HHS Public Access

Author manuscript

Soc Sci Med. Author manuscript; available in PMC 2025 November 05.

Published in final edited form as:

Soc Sci Med. 2025 November ; 385: 118625. doi:10.1016/j.socscimed.2025.118625.

Chronic pain prevalence and trends in urban, suburban, and rural areas among American adults aged 55+, 1998–2022

Yulin Yang[a,*], **Feinuo Sun**[b], **Zachary Zimmer**[c], **Anna Zajacova**[d], **Rui Huang**[e], **Hanna Grol-Prokopczyk**[e,1], **Jacqueline M. Torres**[a,1]

[a]Department of Epidemiology and Biostatistics, University of California, San Francisco, CA, USA

[b]Department of Kinesiology, University of Texas at Arlington, Arlington, TX, USA

[c]Department of Family Studies and Gerontology, Mount Saint Vincent University, Halifax, Nova Scotia, Canada

[d]Department of Sociology, University of Western Ontario, Ontario, Canada

[e]Department of Sociology, University at Buffalo-State University of New York, Buffalo, NY, USA

Abstract

Rural-urban health disparities in the United States are large and persistent, yet most surveillance efforts focus on mortality and disability. Monitoring rural-urban trends in pain, a major but overlooked indicator of population health, remains understudied. Given changes in demographics and resources of urban, suburban, and rural areas since the turn of the 21st century, which may have altered place-based differences in pain prevalence. Using nationally representative data from the Health and Retirement Study of 35,230 adults aged 55 and older (n = 206,600 person-wave observations), we estimated pain prevalence and trends across urban, suburban, and rural areas from 1998 to 2022. We assessed variation by age, sex/gender, race and ethnicity, and census region. Over 24 years, pain prevalence increased by 70 % (Prevalence Ratio [PR] = 1.70, 95 % Confidence Interval [CI]: 1.64, 1.75) and was consistently highest in rural areas and lowest in urban areas. However, pain prevalence rose most sharply in suburbs as compared to both rural and urban areas (suburban and time interaction vs. rural areas: PR = 1.08, 95 % CI: 1.00, 1.17). Suburban pain prevalence was similar to urban levels in 1998 but converged with that of rural levels by 2022. Stratified analyses revealed broadly similar patterns across demographic and regional groups, with particularly rapid increases among suburban populations in the South.

*Corresponding author. yulin.yang@ucsf.edu (Y. Yang).
1Equal contribution as senior author.
Handling Editor: Social Epidemiology Office

CRediT authorship contribution statement
Yulin Yang: Writing – review & editing, Writing – original draft, Visualization, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Feinuo Sun:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Zachary Zimmer:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing. **Anna Zajacova:** Writing – review & editing, Conceptualization. **Rui Huang:** Data curation. **Hanna Grol-Prokopczyk:** Conceptualization, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Jacqueline M. Torres:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Conceptualization.

Ethics approval
Ethics approval was not required as this study involved secondary analysis of publicly available data.

These findings highlight nationwide increases in chronic pain, with suburban areas emerging as new "hotspots" alongside rural areas. Given that pain is a leading cause of disability and functional decline, monitoring place-based trends is essential for addressing this growing public health concern.

Keywords

Chronic pain; Rurality; Trends; Region; Population health

1. Introduction

Rurality has been increasingly recognized as an important social determinant of health (Bolin et al., 2015). Evidence shows that rural populations face unique challenges that contribute to disparities in physical health, mental health, disability, and mortality (Atherton, 2024; Elo et al., 2019; Monnat, 2020). Moreover, rural-urban disparities in population health have shifted over the course of the 21st century, potentially owing to changing composition and context in rural areas such as population aging and shifts in socioeconomic distribution (Jensen et al., 2020). Consequently, Jensen et al. (2020) calls for more comparative research examining rural and urban differences in health trends among aging populations in 21st-century America. Despite this, rurality has been relatively neglected as a determinant of chronic pain and pain inequities over time.

Chronic pain (often referred to as "pain" for brevity) is defined as pain lasting for three or more months or beyond the healing period (Treede et al., 2015). It has garnered increasing attention among demographers and is considered a "sensitive barometer of population health" (Zajacova et al., 2021b). This growing focus reflects pain's high prevalence and its strong associations with disability, depression, suicide risk, substance use and misuse, and mortality (Case et al., 2020; Covinsky et al., 2009; Dahlhamer et al., 2018; Zis et al., 2017). Pain can be a lens for understanding broader population health trends, yet research on geographic disparities in pain remains limited.

Some recent scholarship points to considerable subnational geographic disparities in pain (Huang et al., 2023; Sun et al., 2024a,b; Zajacova et al., 2022). For example, Zajacova et al. (2022) found significant variability in pain prevalence within the US and Canada, with US states in the Deep South, Appalachia, and parts of the West standing out as pain "hotspots." These areas are characterized by rural landscapes and large rural populations, with areas like Appalachia and the Mountain West particularly hard-hit by the opioid epidemic (Rigg et al., 2018). Moreover, compared to their peers in suburban or urban areas, residents in rural areas have been found to have fewer pain-free years of life (Sun et al., 2024a,b) and are more likely to transition from no or mild pain to severe pain conditions (Sun et al., 2025). This evidence highlights the importance of understanding pain patterns and trends across the rural-urban continuum.

Rurality can be theorized as an important place-based factor that may shape pain outcomes over time (Eberhardt and Pamuk, 2004). Rural areas tend to have fewer economic opportunities and sometimes weaker social safety nets (e.g., food insecurity or economic insecurity, see Men et al., 2021; Tamargo et al., 2024), limited access to healthcare services (Johnston et al., 2019) and fewer built environment amenities (e.g., groceries or dispersed settlement patterns, see Skerratt et al., 2017), which may contribute to pain and pain disparities via limiting individuals' ability to adopt health-promoting behaviors such as seeking medical care, exercising, and maintaining a healthy diet (Matthews, 2017).

Occupational segregation between rural and urban areas may also contribute to inequities in late-life pain outcomes. For example, rural residents are more likely to engage in physically demanding and hazardous occupations such as farming, mining, and manual labor, which increase the risk of chronic musculoskeletal pain and related conditions later in life (Baker et al., 2024). Rural areas often exhibit higher rates of obesity and smoking compared to urban areas (Doogan et al., 2017; Hales et al., 2018), both of which are significant risk factors contributing to chronic pain and other adverse health outcomes. However, only a limited number of recent studies have directly examined rural-urban pain disparities (Rafferty et al., 2021; Sun et al., 2025; Sun et al., 2024a,b; Zelaya et al., 2020), and these either have used cross-sectional designs or have examined transitions based on two consecutive years of data. Long-term trends in pain prevalence across the rural-urban continuum are less clear.

A growing body of research shows substantial increases in pain prevalence over time in the US and Europe, particularly among older adults (Zajacova et al., 2021a; Zimmer et al., 2020, 2021). However, evidence regarding rural-urban patterns remains limited. Over the past two decades, rural areas have experienced numerous demographic and social changes. For instance, average poverty rates have consistently been higher in rural areas than in urban areas, with a disproportionate gap in Southern states (USDA ERS, 2023). Additionally, rural America has been experiencing significant depopulation since the 1990s (Johnson and Lichter, 2019). Concurrently, population aging is occurring at a faster rate in rural areas (Berry and Kirschner, 2012; Jensen et al., 2020), reflecting a greater demand for health care services and other essential services. These combined trends may contribute to widening rural-urban inequities in pain prevalence over time.

Understanding rural-urban disparities in pain trends may help to explain the rural mortality penalty (i.e., higher mortality rates in rural areas), which emerged in the 1990s and has been widening since (Cosby et al., 2019; Cross et al., 2021). Evidence of pain trends in rural versus urban areas may help explain the recent increase in drug, alcohol, and suicide deaths in rural areas, which has contributed to the growing gap in rural-urban mortality risks (Vierboom et al., 2019). Pain may play a role in substance use or addiction due to the legalization of opioid prescriptions for pain management (Deaton and Harper, 2020). Rural residency is associated with a higher likelihood of transitioning to opioid misuse from prescription pain medications, with individuals often identifying prescription pain drugs as their primary source (Palombi et al., 2018).

Studies have shown that population health outcomes, including pain, may exhibit unique patterns for those suburban areas, emphasizing the full rural-urban continuum (Monnat and Pickett, 2011; Sun et al., 2024a,b). Suburban areas in the U.S. have experienced rapid demographic, economic, and lifestyle shifts, including population aging, economic fluctuations, environmental pollution, unhealthy behaviors, and limited health infrastructure

(Chen et al., 2023; Fry, 2020; Khayat et al., 2017; Miller, 2018; Schnake-Mahl and Sommers, 2017; Slack and Jensen, 2020). For example, the poverty rate in suburban areas increased significantly in the 2000s (Kneebone and Berube, 2013; Schnake-Mahl and Sommers, 2017), which may be associated with an elevated risk of pain (Keralis, 2021).

Our study aims to understand differences in pain prevalence and trends over time across rural, suburban, and urban areas in the US. We analyze longitudinal data from a nationally representative sample of middle-aged and older Americans and quantify disparities in pain across rural, suburban, and urban areas over the first two decades of the 21st century. Motivated by evidence on the rural mortality penalty, which highlights variation across geographic areas and population subgroups (Elo et al., 2019; Rhubart and Santos, 2023), we also consider heterogeneity in rural-urban pain prevalence and trends by age, sex/gender, race and ethnicity, and U.S. Census region of residence.

2. Data and methods

2.1. Data

Our analyses are based on 24 years of data from the Health and Retirement Study (HRS; 1998–2022). Supported by the National Institute on Aging and the Social Security Administration, the HRS is a longitudinal study that surveys approximately 20,000 adults aged 51 and above every two years; respondents' spouses are also included, regardless of age. The study is designed to be nationally representative of community-dwelling adults, although respondents are followed into nursing homes. This study used data from the RAND HRS Longitudinal File and the RAND HRS Fat Files (RAND, 2025), provided by the RAND Center for the Study of Aging, as well as rural-urban data from the Cross-Wave Census Region/Division and Mobility File. All data are publicly available and were downloaded from the HRS website.

There were 41,232 respondents who participated in the HRS at any point during our study period (i.e., 1998–2022), contributing to 245,914 person-wave observations. Among those, 1068 respondents under 50 were excluded. Because the HRS refreshes its sample with additional participants every six years, the intermediate waves are representative of adults aged 53+ (two-year follow-up) and 55+ (four-year follow-up). To ensure consistent representativeness across waves, we followed the approach used in prior research (Edwards et al., 2020; Zimmer and Zajacova, 2020) and excluded 2546 respondents (n = 20,976 observations) who were aged 54 or younger at the time of interview, so that all included waves covered individuals aged 55+. Given our focus on community-dwelling adults, we also excluded 4804 observations from waves in which respondents were residing in nursing homes at the time of interview.

Among 37,191 eligible respondents (n = 210,300 person-wave observations), we further excluded individuals with missing data on pain outcomes (n = 704), urban-rural residence status (n = 681), covariates (n = 640), and sampling weights (n = 1675). A detailed sample selection flowchart is presented in the supplementary material (see Fig. A1). Overall missingness was low (1.72 % of observations). Formal tests of the characteristics of respondents with missing information against those included in the analysis are in

Supplementary Appendix Table A1. Participants from certain subgroups (e.g., living in urban areas, reporting pain, people of color) were slightly more likely to be excluded from the analytical sample, although differences were minor. The full analytical sample comprises 206,600 person-wave observations collected from 35,230 unique respondents.

2.2. Measures

2.2.1. Outcome: moderate-to-severe or limiting pain: We created a dichotomous measure of moderate-to-severe limiting pain by combining three pain-related questions from the HRS core survey. Respondents are first asked: "Are you often troubled with pain? (yes/no)." Among the respondents who answer affirmatively, HRS asks two follow up questions regarding the severity and interference of the pain: "How bad is the pain most of the time: mild, moderate, or severe?" and "Does the pain make it difficult for you to do your usual activities such as household chores or work? (yes/no)." Following previous studies (Li et al., 2021; Zimmer and Zajacova, 2020), we used all three questions and classified respondents who answered "yes" to the first question and rated their pain as moderate or severe, and/or who reported having difficulty with usual activities, as having "moderate-to-severe or limiting pain"—referred to hereafter as "chronic pain" or "pain" for brevity. All other responses are classified as "no pain or mild/non-limiting pain" or "no pain" for brevity.

Due to the absence of information regarding the duration of pain, the HRS pain measure is not guaranteed to correspond to the ICD-11 definition of chronic pain as lasting for three months or more. However, previous studies suggest that respondents pay attention to the "*often* troubled" aspect of the initial question and typically do not report transient or minor pain (Banks et al., 2009). Additionally, prevalence estimates of chronic pain derived from the HRS closely align with those from other studies that do specify pain duration (Grol-Prokopczyk, 2017; Yang and Grol-Prokopczyk, 2021). We thus consider the HRS question to be a reasonable measure of chronic pain.

2.2.2. Exposure: rural-suburban-urban residence: This study used the publicly available data from the "HRS Cross-Wave Census Region/Division and Mobility File" (Health and Retirement Study, 2023). Based on the Beale Rural-Urban Continuum Codes (hereinafter referred to as Beale codes; see U.S. Department of Agriculture, 2013), the HRS reclassified rural-urban residence status in each survey wave into three categories: urban, suburban, and ex-urban (also referred to as rural). We used the rural-urban variable based on the 2003 Beale codes to correspond to the data in the waves of 2000–2008, and the 2013 Beale codes for the 2010–2022 waves. Urban residence indicates "counties in metro areas of 1 million population or more" (Beale code = 1). Suburban residence indicates "counties in metro areas of 250, 000 to 1 million population" (Beale code = 2). Rural residence indicates several categories ranging from "counties in metro areas of fewer than 250,000 population" (Beale code = 3) to non-core metropolitan areas, which are "completely rural or less than 2500 urban population, not adjacent to a metro area" (Beale codes 4 through 9).

There are multiple approaches to defining the rural–urban divide (Hall et al., 2006). For example, the National Center for Health Statistics (NCHS) classifies counties with populations under 250,000 (Beale code = 3) as small metro areas, whereas the HRS categorizes these as rural. To assess robustness, we conducted a sensitivity analysis using the NCHS measure, defining Beale code 1 as urban, 2–3 as suburban, and 4–9 as rural.

2.2.3. Covariates: We included age (in years), sex/gender (women vs. men), race and ethnicity (non-Hispanic Black, Hispanic, and non-Hispanic White), marital status (married, widowed, separated/divorced, and single), education (less than high school, high school, some college, and college degree or higher), and household wealth quartiles. We also included a categorical variable for U.S. Census regions (Northeast, Midwest, South, and West) to account for regional variations in the associations between rural-urban status and pain outcomes.

2.3. Analytic strategy

We used pooled data analyzed with a repeated cross-sectional design. First, we provided descriptive statistics at baseline and graphed the weighted crude prevalence of pain at each wave for urban, suburban, and rural areas across 24 years. We then fitted a series of nested models using generalized estimating equations (GEE) with the Poisson distribution, log link, and robust standard errors. GEE models effectively handle the non-independence of respondents who appear across multiple waves. Consistent with the modified Poisson regression (Zou, 2004), our specification using Poisson distribution and robust standard errors yields direct estimates of prevalence ratios, producing unbiased results when the outcome is common.

We rescaled the time variable reflecting continuous years between 1998 and 2022, to a binary 0–1 measure ([year-1998]/24, with zero indicating 1998 and 1 indicating 2022), so the exponentiated coefficient was interpretable as the prevalence in 2022 relative to 1998 and thus showed the change across the entire 24-year period.

Model 1 only included rural-urban residence and the binary time variable. In Model 2, to estimate pain trends over 24 years, we additionally included multiplicative interaction terms between rural-urban residence and time to test whether trends varied by rural-urban status. In Model 3, we additionally included demographic and geographic covariates (age, sex/gender, race/ethnicity, marital status, and Census region). And lastly, in Model 4, we further adjusted for socioeconomic status (educational attainment and household wealth). We further conducted analyses stratified by age (55–64 vs. 65+), sex/gender (women vs. men), race and ethnicity (non-Hispanic Black, Hispanic, and non-Hispanic White), and U.S. Census regions with the same adjustment in Model 4.

For visualization purposes (including to visualize any nonlinear trends), we present marginal estimates of pain prevalence by rural-urban status, whereby time is modeled as a categorical variable and includes demographic, geographic, and socioeconomic covariates as detailed above. For stratified analyses, we modeled time as a continuous variable to reduce noise in the smaller subgroup-specific samples.

All models incorporate HRS survey weights to account for the complex sampling frame. Because respondents can be observed across multiple waves, we followed the approach used by Edwards et al. (2020) and calculated respondents' average survey weights.

In sensitivity analysis, we used several alternative measures of the rural-urban variables: (1) National Center for Health Statistics (NCHS) rural-urban classification (Beale code = 1 as urban, 2 or 3 as suburban, and 4–9 as rural), (2) rural-urban variables based on the 2003 Beale codes across all waves, and (3) rural-urban variables based on 2013 Beale codes across all waves. Lastly, we controlled for obesity (body mass index [BMI] ≥ 30), which may mediate the associations between rural–urban differences and pain outcomes, given evidence that rising BMI over time has contributed to upward trends in both mild and severe pain among middle-aged populations (Stokes et al., 2020). The results for all these are in Supplementary Appendix Tables A3–A10.

3. Results

Weighted descriptive statistics by rural-suburban-urban residence at baseline are presented in Table 1. Respondents had an average age of 61 years (SD = 8.2), with suburban (61.2 years) and rural (61.2 years) respondents slightly older than their urban peers (60.5 years). The percentage of women was similar across rural-urban areas (~52 %). The proportion of non-Hispanic White respondents was higher in rural areas (85 %) compared to suburban (75 %) and urban areas (70 %), while the percentage of non-Hispanic Black respondents was higher in urban areas (13 % vs. 10 % in suburban and 7 % in rural). The percentage of respondents with a college degree was higher in urban areas (31 %) than in suburban (23 %) and rural areas (18 %). The percentage of married or partnered individuals was higher in rural areas, while the percentage of widowed individuals was higher in suburban areas. Rural residents had the lowest wealth and were more concentrated in the South and least in the Northeast and the West.

Fig. 1 shows the weighted unadjusted prevalence of pain across rural, suburban, and urban areas over the 24-year study period. Pain prevalence trends in urban and rural areas exhibit a pronounced but largely linear increase over time, with the gap between rural and urban areas only slightly widening. The prevalence of pain rose from 25.1 % in 1998 to 38.3 % in 2022 among rural residents and from 21.8 % to 31.5 % among urban residents. The rural-urban pain gap increased from 3.3 percentage points in 1998 to 6.8 percentage points in 2022 (largest 7.9 pp in 2020), driven by a flattening trend in urban areas between 2014 and 2020, while rural areas continued to see a rise during most of that period. In suburban areas, the pain prevalence rose more rapidly, going from a prevalence that was nearly identical to that of urban residents in 1998 (22.7 %) to a prevalence that was much closer to that of rural residents by 2006 (29.7 %), and almost the same by 2022 (36.1 %). Notably, pain prevalence decreased in 2020 across rural, suburban, and urban areas, but increased again in 2022.

Table 2, Model 1, presents the prevalence ratios of pain by rural-urban residence and time. Compared to rural residents, urban and suburban residents had significantly lower prevalence of pain—approximately 13 % and 5 % lower for urban and suburban residents respectively (Prevalence Ratio [PR] for urban residence: 0.87, 95 % Confidence Interval [CI]:0.84 0.89; $p < 0.001$; PR for suburban residence: 0.95, 95 % CI: 0.92, 0.98; $p = 0.004$), indicating a rural-urban gradient in pain prevalence.

Model 2 includes interaction terms between rural-urban residence and time. The interaction term between urban (vs. rural) residence and time was not significant (PR:1.02, 95 % CI: 0.95, 1.09), indicating that the rural–urban disparity observed in the crude prevalence estimates remained generally consistent over time. In contrast, the interaction term between suburban residence and time (PR: 1.08, 95 % CI: 1.00, 1.17; $p = 0.046$) indicated a steeper increase in suburban vs. rural areas.

In Model 3, we additionally adjusted for demographic and geographic covariates. The estimates of the rural–urban gap and the increase in pain prevalence in suburban areas over time persisted, although the latter estimate was only marginally significant (PR: 1.08, 95 % CI: 1.00, 1.17; $p < 0.10$). In Model 4, we further included SES covariates (i.e., educational attainment and household wealth), and the results remained unchanged.

Fig. 2 presents the predicted probabilities from 1998 to 2022 across rural, suburban, and urban residence, with time modeled as a categorical variable and adjusting for age, sex/gender, race and ethnicity, marital status, and census region, following prior guidance on reporting interactions in regression models for binary outcomes (Mize, 2019). Rural residents consistently reported the highest pain prevalence, followed by suburban and then urban residents, though the gaps narrowed in more recent years. Despite some fluctuations, the upward trends were consistent across groups, highlighting a growing and widespread burden of pain in later life.

To quantify the pain prevalence gap for suburban and rural vs. urban residents, we re-estimated models instead using urban residence as the reference group, and the results are presented in Supplementary Appendix Table A2. The interaction term between suburban and time was two percentage points larger when the reference was set to rural areas than urban areas (PR: 1.06, 95 % CI: 0.98, 1.14).

Estimates stratified by demographic and geographic characteristics are presented in Appendix Tables A3–6 (see supplementary materials), and the predicted prevalence based on those models is visualized in Figs. 3–5. Fig. 3 (see also Appendix Tables A3) shows estimated pain trends across rural-urban areas by age (i.e., 55–64 on the left and 65+ on the right) or sex/gender. Among the population aged 55–64, those in rural areas had the highest prevalence, followed by suburban areas, while those in urban areas had the lowest prevalence. The rural-urban gap widened over time, with steeper slopes for those in rural and suburban areas compared to urban areas. Among the population aged 65 and older, pain prevalence was similar across all areas in 1998. However, the rate of increase was more rapid in suburban areas, followed by rural areas, resulting in a widening gap between rural/suburban and urban areas among older adults over the study period.

In Fig. 3 (Also Appendix Table A4), the prevalence of pain among men was consistently lower than that of women across years and rural-urban areas. Trends among men mirrored the overall patterns, with the rural-urban gap remaining relatively stable over time; however, pain prevalence in suburban areas increased more rapidly. Among women, pain prevalence was similar across rural, suburban, and urban areas in 1998. However, since 2008, prevalence estimates in rural and suburban areas began to overlap and showed a steeper increase, resulting in a widening gap between rural/suburban and urban areas.

Fig. 4 (see also Appendix Table A5) shows estimated pain trends across rural-urban areas by race and ethnicity. Overall, across different racial and ethnic subgroups, predicted pain prevalence increases over time and was highest in rural areas. However, there were intriguing exceptions: estimates among non-Hispanic Black participants show higher pain prevalence in suburban vs. rural areas, although relatively small sample sizes do lead to overlapping confidence intervals. The trends for the non-Hispanic White population generally mirrored the overall patterns. In contrast, among Hispanic respondents, pain prevalence estimates and trends over time were nearly identical in rural and suburban areas. Estimates for the non-Hispanic “Other” group had low precision, with extremely wide confidence intervals due to small sample sizes.

Fig. 5 (see also Appendix Table A6) shows estimated pain trends by U.S. Census region of residence. We observed that the gap in pain prevalence between rural vs suburban/urban areas was largest and most consistent over time in the Northeast. In the Midwest and West, differences across groups were smaller, although urban groups consistently had the lowest point estimates for pain prevalence over time. In the South, the shift of the suburban group from a relatively low pain prevalence (21.9 % in 1998) on par with urban residents to a higher prevalence resembling rural residents (42.1 % in 2022) was clearest; a significant interaction term between suburban residence and time in the South (but not in other regions) confirms this steeper increase in pain prevalence of suburban vs. urban areas in Southern states.

We conducted several sensitivity analyses. First, we modeled time as a categorical variable representing each survey wave (Fig. A2), which yielded pain trends consistent with our main findings. We also applied alternative rural–urban measures; results were similar, though the suburban time interaction was strongest with the NCHS classification (PR = 1.16, 95 % CI: 1.07–1.26, $p < 0.001$; Table A7), slightly stronger than the main results when using the 2013 Beale code (PR = 1.09, 95 % CI: 1.01–1.19, $p < 0.05$; Table A9), and weakest with the 2003 Beale code (PR = 1.04, 95 % CI: 0.96–1.13; Table A8). Results from models additionally adjusting for obesity status (Table A10) show that obesity was a significant predictor of pain; however, the rural–urban pain prevalence ratios remained nearly identical to those from the main models. Overall, results remained largely unchanged across sensitivity analyses, providing further support for the stability and reliability of our findings.

4. Discussion

To our knowledge, this study is the first to estimate the prevalence of and trends in chronic pain across urban, suburban, and rural settings over the first part of the 21st century in adults aged 55 and above. Our findings, based on 24 years of nationally representative data, show a clear trend of increasing chronic pain prevalence across rural, suburban, and urban areas, even after adjusting for demographic and socioeconomic characteristics. While rural residents consistently exhibited higher pain prevalence than their urban counterparts across the study period (by about 10 percentage points), the slopes were similar for both groups. In contrast, suburban residents experienced a steeper increase in pain prevalence over time. Initially, their pain prevalence was similar to that of urban residents, but over time it converged with that of rural residents. We also observed some heterogeneity in these patterns based on age, sex/gender, race and ethnicity, and census region, which we detail further below.

The higher pain prevalence observed among rural versus urban residents confirms prior cross-sectional research indicating that individuals in rural areas experience a greater burden of chronic pain compared to urban residents (Rafferty et al., 2021; Sun et al., 2025; Zelaya et al., 2020). This finding is also in line with other rural-urban differences in physical health and disability outcomes (Monnat and Pickett, 2011; Zhao et al., 2019), and may be attributed to compositional and structural place-based risk factors associated with rurality. For example, Some socioeconomic (e.g., education, financial insecurity) and food insecurity are established risk factors found to be associated with increased pain risk (Case et al., 2020; Huang et al., 2023; Men et al., 2021; Tamargo et al., 2024), and rural areas consistently have higher concentrations of adults with less education and higher financial insecurity and distress.

The rural–urban gap in pain prevalence may be partly explained by long-standing differences in occupational structures. Rural residents are more likely to work in physically demanding and hazardous jobs—such as agriculture, mining, and manual labor—that elevate pain risk through injuries and exposure to harmful pollutants (Baker et al., 2024). Structural inequities, including wage discrimination and occupational segregation, further contribute to financial insecurity and psychosocial distress. Over time, these combined factors increase the risk of chronic musculoskeletal pain and related conditions in later life.

Behavioral and health profile trends also contribute to the elevated pain risk in rural communities over time, as rural areas tend to have higher prevalence rates of obesity and smoking compared to urban areas (Doogan et al., 2017; Hales et al., 2018), both of which are well-established behavioral risk factors linked to chronic pain and broader health complications. Rural residents are more likely to develop chronic conditions, such as diabetes, cardiovascular disease, chronic lower respiratory disease, and stroke (Cosby et al., 2019; Monnat and Pickett, 2011), which often lead to secondary pain symptoms. Meanwhile, rural communities historically lack access to primary care providers and pain specialists (Weinhold and Gurtner, 2014), and rural health care providers are often less prepared to take non-pharmacological approaches to pain management (Mezei et al., 2011).

Despite the overall rural-urban disparity, we found the slopes of the increase in pain over time to be similar between rural and urban residents, showing a persistent pain ‘penalty’ in rural areas. This finding seemingly does not mirror the widening gap in the rural-urban age-adjusted mortality trends (Cross et al., 2021). Previous research has documented that rural areas have higher rates of premature death, including *deaths of despair*, i.e., deaths from suicide, drug and alcohol misuse, and alcohol-related liver disease (Deaton and Harper, 2020; Monnat, 2020). Parallel pain trends between rural and urban areas overall may reflect the overall trend towards higher pain prevalence, with both rural and urban areas experiencing similar shifts in pain-related factors (e.g., age-related chronic conditions such as arthritis) over time. The trends surrounding the pandemic era were almost identical to a recent study analyzing data from the National Health Interview Survey (Zajacova et al., 2025). However, stable differences over time could also potentially be due to mortality selection driven by premature deaths in rural areas.

In contrast, we observed a steeper increase in pain prevalence among suburban residents, who initially resembled urban populations but over time reached levels comparable to rural residents. At first glance, this pattern may seem counterintuitive, as suburbs were historically home to predominantly white and relatively affluent populations shaped by discriminatory housing policies. However, Suburban development and sprawl have driven rapid demographic and economic changes, including regional economic fluctuations, and shifts in racial and socioeconomic composition (Fry, 2020; Slack and Jensen, 2020), particularly since the Great Recession, have made many suburbs increasingly economically and racially diverse, which may help explain the convergence with rural pain levels.

One possible factor driving the escalation of pain trends in suburban areas is the increasing concentration of residents with lower educational attainment and greater financial insecurity resulting from economic restructuring. Job growth has shifted toward cities, while the decline of traditional manufacturing in suburbs contributed to falling incomes after the Great Recession (Pooley, 2016). By 2014, more suburban than urban residents were living in poverty (Allard, 2017). However, adjusting for individual household poverty in our analyses did not attenuate the rapid increase in suburban pain trends, suggesting that individual-level economic status alone does not fully explain the pattern. Instead, broader contextual factors, such as neighborhood-level poverty, may help explain the rapid suburban increases in pain prevalence. Older adults and low-income individuals priced out of urban areas may relocate to suburbs, where social and health services often struggle to keep pace with the changing demographic and financial profiles of residents.

The rapid increase in pain prevalence in suburban areas may be linked to lower rates of health insurance, driven by escalating poverty and financial insecurity in these communities (Keralis, 2021; Kneebone and Berube, 2013). Studies have shown that many suburban residents lack insurance and face significant barriers to care, highlighting the need for stronger policy attention to these populations (Schnake-Mahl and Sommers, 2017). Unlike cities, suburbs often have fewer healthcare facilities and social services to buffer the effects of poverty, leaving residents with limited options for timely pain management and safety-net providers. This combination of economic hardship, higher uninsured rates, and insufficient access to care likely contributes to the steeper increase in pain prevalence observed in suburban areas. Future research should incorporate neighborhood- or county-level poverty and healthcare availability to capture these contextual factors better.

Suburban infrastructure may also make it harder to maintain healthy lifestyles that help prevent pain. Many suburban communities are car-dependent and lack walkable neighborhoods or accessible recreational spaces for physical activity (Doescher et al., 2014). These limitations can contribute to obesity, musculoskeletal problems, and chronic pain by hindering both prevention and effective pain management. Together, these factors can elevate the risk of pain among suburban populations.

Our analyses show some evidence of heterogeneity in models stratified by demographic characteristics. In particular, the rural–urban gap in pain prevalence widened over time across age strata (55–64 years vs. 65+). The prevalence was consistently higher—and the widening trend more pronounced—among adults aged 55–64 compared to those aged 65 and older. For example, among adults aged 55–64, the rural–urban gap increased from 2 percentage points in 1998 to 5 percentage points in 2022. In contrast, among adults aged 65 and older, the gap increased from 1 percentage point in 1998 to 2.5 percentage points in 2022. Using 2019; 2020 data from the NHIS data, Sun et al. (2025) found similar results that rural-urban gaps in pain prevalence were more pronounced among middle-aged adults compared to older adults. On the other hand, the narrower rural-urban health gap at older ages could be driven by selective survival, including due to higher rates of premature deaths in rural areas (Singh and Siahpush, 2014).

We also found lower pain prevalence among men than women across rural, suburban, and urban areas. Rural-urban pain trends among men generally mirrored the overall pattern, with prevalence increasing over time, particularly in suburban areas. In contrast, for women, the rural-urban pain gap widened over time, though even by 2022 it remained narrower than that observed for men at any point. While some gender differences exist in language use to describe pain (Strong et al., 2009), our results are unlikely to be biased by reporting patterns, as they are consistent with previous evidence showing that rural-urban pain disparities are larger and more pronounced for men (Sun et al., 2025). It is possible that men in rural areas and more recently in suburban areas were more likely to be influenced by the place-based factors, such as in manual labor occupations, that may cause painful conditions or injuries. It is also possible that men in rural and suburban areas were more likely to adopt unhealthy behaviors and beliefs that increase health risks (Courtenay, 2000; Fillingim et al., 2009). Additionally, dominant norms of masculinity have been shown to discourage men, especially in rural and suburban contexts, from expressing pain or seeking treatment, contributing to underreporting and the lower pain prevalence observed.

Rural-urban pain trends over time were relatively consistent across most racial and ethnic groups. While the analysis from Sun et al. (2025) shows that the rural-urban gap was more pronounced among non-Hispanic White 18+ individuals in NHIS, we found that patterns among non-Hispanic White 55+ individuals generally mirrored the overall findings. However, pain prevalence was higher among non-Hispanic Black individuals and appeared to increase slightly more rapidly in suburban areas compared to rural and urban areas. Among Hispanic individuals, pain prevalence and rates of change in suburban and rural areas were consistently similar, with both showing a wider gap relative to urban areas. Findings for individuals categorized as non-Hispanic Other need to be interpreted with caution.

We also found the variation in pain trends across US Census regions. The rural-urban gap in pain prevalence was the most pronounced (i.e., five percentage points) and stable over time in the Northwest. The Midwest and West showed smaller differences, with urban residents having the lowest pain rates. In the South, suburban pain prevalence shifted from being similar to urban areas to resembling rural levels, indicating a sharper increase over time. This trend was supported by a significant interaction term between suburban residence and time. This distinct trajectory highlights how geographic intersectionality—where urbanicity or rurality intersect with regional context—shapes pain disparities in ways not captured by urban–rural comparisons alone.

Overall, we observed systematic increases in pain prevalence across levels of urbanicity among adults aged 55 and older in the last two decades, across sociodemographic groups and regions. Our findings align with previous studies documenting linear, widespread increases in pain prevalence across all adult age groups and most pain sites (Zajacova et al., 2025; Zajacova et al., 2021a; Zimmer and Zajacova, 2020). While the underlying mechanisms remain unclear, these trends likely reflect the rising burden of painful health conditions and related factors. For example, studies have shown increases in diagnosed conditions such as arthritis and obesity across U.S. population subgroups and rural-urban areas over recent decades (Nahin et al., 2019; Stokes et al., 2020). Pain is also associated with mental health problems, including depression, which has risen across sociodemographic groups and urbanicity levels (Goodwin et al., 2022; Ivey-Stephenson, 2017). Additionally, growing societal awareness of pain management—particularly opioid use—can have contributed to increased pain reporting (Lembke, 2016). While some of these factors may be common across groups, the underlying causes of rising pain prevalence likely differ by subgroup. Future research should therefore evaluate subgroup-specific mechanisms driving these trends.

Several limitations should be acknowledged. First, the measure of chronic pain in the HRS does not capture information on pain location, duration, or cause. Second, the classification of rural, suburban, and urban areas in this study relies on publicly available data; future research could explore alternative measures of rurality, such as the Rural-Urban Commuting Area (RUCA) codes. Third, due to the limited sample size in rural areas, our stratified models may be underpowered for some subgroups. Monnat and Elo (2022) have suggested that the HRS should consider oversampling rural respondents to address these limitations and support more robust rural-urban analyses. Lastly, although we offered theoretical explanations for potential mechanisms, we did not conduct a formal mediation analysis; further studies are needed to evaluate these pathways.

Despite these limitations, this study elucidates rural-suburban-urban differences in pain prevalence and trends over 22 years using population-based data. We found pain prevalence to be highest in rural areas and lowest in urban areas, and that while pain prevalence increased substantially over time across rurality categories, these increases were more pronounced in suburban areas. These patterns showed that some potential variation exists across demographic subgroups and US Census regions. The observed increases in chronic pain among middle-aged and older adults in the US, including across geographic and sociodemographic groups, call for expanded research and targeted policy responses. Future studies should examine the underlying structural, social, and environmental drivers of chronic pain, including changes in labor markets, healthcare access, and neighborhood infrastructure. Longitudinal and multilevel analyses are especially needed to better understand causal pathways and life-course exposures that contribute to pain disparities. From a policy perspective, interventions that improve access to comprehensive pain management—particularly in underserved suburban and rural areas—are urgently needed.

The policy interventions include expanding insurance coverage, integrating behavioral and physical health services, and addressing transportation and provider shortages. Additionally, public health programs should prioritize pain prevention through upstream strategies, such as promoting physical activity, mitigating social isolation, and addressing economic insecurity. Together, these efforts can help reduce the growing burden of chronic pain and advance equity in pain outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This study was supported by the National Institute on Aging of the National Institutes of Health under Award Number R01AG065351 (PI: Grol-Prokopczyk), P01AG082653 (mPI: Torres), and R24AG065159 (Pilot PI: Sun), as well as funding from the Social Sciences and Humanities Research Council of Canada through the Canada Research Chairs Program (PI: Zimmer). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health and Canada Research Chairs Program.

Data availability

The data is publicly available

References

Allard SW, 2017. Places in Need: the Changing Geography of Poverty. Russell Sage Foundation.

Atherton OE, 2024. Are there place-based disparities in mortality risk? Findings from two longitudinal studies. Health Psychol.

Baker MB, Liu EC, Bully MA, Hsieh A, Nozari A, Tuler M, Binda DD, 2024. Overcoming barriers: a comprehensive review of chronic pain management and accessibility challenges in rural America. Healthcare.

Banks J, Kapteyn A, Smith JP, Van Soest A, 2009. Work disability is a pain in the****, especially in England, the Netherlands, and the United States. In: Health at Older Ages: the Causes and Consequences of Declining Disability Among the Elderly. University of Chicago Press, pp. 251–293.

Berry EH, Kirschner A, 2012. Demography of rural aging. In: Rural Aging in 21st Century America. Springer, pp. 17–36.

Bolin JN, Bellamy GR, Ferdinand AO, Vuong AM, Kash BA, Schulze A, Helduser JW, 2015. Rural healthy people 2020: new decade, same challenges. J. Rural Health 31 (3), 326–333. [PubMed: 25953431]

Case A, Deaton A, Stone AA, 2020. Decoding the mystery of American pain reveals a warning for the future. Proc. Natl. Acad. Sci 117 (40), 24785–24789. https://www.pnas.org/content/pnas/117/40/24785.full.pdf. [PubMed: 32958666]

Chen T-HK, Horsdal HT, Samuelsson K, Closter AM, Davies M, Barthel S, Pedersen CB, Prishchepov AV, Sabel CE, 2023. Higher depression risks in medium-than in high-density urban form across Denmark. Sci. Adv 9 (21), eadf3760. [PubMed: 37224254]

Cosby AG, McDoom-Echebiri MM, James W, Khandekar H, Brown W, Hanna HL, 2019. Growth and persistence of place-based mortality in the United States: the rural mortality penalty. Am. J. Publ. Health 109 (1), 155–162.

Courtenay WH, 2000. Constructions of masculinity and their influence on men's well-being: a theory of gender and health. Soc. Sci. Med 50 (10), 1385–1401. [PubMed: 10741575]

Covinsky KE, Lindquist K, Dunlop DD, Yelin E, 2009. Pain, functional limitations, and aging. J. Am. Geriatr. Soc 57 (9), 1556–1561. [PubMed: 19682122]

Cross SH, Califf RM, Warraich HJ, 2021. Rural-urban disparity in mortality in the US from 1999 to 2019. JAMA 325 (22), 2312–2314. [PubMed: 34100876]

Dahlhamer J, Lucas J, Zelaya C, Nahin R, Mackey S, DeBar L, Kerns R, Von Korff M, Porter L, Helmick C, 2018. Prevalence of chronic pain and high-impact chronic pain among adults—United States, 2016. Morb. Mortal. Wkly. Rep 67 (36), 1001.

Deaton A, Harper K, 2020. Deaths of Despair and the Future of Capitalism. Princeton University Press, Princeton, NJ.

Doescher MP, Lee C, Berke EM, Adachi-Mejia AM, Lee C. k., Stewart O, Patterson DG, Hurvitz PM, Carlos HA, Duncan GE, 2014. The built environment and utilitarian walking in small US towns. Prev. Med 69, 80–86. [PubMed: 25199732]

Doogan N, Roberts M, Wewers M, Stanton C, Keith D, Gaalema D, Kurti A, Redner R, Cepeda-Benito A, Bunn J, 2017. A growing geographic disparity: rural and urban cigarette smoking trends in the United States. Prev. Med 104, 79–85. [PubMed: 28315761]

Eberhardt MS, Pamuk ER, 2004. The importance of place of residence: examining health in rural and nonrural areas. Am. J. Publ. Health 94 (10), 1682–1686.

Edwards RD, Brenowitz WD, Portacolone E, Covinsky KE, Bindman A, Glymour MM, Torres JM, 2020. Difficulty and help with activities of daily living among older adults living alone with cognitive impairment. Alzheimer’s Dement. 16 (8), 1125–1133. [PubMed: 32588985]

Elo IT, Hendi AS, Ho JY, Vierboom YC, Preston SH, 2019. Trends in non-hispanic white mortality in the United States by metropolitan-nonmetropolitan status and region, 1990–2016. Popul. Dev. Rev 45 (3), 549. [PubMed: 31588154]

Fillingim RB, King CD, Ribeiro-Dasilva MC, Rahim-Williams B, Riley III JL, 2009. Sex, gender, and pain: a review of recent clinical and experimental findings. J. Pain 10 (5), 447–485. [PubMed: 19411059]

Fry R, 2020. Prior to COVID-19, urban core counties in the U.S. were gaining vitality on key measures. https://www.pewresearch.org/social-trends/2020/07/29/prior-to-covid-19-urban-core-counties-in-the-u-s-were-gaining-vitality-on-key-measures/.

Goodwin RD, Dierker LC, Wu M, Galea S, Hoven CW, Weinberger AH, 2022. Trends in US depression prevalence from 2015 to 2020: the widening treatment gap. Am. J. Prev. Med 63 (5), 726–733. [PubMed: 36272761]

Grol-Prokopczyk H, 2017. Sociodemographic disparities in chronic pain, based on 12-year longitudinal data. Pain 158 (2), 313. [PubMed: 28092650]

Hales CM, Fryar CD, Carroll MD, Freedman DS, Aoki Y, Ogden CL, 2018. Differences in obesity prevalence by demographic characteristics and urbanization level among adults in the United States, 2013–2016. JAMA 319 (23), 2419–2429. [PubMed: 29922829]

Hall SA, Kaufman JS, Ricketts TC, 2006. Defining urban and rural areas in US epidemiologic studies. J. Urban Health 83, 162–175. [PubMed: 16736366]

Health and Retirement Study, 2023. Cross-Wave Census Region/Division and mobility file. https://hrsdata.isr.umich.edu/data-products/cross-wave-census-regiondivision-and-mobility-file.

Huang R, Yang Y, Zajacova A, Zimmer Z, Li Y, Grol-Prokopczyk H, 2023. Educational disparities in moderate or severe joint pain within and across U.S. states: do macro sociopolitical contexts matter? Pain 164 (10), 2358–2369. 10.1097/j.pain.0000000000002945. [PubMed: 37399230]

Ivey-Stephenson AZ, 2017. Suicide Trends Among and Within Urbanization Levels by Sex, race/ethnicity, Age Group, and Mechanism of death—United States, 2001–2015. MMWR, vol. 66. Surveillance Summaries.

Jensen L, Monnat SM, Green JJ, Hunter LM, Sliwinski MJ, 2020. Rural population health and aging: toward a multilevel and multidimensional research agenda for the 2020s. Am. J. Publ. Health 110 (9), 1328–1331. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7427233/pdf/AJPH.2020.305782.pdf.

Johnson KM, Lichter DT, 2019. Rural depopulation: growth and decline processes over the past century. Rural Sociol. 84 (1), 3–27.

Johnston KJ, Wen H, Joynt Maddox KE, 2019. Lack of access to specialists associated with mortality and preventable hospitalizations of rural medicare beneficiaries. Health Aff 38 (12), 1993–2002.

Keralis JM, 2021. Pain and poverty: disparities by poverty level in the experience of pain-related interference. Pain Med 22 (7), 1532–1538. [PubMed: 33527133]

Khayat S, Dolatian M, Navidian A, Mahmoodi Z, Sharifi N, Kasaeian A, 2017. Lifestyles in suburban populations: a systematic review. Electron. Physician 9 (7), 4791. [PubMed: 28894537]

Kneebone E, Berube A, 2013. Confronting Suburban Poverty in America. Brookings Institution Press.

Lembke A, 2016. Drug Dealer, MD: How Doctors were Duped, Patients got Hooked, and Why It's so Hard to Stop. JhU press.

Li R, Dworkin RH, Chapman BP, Becerra AZ, Yang L, Mooney CJ, Seplaki CL, 2021. Moderate to severe chronic pain in later life: risk and resilience factors for recovery. J. Pain 22 (12), 1657–1671. [PubMed: 34174387]

Matthews KA, 2017. Health-Related Behaviors by Urban-Rural County Classification—United States, 2013, vol. 66. MMWR. Surveillance Summaries.

Men F, Fischer B, Urquia ML, Tarasuk V, 2021. Food insecurity, chronic pain, and use of prescription opioids. SSM-Popul. Health 14, 100768. [PubMed: 33763516]

Mezei L, Murinson BB, Team JHPCD, 2011. Pain education in North American medical schools. J. Pain 12 (12), 1199–1208. [PubMed: 21945594]

Miller P, 2018. Health impacts of suburban development patterns. Delaware J. Public Health 4 (2), 32.

Mize TD, 2019. Best practices for estimating, interpreting, and presenting nonlinear interaction effects. Sociol. Sci 6, 81–117.

Monnat SM, 2020. Trends in US Working-age Non-Hispanic white mortality: rural–urban and within-rural differences. Popul. Res. Pol. Rev 39 (5), 805–834.

Monnat SM, Elo IT, 2022. Enhancing the utility of the Health and Retirement Study (HRS) to identify drivers of rising mortality rates in the United States. Forum Health Econ. Pol

Monnat SM, Pickett CB, 2011. Rural/urban differences in self-rated health: examining the roles of county size and metropolitan adjacency. Health Place 17 (1), 311–319. [PubMed: 21159541]

Nahin RL, Sayer B, Stussman BJ, Feinberg TM, 2019. Eighteen-year trends in the prevalence of, and health care use for, noncancer pain in the United States: data from the medical expenditure panel survey. J. Pain 20 (7), 796–809. [PubMed: 30658177]

Palombi LC, St Hill CA, Lipsky MS, Swanoski MT, Lutfiyya MN, 2018. A scoping review of opioid misuse in the rural United States. Ann. Epidemiol 28 (9), 641–652. [PubMed: 29921551]

Pooley KB, 2016. Debunking the "cookie-cutter" myth for suburban places and suburban poverty: analyzing their variety and recent trends. In: The New American Suburb. Routledge, pp. 39–78.

Rafferty AP, Luo H, Egan KL, Bell RA, Little N, Imai S, 2021. Rural, Suburban, and Urban Differences in Chronic Pain and Coping Among Adults in North Carolina: 2018 Behavioral Risk Factor Surveillance System.

RAND, 2025. RAND HRS Longitudinal File 2022 (V1).

Rhubart D, Santos A, 2023. Research note showing that the rural mortality penalty varies by region, race, and ethnicity in the United States, 1999–2016. Demography 60 (6), 1699–1709. [PubMed: 38015809]

Rigg KK, Monnat SM, Chavez MN, 2018. Opioid-related mortality in rural America: geographic heterogeneity and intervention strategies. Int. J. Drug Pol 57, 119–129.

Schnake-Mahl AS, Sommers BD, 2017. Health care in the suburbs: an analysis of suburban poverty and health care access. Health Aff 36 (10), 1777–1785.

Singh GK, Siahpush M, 2014. Widening rural–urban disparities in all-cause mortality and mortality from major causes of death in the USA, 1969–2009. J. Urban Health 91 (2), 272–292. [PubMed: 24366854]

Skerratt S, Meador J, Spencer M, 2017. National Rural Mental Health Survey Scotland: Report of Key Findings.

Slack T, Jensen L, 2020. The changing demography of rural and small-town America. Popul. Res. Pol. Rev 39 (5), 775–783.

Stokes AC, Xie W, Lundberg DJ, Hempstead K, Zajacova A, Zimmer Z, Glei DA, Meara E, Preston SH, 2020. Increases in BMI and chronic pain for US adults in midlife, 1992 to 2016. SSM-Popul. Health 12, 100644. [PubMed: 33134473]

Strong J, Mathews T, Sussex R, New F, Hoey S, Mitchell G, 2009. Pain language and gender differences when describing a past pain event. PAIN® 145 (1–2), 86–95. [PubMed: 19586722]

Sun F, Yang Y, Nahin RL, 2025. Development of chronic pain and high-impact chronic pain across the US rural–urban continuum, 2019–2020. J. Rural Health 41 (2), e70036. [PubMed: 40405377]

Sun F, Zajacova A, Grol-Prokopczyk H, 2024a. The geography of arthritis-attributable pain outcomes: a county-level spatial analysis. Pain 165 (7), 1505–1512. [PubMed: 38284413]

Sun F, Zimmer Z, Brouard N, 2024b. Rural-urban residence and life expectancies with and without pain. Health Place. 10.1016/j.healthplace.2024.103305.

Tamargo JA, Strath LJ, Karanth SD, Spector AL, Sibille KT, Anton S, Cruz-Almeida Y, 2024. Food insecurity is associated with chronic pain and high-impact chronic pain in the USA. Public Health Nutr 27 (1), e7.

Treede R-D, Rief W, Barke A, Aziz Q, Bennett MI, Benoliel R, Cohen M, Evers S, Finnerup NB, First MB, 2015. A classification of chronic pain for ICD-11. Pain 156 (6), 1003. [PubMed: 25844555]

U.S. Department of Agriculture, 2013. Rural-urban continuum codes. E. R. S. E. https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/.

USDA ERS, 2023. Rural Poverty & Well-Being. Wednesday, November 15, 2023. (Accessed 22 July 2024).

Vierboom YC, Preston SH, Hendi AS, 2019. Rising geographic inequality in mortality in the United States. SSM-Popul. Health 9, 100478. [PubMed: 31649997]

Weinhold I, Gurtner S, 2014. Understanding shortages of sufficient health care in rural areas. Health Policy 118 (2), 201–214. [PubMed: 25176511]

Yang Y, Grol-Prokopczyk H, 2021. Chronic pain and friendship among middle-aged and older U.S. adults. J. Gerontol. B Psychol. Sci. Soc. Sci 76 (10), 2131–2142. 10.1093/geronb/gbaa185. [PubMed: 33119081]

Zajacova A, Grol-Prokopczyk H, Nahin RL, 2025. Pain among US adults before, during, and after the COVID-19 pandemic: a study using the 2019 to 2023 National Health Interview Survey. Pain 10, 1097. 10.1097/j.pain.0000000000003764.

Zajacova A, Grol-Prokopczyk H, Zimmer Z, 2021a. Pain trends among American adults, 2002–2018: patterns, disparities, and correlates. Demography 58 (2), 711–738. 10.1215/00703370-8977691. [PubMed: 33834222]

Zajacova A, Grol-Prokopczyk H, Zimmer Z, 2021b. Sociology of chronic pain. J. Health Soc. Behav 62 (3), 302–317. 10.1177/00221465211025962. [PubMed: 34283649]

Zajacova A, Lee J, Grol-Prokopczyk H, 2022. The geography of pain in the United States and Canada. J. Pain 23 (12), 2155–2166. [PubMed: 36057388]

Zelaya CE, Dahlhamer JM, Lucas JW, Connor EM, 2020. Chronic Pain and High-Impact Chronic Pain Among US Adults, p. 2019.

Zhao G, Okoro CA, Hsia J, Garvin WS, Town M, 2019. Prevalence of disability and disability types by urban–rural county classification—US, 2016. Am. J. Prev. Med 57 (6), 749–756. [PubMed: 31753256]

Zimmer Z, Fraser K, Grol-Prokopczyk H, Zajacova A, 2021. A global study of pain prevalence across 52 countries: examining the role of country-level contextual factors. Pain. 10.1097/j.pain.0000000000002557.

Zimmer Z, Zajacova A, 2020. Persistent, consistent, and extensive: the trend of increasing pain prevalence in older Americans. J. Gerontol.: Series B 75 (2), 436–447.

Zimmer Z, Zajacova A, Grol-Prokopczyk H, 2020. Trends in pain prevalence among adults aged 50 and older across Europe, 2004 to 2015. J. Aging Health 32 (10), 1419–1432. 10.1177/0898264320931665. [PubMed: 32583713]

Zis P, Daskalaki A, Bountouni I, Sykioti P, Varrassi G, Paladini A, 2017. Depression and chronic pain in the elderly: links and management challenges. Clin. Interv. Aging 709–720. [PubMed: 28461745]

Zou G, 2004. A modified poisson regression approach to prospective studies with binary data. Am. J. Epidemiol 159 (7), 702–706. [PubMed: 15033648]

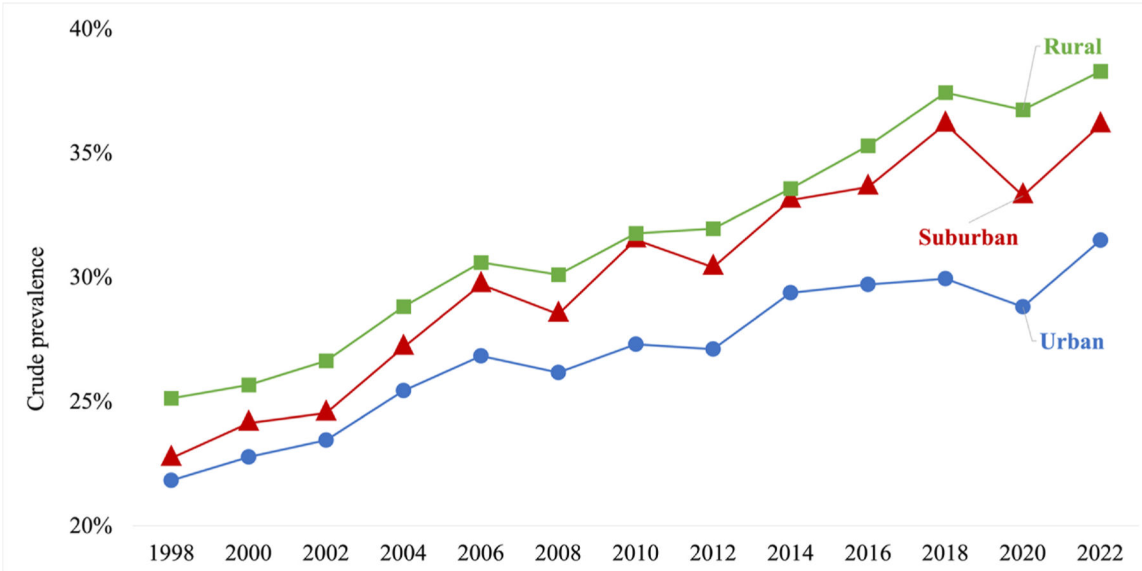

Fig. 1.
Weighted crude prevalence of moderate-to-severe or limiting pain in rural, suburban, and urban areas among adults 55+ (Health and Retirement Study, 1998–2022, n = 35,230, obs. = 206,600).

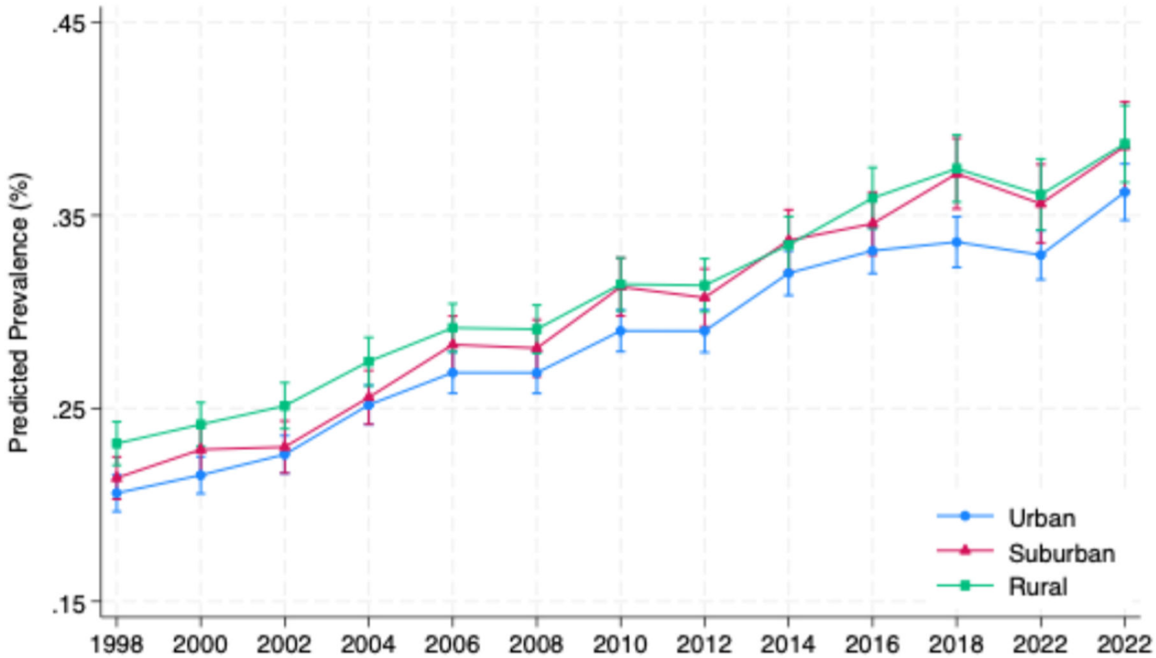

Fig. 2.

Predicted prevalence of moderate-to-severe or limiting pain in rural, suburban, and urban areas among adults 55+, with 95 % confidence intervals with time as non-linear categorical variable (Health and Retirement Study, 1998–2022).

Notes: Estimates are based on Model 4 in Table 2 via generalized estimating equations (GEE) with a Poisson distribution, log link, and robust standard errors but time measured as categorical variable, i.e., each survey wave year. The model adjusted for age, sex/gender, race and ethnicity, marital status, education, household wealth, and census region and average survey weights.

Author Manuscript

Author Manuscript

Author Manuscript

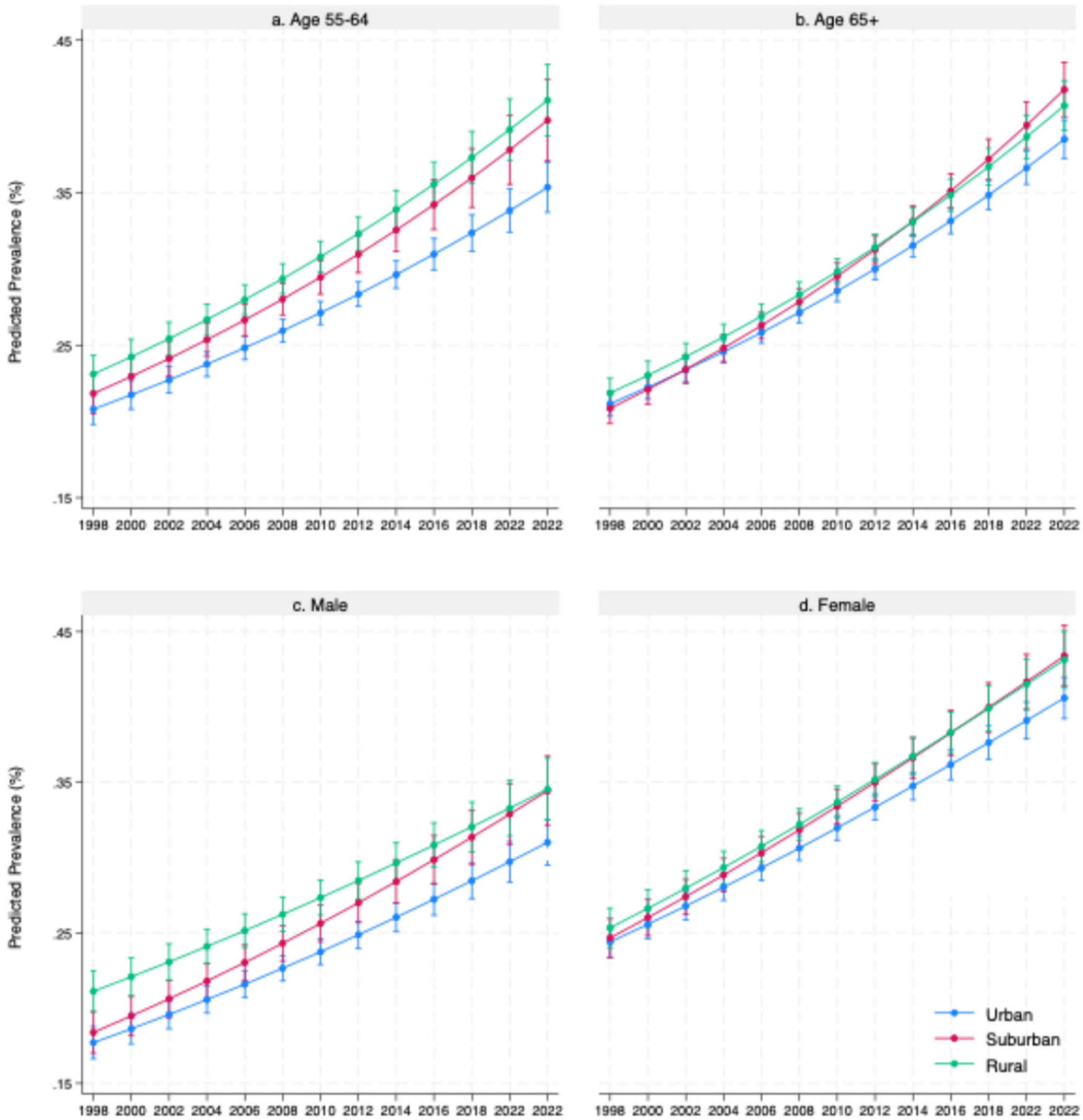

Fig. 3.

Predicted prevalence of moderate-to-severe or limiting pain in rural, suburban, and urban areas among adults 55+, by age (55–64 vs 65+) or sex/gender (female vs male) with 95 % confidence intervals (Health and Retirement Study, 1998–2022). Estimates are based on generalized estimating equations (GEE) with a Poisson distribution, log link, and robust standard error, adjusting for average survey weights and covariates (i.e., race and ethnicity, marital status, education, household wealth, and census region).

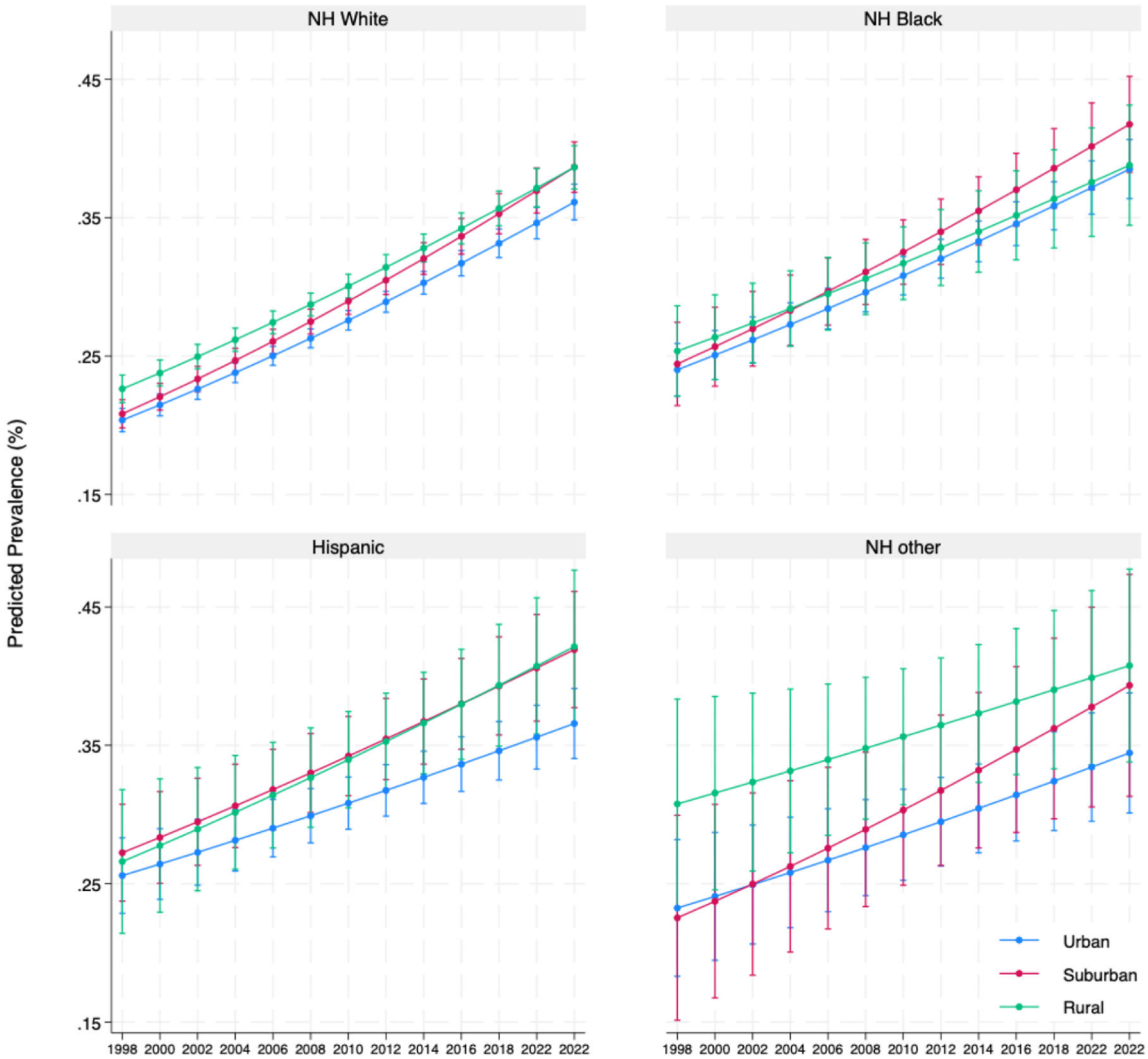

Fig. 4.

Predicted prevalence of moderate-to-severe or limiting pain in rural, suburban, and urban areas among adults 55+, by race/ethnicity (non-Hispanic Black, Hispanics, non-Hispanic other, and non-Hispanic White), with 95 % confidence intervals (Health and Retirement Study, 1998–2022). Estimates are based on generalized estimating equations (GEE) with a Poisson distribution, log link, and robust standard error, adjusting for average survey weights and covariates (i.e., age, sex/gender, marital status, education, household wealth, and census region).

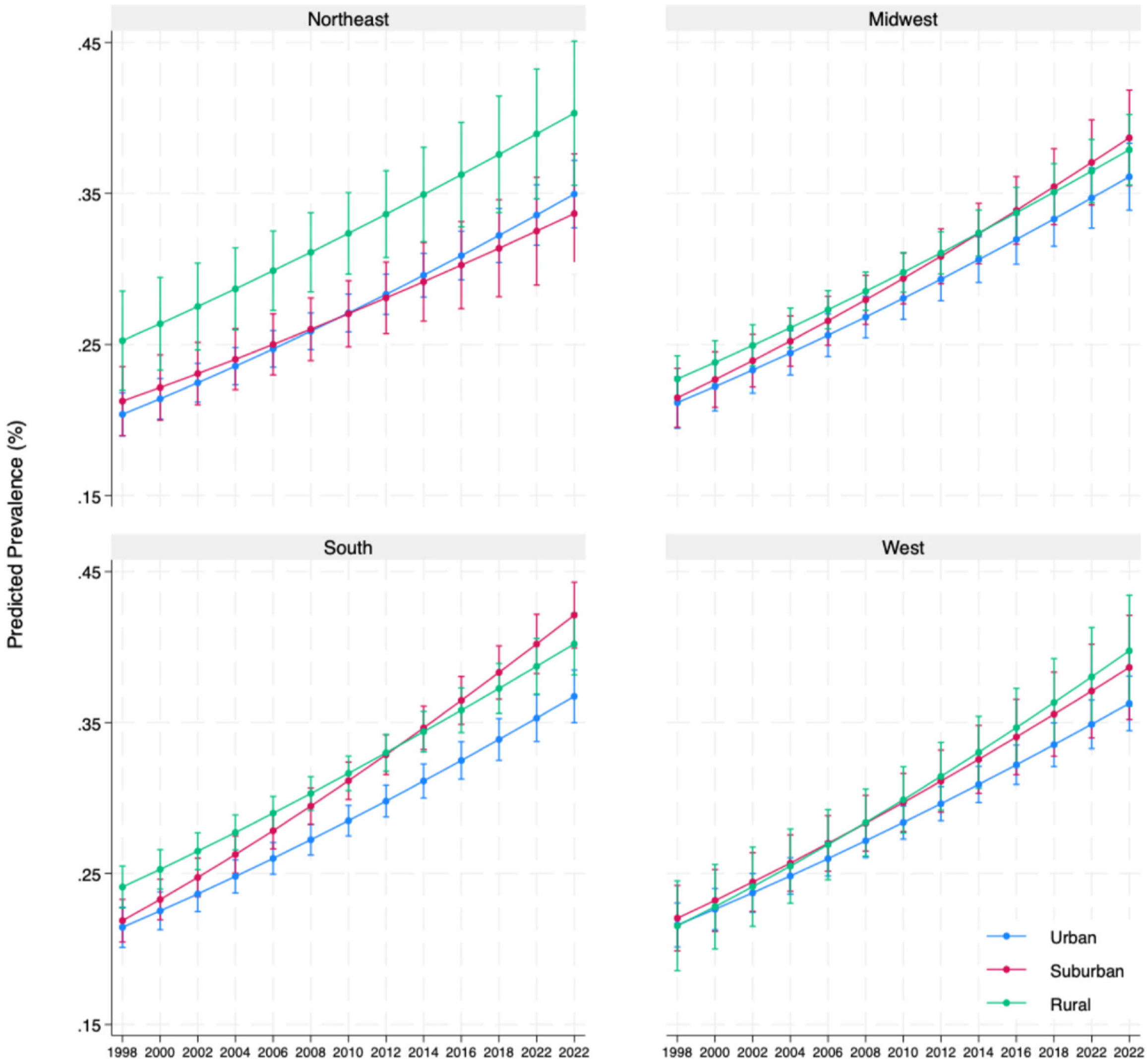

Fig. 5.

Predicted prevalence of moderate-to-severe or limiting pain in rural, suburban, and urban areas among adults 55+, by U.S. Census region, with 95 % confidence intervals (Health and Retirement Study, 1998–2022). Estimates are based on generalized estimating equations (GEE) with a Poisson distribution, log link, and robust standard error, adjusting for average survey weights and covariates (i.e., age, sex, race and ethnicity, marital status, education, and household wealth).

Table 1

Weighted baseline sociodemographic and geographic characteristics across urban, suburban and rural samples among respondents aged 55+ (Health and Retirement Study, 1998–2022, n = 33,230).

	Full Sample (n = 35,230)	Urban (n = 17,588)	Suburban (n = 8637)	Rural (n = 9005)	P-value
Pain prevalence	0.27	0.24	0.28	0.30	<0.001
Age, mean (SD)	60.66 (8.19)	60.45 (8.27)	61.24 (8.77)	61.17 (8.32)	<0.001
Female gender	0.52	0.51	0.53	0.51	0.324
Race/ethnicity					<0.001
NH White	0.75	0.70	0.75	0.85	
NH Black	0.11	0.13	0.10	0.07	
Hispanic	0.09	0.11	0.11	0.05	
NH other	0.05	0.06	0.03	0.04	
Education					<0.001
Less than high school	0.17	0.15	0.20	0.20	
High school	0.32	0.28	0.32	0.39	
Some college	0.25	0.26	0.25	0.23	
College and above	0.26	0.31	0.23	0.18	
Marital status					<0.001
Married/partnered	0.69	0.69	0.69	0.71	
Divorced/separated	0.14	0.15	0.14	0.13	
Widowed	0.10	0.09	0.11	0.11	
Never married	0.06	0.07	0.06	0.05	
Household					<0.001
Wealth					
Quartile 1 (least)	0.24	0.23	0.24	0.25	
Quartile 2	0.24	0.20	0.27	0.30	
Quartile 3	0.25	0.26	0.25	0.24	
Quartile 4 (wealthiest)	0.26	0.31	0.24	0.20	
Regions of residence					<0.001
Northeast	0.18	0.24	0.17	0.08	
Midwest	0.24	0.19	0.22	0.35	
South	0.37	0.30	0.41	0.46	
West	0.21	0.27	0.19	0.11	

Notes: Baseline was defined as the first observation during the study period. Proportions were presented except for age. SD–standard deviation; NH-non-Hispanic. Weighted estimates use average survey weights. Significance tests use ANOVA for continuous variables (e.g., age) and chi-square tests for categorical variables (e.g., sex/gender).

Table 2

Prevalence ratios and 95 % confidence intervals for models of moderate-to-severe or limiting pain across urban, suburban, and rural areas (HRS, 1998–2022, n = 35,230, obs. = 206,600).

	Model 1	Model 2	Model 3	Model 4
	PR (95 % CI)	PR (95 % CI)	PR (95 % CI)	PR (95 % CI)
Rural-urban (ref. Rural)				
Urban	0.87 *** (0.84–0.89)	0.86 *** (0.82–0.90)	0.86 *** (0.81–0.90)	0.91 *** (0.86–0.95)
Suburban	0.95 ** (0.92–0.98)	0.91 *** (0.86–0.96)	0.90 *** (0.85–0.95)	0.93 ** (0.89–0.98)
Time (0–1)	1.70 *** (1.64–1.75)	1.65 *** (1.56–1.75)	1.49 *** (1.41–1.58)	1.66 *** (1.57–1.76)
Urban X time		1.02 (0.95–1.09)	1.01 (0.94–1.08)	1.02 (0.95–1.10)
Suburban X time		1.08 * (1.00–1.17)	1.08 † (1.00–1.17)	1.08 † (1.00–1.17)
Age (in years)			1.01 *** (1.00–1.01)	1.00 *** (1.00–1.00)
Sex/gender (ref. male)				
Female gender			1.26 *** (1.22–1.31)	1.24 *** (1.20–1.28)
Race or ethnicity (ref. NH White)				
Non-Hispanic Black			1.07 ** (1.02–1.12)	0.90 *** (0.87–0.95)
Hispanic			1.10 *** (1.05–1.16)	0.86 *** (0.82–0.91)
Non-Hispanic Other			1.06 (0.97–1.16)	1.02 (0.94–1.12)
Census region (ref. Northeast)				
Midwest			1.02 (0.97–1.07)	1 (0.95–1.05)
South			1.05 * (1.01–1.10)	1.04 † (0.99–1.09)
West			1.05 † (1.00–1.11)	1.09 ** (1.03–1.14)
Marital status (ref. married/partnered)				
Divorced/separated			1.13 *** (1.09–1.17)	1.04 * (1.01–1.08)
Widowed			1.01 (0.98–1.04)	0.95 *** (0.92–0.97)
Never married			1.08 * (1.01–1.16)	1.02 (0.95–1.09)
Education (ref. less than high school)				
High school/GED				0.89 *** (0.86–0.93)
Some college				0.84 *** (0.80–0.88)
College and above				0.56 *** (0.53–0.59)

	Model 1	Model 2	Model 3	Model 4
	PR (95 % CI)	**PR (95 % CI)**	**PR (95 % CI)**	**PR (95 % CI)**
Household wealth Quartiles (ref. Q1)				
Quartile 2				0.90 *** (0.88–0.93)
Quartile 3				0.79 *** (0.77–0.82)
Quartile 4 (Wealthiest)				0.73 *** (0.71–0.76)

Notes: PR-prevalence ratio; CI-confidence intervals. We fit generalized estimating equations (GEE) with a Poisson distribution, log link and robust standard errors. Time is converted to a 0–1 scale with 0 indicating 1998 and 1 indicating 2022, showing estimates for the changes over the entire study period. Both models are adjusted for average survey weights. *P*-value,

† <0.10,

* <0.05,

** <0.01,

*** <0.001.