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Original Article

County-level determinants of mental and physical health in the United States: comparative analysis of environmental, socioeconomic, and demographic factors

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Abstract

Background and objectives: Mental and physical health are influenced by a complex interplay of environmental, socioeconomic, and demographic factors, yet county-level determinants and their differential effects on these outcomes remain underexplored. Accordingly, this study examines the associations between a comprehensive set of environmental, socioeconomic, and demographic factors and county-level mental and physical health outcomes in the U.S., with particular attention to differences in their determinants.

Materials and Methods: Data from 2145 counties were analyzed, focusing on the percentage of adults experiencing frequent mental distress and frequent physical distress, defined as 14 or more days of poor health per month. Descriptive analyses summarized outcome distributions and their associations with county characteristics, while multivariate ordinary least squares regressions with state-clustered standard errors identified significant predictors across living environment, socioeconomic, and demographic domains.

Results: Housing quality, insufficient sleep, and access to healthy food were significantly associated with both mental and physical distress, with mental health particularly sensitive to housing and sleep challenges. Educational attainment and household income were negatively associated with both outcomes, while poverty was positively associated with distress across domains. Demographic factors showed outcome-specific patterns: female population share was associated with both mental and physical health, non-Hispanic white population share was significant only for mental health, rurality only for physical health, and older age was negatively associated for physical but not mental distress.

Conclusion: These findings highlight that county-level structural, socioeconomic, and demographic characteristics were jointly associated with mental and physical health, with both shared and outcome-specific effects, offering guidance for targeted public health interventions, resource allocation, and policy development.

Introduction

Mental and physical health are fundamental indicators of population well-being and are closely linked to quality of life, productivity, and social functioning. Research has consistently shown that poor mental health can increase the risk of chronic

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physical conditions, while physical health problems can exacerbate psychological distress, highlighting the interdependence of these outcomes. However, health outcomes are not solely linked at the individual level; structural and contextual factors at the community or county level play a critical role in shaping patterns of distress. County-level characteristics such as housing quality, access to healthcare providers, neighborhood safety, environmental exposures, and local food environments can create systematic variations in both mental and physical health across populations. Similarly, socioeconomic conditions—including educational attainment, income levels, and social support—and demographic composition, such as age, gender, race, and rurality, are further associated with population health, potentially amplifying or mitigating health disparities.

Despite growing recognition of the importance of county-level determinants, existing research has often focused on either mental or physical health outcomes in isolation or has examined individual-level risk factors without accounting for broader structural contexts [1, 2, 3]. As a result, it remains unclear how environmental, socioeconomic, and demographic factors simultaneously relate to mental and physical health at the county level, and whether the same factors are significant for both outcomes. Understanding these differences is critical for designing targeted public health interventions, allocating resources efficiently, and addressing health disparities effectively.

This study aims to fill this gap by integrating two publicly available datasets—the County Health Rankings National Data and county-level poverty measures from the U.S. Department of Agriculture (USDA)—to examine the associations between county-level living environment, socioeconomic conditions, and demographic characteristics with the prevalence of frequent mental and physical distress among adults. Mental distress and physical distress are defined as experiencing 14 or more days of poor mental or physical health in a month, allowing for a standardized measure of burden across counties. By combining descriptive analyses with multivariate regression models, we provide a comparative assessment of the correlates of mental versus physical health, highlighting which county-level factors are significantly associated with each outcome and offering evidence to guide management and policy decisions.

This study is anchored in the Social Determinants of Health (SDoH) framework, which posits that population health is shaped by the conditions in which people live and work. Rather than viewing health as a purely biological outcome, this framework allows us to systematically categorize county-level predictors into three critical domains: living environment (e.g., housing and food access), socioeconomic status (e.g., income and education), and demographic composition (e.g., age and rurality). By applying this framework, we can theorize how structural inequities and resource distribution are differentially linked to mental versus physical distress across U.S. counties.

Materials and methods

Two publicly available datasets were merged. The first dataset was the County Health Rankings National Data, obtained from the County Health Rankings & Roadmaps website (released January 2025) [4]. The second dataset was the County-Level Poverty Data (released January 31, 2025), obtained from the U.S. Department of Agriculture (USDA) Economic Research Service [5].The County Health Rankings dataset provided county-level information for 3,159 counties across the 50 U.S. states, including two mental health outcome measures: the *percentage of adults experiencing frequent mental distress* and the *percentage of adults experiencing frequent physical distress*, defined as reporting 14 or more days of poor mental and physical health per month. Additionally, the dataset included a comprehensive set of county-level covariates capturing living environment conditions (such as primary care physician density, mental health provider density, the food environment index, the share of households with severe housing problems, the prevalence of insufficient sleep, the proportion of long-commute workers who drive alone, and average daily particulate matter-PM2.5 concentrations), social and economic factors (educational attainment, median household income, and the prevalence of inadequate social and emotional support), and demographic characteristics (the proportion of residents aged 65 and older, female, non-Hispanic white, and living in

rural areas). To account for broader socioeconomic context at the state level, a state-level poverty indicator from the USDA was merged into the county-level dataset.

Analysis focuses on county-level mental and physical health by examining two outcome measures: the percentage of adults reporting frequent mental distress and the percentage reporting frequent physical distress. Both measures are defined as experiencing 14 or more days of poor mental or physical health within a month. Missing data were addressed using listwise deletion to ensure the consistency and integrity of the multivariate analysis. From the initial 3,159 U.S. counties, observations with missing values in any of the primary outcomes or the 15 covariates were excluded. This process resulted in a final analytic sample of 2,145 counties, covering approximately 70% of all U.S. counties. The use of listwise deletion ensures that all comparative analyses between mental and physical health outcomes are based on an identical set of observations, thereby enhancing the internal validity of the findings.

We first conducted descriptive analyses to assess the distribution of each outcome across counties. Histogram-based visualizations were used to summarize key distributional features, including central tendency, dispersion, skewness, and the presence of extreme values. These descriptive results provide an overview of cross-county variation in mental and physical health and inform the subsequent empirical analysis.

To assess bivariate associations, we explored how environmental, socioeconomic, and demographic characteristics vary with levels of each health outcome. A series of visualizations (scatter plots) was employed to examine the conditional distributions of key covariates across different degrees of mental and physical health burden. This exploratory analysis offers an intuitive depiction of potential relationships between predictors and outcomes and helps identify patterns that motivate the multivariate regression framework.

The explanatory variables comprise a broad set of county-level indicators capturing living environment conditions, socioeconomic circumstances, and population structure. Living environment measures include primary care physician supply, mental health provider supply, the food environment index, the proportion of households facing severe housing problems, the prevalence of insufficient sleep, the share of workers with long commutes who drive alone, and average daily concentrations of PM2.5. Socioeconomic variables include educational attainment, median household income, poverty, and the prevalence of inadequate social and emotional support. Demographic controls include the proportion of the population aged 65 and older, female, non-Hispanic White, and residing in rural areas.

Because counties are nested within states, we estimated multivariate ordinary least squares (OLS) models with standard errors clustered at the state level to account for within-state correlation arising from shared policy environments, economic conditions, and institutional contexts. Separate regressions were estimated for mental distress and physical distress, enabling direct comparison of coefficient magnitudes and statistical significance across the two outcomes.

Taken together, the descriptive and regression analyses provide a comparative assessment of the correlates of mental and physical health at the county level, highlighting how environmental, socioeconomic, and demographic factors are differentially associated with each outcome. All analyses were implemented in Python 3.12.12 using Google Colab**.**

Results

A descriptive assessment of the distributions of the two health outcome measures: the percentage of adults experiencing frequent mental distress and the percentage of adults experiencing frequent physical distress was conducted. The purpose of this step was to determine where county-level observations are most concentrated and to summarize the overall dispersion of each outcome before proceeding to multivariate analysis. The histogram of adults reporting frequent mental distress indicates that the largest share of counties falls within the range of approximately 18% to 19% per month, suggesting this interval reflects the modal level of mental health burden across counties. In contrast, the distribution of adults

reporting frequent mental distress shows the greatest concentration between 12% to 13% per month. Taken together, these patterns indicate that, at their most commonly observed levels, counties report marginally higher frequencies of mental distress than physical distress.

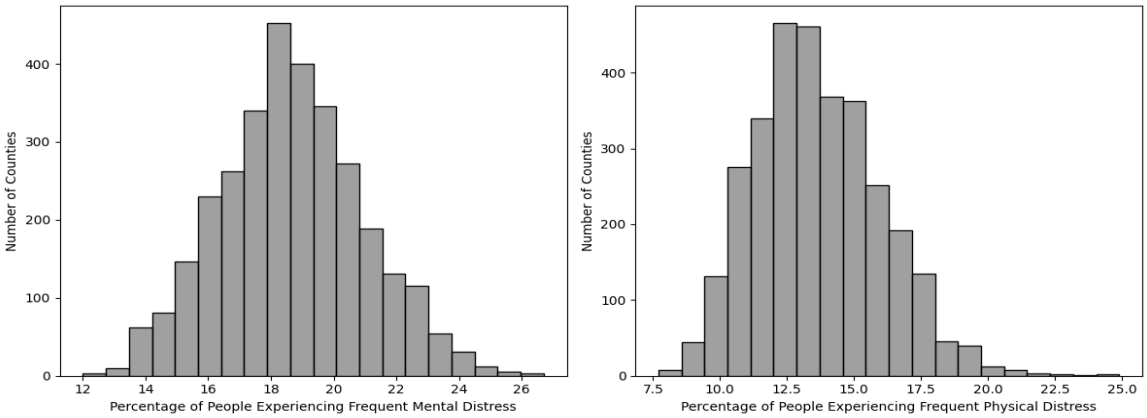

Figure-1*: Distributions of mental and physical health outcome variables across counties*

To examine bivariate associations, we assessed the distributions of key covariates conditional on levels of mental and physical health outcomes, providing insight into how county characteristics vary with the intensity of health burden. Figure-2 presents the distributions of county-level covariates across the share of adults reporting frequent mental distress. Counties with higher prevalence of insufficient sleep, larger rural populations, and weaker social and emotional support tend to exhibit more mentally unhealthy days. In contrast, more favorable food environments, higher educational attainment, and greater median household income are associated with fewer days of mental distress.

Figure-3 illustrates the distributions of county-level covariates across levels of frequent physical distress and reveals patterns that closely mirror those observed for mentally unhealthy days. Counties with higher prevalence of insufficient sleep, greater rural population shares, and higher levels of inadequate social and emotional support tend to report more physically unhealthy days. By contrast, more favorable food environments, higher educational attainment, and higher median household income are associated with fewer physically unhealthy days.

To assess how county-level characteristics relate to mental and physical health, we estimated multivariate ordinary least squares (OLS) regression models with standard errors clustered at the state level. When examining the percentage of adults experiencing frequent mental distress, several predictors exhibit statistically significant positive relationships. Counties facing more severe housing challenges tend to experience higher levels of mental distress (coefficient = 0.057, p = 0.015). Similarly, a higher prevalence of insufficient sleep is associated with an increase in the percentage of experiencing frequent mental distress (coefficient = 0.189, p< 0.001). Mental distress is also more pronounced in counties with larger shares of non-Hispanic white residents (coefficient = 0.042, p < 0.001), higher poverty rates (coefficient = 0.184, p = 0.035), and greater proportions of female residents (coefficient = 0.103, p< 0.001).

In contrast, several socioeconomic indicators are inversely related to the percentage of adults experiencing frequent mental distress. Higher educational attainment is associated with lower levels of reported mental distress (coefficient = −0.055, p < 0.001), as is the food environment index (coefficient = −0.263, p = 0.005). Median household income likewise shows a negative association with mentally unhealthy days, although the magnitude of this relationship is relatively modest (coefficient = −0.00001, p = 0.006).

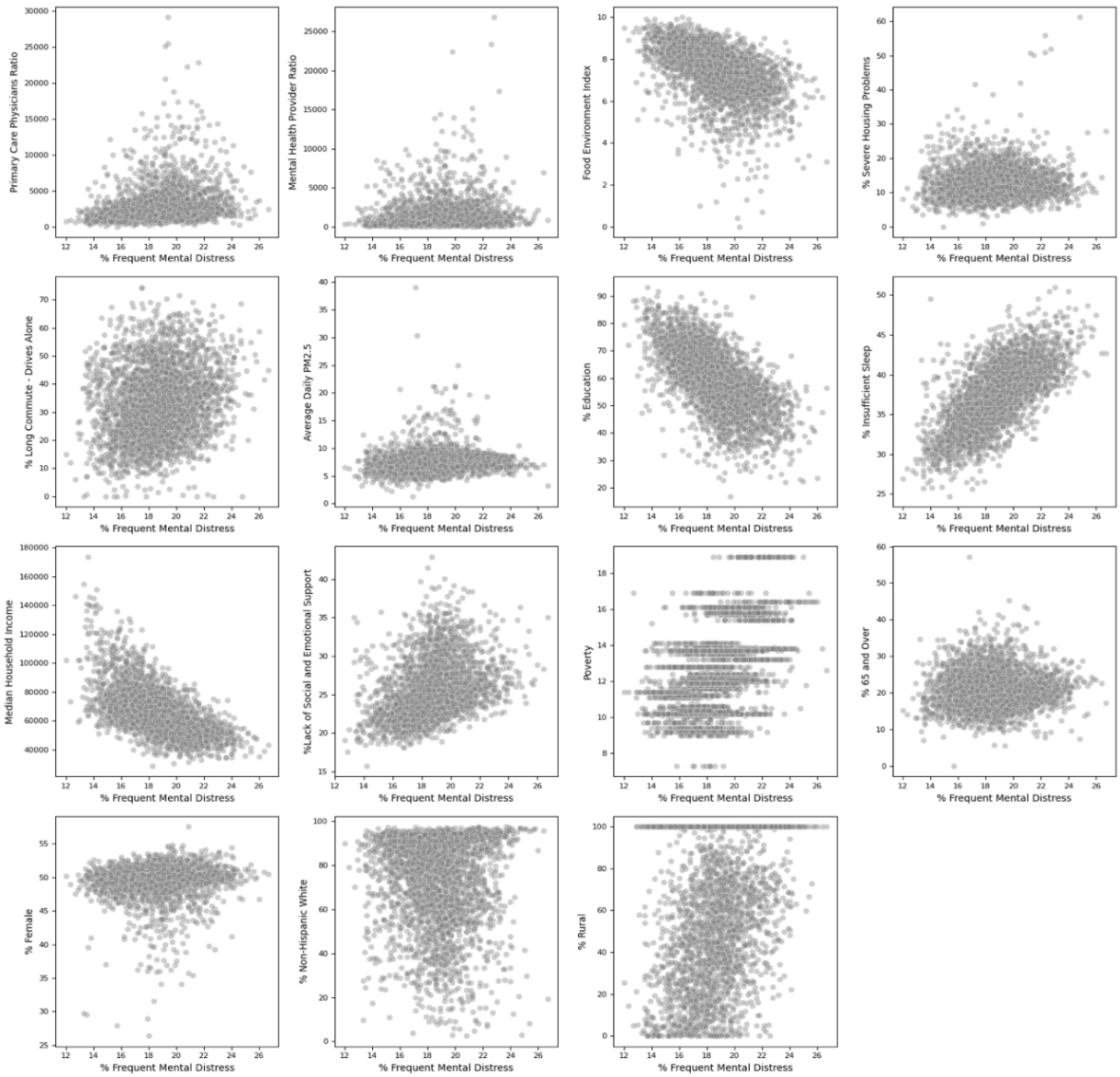

Figure-2: *Distributions of county-level covariates across percentage of people experiencing frequent mental distress*

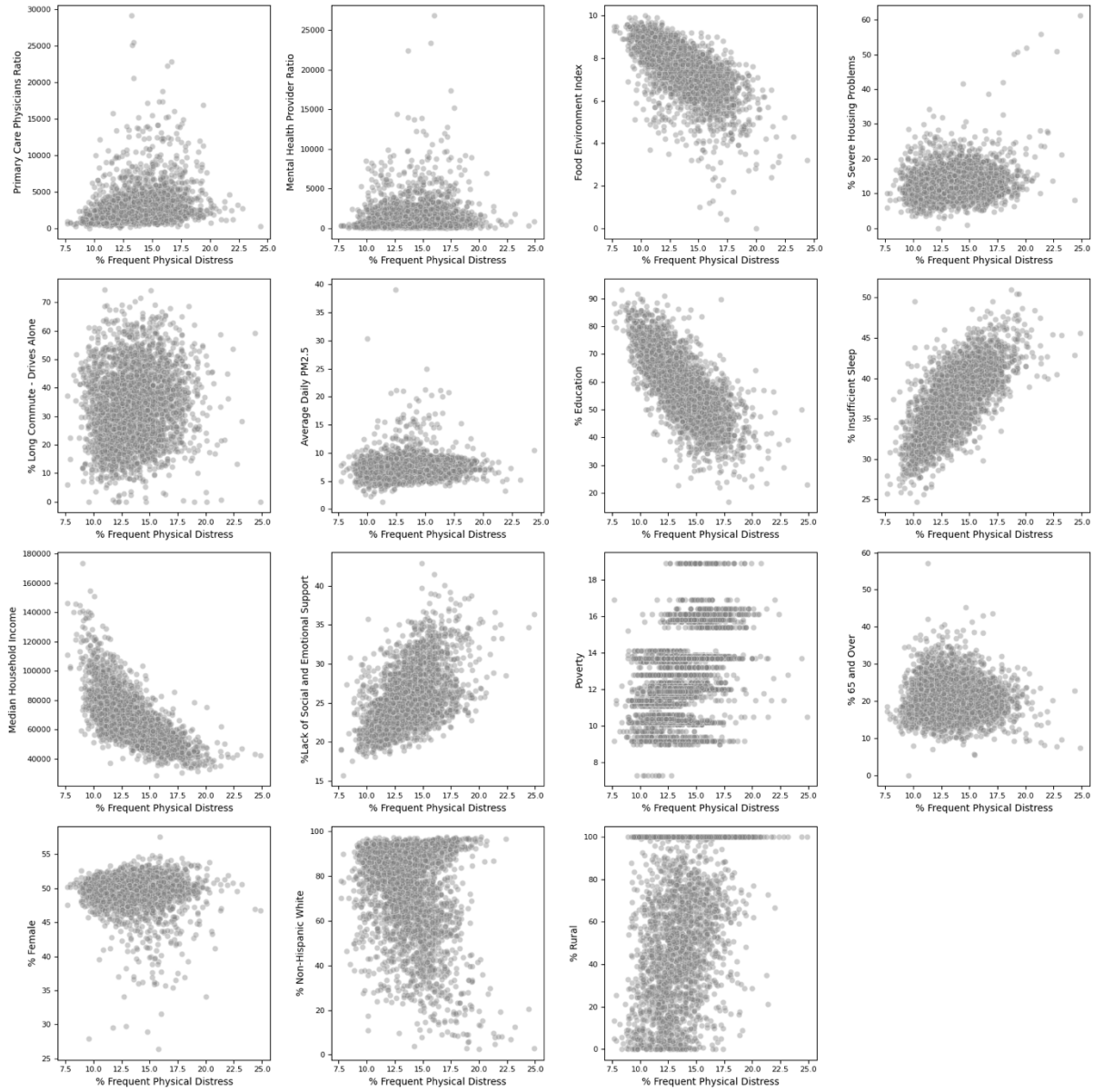

Figure-3: *Distributions of county-level covariates across percentage of people experiencing frequent physical distress*

The pattern of associations changes when focusing on physical health outcomes. Several county-level characteristics are positively and significantly related to the share of adults reporting frequent physical distress. Counties with more severe housing problems tend to have higher levels of physical distress (coefficient = 0.084, $p< 0.001$). A higher prevalence of insufficient sleep is likewise associated with a greater proportion of adults experiencing frequent physical distress (coefficient = 0.148, $p< 0.001$). Physical distress is also more prevalent in counties with larger female populations (coefficient = 0.043, $p= 0.010$), higher poverty rates (coefficient = 0.128, $p= 0.009$), and a greater share of residents living in rural areas (coefficient = 0.009, $p< 0.001$).

In contrast, several factors are inversely associated with frequent physical distress. Higher levels of educational attainment are linked to a lower percentage of adults reporting physical distress (coefficient = −0.061, $p< 0.001$), and median household income shows a similar negative relationship, although the magnitude is relatively small (coefficient = −0.00003, $p< 0.001$). In addition, more favorable food environments are associated with reduced physical distress (coefficient = −0.404, $p< 0.001$), as is a higher proportion of residents aged 65 and older (coefficient = −0.049, $p< 0.001$).

Table-1: *OLS regression results for mental and physical health outcomes*

	% Frequent Mental Distress				% Frequent Physical Distress			
Covariates	Coefficients	standard error	z	*p* value	Coefficients	standard error	z	*p* value
Primary Care Physicians Ratio	-0.0000008	0.00001	-0.062	0.951	0.00002	0.00001	1.503	0.133
Mental Health Provider Ratio	-0.00004	0.00004	-1.110	0.267	-0.00004	0.00002	-1.905	0.057
Food Environment Index	-0.263	0.094	-2.786	0.005	-0.404	0.068	-5.979	<0.001
Insufficient Sleep	0.189	0.036	5.191	<0.001	0.148	0.025	6.000	<0.001
% Severe Housing Problems	0.057	0.024	2.428	0.015	0.084	0.018	4.635	<0.001
% Long Commute by Driving Alone	0.001	0.005	0.273	0.785	-0.005	0.004	-1.273	0.203
Average Daily PM2.5	0.008	0.048	0.160	0.873	0.045	0.039	1.157	0.247
% Poverty	0.184	0.087	2.110	0.035	0.128	0.049	2.616	0.009
% Education	-0.055	0.007	-8.086	<0.001	-0.061	0.004	-13.722	<0.001
Median Household Income	-0.00001	0.000005	-2.762	0.006	-0.00003	0.000007	-4.180	<0.001
% Lacking of Social and Emotional Support	0.085	0.054	1.569	0.117	0.026	0.035	0.743	0.458
% 65 and Over	-0.015	0.016	-0.933	0.351	-0.049	0.008	-6.100	<0.001
% Female	0.103	0.020	5.162	<0.001	0.043	0.017	2.566	0.010
% Non-Hispanic White	0.042	0.010	4.254	<0.001	0.011	0.006	1.732	0.083
% Rural	0.004	0.003	1.279	0.201	0.009	0.002	4.889	<0.001
Observations (N)		2145				2145		
R^2		0.717				0.795		
Adjusted R^2		0.715				0.793		
F-statistic		131.1				344.8		

The multivariate OLS models demonstrate high explanatory power for both health outcomes. The model for frequent physical distress achieved an R^2 of 0.795 (adjusted R^2 = 0.793), while the model for frequent mental distress yielded an R^2 of 0.717 (adjusted R^2= 0.715), indicating that the environmental, socioeconomic, and demographic predictors account for a substantial portion of the variance in county-level health. The F-statistics for both the physical health model (F = 344.8, p< 0.001) and the mental health model (F = 131.1, p< 0.001) were highly significant, confirming the overall statistical validity of the models. To address potential heteroscedasticity and within-state correlation, state-clustered standard errors were employed, ensuring the robustness of the reported significance levels.

To ensure the statistical rigor of our multivariate models, we conducted a formal diagnostic assessment for multicollinearity across all predictors. The Variance Inflation Factor (VIF) analysis revealed that all individual VIF values range from 1.231 to 3.364, well below the conservative threshold of 5, indicating that the estimated OLS coefficients are stable and reliable. Furthermore, a Pearson correlation matrix was examined to inspect pairwise relationships between socioeconomic, environmental, and demographic factors. No pairwise correlations between independent variables exceeded the 0.80 threshold. These results confirm that while the predictors are theoretically linked under the SDoH framework, they remain statistically distinct, allowing for a robust comparative analysis of mental and physical health determinants.

Table-2: *VIF results for independent variables*

Covariates	VIF Results
Primary care physicians ratio	1.372
Mental health provider ratio	1.255
Food Environment Index	2.012
Insufficient Sleep	2.694
% Severe Housing Problems	1.782
% Long Commute by Driving Alone	1.692
Average Daily PM2.5	1.278
% Poverty	1.573
% Education	2.651
Median Household Income	3.364
% Lacking of Social and Emotional Support	3.287
% 65 and Over	1.478
% Female	1.231
% Non-Hispanic White	2.967
% Rural	2.558

Discussion

Our county-level analyses reveal that environmental, socioeconomic, and demographic factors collectively shape mental and physical health outcomes across U.S. counties. Comparing these outcomes highlights both shared determinants and outcome-specific significance, providing insights into how structural and contextual factors are linked to population well-being. Recognizing which factors are significantly associated with mental versus physical health is essential for guiding targeted public health strategies and management interventions.

Living environment factors, including housing quality, sleep patterns, and access to a healthy food environment, are consistently associated with health outcomes. Severe housing problems and insufficient sleep are significantly associated with both mental and physical distress, though mental health appears particularly sensitive [6,7]. Similarly,

more favorable food environments are significantly protective for both outcomes [8]. These findings suggest that interventions to improve housing stability, promote adequate sleep, and expand access to nutritious foods could benefit both mental and physical health. Public health agencies could prioritize mental health services in areas with severe housing or sleep challenges, while partnering with community organizations and local authorities to address food access and housing conditions.

Socioeconomic factors also demonstrate important associations. Higher educational attainment is significantly protective for both mental and physical health. Median household income similarly shows significant protective effects. These results underscore the importance of upstream interventions that address social determinants, including education and income support programs [9, 10]. Health managers can leverage these insights to design integrated strategies that simultaneously improve mental and physical well-being, such as combining community education programs with social support initiatives in high-poverty areas.

Demographic characteristics show outcome-specific significance. Female population share is associated with both mental and physical distress, reflecting social and caregiving roles that may increase overall vulnerability [11, 12]. Non-Hispanic white population share is significant only for mental health, possibly due to psychosocial stressors or cultural factors influencing psychological well-being, while rurality is significant only for physical health, likely because limited healthcare access and preventive services are directly associated physical outcomes [13]. This result about non-Hispanic white population aligns with the well-documented framework of “deaths of despair”, which demonstrates that socioeconomically distressed white communities in the U.S. have experienced severe declines in mental well-being, driven by economic stagnation, erosion of social infrastructure, and the opioid epidemic[14]. Conversely, counties with higher shares of racial and ethnic minority populations may benefit from localized cultural protective factors. Sociological literature suggests that minority-concentrated communities often exhibit high levels of social cohesion, deep-seated religious capital network structures, and robust kinship support systems [15, 16, 17].Although aging is typically linked to increased chronic illness, our finding that a higher share of residents aged 65 and older correlates with reduced county-level physical distress may be explained by the universal healthcare coverage and financial security provided by Medicare eligibility at age 65 [18]. This trend likely reflects survivorship bias, where the remaining elderly population represents a more resilient demographic, alongside higher preventive care utilization patterns (e.g., wellness visits) that facilitate more effective chronic disease management at the community level. These patterns highlight the importance of tailoring interventions to demographic context, such as gender-sensitive mental health programs, improved rural healthcare access, and age-appropriate preventive services.

Overall, our findings indicate that structural, socioeconomic, and demographic factors collectively shape health outcomes, with some determinants linked with both mental and physical health and others showing outcome-specific significance. Understanding these patterns can help public health officials prioritize interventions, allocate resources effectively, and develop programs that improve overall population health. Second, the use of listwise deletion resulted in the exclusion of approximately 30% of U.S. counties from the initial pool due to missing values across the 15 covariates. It is possible that these excluded counties are not missing at random, introducing selection bias. While our findings highlight significant predictors, we cannot rule out the possibility of reverse causality or residual confounding from unmeasured factors. Future research should further explore causal pathways and interactions among determinants to refine management strategies and reduce health disparities across counties; future studies using longitudinal or panel data could better capture temporal relationships and policy effects. Additionally, county-level analyses may mask within-county heterogeneity, suggesting that more granular data at the neighborhood or individual

level could provide additional insights into localized health disparities.

Our findings indicate that county-level environmental, socioeconomic, and demographic characteristics collectively shape mental and physical health outcomes, with some determinants influencing both outcomes and others exhibiting outcome-specific significance. Factors in living environment such as housing quality, sleep patterns, and access to nutritious food are significantly associated with both mental and physical distress, while socioeconomic resources including education and income provide protective effects across outcomes. Demographic factors demonstrate more nuanced patterns, with female population share associated with both outcomes, non-Hispanic white population share significant only for mental health, rurality significant only for physical health, and older age protective for physical but not mental distress. These results underscore the importance of tailoring public health interventions to local context, addressing environmental stressors, enhancing socioeconomic support, and targeting demographic-specific vulnerabilities. By identifying which county-level factors are significantly associated with mental versus physical health, policymakers and public health managers can prioritize resources, design integrated interventions, and implement strategies that reduce health disparities and improve overall population well-being. Future research should explore the causal pathways and interactions among these determinants to further inform effective, context-specific management approaches.

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Conflict of interest

The authors declared that they have no financial, personal, or institutional conflicts of interest that could have influenced the preparation or outcomes of this study.

Ethics approval

The data that support the findings of this study are openly available in County Health Release National Data and County-level Data Sets- Poverty at https://www.countyhealthrankings.org/health-data/california/data-and-resources. [Accessed in January 2026] and https://data.ers.usda.gov/reports.aspx?ID=4040. [Accessed in January 2026], reference number [4, 5].

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