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RIVERSIDE

Association Between CDC Social Vulnerability Index Scores and Area-Level Mental
Health Outcomes in Inland Empire Zip Code Tabulation Areas

A Thesis submitted in partial satisfaction
of the requirements for the degree of

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in

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ABSTRACT OF THE THESIS

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by

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Master of Public Health, Graduate Program in Public Health
University of California, Riverside, June 2026
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Mental health disorders, such as Major Depressive Disorder, depression, and dysthymia, represent a significant public health burden in the United States. However, area-level structural conditions that drive these disparities in mental health outcomes remain understudied at the community level. Limited research has examined the association between the CDC Social Vulnerability Index and area-level mental health outcomes at the Zip Code Tabulation Area level, especially in high-vulnerability regions

such as the Inland Empire. This study employed an ecological, cross-sectional secondary data analysis to examine the association between CDC AVI scores and three area-level mental health outcomes (poor mental health days, depression, insufficient sleep) across 168 ZCTAs in the Inland Empire, comprising Riverside and San Bernardino counties. Social vulnerability data were obtained from the American Community Survey, and mental health outcomes were obtained from CDC PLACES Better Health data. Simple and multiple linear regression models were estimated for the overall SVI scores and individual SVI theme scores. Interaction models were examined to determine whether proximity to a college or university modified the association between SVI and mental health among Inland Empire ZCTAs. It was found that SVI scores were significantly associated with poor mental health days and insufficient sleep, but not with depression prevalence. Socioeconomic status was the strongest and most consistent domain-level predictor across all three outcomes. The inverse association between minority status and depression prevalence likely reflects diagnostic access barriers. University proximity did not significantly modify the association between SVI and prevalence of mental health disorders within Inland Empire ZCTAs, but proximity was found to be an independent predictor of mental health outcome, with ZCTAs closer to universities having better mental health outcomes. These findings highlight the importance of upstream socioeconomic interventions and expanded diagnostic access in high-vulnerability regions.

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Chapter 1: Introduction

Social determinants of health are non-medical factors that affect health outcomes and quality of life (U.S. Department of Health and Human Services, 2020). These conditions include where people are born, grow, live, work, and age. They also go beyond individual factors and are more strongly influenced by broader social, economic, and environmental circumstances that can shape one's life (Cotton & Shim, 2022). Recognizing the influence of these factors is central to understanding population-level health outcomes, particularly in mental health.

Social Determinants of Health and Social Vulnerability

To better understand how social determinants can shape health, the United States Department of Health and Human Services' Healthy People 2030 recognizes five key domains of Social Determinants of Health. These are economic stability, education access and quality, healthcare access and quality, neighborhood and built environment, and social and community context (U.S. Department of Health and Human Services, 2020). Economic stability can include factors such as income, employment, poverty, and food insecurity. Education covers literacy, language, and educational attainment. Healthcare access looks at the availability of services, insurance coverage, and cultural competency (Brandt et al., 2023). Neighborhood and built-environment factors in housing quality, safety, transportation, and access to healthy foods. Lastly, social and

community factors include social support systems, discrimination, and community engagement (Brandt et al., 2023). These domains illustrate how structural conditions shape health outcomes at the individual and community levels.

Building on this framework, the concept of structural vulnerability provides a lens for understanding how inequalities are produced and maintained. Structural vulnerability can also be understood as a condition that is shaped by an individual's position within social and economic hierarchies. Structural vulnerability refers to the physical and emotional harm that can be imposed on specific populations due to economic, cultural, and racial forms of discrimination (Bourgois et al., 2017). Within this framework, individuals in a position of less advantage or more likely to be exposed to conditions that can harm health are highlighted, indicating that risk is not random but related to social differentiation (Burton-Jeangros et al., 2024). Structural vulnerability can also be characterized by limited agency, limited resilience, and imposed risk due to systemic discrimination reinforced by broader social hierarchies (Sutton et al., 2025). In the context of mental health, structural conditions to which individuals are exposed include income, employment, housing, discrimination, and neighborhood conditions, and they are shaped by the distribution of resources (Kirkbride et al., 2024). These factors work together to show how structural vulnerability can lead to disadvantage at the community level in relation to mental health outcomes.

Upstream and Downstream Determinants of Mental Health

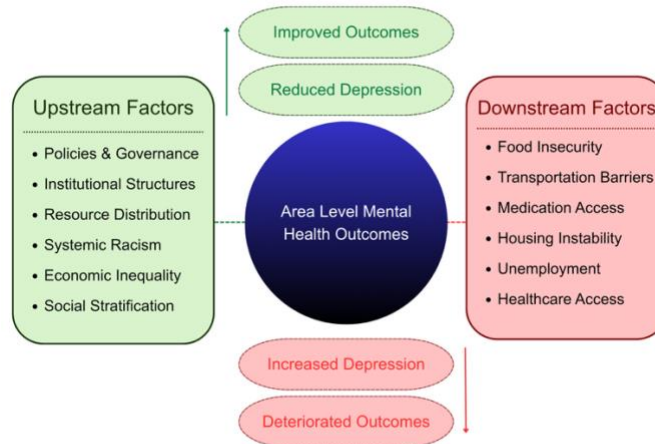


Figure 1: *Upstream and Downstream Determinants of Mental Health Outcomes*

Social determinants act as a patterned system of inequality. Research on the social gradient in health helps demonstrate that health outcomes improve incrementally with each step up the socioeconomic hierarchy, rather than differing only between the most and least advantaged groups. In an article, the author argues that relative position within social and economic hierarchies influences exposure to chronic stress, autonomy, and access to material resources, all of which contribute to health disparities (Marmot, 2017). A complementary way to conceptualize social determinants is through upstream and downstream factors as can be seen in Figure 1. Upstream determinants include factors over which individuals may have little control, such as policies, institutions, and resource distribution. Downstream factors are considered to have more direct effects, such as food insecurity, transportation barriers, and medication access (White-Williams et al., 2020).

Within the Social Determinants of Health framework, racism also plays a major role. Racism drives poverty and health inequities by limiting access to economic opportunities, safe housing, quality education, and healthcare (Nkemdirim Okere et al., 2022). As a result, social determinants are widely recognized as primary drivers of health disparities, and research shows that 80% of an individual's quality of life and life expectancy are shaped by these factors rather than by clinical care alone (Brignone et al., 2024).

The Social Vulnerability Index (SVI)

Given the influence of these structural conditions, social vulnerability offers a useful lens for examining how place-based factors affect health outcomes. Like social determinants of health, social vulnerability helps explain how factors such as where someone is born, lives, or works can affect their health outcomes (Mah, Penwarden et al., 2023). This lens is particularly relevant to mental health outcomes, as they are often shaped by long-term exposure to social and economic stressors. Figure 1 highlight stressors both upstream and One widely used tool for assessing social vulnerability is the Social Vulnerability Index (SVI), developed by the Center for Disease Control and Prevention (CDC). and the Agency for Toxic Substances and Disease Registry. The SVI helps identify vulnerable areas based on variables from the American Community Survey. Created in 2011 to identify populations at risk during natural disasters, the SVI has since been applied to a variety of public health assessments (Flanagan et al., 2011). More recent studies have used the index to examine outcomes related to the spread of

infectious diseases and how social vulnerability can affect the risk of cardiometabolic conditions, cancer, and mortality from chronic lung disease (Brignone et al., 2024). For cancer specifically, a study used the SVI to examine geographic disparities in cancer patients, including factors such as cancer-causing exposures, diagnosis, treatment, and even mortality at a community level (Tran et al., 2023). During the COVID-19 pandemic, a study highlighted the use of SVI as a tool to identify areas vulnerable to COVID-19 disease and death to inform better resource allocation (Al Rifai et al., 2022). These applications help highlight the relevance of the SVI as a tool for examining health outcomes beyond emergency preparedness.

The SVI comprises four major thematic domains. The first theme, socioeconomic status, includes variables such as living below 150% of the poverty line, being unemployed, having a high housing cost burden, having no high school diploma, and having no health insurance. The second theme covers household characteristics, including adults aged 65 or older, children under 17, civilians with disabilities, single-parent households, and English-language proficiency. Next is the theme of racial and ethnic minority status, which includes all races and ethnic groups not considered White (Latinx or Hispanic, Black, Asian, Native American, Native Hawaiian and Pacific Islander, etc.). The last theme in this index is housing type and transportation. The variables are multi-unit structures, mobile homes, crowding, no vehicles, and group quarters (CDC, 2024).

Each of these themes covers a facet of social disadvantage that has been independently linked to mental health outcomes, independently of the others.

Socioeconomic stressors such as poverty, unemployment, and housing instability are associated with chronic stress and increased risk of depression and anxiety (Tibber et al., 2022). Household characteristics reflect reduced social support and caregiving burden, which are known psychosocial risk factors for mental health (Kirkbride et al., 2024). Racial and ethnic minority states show how exposure to structural racism and discrimination can lead to negative emotional and physiological responses, as these factors have been identified as psychosocial stressors (Salem & Robinson, 2025). Housing instability and lack of transportation can limit access to mental health services and compound existing vulnerabilities (Quesada et al., 2024). These themes make the SVI an appropriate tool for examining mental health outcomes, as the index includes structural conditions linked to poor mental health.

Even though this tool is ideal for measuring mental health outcomes at the area-level, it has limitations. Since the index combines variables across different constructs, it can be difficult to determine which individual dimensions of vulnerability affect outcomes (Hinnant et al., 2022). The SVI can also be subject to the ecological fallacy, in which associations observed at the zip code level do not directly reflect the experiences of individuals within those zip codes (Brzoska & Razum, 2019). Despite its limitations, the SVI remains a widely used tool for identifying communities at higher risk.

Social Vulnerability and Mental Health Outcomes

In the context of mental health, social vulnerability is important to consider at the ZIP code level because area-level conditions can shape access to resources and exposure to chronic stressors. Socioeconomic factors such as income levels, educational backgrounds, social class, occupation, living standards, and even resource availability have been shown to influence mental health outcomes substantially (Tibber et al., 2022). Research also shows that individuals from lower social classes defined through the Gini coefficient often experience chronic stress, which can be caused by long-term financial instability, harmful living conditions, or job insecurity (Salem & Robenson, 2025).

There is also compelling evidence to support that the risk of developing any mental health condition is deeply linked to life circumstances, highlighting that a higher burden of psychiatric morbidity is experienced by individuals closer to the margin of society (Kirkbride et al., 2024; Salem & Robenson, 2025). Income inequality has also been linked to mental health outcomes at the population level. A review of studies examining the association between income inequality and mental health-related outcomes found that about a third reported a positive association between income inequality and the prevalence or incidence of mental health problems (Patel et al., 2018; Salem & Robenson, 2025; Haselbach et al., 2025). Education also plays a critical role in health outcomes, with lower educational attainment associated with poorer general health and increased psychological distress (Ramirez et al., 2025).

Mental Health

In 2022, the World Health Organization defined mental health as “a state of mental well-being that enables people to cope with the stresses of life, to realize their abilities, to learn well and work well, and to contribute to their communities” (Galderisi, 2024). In the United States, one in five adults and adults ages 9 and older experience mental illness each year. Furthermore, research has also found that the mental health outcomes have become worse post the Covid-19 pandemic (McGinty, 2023). These structural factors are particularly salient for young adults, a population that has had increased rates of mental health challenges. Data from the National Survey on Drug Use and Health and the Behavioral Risk Factor Surveillance System survey show that there has been a steady and disproportionate rise in mental illness, depression, and suicidality among youth aged 18–24 when compared to other adults over the years of 2011 to 2021 (Brunette et al., 2023). A study shows that this time period tends to be the peak incidence period for the onset of mental disorders. A study conducted found that half of those who develop a mental disorder before the age of 75 have their onset between 19 and 20 (McGrath et al., 2023). This critical window of early adulthood onset highlights the importance of examining area-level social conditions that young adults in high vulnerability regions like the Inland Empire are exposed to during this vital period of development. Studying area-level data can underscore public health interventions and communities within the Inland Empire that could most benefit from public health efforts.

When looking at mental health outcomes due to social vulnerability, there do seem to be plausible pathways linking these factors established through research. In terms of being a minority, research has found that discrimination acts as a psychosocial

stressor, meaning it creates a stress response that can lead to negative emotional responses (Berger & Sarnyai, 2015).

Regional Context: The Inland Empire

Within the broader context of mental health, Latinx populations are found to experience elevated rates of mental health challenges. Among adolescents, approximately 46% of Latinx high school students report persistent feelings of sadness or hopelessness, indicating a substantial burden of emotional distress (Roche et al., 2024). These outcomes are shaped in part by structural conditions, as Latinx communities experience higher rates of poverty and residential crowding compared to non-Latinx populations (Guan et al., 2025). Access to healthcare represents an additional and critical barrier. Hispanic populations have the highest rates of uninsurance in the United States, with approximately 17.7% lacking coverage; nearly one-quarter of Hispanic women are uninsured (Quesada et al., 2024). This lack of health insurance contributes to geographic barriers, as Latinx populations are more likely to reside in areas with fewer healthcare facilities and pharmacies (Quesada et al., 2024).

These patterns are particularly relevant in the Inland Empire region of Southern California, which encompasses both Riverside and San Bernardino counties. Figure 2 shows the Inland Empire region of California. The Inland Empire is home to over 4.6 million residents and has a Latinx population of approximately 52.5%. The Inland Empire also has a higher percentage of younger individuals, with a median age of 32,

which is 5 years younger than the state average. The region also had over a quarter of the population under the age of 18 (*The Inland Empire*, n.d.). When looking at the workforce, the area's workforce tends to be a bit younger than the rest of California, with about 13% being between 18 and 24 (Bardnard et al., 2025). The region includes both urban centers and sparsely populated rural areas (Krishna & Polonijo, 2024).

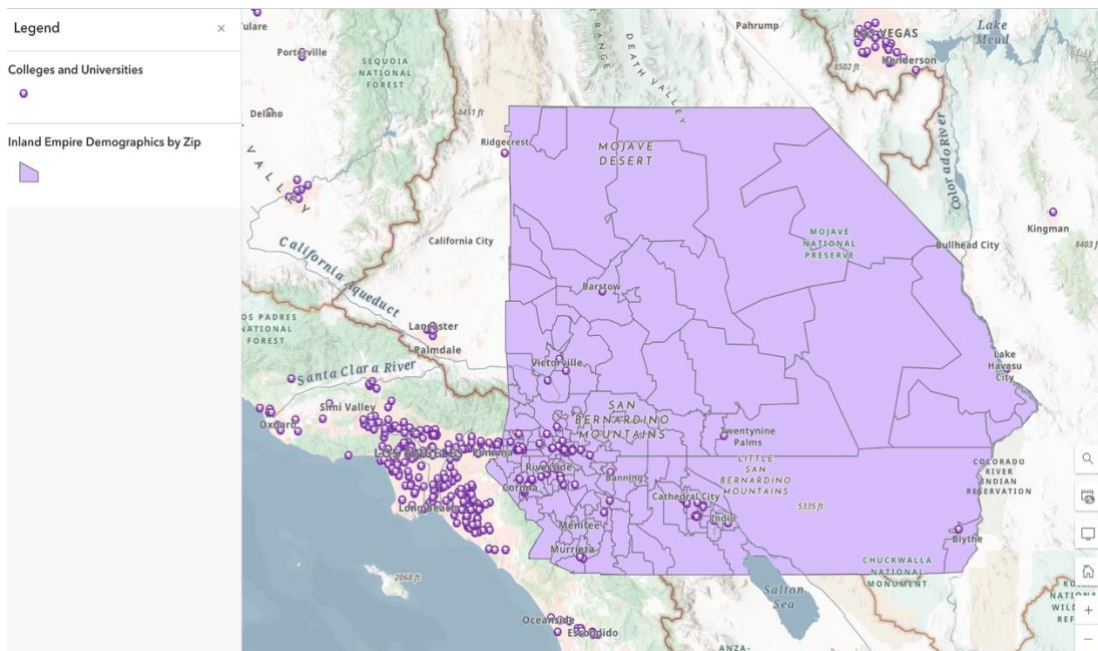


Figure 2: Map of the Inland Empire

Socioeconomic conditions in the Inland Empire reflect many of the social vulnerabilities described in the literature. Figure 2 reflects a map of the region of interest. Workers in the region often receive lower compensation than those in other parts of California, and about 13.7% of residents live below the federal poverty line (Center for Social Innovation, 2018; Krishna & Polonijo, 2024). These low wages have also

contributed to higher rates of multi-family housing and overcrowding as families seek to manage the rising housing costs (Clark & Araiza, 2021). Educational attainment in the region is also comparatively lower, with about 33.79% of workers having less than a college education (Barnard et al., 2025). The region has also been deemed medically underserved. This is due to a significant shortage of healthcare providers and the expansive geography, which makes it challenging for some residents to travel long distances to receive care (Newman & Paci, 2021). The median annual per-person income of the region is about \$36,747, which is below the Southern California and overall state average (Bates et al., 2024). Additionally, a growing mismatch between earnings and rent has led to the previously mentioned increase in housing instability and crowding.

Gaps in Research

Mental health outcomes vary substantially across geographic communities, yet the structural and area-level determinants underlying these differences are examined inconsistently in population-based research. While individual-level risk factors are widely studied, fewer studies evaluate how broader community conditions shape mental health disparities across geographic contexts. The CDC SVI provides a standardized measure of community vulnerability and has been widely used in disaster preparedness and public health research (National Institute of Mental Health, 2024). Systematic reviews indicate that SVI is most commonly applied to study infectious disease transmission, chronic disease burden, and healthcare access rather than mental health outcomes specifically

(Valentin et al., 2025; Mah et al., 2023). Consequently, relatively little research has examined associations between SVI and population-level mental health outcomes at the ZIP Code Tabulation Area (ZCTA) level. Existing studies that link social vulnerability to mental health frequently focus on clinical populations or access to treatment rather than broader community-level prevalence patterns (Valentin et al., 2025). Although geographic context has received increasing attention in research on social determinants of health, few studies examine whether proximity to institutions such as colleges or universities modifies area-level vulnerability patterns (Campbell et al., 2025). Research on spatial determinants of health has largely focused on healthcare access and mortality outcomes rather than the influence of institutional environments (Mah et al., 2023). As a result, there is limited evidence on whether mental health outcomes vary across ZCTAs with different levels of social vulnerability and whether proximity to universities modifies this relationship. This gap is particularly relevant in the Inland Empire, a region characterized by elevated social vulnerability and pronounced health disparities. Examining mental health patterns in this context has direct implications for regional public health planning and resource allocation.

Existing research demonstrates that structural and area-level social conditions are closely associated with mental health outcomes (Mezzina et al., 2022). The SDOH framework identifies socioeconomic stratification, housing instability, discrimination, and limited healthcare access as key contributors to psychological distress and psychiatric morbidity. At the same time, the SVI offers a composite, place-based measure of

structural vulnerability that is widely used in disaster preparedness and chronic disease research. Despite its increasing use in public health, comparatively little work has examined whether composite measures of social vulnerability are associated with population-level mental health patterns across geographic units, such as ZCTAs.

Although geographic disparities in mental health have been documented (Valentin et al., 2025), fewer studies evaluate how institutional environments interact with area-level vulnerability. Public universities, for example, function as major hubs of economic activity, healthcare services, and social infrastructure within surrounding communities. Yet it remains unclear whether proximity to such institutions modifies the relationship between community-level vulnerability and mental health outcomes. To address these gaps, the present study examines the association between community-level social vulnerability, measured using the CDC SVI, and population-level mental health outcomes across ZCTAs in the Inland Empire region of Southern California.

Research Questions and Hypotheses

RQ 1: Are higher CDC Social Vulnerability Index (SVI) scores associated with worse area-level mental health outcomes across Inland Empire ZCTAs?

Hypothesis: ZCTAs with higher overall SVI scores has a higher prevalence of poor mental health outcomes.

RQ 2: Which SVI domains are most strongly associated with mental health outcomes?

Hypothesis: The socioeconomic status domain is most likely associated with a higher prevalence of poor mental health outcomes.

RQ 3: Does proximity to universities modify the association between SVI and mental health outcomes?

Hypothesis: Proximity to universities modify the association between SVI and mental health outcomes.

Chapter 2: Methods

Study Design

This study is an ecological, cross-sectional secondary data analysis examining the association between area-level social vulnerability and mental health outcomes across Zip Code Tabulation Areas (ZCTAs) in the Inland Empire region of California. Zip codes were selected as the unit of analysis, and all data used in this study were obtained from existing, publicly available sources. Primary data collection was not conducted for this study. The study setting encompasses all ZCTAs within the Inland Empire, which include Riverside and San Bernardino counties. This area was chosen as the region of focus due to high levels of social vulnerability, large minority populations, and its status as a medically underserved region.

Data Sources

Two publicly available data sources were used in this study. Social Vulnerability data was derived from the American Community Survey data through the US Census. Mental health outcomes data were taken from the PLACES Better Health data, which used survey results from the Behavioral Risk Factor Surveillance System. This is a national, state-based telephone survey that collects data on health-related behaviors, chronic conditions, and the use of preventive services among adults in the U.S.

University ZIP code data were obtained from the ArcGIS repository, which is based on the National Center for Education Statistics.

Variables

Independent variables for this study include the CDC SVI overall scores and the four theme scores. The four themes for SVI are socioeconomic status, household characteristics, racial and ethnic minority status, and housing type and transportation. The dependent variables include the three mental health outcomes derived from the PLACES CDC data which include poor mental health days (>14 days of feeling not good in regards to mental health during the past 30 days), Prevalence of depression (ever being diagnosed by a doctor to have a depressive disorder in their lifetime), and insufficient sleep (<7 of sleep in the last 24 hours). A binary indicator variable was used to classify each ZCTA as being part of the Inland Empire (True) or overall California (False)

Analytic Strategy

Before analysis, the data was cleaned to ensure proper findings. ZIP Code Tabulation Areas that did not have sufficient populations as recorded by the CDC or did not include information on variables or had missing values were excluded from analysis. 120 ZCTAs were excluded from the analysis, leaving a final analytical sample of 1883 ZCTAs (California and Inland Empire). All variables were standardized using z-score transformation to allow direct comparison of effect sizes across SVI themes, scores, and outcome variables. Data cleaning was conducted in Python. All statistical analyses were conducted in R using the dplyr, ggplot2, stargazer, and xtable packages.

Analysis was conducted in stages corresponding to the three research questions. Descriptive analysis was initially conducted for all study variables such as means, standard deviations, medians that were stratified by Inland Empire status. Distributions were then visualized using violin plots with embedded box plots to compare SVI and mental health outcomes between California and Inland Empire ZCTAs. Simple linear regression models were also used to analyze the association of overall mental health outcomes and SVI for the Inland Empire as a whole. For the second research question on which SVI theme is most strongly associated with mental health outcomes, another simple linear regression was used to estimate associations of mental health outcomes with each of the SVI themes. Multiple regression models were also estimated with all four SVI themes entered simultaneously as predictors for each outcome, allowing for assessment

of the independent contributions of each theme while also accounting for the others. For the third research question, multiple linear regression models were used to examine whether geographic proximity to universities modifies the association between SVI scores and mental health outcomes. An interaction term (SVI x Proximity) was included in the model to test the strength or direction of the association. University proximity was defined as the straight-line distance in miles from the internal geographic centroid and inclusion criteria were colleges or universities located in the Inland Empire with a minimum population of at least 1,000 students. A total of 239 institutions met the inclusion criteria within California, and 22 for the Inland Empire. Results are reported as β coefficients with standard errors. Statistical significance was also evaluated at an alpha level of 0.05 and reflected through p-values.

Chapter 3: Results

A total of 168 Inland Empire ZCTAs met the inclusion criteria and were used for final analysis. Descriptive statistics for all study variables are presented in Tables 1 and 2. Of these, 76 were part of Riverside County, and 92 were within San Bernardino County. Because 11 ZCTAs spanned both county boundaries, county-specific counts should be interpreted as non-mutually exclusive. 23 universities and colleges with a ZCTA in the analytic sample include American Career College Ontario, Barstow Community College, California State University San Bernardino, Chaffey College, Copper Mountain Community College, Crafton Hills College, DeVry University California, Loma Linda University, San Bernardino Valley College, San Joaquin Valley College Ontario, Universal Technical Institute, University of Redlands, Victor Valley College, and West Coast University Ontario, California Baptist University, College of the Desert, La Sierra University, Moreno Valley College, Mt. San Jacinto College, Norco College, Palo Verde College, and Riverside City College. The University of California, Riverside, was identified as a qualifying institution, but its ZIP code (92521) is an institutional code assigned by the United States Postal Service and does not correspond to a Census Bureau ZCTA. Of the 23 qualifying institutions, 22 were used as reference points in the straight-line distance calculation for university proximity.

Table 1. *Summary of Inland Empire ZIP code Tabulation Areas and Colleges/Universities*

	Riverside County	San Bernardino County	Total
Total ZCTAs in analytic sample	76	92	168
ZCTAs spanning both county boundaries	11	11	11
Qualifying institutions in analytic sample	8	14	22
Qualifying institutions outside analytic sample	1	0	1

Note. Qualifying institutions are defined as postsecondary colleges or universities located within Riverside or San Bernardino counties with a minimum total enrollment of 1,000 students per IPEDS data.

Table 2. Analytic Sample Characteristics by County and University Representation

County	ZCTA	Qualifying Postsecondary Institutions (if applicable)
San Bernardino County	91701, 91708, 91709, 91710, 91730, 91737, 91739, 91752, 91759, 91761, 91762, 91763, 91764, 91766, 91784, 91786, 92223, 92225, 92242, 92252, 92256, 92268, 92277, 92284, 92285, 92301, 92305, 92307, 92308, 92309, 92310, 92311, 92313, 92314, 92315, 92316, 92320, 92321, 92322, 92324, 92325, 92327, 92332, 92333, 92335, 92336, 92337, 92339, 92341, 92342, 92344, 92345, 92346, 92347, 92352, 92354, 92356, 92358, 92359, 92363, 92364, 92365, 92368, 92371, 92372, 92373, 92374, 92376, 92377, 92378, 92382, 92385, 92386, 92391, 92392, 92394, 92395, 92397, 92398, 92399, 92401, 92404, 92405, 92407, 92408, 92410, 92411, 92509, 92880, 93516, 93555, 93562	American Career College – Ontario (91764), Barstow Community College (92311), California State University, San Bernardino (92407), Chaffey College (91737), Copper Mountain Community College (92252), CRAFTON HILLS College (92339), DeVry University – California (91764), Loma Linda University (92350†), San Bernardino Valley College (92410), San Joaquin Valley College – Ontario (91764), Universal Technical Institute (91730), University of Redlands (92373), Victor Valley College (92395), West Coast University – Ontario (91761)
Riverside County	91752, 91761, 91762, 92028, 92201, 92203, 92210, 92211, 92220, 92223, 92225, 92230, 92234, 92236, 92239, 92240, 92241, 92253, 92254, 92258, 92260, 92262, 92264, 92270, 92274, 92276, 92282, 92320, 92324, 92373, 92399, 92501, 92503, 92504, 92505, 92506, 92507, 92508, 92509, 92518, 92530, 92532, 92536, 92539, 92543, 92544, 92545, 92548, 92549, 92551, 92553, 92555, 92557, 92561, 92562, 92563, 92567, 92570, 92571, 92582, 92583, 92584, 92585, 92586, 92587, 92590, 92591, 92592, 92595, 92596, 92860, 92879, 92880, 92881, 92882, 92883	California Baptist University (92504), College of the Desert (92260), La Sierra University (92505), Moreno Valley College (92551), Mt. San Jacinto College (92583), Norco College (92860), Palo Verde College (92225), Riverside City College (92506)
Institution	ZIP Code	Note
University of California, Riverside	92521	<i>Institutional ZIP* — not a ZCTA</i>

Note.

* Institutional ZIP code assigned by the United States Postal Service due to high mail volume; does not correspond

Descriptive Analysis

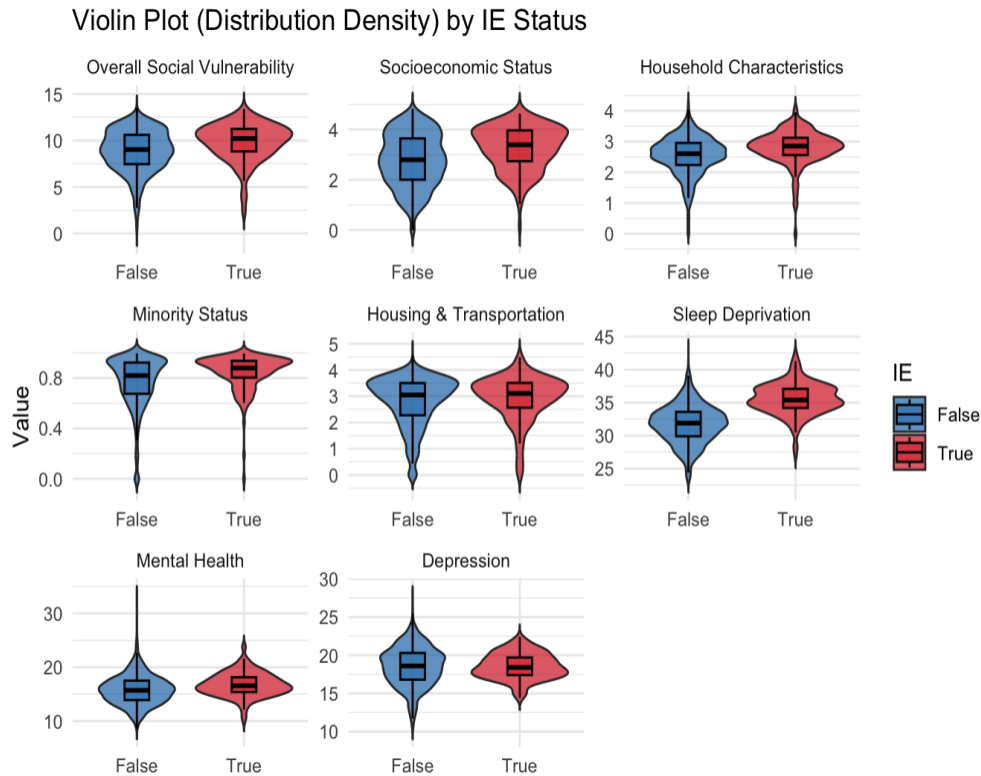


Figure 3. *Distribution of Social Vulnerability Index Theme Scores and Area-Level Mental Health Outcomes Across Inland Empire and California ZCTAs*

Figure 3 compares the distributions of social vulnerability scores and mental health outcomes across Inland Empire ZCTAs (IE = True) and California overall (IE = False). The analytic comparison included 168 Inland Empire ZCTAs and 1,715 non-Inland Empire California ZCTAs. In terms of social vulnerability, Inland Empire ZCTAs had higher median scores across all SVI measures. A higher median score indicates higher rates of social vulnerability. Since the reported SVI values are constructed scores rather than CDC percentile rankings, the scores reflect summed vulnerability indicators

rather than CDC SVI percentile scores. If the analysis is intended to use percentile scores, the reported median needs to be corrected to the 0-1 scale. Overall, SVI had a median of 10, compared to 8 for the state of California. Across all variables, Inland Empire ZCTAs demonstrated consistently higher values and more concentrated distributions than the broader California sample, reflecting the region's elevated structural vulnerability. Inland Empire ZCTAs showed worse mental health outcomes across all three indicators compared with non-Inland Empire California ZCTAs. Median prevalence of insufficient sleep was higher in the Inland Empire than in California (35% versus 32%). The IE also had a more concentrated and elevated spread of Poor mental health days (mental health not good for 14 or more days in the past 30 days) at 17% compared to 15% in California overall. Distributions of depression diagnosis were the most similar, with the Inland Empire being at 19% and California 18%. Inland Empire ZCTAs reflect a more concentrated distribution at higher vulnerability and worse mental health outcomes, consistent with the region's status as a high-vulnerability area. Household characteristic scores showed a modest difference, with both groups clustering around a median of 2.5-5

Primary Analysis: Association Between Overall SVI Score and Mental Health Outcomes

Table 3 presents the regression coefficients for the association between overall CDC Social Vulnerability Index scores and the three mental health outcomes examined across Inland Empire ZCTAs. SVI scores showed significant positive associations with

poor mental health days ($\beta = 0.49$, $SE = 0.02$, $p < .001$) and insufficient sleep ($\beta = 0.52$, $SE = 0.02$, $p < .001$), indicating that ZCTAs with higher overall social vulnerability had a greater prevalence of both outcomes. There was no significant association found between the overall SVI score and depression prevalence ($\beta = -0.03$, $SE = 0.02$, $p = 0.25$). These findings partially support the first study hypothesis, suggesting that higher area-level social vulnerability is associated with worse mental health outcomes for some of the indicators examined.

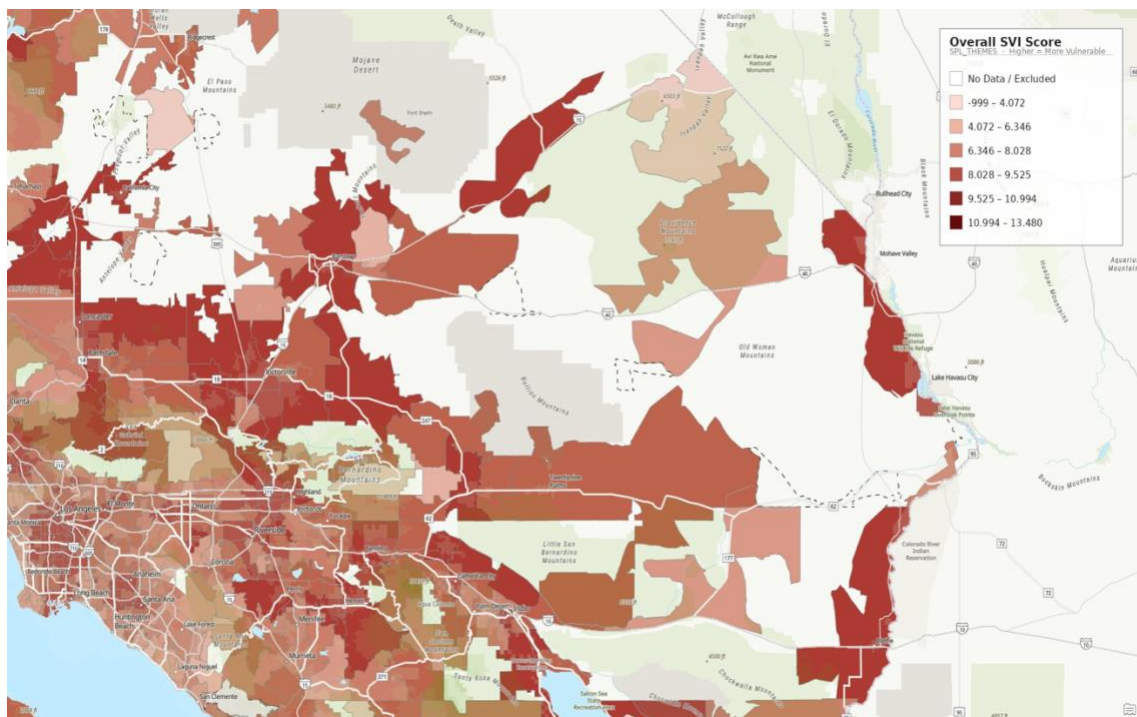


Figure 4: SVI Inland Empire Heat Map

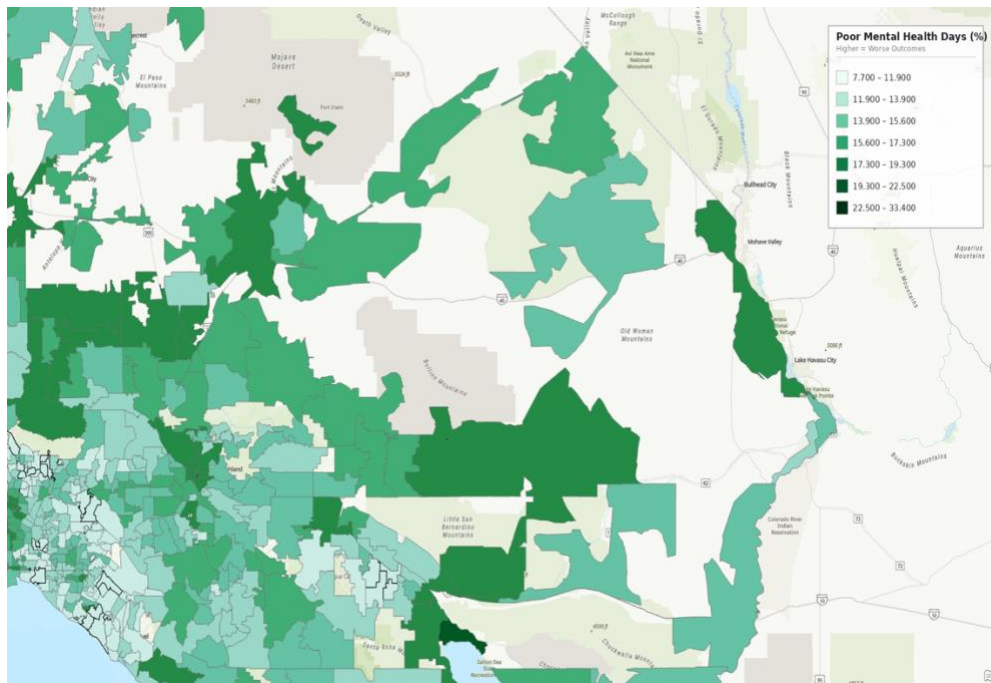


Figure 5: *Poor Mental Health in the Inland Empire ZCTA Distribution*

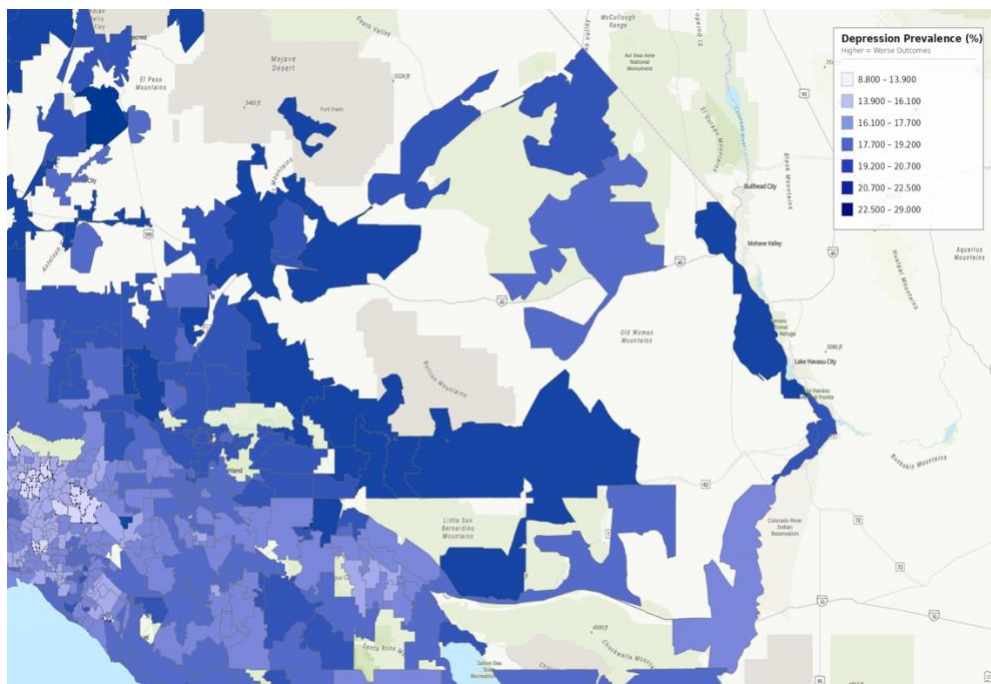


Figure 6: *Depression in the Inland Empire ZCTA Distribution*

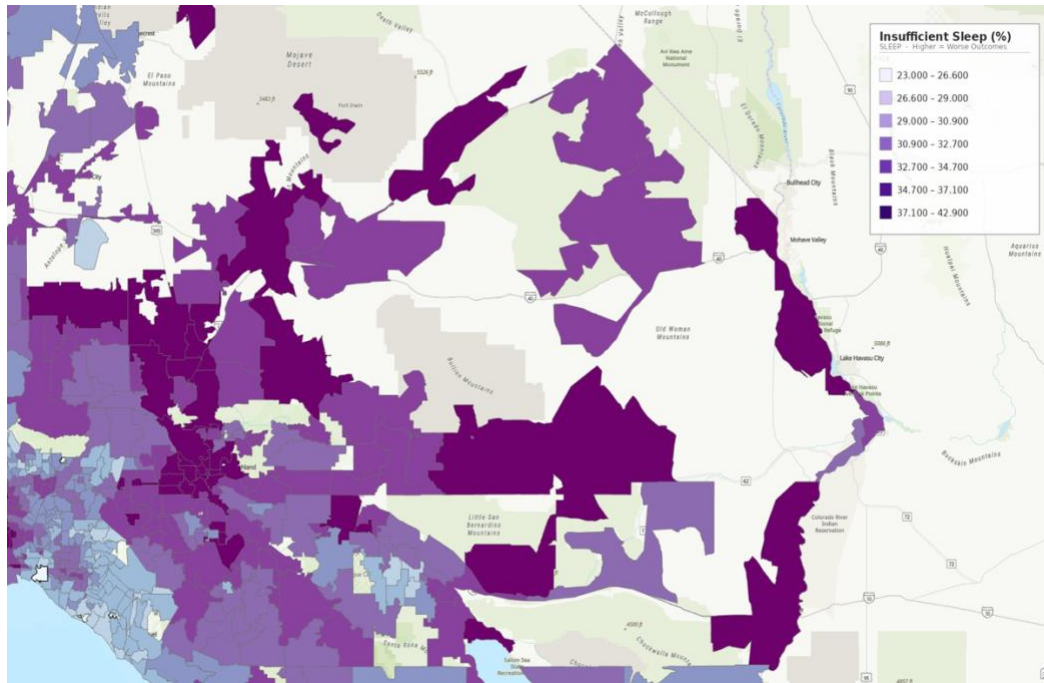


Figure 7: *Insufficient Sleep in the Inland Empire ZCTA Distribution*

Figures 4 through 7 present heat maps illustrating the geographic distribution of overall SVI scores, depression prevalence, poor mental health days, and insufficient sleep across the 168 Inland Empire ZCTAs included in the analytical sample. Darker shading indicates higher values, such as greater social vulnerability or mental health outcome across both Riverside and San Bernardino counties. The map reveals spatial clustering of elevated SVI scores and worse mental health outcomes in ZCTAs concentrated in the western and southern portions of the Inland Empire. Geographically remote regions show more variable SVI and a different pattern across mental health outcomes. The depression prevalence map shows the most uniform distribution across the region.

Table 3. Standardized Regression Coefficients for Social Vulnerability Index Predictors and Mental Health Outcomes

Predictor	Depression	Poor Mental Health Days	Insufficient Sleep
Theme 1: Socioeconomic Status	0.204*** (0.023)	0.672*** (0.017)	0.659*** (0.017)
Theme 2: Household Characteristics	0.029 (0.023)	0.258*** (0.022)	0.324*** (0.022)
Theme 3: Minority Status	-0.360*** (0.022)	0.217*** (0.023)	0.327*** (0.022)
Theme 4: Housing & Transportation	-0.232*** (0.022)	0.200*** (0.023)	0.212*** (0.023)
Social Vulnerability Index: Overall Score	-0.026 (0.023)	0.490*** (0.020)	0.518*** (0.020)

Note. Values are standardized regression coefficients. Standard errors are shown in parentheses. Each row represents a separate bivariate regression model predicting the indicated mental health outcome. All predictors and outcomes were standardized prior to analysis. *** $p < .001$.

*** $p < .001$.

Domain-Level Analysis: SVI Theme Scores and Mental Health Outcomes

Table 3 presents the analysis of the association between SVI and each specific theme and the three mental health outcomes. Across all models, socioeconomic status showed the strongest and most consistent association with mental health outcomes. Higher socioeconomic vulnerability was found to be significantly associated with greater prevalence of poor mental health days ($\beta = 0.67, p < 0.001$) and insufficient sleep ($\beta = 0.32, p < 0.001$). The household characteristics theme was significantly associated with

poor mental health days ($\beta = 0.26$, $SE = 0.02$, $p < .001$) and insufficient sleep ($\beta = 0.32$, $SE = 0.02$, $p < 0.001$), though no significant association was observed with depression prevalence ($\beta = 0.03$, $SE = 0.02$, $p = 0.20$). The theme of minority status had a significant association with poor mental health days ($\beta = 0.22$, $SE = 0.02$, $p < 0.001$) and insufficient sleep ($\beta = 0.33$, $SE = 0.02$, $p < 0.001$). The racial and ethnic minority status theme was positively associated with poor mental health days showed a significant inverse association with depression ($\beta = -0.36$, $SE = 0.02$, $p < 0.001$), indicating ZCTAs where a majority of the population identifies as a racial minority had a lower prevalence of depression. Also, the housing and transportation theme was significantly associated with poor mental health days ($\beta = 0.20$, $SE = 0.02$, $p < 0.001$) and insufficient sleep $\beta = 0.21$, $SE = 0.02$, $p < 0.001$) but showed a statistically significant inverse association with depression ($\beta = -0.23$, $SE = 0.02$, $p < 0.001$).

Interaction Analysis: University Proximity as a Modifying Variable

Table 4 presents result from interaction models examining whether geographic proximity to a postsecondary institution modified the association between overall SVI and mental health outcomes among Inland Empire ZCTAs. University proximity was defined as the straight-line distance from each ZCTAs geographic centroid to the nearest qualifying postsecondary institution within the Inland Empire that had a minimum enrollment of 1,000 students. The interaction term between overall SVI and university proximity was not statistically significant for depression prevalence ($\beta = 0.009$, $SE =$

0.050, $p = .858$), poor mental health days ($\beta = 0.076$, $SE = 0.052$, $p = .143$), or insufficient sleep ($\beta = 0.071$, $SE = 0.052$, $p = .173$).

Table 4. Association Between SVI Theme Scores, University Proximity, and Mental Health Outcomes Among Inland Empire ZCTAs

Predictor	Depression		Poor Mental Health Days		Insufficient Sleep	
	(1)	(2)	(3)	(4)	(5)	(6)
Socioeconomic Status	0.458*** (0.064)	0.459*** (0.064)	0.665*** (0.068)	0.654*** (0.065)	0.517*** (0.072)	0.502*** (0.066)
Household Characteristics	0.086 (0.061)	0.080 (0.068)	-0.076 (0.065)	0.048 (0.069)	-0.113 (0.069)	0.058 (0.070)
Minority Status	-0.110 (0.082)	-0.117 (0.090)	0.404*** (0.087)	0.555*** (0.092)	0.535*** (0.092)	0.744*** (0.093)
Housing & Transportation	-0.273*** (0.066)	-0.268*** (0.071)	-0.121* (0.071)	-0.216*** (0.072)	-0.167** (0.075)	-0.300*** (0.073)
Distance to University	0.266*** (0.055)	0.271*** (0.061)	0.309*** (0.059)	0.197*** (0.062)	0.213*** (0.062)	0.058 (0.063)
Population Density		-0.006 (0.030)		0.124*** (0.031)		0.172*** (0.031)
Constant	-0.117** (0.051)	-0.113** (0.056)	-0.017 (0.055)	-0.111* (0.057)	0.820*** (0.058)	0.689*** (0.058)
Observations	168	168	168	168	168	168
R ²	0.418	0.418	0.550	0.591	0.439	0.528
Adjusted R ²	0.400	0.397	0.536	0.576	0.421	0.511

Note. * $p < .10$. ** $p < .05$. *** $p < .01$

Despite the non-significant interaction, when looking at distance to postsecondary institution and mental health it did results as a significant independent predictor in all three mental health outcomes after controlling for all SVI themes. Before density adjustment, greater distance from a qualifying college or university was significantly associated with higher depression prevalence ($\beta = 0.266$, $SE = 0.055$, $p < .01$), poor mental health ($\beta = 0.309$, $SE = 0.059$, $p < .01$) and insufficient sleep ($\beta = 0.213$, $SE = 0.062$, $p < .01$), indicating that ZCTAs located closer to a university or college had better mental health outcomes independent of their structural vulnerability. When population

density was added as a covariate, the association between distance and prevalence of depression ($\beta = 0.271$, $SE = 0.061$, $p < .01$) and poor mental health days ($\beta = 0.197$, $SE = 0.062$, $p < .01$) remained statistically significant. The association of insufficient sleep because insignificant ($\beta = 0.058$, $SE = 0.063$, $p = 0.36$). Population density itself was significantly and positively associated with poor mental health days ($\beta = 0.124$, $SE = 0.031$, $p < .01$) and insufficient sleep ($\beta = 0.172$, $SE = 0.031$, $p < .01$)

Chapter 4: Discussion

This study examined the association between CDC Social Vulnerability Index scores and area-level mental health outcomes across 168 ZCTAs in the Inland Empire region. The findings provide partial support for the first study hypothesis and largely support the second. Overall, SVI scores were significantly associated with poor mental health days and insufficient sleep, but not with the prevalence of depression. When looking at each of the individual themes, socioeconomic status was the strongest and most consistent predictor across all three mental health outcomes, while minority status and housing transportation themes demonstrated inverse association with depression prevalence.

Association Between Overall SVI and Mental Health Outcomes

The finding that higher overall SVI scores were significantly associated with greater prevalence of poor mental health days and insufficient sleep is consistent with the literature. Research has shown that individuals and communities exposed to greater structural disadvantages experience a higher rate of psychiatric morbidity, with structural conditions including poverty, housing instability, and limited access to resources acting as drivers of mental health disparities (Kirkbride et al., 2024). The statistically significant association observed for poor mental health days, and insufficient sleep can suggest that area-level social vulnerability captures variations within community mental health

burdens across Inland Empire ZCTAs, supporting the validity of the SVI as a tool for identifying communities at elevated mental health risk beyond its original application. SVI and depression prevalence were not significantly associated. Unlike the other two outcomes that are completely self-reported, depression prevalence needs a clinical diagnosis from a medical provider. In highly vulnerable communities, factors such as lack of access to healthcare, transportation barriers, and cultural stigma around mental health can prevent those in ZCTAs from obtaining a formal diagnosis, leading to lower rates of depression even when depression symptoms are elevated (Tran et al., 2023). This also aligns with the Inland Empire's status as a medically underserved region where provider-to-patient ratios reflect a lack of proper medical support (Shin et al., 2024). The findings of this study are also consistent with other limited research examining the association between social vulnerability and mental health outcomes. Gibbons et al. (2024) conducted a national examination of social vulnerability and mental health and found significant associations between social vulnerability and mental health. The present study extends this work by applying SVI at the ZCTA level and a study conducted by Ng et al. (2025) validated that the SVI at the ZCTA level is valid and reproduceable framework for community health disparities.

Domain-level Association Between SVI and Mental Health Outcomes

Domain-level analysis highlighted variation in the strength and direction of association across different SVI themes. Socioeconomic status was the strongest and

most consistent predictor across all three outcomes, demonstrating a statistically significant positive association with poor mental health days, insufficient sleep, and depression prevalence. This finding is consistent with the second study hypothesis (Socioeconomic status will be the strongest predictor of mental health outcomes) and align with research which demonstrates that socioeconomic disadvantage is a fundamental determinant of mental health outcomes across the life course (Kirkbride et al., 2024; Tibber et al., 2022). Socioeconomic stressors include living below the federal poverty line, unemployment, housing cost burden, and lack of health insurance (Reiss et al., 2019). These are also well-established risk factors for depression and psychological distress. This operates through pathways of chronic stress, reduced access to protective services, and limited autonomy on one's health (Salem & Robenson, 2025). When looking specifically at poor mental health and insufficient sleep, these reflect a daily lived experience and highlight that socioeconomic vulnerability may have a direct effect through chronic stress and shape everyday well-being. The theme of household characteristics was also significantly associated with poor mental health days and insufficient sleep, but not with depression prevalence. This pattern shows that daily symptom experience is more sensitive to area-level vulnerability than clinically diagnosed conditions. The lack of significance of depression prevalence for this theme further supports the idea that diagnostic access barriers reduce the observable relationship between vulnerability and clinically measured mental health outcomes in the study context (Vincent et al., 2024). The most notable finding is the inverse association between minority status theme and depression prevalence, indicating that ZCTAs with

higher minority status vulnerability scores had lower prevalence of diagnosed depression. This inverse association was also observed for the theme of housing and transportation. While these findings may seem counterintuitive given the established literature linking structural racism and minority status to elevated mental health burden, there are explanations for this outcome (Beech et al., 2021; Mezzina et al., 2022). First, the Latino health paradox is a well-documented epidemiological phenomenon in which Latinx populations demonstrate health outcomes that are better than expected in relation to their socioeconomic position, which can contribute to the inverse in depression prevalence (Roche et al, 2024; Anouti et al., 2023; Arpawong et al., 2023). Also, given that about 52.5% of the Inland Empire population identifies as Latinx and that the minority status theme is heavily weighted toward Hispanic and Latinx populations in this region, it can be inferred that communities with high populations of minority status may reflect the protective effects of cultural social support and community cohesion (Ruiz et al., 2016). But the depression in the context of this study requires an official diagnosis by a provider. Furthermore, racial minorities and ZCTAs with poor transportation may not get diagnoses due to cultural stigma and lack of transportation access to health services, leading to underreporting, especially since there was a high rate of poor mental health days in these themes (Kumar et al., 2025). This is also consistent with literature that highlights that Latinx populations face significant structural barriers to mental health access and have the highest rates of uninsurance (Quesada et al., 2024; Pérez-Flores et al., 2025; Sorkin et al., 2016). The interpretation of the inverse depression findings in this study is further informed by broader literature on Latino mental health through the

National Latino and Asian American Study. Algeria et al. (2004) developed the NLAAS to address the gap in population-level mental health data for Latino and Asian American communities. A major finding of this study highlighted that standard diagnostic instruments underestimate the prevalence of psychiatric disorders in these communities. The interpretation of the inverse depression findings in this study is further informed by broader literature from contributions of the National Latino and Asian American Study. The study highlighted that standard diagnostic tools may underestimate actual disease burden prevalence in Latino populations through construction bias (Algeria et al., 2004). Applied to the present study, this evidence suggests that lower rates of diagnosed depression overall in high-risk communities may reflect structural burden and protective factors, but also a fundamental mismatch between standard measures and cultural signs of distress. Since minority theme status aggregates all non-white racial and ethnic groups, heterogeneity may be masked in mental health outcomes across different communities, as different racial and ethnic groups may have distinct mental health profiles and exposure patterns, and stigma-related suppression operates alongside structural access barriers to further widen the gap between true symptom burden and measured depression prevalence. This shows that future research can benefit from looking at SVI and mental health outcomes for different minority groups specifically.

University Proximity and Association between SVI and Mental Health Outcomes

The third research question examined whether geographic proximity to postsecondary institutions modified the association between social vulnerability and mental health outcomes among ZCTAs in the Inland Empire. The interaction term of university proximity was not statistically significant for any of the three outcomes examined, which did not support the third hypothesis (University proximity will modify the association between SVI and mental health within Inland Empire ZCTAs). The non-significant interaction should be considered, given the study's sample size. With only 168 ZCTAs, the interaction model may have been underpowered to detect a meaningful modifying effect, even if one exists at the population level, leading to a type II error (Mascha & Vetter, 2018). Despite there not being a significant interaction, distance to the postsecondary institution emerged as a significant independent predictor of depression prevalence and poor mental health days, controlling for all four SVI themes and population density. This suggests that while proximity does not modify the SVI-mental health relationship, it highlights an independent dimension of community resource access not fully captured by SVI. One mechanism for these findings is access to resources. Universities, especially those with affiliated medical schools or teaching hospitals, may concentrate mental health professionals in surrounding areas. Research shows that at the ZCTA level, there is variation in the availability of specialty mental health treatment resources across communities, with communities in rural areas farther from things like universities having reduced access to mental health care (Cummings et al., 2017). A

spatial analysis across almost 40,000 ZIP code communities found that rural and economically disadvantaged communities, those that tend to be farther from universities, had the highest likelihood of experiencing psychiatrist shortages (Bacolod et al., 2023). In the Inland Empire, the region is designated as medically underserved, with large patient-to-provider ratios. Likely, the concentration of mental health providers near universities and affiliated clinics or programs may help potentially explain why ZCTAs closer to the qualifying postsecondary institutions showed better mental health outcomes (Shin et al., 2024).

The change in significance of insufficient sleep when density was taken into consideration is also key. The proximity benefit for sleep observed in the unadjusted model was driven by a higher population in university-adjacent ZCTAs rather than proximity to the university itself. Population density was itself significantly and positively associated with insufficient sleep ($\beta = 0.172$, $SE = 0.031$, $p < .01$), meaning that denser ZCTAs near universities actually had worse sleep outcomes. These findings are consistent with research demonstrating that denser urban environments expose residents to chronic noise from traffic and crowding, artificial light, and neighborhood disorder, which have been linked to poor sleep and reduced sleep. Minor populations were more vulnerable to these disturbances (Johnson et al., 2018). Once population density was accounted for, proximity to a university no longer explained sleep outcomes, which indicated that the sleep findings in the unadjusted model were an effect of density rather than a true proximity effect.

Limitations

Several methodological limitations should be considered when interpreting this study's findings. The study design is cross-sectional and ecological, so causality cannot be established. There is also a risk of ecological fallacy, in which associations observed at the ZCTA level cannot be assumed to reflect generalizability to individual-level relationships. Also, since the unit of analysis for this study is ZCTA, it is not possible to determine whether residents most exposed to social vulnerability within a given ZCTA are the same individuals experiencing poor mental health outcomes. There are also limitations around the possibility of confounding variables, as well as factors not taken into consideration that could contribute to social vulnerability. An example for this would be food insecurity, which can lead to poor mental health outcomes through chronic stress pathways, and those who are food insecure are also likely to face vulnerability (Ejiohu et al., 2024). For the third research question, straight line distance does not account for travel time, road access, public transportation availability, or the range of community-facing programs offered by each institution. These factors can be more accurate at capturing whether a resident can meaningfully access resources than geographic distance alone (National Academies of Sciences, Engineering, and Medicine, 2017). Also, the small sample of 168 ZCTAs may have limited statistical power, and further studies should consider larger regional samples and more proximal measures of university-community engagement to better test the modifying role of institutional proximity on area-level mental health outcomes.

Public Health Implications

For future public health practice, distinguishing between genuine cultural protection and structural barriers to diagnostic access in communities where higher minority status is associated with lower depression prevalence requires a multimethod approach that moves beyond cross-sectional ecological data. Several practical strategies could help detangle these mechanisms in the Inland Empire context. First, administering validated symptom-based depression screens alongside diagnostic-based prevalence measures in the same communities would provide a direct empirical test for the diagnostic gap hypothesis. Second, examining mental health emergency department utilization rates, crisis intervention contacts, and unmet need data with depression diagnosis rates would further help clarify whether low diagnostic prevalence reflects lower symptom burden. Third, there culturally adapted diagnostic instruments should be incorporated to allow for a more accurate estimation of true depression prevalence in Latino communities whose symptom expression may not align with standard diagnostic criteria (Algeria et al., 2004).

The findings of the study most directly support upstream policy approaches targeting the socioeconomic status domain of the SVI, which was the strongest and most consistent predictor of poor mental health days and insufficient sleep across all models. Translating this into policy recommendations should focus on expanding Medi-Cal mental health benefit coverage to include preventative and community-based mental

health services within ZCTAs that have the highest level of vulnerability. Other policies around affordable housing initiatives and investment in federally qualified health centers can also be targeted to improve components around poverty, unemployment, housing cost burden, and more. This recommendation is grounded specifically in the socioeconomic status theme and is further supported by evidence from other research demonstrating that social position is a primary determinant of psychiatric disorder risk in communities with high levels of minority populations (Algeria et al, 2004;Roche et al, 2024; Anouti et al., 2023; Arpawong et al., 2023).

Chapter 5: Conclusion

This study examined the association between SVI scores and area-level mental health outcomes, such as poor mental health days, depression, and lack of sufficient sleep. The findings of this study make several important contributions to the existing literature. The study extends the use of the SVI beyond its traditional applications in disaster preparedness and chronic disease research, demonstrating its benefits as a tool for identifying ZCTAs with elevated risk of poor mental health outcomes. The study also highlights that composite vulnerability measures may perform differently across mental health outcomes, depending on whether the outcomes require a clinical diagnosis, suggesting the need for methodological nuance in future area-level mental health research. The study also provides grounded evidence of the mental health burden that is carried by Inland Empire communities, which is a region that has historically been underrepresented in population-level mental health research despite its growing population.

Future research should build on these findings in several ways. Studies that incorporate individual-level data alongside area-level SVI measures would help address the ecological fallacy and provide a more complete picture of how structural vulnerability affects mental health at both the community and individual levels. Future research should also build on the null findings from the proximity analysis and examine more direct measures of university-based community engagement that more accurately capture

universities' influence on mental health. There should also be a direct examination of what specific mechanisms mediate the associations found between university proximity and mental health outcomes, incorporating larger regional samples. Research that disaggregates mental health outcomes by specific racial and ethnic groups, such as Latinx or African American populations, instead of a composite minority, can aid in advancing the understanding of distinct pathways through which structural disadvantage affects different communities. Addressing mental health disparities in structurally vulnerable communities requires moving beyond individual-level clinical interventions toward upstream structural approaches that target the socioeconomic conditions, healthcare access barriers, and systemic inequities that drive poor mental health outcomes at the community level. The findings of this study provide an empirical foundation for approaches in the Inland Empire and provide a replicable framework for examining the structural determinants of mental health in regions with high vulnerability across the United States.

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