discrimination, and low socioeconomic status as measured by education, income and occupation.[10] Of these risk factors, one of the components of income, that is, wages, has not been studied extensively despite evidence showing that low wages are strong predictors of hypertension in younger adults aged, 25-44 years.[11]

Wages are critical components in addressing the existing health inequities given their role in improving daily living conditions.[12] Yet, research in the United States (US) has consistently documented that wages for low-skilled workers have steadily declined for decades.[13,14] In 2019, the federal minimum wage was worth 17% less than it was in 2009 (or about $3,016 in earnings

lost per year) and 31% less than its value in 1968 (or nearly $6,843 in earnings lost per year).[13] Moreover, some studies have argued that the documented decline in wages has been a contributing factor to the current problem of income inequality in the US.[15] Pre-pandemic data between 2018 and 2019 showed that about 1.7 million workers (or 2.1% of all hourly paid workers) to 1.6 million workers (or 1.9% of all hourly paid workers) had wages at or below the federal minimum wage.[16,17] In addition, majority of minimum wage earners identified as Black although they differed little in race-ethnicity and worked in service occupations. Moreover, most minimum wage earners lived in the South,[16] a region with the most number of states with preemption minimum wage laws. Preemption minimum wage laws are known to forbid increases in minimum wage beyond the state minimum by local governments.[18]

The current federal minimum wage stands at $7.25 per hour and totals to about $15,080 annually. This amount, $15,080, had fallen below the 2019 poverty threshold of $17,622 assuming a worker is fulltime and supports one adult and a child.[19] Thus, it is plausible that a minimum wage worker living in a state with stagnant wages may experience great financial strain[20] which in turn may shape the type of neighborhood they can afford. Residence in more deprived neighborhoods is a source of chronic stress which may subsequently lead to hypertension.[21,22] Alternatively, the resultant stress from residence in deprived areas may influence negative health behaviors such as consuming an unhealthy diet,[23] a known risk factor of hypertension. Prior studies of the association between minimum wage and hypertension have had inconsistent results. Some studies have found that higher minimum wages were inversely associated with the likelihood of hypertension.[24,25] On the contrary, other studies have detected no associations between minimum wage and hypertension,[25–28] while others have reported mixed results such that higher minimum wages were associated with an increased likelihood of

hypertension among women but a lower likelihood among men.[27] While informative, previous studies have primarily concentrated on the overall adult population with ages ranging from 21-65 and older years;[24–28] have had methodological flaws by comparing high (particularly, with some college education or more) and low skilled workers (that is, with a high school education or less) despite high skilled workers being an appropriate control group[29] since they are likely to be paid wages above a minimum wage rate.[24,27,28] Furthermore, the studies have been limited in providing granularity in racial-ethnic analyses;[26–28] and have used older hypertension guidelines before the change in the 2017 American College of Cardiology/American Heart Association (ACC/AHA);[26–28] and have had limited generalizability to the US context.[26] No existing studies have assessed the association between state minimum wage and hypertension only in young adults. To address these aforementioned methodological issues and knowledge gaps, this study used a racially diverse, population-based sample of young adult workers with a high school education or less, 18-39 years to 1) evaluate the association between state minimum wage and hypertension (as defined by the latest guidelines) and 2) assess whether race-ethnicity and geographical region modified the state minimum wage-hypertension association.

This study may help researchers and policymakers understand how structural factors such as minimum wages influence the cardiovascular health of a seldom examined group of young adult workers with a high school education or less. In addition, the study may help identify racial-ethnic groups and or geographical regions where young adults are at the most risk of hypertension and thus, in need of targeted approaches that promote primary prevention.

Methods

Study design and population

This cross-sectional study used data from the 2019 Behavioral Risk Factor Surveillance System (BRFSS) and 2019 University of Kentucky Center for Poverty Research's (UKCPR)

National Welfare Data. Considering that the study used publicly accessible, de-identified data, approval from our assigned Institutional Review Board was not necessary. The BRFSS is an ongoing state-based survey that obtains identical data on risk factors, chronic health conditions and preventive health practices in noninstitutionalized adults (aged ≥18 years) living in the US. State health departments obtain data monthly through interviews with technical support provided by the CDC.[30] Interviews are carried out over landline and cellular phones and nearly 400,000 adults are interviewed each year.[31] The 2019 survey incorporated both cellphone and landline respondents into one dataset. Considering the survey uses complex sampling techniques the CDC recommends that analysis of data incorporate stratification and weighting.[31] The median response rates for all the states and the District of Columbia in 2019 was 49.4% and ranged from 37.3% to 73.1%.[32] In 2019, New Jersey was not included in the BRFSS combined dataset due to inadequate data.[30]

The UKCPR National Welfare Data are ecological. They cover a variety of topics such as population, employment and unemployment estimates, food insecurity, wealth, poverty, welfare and politics for the 50 states and the District of Columbia, from 1980 through 2019.[33] The UKPCR obtains the state and federal minimum wage data from a secondary source, that is, the US Department of Labor, Wage and Hour Division.[34] In the current investigation, only the 2019 UKCPR National Welfare Data were used.

For this study, the BRFSS 2019 dataset was linked to 2019 UKCPR National Welfare Data by the state FIPS code. For this analysis, we excluded individuals who 1) were from Guam and Puerto Rico (n=781), 2) were not 18 to 39 years of age (n=321,822), 3) had more than a high school degree (n=59,425), 4) were homemakers, students, retired, long-term unemployed, or unable to work (n=6,450), 5) did not provide complete information on hypertension while

completing the BRFSS survey (n=1,572), 6) only reported having hypertension during pregnancy (n=3,072) and 7) were missing key covariates such as education (n=276), health insurance (n=506), marital status (n=246), employment status (n=258), smoking status (n=1,956), chronic stress (n=377), BMI (n=2,735) or race-ethnicity (n=329). Thus, data on 18,463 individuals were included in this analysis.

Primary Outcome Variable

Hypertension was the outcome variable. During the BRFSS interviews, participants self-reported if a doctor, nurse or other health professional told them they had high blood pressure. Only those individuals who reported they had hypertension were considered to have the outcome of interest.

Main Exposure Variable

State minimum wage was a state-level variable from the UKCPR National Welfare Data. It was operationalized as a binary variable indicating whether there was a state minimum wage policy in the respondent's state. The variable was coded as "yes" if the state minimum wage was above the federal minimum wage rate of $7.25/hour on or before January 1, 2019. The variable was coded as "no" if the state minimum wage policy was non-existent or the wage was set at a lower rate, and thus the federal rate applied.[35]

Other Covariates

Variables that could potentially confound the association between state-level minimum wage and hypertension were included based on a review of the relevant literature.[25,27,28,36–39]These variables were individual-level and self-reported during the BRFSS interviews. Sociodemographic variables included age (18-29, 30-39), sex (male, female), highest level of education (less than high school, high school graduate), whether the participant had health insurance (yes, no), marital status (married, previously married, never married), employment

status (employed for wages, unemployed for less than a year, self-employed), race-ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Other) and geographical region (Northeast, Midwest, South, West). Behavioral variables included smoking status (current, previous, never smoked), chronic stress (≥14 days/month, <14 days/month) and BMI (<18.5, 18.5-24.9, 25.0-29.9, ≥30.0 kg/m^2). Chronic stress was defined as the number of days mental health was not good in the previous 30 days. Race-ethnicity and geographical region were considered potential effect modifiers of the exposure-disease relationship.

Statistical Analysis

Frequencies and proportions were used to describe characteristics of the analytic sample. Unadjusted odds ratio and 95% confidence intervals between all the independent variables and hypertension were calculated using marginal logistic regression adjusted for survey weights. Because the respondents in the study were nested in states, we used a 2-level weighted multilevel logistic regression to investigate the association between state minimum wage and hypertension while controlling for confounders. The first analysis estimated an intercept-only or null model (model 1) and was then used to calculate the variance partition coefficient (VPC). The VPC quantified the amount of variation in the outcome variable at the state level.[40] We then added state minimum wage (model 2). Finally, we added all the individual level covariates to the full model (model 3). To assess whether race-ethnicity and geographical region were effect modifiers of the state minimum wage-hypertension association, stratified analyses were conducted.

To evaluate whether chronic stress mediated the relationship between state minimum wage and hypertension, a four-step approach traditionally used to test for mediation was followed:[41] 1) the risk factor (that is, state minimum wage) should predict the outcome (that is,

hypertension); 2) the risk factor should predict the mediator (that is, chronic stress); 3) the mediator should be significantly associated with the outcome; 4) the effect of the risk factor (that is, state minimum wage) on the outcome (that is, hypertension) should be attenuated when the mediator (that is, chronic stress) is statistically controlled.

Multicollinearity was determined using the variance inflation factor (VIF) in the final models. The predictors in the models yielded VIF values of less than 3, denoting no multicollinearity.[42] All analyses were weighted to account for the complex sampling design utilized by the BRFSS. Significance tests were set at alpha < 0.05. All statistical analyses were conducted with SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

Results

Among the 18,463 young adults in this analysis, 18.29% (**Table 1.3**) reported hypertension. Majority were younger than age 30 years (55.14%), had a high school education (76.91%), and were non-Hispanic White (51.54%). Additionally, nearly 80% were employed for wages, and 57.18% lived in states where the minimum wage rate was above $7.25/hour.

In unadjusted results, non-Hispanic Black young adults had 28% increased odds of hypertension compared to non-Hispanic White (OR 1.28; 95% CI: 1.05-1.57; **Table 2.3**). Conversely, Hispanic young adults had 75% decreased odds of hypertension (OR 0.75; 95% CI: 0.63-0.90) while those of other race-ethnicity had 37% decreased odds of hypertension (OR 0.63; 95% CI: 0.51-0.79). Females had 22% decreased odds of reporting hypertension compared to males (OR 0.78; 95% CI: 0.67-0.91). Compared to young adults living in states above the minimum wage rate, those living in states below the minimum wage rate had slightly increased odds of hypertension; however, these results were not statistically significant (OR 1.08; 95% CI: 0.94-1.24).

After adjusting for age, sex, education, marital status, health insurance, employment status, smoking status, body mass index, and chronic stress, the magnitude of the association between living in states below the minimum wage rate and hypertension remained largely unchanged (OR 1.11; 95% CI: 0.97-1.28; **Table 3.3**). In stratified analyses, race-ethnicity modified the association between state minimum wage and hypertension (Breslow-Day test of homogeneity $p<0.0001$; **Table 4.3**). Among 'other' young adults, those living in states below the minimum wage rate had increased odds of hypertension compared to those living in states above the minimum wage rate (OR 1.21; 95% CI: 0.34-4.36; **Table 4.3**). There was no association among non-Hispanic White or non-Hispanic Black young adults living in states below the minimum wage rate compared to those living in states above the minimum wage rate (OR 1.02; 95% CI: 0.75-1.38; OR 1.03; 95% CI: 0.20-5.41, respectively). However, among Hispanic young adults, those living in states below the minimum wage rate had decreased odds of hypertension compared to those living in states above the minimum wage rate (OR 0.77; 95% CI: 0.33-1.79).

In stratified analyses, while there were differences in the association between state minimum wage and hypertension by geographic region, the Breslow Day test of homogeneity was not statistically significant ($p=0.06$; **Table 5.3**). Among young adults living in the West, those living in states below the minimum wage rate had statistically significant odds of hypertension compared to those living in states above the minimum wage rate (OR 1.28; 95% CI: 1.03-1.59; **Table 5.3**). There was no strong association between minimum wage rate and hypertension among those living in the South or Midwest (OR 1.08; 95% CI: 0.84-1.39; OR 0.95; 95% CI: 0.65-1.40, respectively). On the contrary, among young adults living in the Northeast, those living in states below the minimum wage rate had decreased odds of

hypertension compared to those living in states above the minimum wage rate, and this finding was not statistically significant (OR 0.61; 95% CI: 0.23-1.59).

Results for step 1, 2, 3 and 4 of the mediation analysis are displayed in **Table 6.3**. State-minimum wage predicted hypertension (OR 1.08; 95% CI: 0.94-1.24). The potential mediator, chronic stress, was associated with 84% increased odds of hypertension (OR 1.84; 95% CI: 1.56-2.16). However, the model controlling for chronic stress failed to support the hypothesis that chronic stress mediated the association between state-minimum wage and hypertension.

Discussion

In this population-based study of young adult workers with a high school education or less, we found no association between state minimum wage and hypertension after adjustment for confounders in our overall sample. Nonetheless, our stratified analysis indicated that race-ethnicity was an effect modifier of the state minimum wage-hypertension association. In particular, among non-Hispanic White and non-Hispanic Black young adults, state minimum wage was not associated with odds of hypertension. However, among 'other' and Hispanic young adults, state minimum wage was associated with increased and decreased odds of hypertension, respectively. In our stratified analyses by geographical region, among young adults living in the South and Midwest, state minimum wage was not associated with odds of hypertension. Conversely, among young adults living in the West and Northeast regions, state minimum wage was associated with increased and decreased odds of hypertension, respectively.

As previously mentioned, studies of minimum wage and hypertension have had inconsistent findings. Nevertheless, our overall findings are consistent with other investigations that suggest that minimum wages have no association with hypertension.[25–28] For example, a recent retrospective cohort study of 13,730 US adults aged 25-64 years using the 1999-2017 Panel Study of Income Dynamics (PSID) examined the association between current and 2 year-

lagged state minimum wage and various health outcomes, including hypertension. In their overall sample, no association was found between higher state minimum wages and risk of hypertension.[28] Another prior study of 131,430 US adults aged 25-64 who participated in the 2008-2015 National Health Interview Survey (NHIS) with linkage to state level variables capturing minimum wage also found no association in its overall sample.[27]Thus, findings suggest the lack of an association between minimum wage and hypertension is persistent across young adults as well as the overall adult population.

Studies examining whether race-ethnicity modifies the minimum wage-hypertension association have been fewer and have often only considered non-Hispanic White and non-Hispanic Black individuals.[24,25,27,28] In our study, we found no association between state minimum wage and hypertension among non-Hispanic White and non-Hispanic Black young adults which is consistent with a number of previous studies.[24,25,27,28] As mentioned, few studies have considered other racial-ethnic groups, however our finding of state minimum wage being associated with decreased odds of hypertension among Hispanic young adults is consistent with a previous study.[28] It is more difficult to put our finding of state minimum wage being associated with increased odds of hypertension among individuals in our 'other' category due to the fact that previous studies have either not included people who identify as Asian, American Indian or Alaskan Native, Native Hawaiian or other Pacific Islander, Other race, and Multiracial in their study, or they have been included with Black, to create a Black, Indigenous and people of color (BIPOC) group. However, our association is consistent with a previous study that found a positive association between state minimum wage and hypertension among individuals who identified as BIPOC.[28] Our finding of differences in the minimum wage-hypertension association among racial-ethnic groups may be due to race-ethnicity acting as a proxy for access

to/or lack of resources that could mitigate or aggravate the effect of minimum wage on odds of hypertension.[43]

While the Breslow Day Test of Homogeneity was not statistically significant for geographical region, we did note some differences in the state minimum wage-hypertension association by region. Specifically, odds of hypertension were increased among individuals residing in the West but decreased among individuals living in the Northeast. Among individuals living in the Midwest and South, there was no association between state minimum wage and hypertension. We had anticipated that the state minimum wage-hypertension association would be elevated among individuals residing in the South due to the fact that the majority of states in the South have preemption laws forbidding increases of the state minimum wage at the local level.[44] However, it appears that there may be other regional level factors that account for the differential susceptibility in odds of hypertension by region. To our knowledge, no previous studies have investigated whether geographical region is an effect modifier of the state minimum wage and hypertension association; thus, additional research is warranted.

Strengths and Limitations

This study had some limitations. First, it was cross-sectional and as a result we could not make causal inferences on the associations observed. Also, measurement of hypertension was self-reported. While it is possible that some respondents may have misreported this information, prior studies have found that measurement of hypertension using self-report yields similar results to the actual measurement of blood pressure.[2,45] Regardless, if nondifferential misclassification of the outcome occurred it would likely bias results towards the null. Also, selection bias could not be ruled out due to a lower survey response rate in the BRFSS. However, the BRFSS uses raking, a weighting methodology, that helps incorporate more demographic variables and thus

reduces the likelihood of selection bias.[46] Last, there may be residual confounding due to unmeasured variables given that this study was restricted to the variables available in our two datasets.

Despite the limitations, the current study had several strengths. Nondifferential misclassification of the exposure was likely minimized given that objective data sources were used to create the UKCPR National Welfare Data. In addition, this was the first known study that limited its sample to young adults; younger adults are understudied and are more likely to be minimum wage workers. Thus, by restricting our study to a young adult population we are better able to examine this association in this specific group. Furthermore, the BRFSS sample was large enough that it allowed us to restrict our study to only those with a high school education or less, and still have an adequate sample size. Restricting the study to individuals with a high school education or less is important since these individuals would be more likely to be paid a minimum wage rate compared to individuals with a college education or more. Finally, due to the complex sampling used by the BRFSS and the large sample size, results may be generalizable to similar less educated, non-institutionalized young adults of ages 18-39 years.

In conclusion, this study contributed to the growing research on the association between minimum wage and hypertension in an understudied population of young adult workers. The study revealed that the association between state minimum wage and hypertension varies by race-ethnicity. Differences by geographic region, while not statistically significant, were also noted. Given the importance of hypertension as a major risk factor of cardiovascular disease,[1]policy makers should examine ways of strengthening the safety nets in their states in order to alleviate the financial hardship of their minimum wage workforce. In addition, public health efforts to prevent the development of hypertension in young adults should continue.

Future studies of minimum wage and hypertension should consider subgroup analyses by race-ethnicity and geographic region as this has wider implications on health equity.

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Table 1.3 Characteristics of young adults in BRFSS 2019

Variables	HTN n = 2,855 Weighted (%)	No HTN n = 15,608 Weighted (%)
Individual level		
Age		
18-29	1,121 (6.16)	8,699 (48.98)
30-39	1,734 (8.22)	6,909 (36.64)
Sex		
Male	2,085 (10.22)	10,167 (56.19)
Female	770 (4.16)	5,441 (29.43)
Education		
Less than high school	489 (3.53)	2,355 (19.56)
High school	2,366 (10.85)	13,253 (66.06)
Marital Status		
Married	917 (4.55)	4,688 (25.48)
Previously married	398 (1.71)	1,453 (7.17)
Never married	1,540 (8.12)	9,467 (52.97)
Health Insurance		
Yes	2,168 (10.42)	11,422 (60.93)
No	687 (3.96)	4,186 (24.69)
Employment status		
Employed for wages	2,243 (10.87)	12,469 (67.84)
Unemployed	245 (1.38)	1,259 (6.92)
Self-employed	367 (2.13)	1,880 (10.86)
Smoking Status		
Current	1,043 (5.23)	4,330 (22.02)
Previous	646 (3.03)	2,790 (14.54)
Non-smoker	1,166 (6.12)	8,488 (49.06)
Body Mass Index (kg/m^2)		
<18.5	33 (0.20)	447 (2.74)
18.5-24.9	558 (3.04)	5,759 (31.10)
25.0-29.9	809 (4.43)	5,101 (28.40)
≥30.0	1,455 (6.71)	4,301 (23.39)
Days mental health not good		
<14 days/month	2,099 (10.37)	12,832 (70.72)
≥14 days/month	756 (4.01)	2,776 (14.90)
Race-ethnicity		
NH-White	1,804 (7.84)	9,471 (43.70)
NH-Black	324 (2.44)	1,398 (10.58)
Hispanic	444 (3.45)	3,289 (25.52)
Other	283 (0.66)	1,450 (5.82)
Geographical Region		
Northeast	320 (1.60)	1,914 (11.34)

Table 1.3 Characteristics of young adults in BRFSS 2019 (Continued)

Variables	HTN n = 2,855 Weighted (%)	No HTN n = 15,608 Weighted (%)
Midwest	741 (3.11)	4,438 (18.13)
South	1,013 (6.35)	4,565 (33.16)
West	781 (3.31)	4,691 (23.00)
State level		
State minimum wage		
Yes	1,657 (7.99)	9,510 (49.19)
No	1,198 (6.39)	6,098 (36.43)

Table 2.3 Unadjusted odds ratios and 95% confidence intervals (CI) of the association between state minimum wage and hypertension

Variables	OR 95% CI
Individual level	
Age	
18-29	1.00
30-39	1.79 (1.56-2.05)
Sex	
Male	1.00
Female	0.78 (0.67-0.91)
Education	
Less than high school	1.10 (0.92-1.31)
High school	1.00
Marital Status	
Married	1.00
Previously married	1.33 (1.05-1.70)
Never married	0.86 (0.74-1.00)
Health Insurance	
Yes	1.00
No	0.94 (0.80-1.10)
Employment status	
Employed for wages	1.00
Unemployed	1.25 (0.99-1.57)
Self-employed	1.23 (0.99-1.51)
Smoking Status	
Current	1.91 (1.63-2.23)
Previous	1.67 (1.40-1.99)
Non-smoker	1.00
Body Mass Index (kg/m^2)	
<18.5	0.77 (0.39-1.51)
18.5-24.9	1.00
25.0-29.9	1.60 (1.31-1.95)
≥30.0	2.94 (2.46-3.51)
Days mental health not good	
<14 days/month	1.00
≥14 days/month	1.84 (1.56-2.16)
Race-ethnicity	
NH-White	1.00
NH-Black	1.28 (1.05-1.57)
Hispanic	0.75 (0.63-0.90)
Other	0.63 (0.51-0.79)
Geographical Region	
Northeast	1.00

Table 2.3 Unadjusted odds ratios and 95% confidence intervals (CI) of the association between state minimum wage and hypertension (Continued)

Variables	**OR 95% CI**
Midwest	1.22 (0.97-1.52)
South	1.36 (1.09-1.68)
West	1.02 (0.81-1.28)
State level	
State minimum wage	
Yes	1.00
No	1.08 (0.94-1.24)

Table 3.3 Multivariable multilevel logistic regression of the association between state minimum wage and hypertension in young adults

Variables	Null Model	Model 1 OR (95% CI)	Full model OR (95% CI)
Individual level			
Age			
18-29			1.00
30-39			1.64 (1.63-1.64)
Sex			
Male			1.00
Female			0.68 (0.67-0.68)
Education			
Less than high school			0.99 (0.99-1.00)
High school			1.00
Marital Status			
Married			1.00
Previously married			1.33 (1.32-1.34)
Never married			1.13 (1.12-1.13)
Health Insurance			
Yes			1.00
No			0.85 (0.84-0.85)
Employment Status			
Employed for wages			1.00
Unemployed			1.26 (1.26-1.27)
Self-employed			1.23 (1.23-1.24)
Smoking Status			
Current			1.57 (1.57-1.58)
Previous			1.41 (1.40-1.41)
Non-smoker			1.00
Body Mass Index (kg/m^2)			
<18.5			0.76 (0.76-0.77)
18.5-24.9			1.00
25.0-29.9			1.52 (1.52-1.53)
≥30.0			2.92 (2.91-2.93)
Days mental health not good			
<14 Days/month			1.00
≥14 Days/month			1.93 (1.92-1.94)
State Level			
State Minimum Wage			
Yes		1.00	1.00
No		1.09 (0.95-1.26)	1.11 (0.97-1.28)
Fixed effect Intercept	-1.789 (0.037)	-1.828 (0.047)	-2.876 (0.046)

Table 3.3 Multivariable multilevel logistic regression of the association between state minimum wage and hypertension in young adults (Continued)

Variables	**Null Model**	**Model 1 OR (95% CI)**	**Full model OR (95% CI)**
Random Effects			
Intercept	0.067 (0.013)	0.065 (0.013)	0.060 (0.010)
VPC (%)	1.99	1.94%	1.79%
Model Fit Statistics			
-2 Log Likelihood	17442165	17442163	16317148
AIC	17442169	17442169	16317182
N	18,463	18,463	18,463

Abbreviations: VPC, Variance partition coefficient; AIC, Akaike's information criterion

Table 4.3 Adjusted odds ratios* (OR) and 95% confidence intervals (Cis)** of the state minimum wage-hypertension association stratified by race-ethnicity

	Race-Ethnicity			
	NH-White **OR (95% CI)**	NH-Black **OR (95% CI)**	Hispanic **OR (95% CI)**	Other **OR (95% CI)**
Minimum wage				
Yes	1.00	1.00	1.00	1.00
No	1.02 (0.75-1.38)	1.03 (0.20-5.41)	0.77 (0.33-1.79)	1.21 (0.34-4.36)

Abbreviations: NH, Non-Hispanic.
*Adjusted for age, sex, education, marital status, health insurance, employment status, smoking status, body mass index, and chronic stress.
**Breslow-Day test of homogeneity: $p<0.0001$.

Table 5.3 Adjusted odds ratios* (OR) and 95% confidence intervals (Cis)** of the state minimum wage-hypertension association stratified by geographical region

	Geographical Region			
	South **OR (95% CI)**	West **OR (95% CI)**	Northeast **OR (95% CI)**	Midwest **OR (95% CI)**
Minimum wage				
Yes	1.00	1.00	1.00	1.00
No	1.08 (0.84-1.39)	1.28 (1.03-1.59)	0.61 (0.23-1.59)	0.95 (0.65-1.40)

*Adjusted for age, sex, education, marital status, health insurance, employment status, smoking status, body mass index, and chronic stress.
**Breslow-Day test of homogeneity: p=0.06

Table 6.3 Degree to which chronic stress mediates association between state minimum wage and hypertension

	Hypertension
Logistic regression	**OR (95% CI)**
State minimum wage predicting hypertension	1.08 (0.94-1.24)
State minimum wage predicting chronic stress	0.89 (0.78-1.01)
Chronic stress predicting hypertension	1.84 (1.56-2.16)
State minimum wage predicting hypertension, controlling chronic stress	1.07 (0.93-1.22)

CHAPTER 5. CONCLUSION

The primary purpose of this dissertation was to examine the association between upstream social factors (that is, county intergenerational deprivation, state income inequality, and state minimum wage) and hypertension in young adults. The dissertation used three separate papers, to determine whether there was an association between each exposure and hypertension among young adults, 18-39 years.

In Paper 1, an association was observed between county intergenerational deprivation and hypertension; specifically, an increase in absolute upward mobility was associated with decreased odds of hypertension in young adults and this association was statistically significant, even after adjusting for confounders. While earlier studies had been inconclusive, findings from the current dissertation showed the results were largely congruent with other studies.
In Paper 2, no association was observed between state income inequality and hypertension. While no association was observed, the findings remained largely congruent with the relatively few studies that have examined the association. As for Paper 3, no association was observed between state minimum wage and hypertension. While previous studies have been inconsistent, the current investigation aligns with a number of prior investigations that did not find an association.

The secondary purpose of this dissertation was to determine whether race-ethnicity and geographical region modified the upstream social factor (county intergenerational deprivation, state income inequality, and state minimum wage)-hypertension associations. Paper 1 revealed that race-ethnicity and geographical region modified the association between county intergenerational deprivation and hypertension. Specifically, increases in absolute upward mobility were associated with increased odds of hypertension only among non-Hispanic Black,

Hispanic and Other young adults. Geographically, decreased odds of hypertension were noted among young adults in the South, Midwest and Northeast, but increased odds were observed among those in the West. With regard to the race-ethnicity differences, Paper 2 findings indicated that race-ethnicity was an effect modifier of the state income inequality-hypertension association. Given that this was the only known study to examine effect modification by race-ethnicity, additional studies are warranted.

In Paper 3, race-ethnicity was observed to modify the state minimum wage-hypertension association. In particular, decreased odds of hypertension were noted among Hispanic young adults, while increased odds were observed among Other young adults. Conversely, there was no association between state minimum wage and hypertension among non-Hispanic White and non-Hispanic Black young adults. With regard to geographical region, differences were observed in the state minimum wage-hypertension association among young adults residing in the West and Northeast, however, the Breslow-Day Test of Homogeneity was not statistically significant. Nonetheless, no known studies had examined effect modification by geographical region and thus additional studies are warranted.

Collectively, findings from the three papers indicate that county intergenerational deprivation may be a more a salient upstream factor in the young adult hypertension literature than state income inequality and state minimum wage. Additionally, all the studies indicated that race-ethnicity was an effect modifier of the exposure-disease associations; however, additional studies are warranted to confirm these findings.

Implications

Since this investigation was written from a health equity perspective with prevention of hypertension as its goal, several implications can be inferred from the dissertation. First, the

study (county intergenerational deprivation) provided a way to measure the manifestations of structurally racist policies (that is, racial residential segregation) and the mechanisms by which these oppressive policies create inequities in hypertension at the individual level. As such, various agencies at the local level and their partners could use this information to invest in opportunity structures that increase school quality, and deconcentrate poverty such as mixed income housing.[1] Also, the information gleaned from this dissertation could be used to direct appropriate resource allocation that prevents hypertension earlier in life. With regard to theory, the CSDH framework is not outrightly clear in mentioning that systemic racism is a root cause of health disparities. Thus, a re-examination of this component may be helpful to researchers comparing different conceptual/theoretical frameworks.

Given that findings from the state income inequality study indicated that some racial-ethnic subgroups may be more sensitive to the widening gaps in the income distribution, researchers should consider elucidating the mechanisms involved. In terms of policy, states may consider pursuing strategies that enhance economic growth while also lessening the widening gaps within the income distributions.

With regard to the implications for research in state minimum wage-hypertension associations, population-based surveys should consider collecting detailed occupation data. This information may be useful in understanding how job-related factors may place individuals at risk.

Future Research

This dissertation offers multiple avenues for future inquiry. First, in the county intergenerational deprivation-hypertension association, poverty was the key mechanism by which the prospects to upward mobility were truncated. While the study only measured poverty

in terms of economic wellbeing, research indicates that poverty is a multidimensional variable.[3] Therefore, future investigations should consider defining poverty in terms of social exclusion and clarify how it mediates the association of county intergenerational deprivation and hypertension. Additionally, future longitudinal studies would be beneficial in establishing causal inference in the county intergenerational-hypertension associations. Furthermore, given the differences observed in terms of geographical region, studies exploring additional variations in geographical region both within and between would be beneficial in elucidating the factors responsible.

In terms of the state income-inequality hypertension association, future studies should consider using panel data that captures state income inequality over longer periods of time. Additionally, state income-inequality hypertension associations will benefit from effect modification by race-ethnicity in order to show the racial-ethnic groups that are most vulnerable. Concerning the state minimum wage-hypertension associations, future studies should consider using longitudinal designs in order to provide evidence of cause and effect as well as stratify results by race-ethnicity in order to show groups that are most vulnerable. More importantly, studies examining state minimum wage-hypertension associations should consider stratifying by gender or occupation. In conclusion, given that hypertension is largely preventable, future work pursuing upstream factors or root causes of health differences will be beneficial as research works toward attaining health equity.

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