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Rural-urban residence and life expectancies with and without pain

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Abstract

This paper analyzes rural-urban disparities in life expectancy with and without pain among upper-middle age and older adults. Data are from the nationally representative Health and Retirement Study, 2000–2018, N = 18,160, age 53+. Interpolated Markov Chain software, based on the multistate life tables, is used to calculate absolute and relative pain expectancies by age, sex, rural-suburban-urban residence and U.S. regions. Results show significant rural disadvantages versus those in urban and often suburban areas. Example: males at 55 in rural areas can expect to live 15.1 years, or 65.2 percent pain-free life, while those in suburban areas expect to live 1.7 more years, or 2.6 percentage points more, pain-free life and urban residents expect to live 2.4 more year, or 4.7 percentage points more. The rural disadvantage persists for females, with differences being a little less prominent. At very old age (85+), rural-urban differences diminish or reverse. Rural-urban pain disparities are most pronounced in the Northeast and South regions, and least in the Midwest and West. The findings highlight that rural-urban is an important dimension shaping the geography of pain. More research is needed to disentangle the mechanisms through which residential environments impact people's pain experiences.

Keywords

Rural-urban health disparities; Chronic pain; Health expectancy; Quality of life

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CRediT authorship contribution statement

Feinuo Sun: Funding acquisition, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Zachary Zimmer:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition, Conceptualization. **Nicolas Brouard:** Writing – review & editing, Validation, Supervision, Software, Methodology.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2024.103305.

1. Introduction

A rising prevalence in chronic pain in recent decades results in increasing concern regarding the causes and consequences of pain (Yong et al., 2022; Zajacova et al., 2021). One issue of interest is the geographic distribution of pain. Some existing studies have shown unequal distribution of pain outcomes across the U.S. states and counties (Sun et al., 2024; Zajacova et al., 2022), but limited research has examined the rural-urban dimension in the spatial inequality. This study uses health expectancy methodology, a tool for evaluating quantity and quality of life simultaneously, to examine life expectancies with and without pain across rural-urban residence.

1.1. Rural-urban health disparities

Place of residence is well established as a determinant of health outcomes, and rural-urban is an important dimension linking place with health (Eberhardt and Pamuk, 2004; Jensen et al., 2020; Phillips and McLeroy, 2004). As the spatial inequality framework (Lobao and Hooks, 2007) suggests, places are different in a range of demographic, economic, and social aspects that are highly associated with residents' life experiences. Rural areas, compared to urban areas, often consist of populations with socioeconomic disadvantages, such as lower education attainment and low-skilled occupations; factors linked to worse health conditions (Adler and Ostrove, 1999; Link and Phelan, 1995; Wilkinson, 1997). In addition, social disorganization and collective efficacy theories suggest that the social and economic disadvantages (e.g., high poverty rates) of living in rural communities/ neighborhoods include lack of healthcare resources and a reduced capacity to utilize what available resources do exist (Monnat and Pickett, 2011; Sampson et al., 1997). Therefore, there are reasons for a variation in population health across residence that is advantageous to those in urbanites.

These rural-urban health disparities in the U.S. have been verified in empirical studies (Jensen et al., 2020; Monnat and Pickett, 2011). Compared to urban populations, people in rural areas are found to have higher all-cause mortality (Probst et al., 2020; Singh and Siahpush, 2014a) and generally worse health outcomes, including higher prevalence of diabetes (O'Connor and Wellenius, 2012), obesity (Cohen et al., 2017; Trivedi et al., 2015), cardiovascular diseases (Fanaroff et al., 2022; Loccoh et al., 2022) and other chronic diseases (Gaffney et al., 2022). Suburban areas generally refer to the transition zones between urban and rural, such as the fringe of a metropolitan area (i.e., residence within a metropolitan statistical area but outside of the central city). Some research suggests suburban health outcomes can differ from both rural and urban, indicating the necessity to distinguish suburban as a separate group. As an example, working-age mortality rates are more favorable in suburban areas than elsewhere (Borders and Booth, 2007; Meit et al., 2014).

But research has also found substantial variations in rural-urban health disparities across subpopulations (Carter and Dean, 2021; Kroneman et al., 2010; Probst et al., 2020; Roberts et al., 2016), suggesting that the association is complex. Given population aging and a disproportionately higher growth of older adults in rural areas, one important area of inquiry is how the association manifests among older persons (Carter and Dean, 2021; Jensen et al., 2020). While researchers generally find stronger impacts of place-based features for older compared to younger adults (Cohen et al., 2018; Population Reference Bureau, 2017), rural-urban differences in heart disease as one example has been shown to narrow for those aged 65 and older (Carter and Dean, 2021). Sex at times also interacts with rural-urban residence. For instance, a rural disadvantage in traumatic health problems is greater for males than females (Kroneman et al., 2010). On study showed rural Black and rural American Indian/ Alaska Native are particularly disadvantaged with very high overall age-adjusted mortality rates. In contrast, the same study showed no rural-urban difference in cancer and stroke mortality was found for Hispanic populations (Probst et al., 2020).

Region is another important dimension when examining rural/urban disparities. For mortality rate and health behaviors like alcohol consumption, smoking and physical activity, rural-urban disparities in the U.S. are most salient in the South, with those living in the rural South often emerging as the most disadvantaged in the country (Borders and Booth, 2007; Martin et al., 2005; Meit et al., 2014; Roberts et al., 2016). In contrast, findings for the Midwest and the West have been mixed, sometimes showing a reverse trend where urban populations fare worse (Martin et al., 2005; Roberts et al., 2016). It is quite possible then that there are important interactions between rural-urban residence and region of the country.

1.2. Chronic pain and health expectancy analysis

One health outcome for which rural-urban disparities have been rarely examined is pain. An alarming rise in prevalence of chronic pain in the U.S. over the last few decades, particularly among upper-middle age and older adults (i.e., adults aged above 55), has led to pain being a rapidly emerging public health concern (Feeny et al., 2012; Zimmer and Zajacova, 2020). Pain is strongly associated with several other health concerns that ultimately effect quality of life, such as disability, psychological health, and life satisfaction (Andrews et al., 2013; Gureje et al., 1998; Niv and Kreitler, 2001; Sun et al., 2023a). A limited number of studies show a rural disadvantage in pain compared to urban and suburban residents based on cross-sectional data in regional and small-size samples (Dahlhamer et al., 2018; Rafferty et al., 2021; Rikard et al., 2023; Zelaya et al., 2020). The present study advances the literature by examining rural-suburban-urban health disparities in pain using population-level longitudinal data. While population-level longitudinal data may be limited at times with respect to details on the cause, location, or duration of pain, such data, when containing very large sample sizes, enable health expectancy approach that can accurately estimate life expectancies as well as expected years with and without specific health conditions (known as “health expectancies”) across places of residence (Lièvre et al., 2008; Saito et al., 2014), allowing for a detailed empirical understanding of geographic differences in pain.

An advantage of the health expectancy approach that is used in the current analysis is that by examining both total life and life with and without pain, it presumes that rising prevalence of chronic pain threatens both quality and quantity of life (Sun et al., 2023b; Zimmer and Rubin, 2016). It does this by simultaneously combining morbidity and mortality into a single outcome that accounts for both changing dynamics of health conditions in the aging process and the selection effects of mortality. The method has been applied for multiple health outcomes, such as disability and cognition (Crimmins et al., 2016a, 2016b). However, to date, there have been only a handful of studies on pain expectancy (Sun et al., 2023b; Zimmer and Rubin, 2016), and none focused on rural/urban differences.

Focusing on a population of upper-middle age and older adults, in this analysis we calculate life expectancies without pain, with milder pain, and with severe pain across rural, suburban, and urban residences for different ages, sexes, and regions of the U.S. Based on previous literature, we test the following hypotheses: H1) those in rural areas live more years and a larger proportion of years with pain compared to those in suburban and urban areas; H2) rural-urban disparities in pain expectancies vary across age, sex, and region. Based on past literature, we can expect disparities to be greater for younger aged older adults, males, and those living in the South.

2. Data and methods

2.1. Data

Data used in this study are from the U.S. Health and Retirement Study (HRS), a biennial national longitudinal panel survey initiated in 1992. The baseline sample used for this study is the HRS population from the 2000 wave. This is the year when HRS began to provide sampling weights for respondents living in nursing homes. We follow those in the 2000 HRS until 2018. While 2020 data were available at time of analysis, mortality in that wave was highly skewed due to the influence of the COVID-19 epidemic (Arias et al., 2021; Murphy et al., 2021). We incorporate the HRS individual level sample weights for respondents in households and nursing homes, making the sample representative of the total U.S. population aged 53 years and older in 2000 (Lee et al., 2021). The original sample includes 18,598 respondents. Four-hundred-and-thirty-eight observations (about 2.3%) are deleted due to incomplete information on key variables, making the final sample size is 18,160.

2.2. Measures

To be consistent with previous studies on pain that use HRS data (Zimmer and Rubin, 2016; Zimmer and Zajacova, 2020), the measure of pain is constructed from three survey questions: “Are you often troubled with pain?” “How bad is the pain most of the time: mild, moderate or severe?” “Does the pain make it difficult for you to do your usual activities?” These items are combined to create a measure with three categories for pain status: no pain, pain that is mild/moderate and does not limit activity (hereinafter as milder pain), and pain that is severe and/or limits activity (hereinafter as severe pain). Dates of birth and death are obtained from HRS “tracker files” (Health and Retirement Study, 2020). For 291 individuals who have information of birth/death year but no specific information of birth/death month, we substitute the midpoint between waves during which the death occurred.

Rural-urban and region of residence are drawn from HRS “Cross-Wave Census Region/ Division and Mobility File” (Health and Retirement Study, 2021). Some live in different places in different survey waves, and so rural-urban status is considered as a time-varying variable. In HRS, rural-urban status for every survey year is coded into “urban,” “suburban,” and “ex-urban (hereinafter as rural)” based on the Beale Rural-Urban Continuum code. Due to the change of rural-urban boundaries in the past decades, the Beale codes have different versions, in 1993, 2003, and 2013 respectively. HRS provides variables of rural-urban residence of each survey year based on all three versions. Our analysis uses the rural-urban variable based on the 2003 Beale codes for the years 2000–2008, and the variable based on the 2013 codes for the years 2010–2018. We only use cases with complete and meaningful rural-urban residence information in every survey year and exclude 383 cases for whom rural-urban residence cannot be determined for one or some years. Region of residence is time-fixed at baseline in 2000 as “Northeast,” “Midwest,” “South,” and “West.” We consider baseline region as time-fixed for several reasons. First, whereas 10.4% of the sample moved between rural/suburban/urban areas, only less than 5% moved from one region to another over the course of the entire longitudinal observation period. Second, research has shown that baseline region is more influential on physical functioning than region to which one moves (Lin and Zimmer, 2002). This is particularly the case with older aged individuals that move across regions.

2.3. Analysis

The Interpolated Markov Chain (IMaCh) software uses a multistate life table approach to estimate life expectancy and life expected in various states of health. IMaCh has been used to examine health expectancies across different outcomes in previous studies (Lièvre et al., 2008; Robine and Ritchie, 1991; Saito et al., 2014), including a small number on pain (Sun et al., 2023b; Zimmer and Rubin, 2016). The approach involves two steps. First, transition probabilities from a baseline state (e.g., without pain) to a follow-up state (e.g., with milder pain) are calculated based on multinomial logistic regressions. Fig. 1 shows the transitions among states considered in this analysis. Baseline states could be either without pain, with milder pain, and with severe pain, while there are four possible follow-up states including the three pain states and having died. The probabilities are estimated for different ages, sexes, rural-urban residences, and regions based on multinomial regressions including these variables and their interactions. The model without region is shown as follows:

$$\ln\left[\frac{P_{ij}}{P_{ii}}\right] = \beta_{ij\ 0} + \beta_{ij\ 1}Age + \beta_{ij\ 2}Sex + \beta_{ij\ 3}Rural\_Urban + \beta_{ij\ 4}Age \times Sex + \beta_{ij\ 5}Age \times Rural\_Urban + \beta_{ij\ 6}Sex \times Rural\_Urban + \beta_{ij\ 7}Age \times Sex \times Rural\_Urban$$

P here is transition probability, i is baseline state at time (t) and j is follow-up state at time $(t+1)$.

When considering the region variable, we estimate a new model that adds region and significant interactions.

In the second step, the transition probabilities from the multinomial regressions are used as input into standard multistate life tables. This allows IMaCh to calculate person years lived in various states, that is, multistate life expectancies. The output includes expected total years of life, pain-free life, and life with milder pain and severe pain for males and females in rural, suburban, and urban areas and across regions. The output also includes standard errors which allows calculation of 95% confidence intervals. Differences between rural/suburban/urban residence are assessed as being statistically significant if there is no overlap in the confidence intervals.

Pain expectancies are reported and assessed using two types of results. First, we assess the degree to which there are rural/suburban/urban differences in net number of years expected in each pain state. This is referred to as absolute results. An absolute urban advantage is assessed if those living in urban areas are found to live a statistically significant greater number of years of life without pain and fewer with milder and severe pain in comparison to others. Second, we assess the degree to which there are rural/suburban/urban differences in the percentage of life expected in different pain states. This is referred to as relative results. A relative urban advantage is assessed if those living in urban areas are found to live a statistically significant greater percentage of remaining life without pain and a lesser percentage with milder and severe pain. While output is available for all ages upon request, we only show results here for exact ages 55, 70 and 85, which represent stages of upper-middle (or younger old), middle old, and upper old (or oldest old) ages.

3. Results

3.1. Descriptive statistics

Table 1 shows descriptive statistics for the subsamples by baseline rural-urban residence and region. To determine the significance of differences in baseline pain prevalence, and in age and sex, across any two areas, we use pair-wise comparison t-tests (Kim, 2015; Yang et al., 2020). Overall, rural areas have significantly lower percentages without pain compared to urban areas, and significantly higher percentages with severe pain compared to either urban or suburban areas. Suburban areas have the highest percentage with milder pain. The mean age of residents in suburban areas is significantly older than in urban areas. The differences in baseline pain states across rural, suburban, and urban areas are not significant in the Northeast and the Midwest. However, in the South region, rural areas have significantly lower percentages without pain and higher percentages with severe pain than urban and suburban areas. In the West region, both rural and suburban areas have lower percentages without pain and higher percentages with severe pain compared to urban areas. In addition, we find that the highest percentage with severe pain is in the rural West, at 26.1%. It is interesting that the percent with severe pain is relatively consistent across urban areas regardless of region (at somewhere around 18%), but differs across rural regions (ranging from less than 18% to over 26%).

3.2. Rural-urban differences in pain expectancies

Table 2 presents absolute pain expectancy results. To facilitate comparisons across areas, we show the absolute years for total life expectancy and life expectancy without pain, with milder pain, and with severe pain for rural areas, and then show absolute difference between this estimate and the estimates in suburban and urban areas. We also present 95% confidence intervals for these differences. The results are for males and females aged 55, 70, and 85. Specific estimates for rural, suburban, and urban as well as 95% confidence intervals for those estimates are shown in Supplemental Table S1.

Rural residents have significantly lower total life expectancy than suburban and urban residents for both sexes and across ages. For example, for males aged 55, those in rural areas expect 23.2 years of total life while those in suburban and urban areas expect 1.6 and 1.9 more years respectively. There is a rural disadvantage in pain expectancy as well. For instance, expected pain-free years for rural males age 55 is 15.1 while urban males at age 55 can expect to live 2.4 more years pain-free and suburban males 1.7 more. Confidence intervals indicate that these differences are statistically significant. Suburban-rural and urban-rural comparisons in milder and severe pain years are non-significant. The patterns are similar for females, although the difference in magnitude is smaller. For example, rural females at age 55 expect 15.5 years of pain-free life while their suburban counterparts expect 1.0 years more, and urban counterparts expect 1.5 more, and these differences are statistically significant. Females age 55 and 70 in urban and suburban areas expect a significantly greater number of years with milder pain (with a difference of 0.3) than their rural counterparts.

For both males and females, the absolute rural-urban differences decrease as age increases. Absolute differences still exist at age 70, with rural residents being disadvantaged, but the net differences are narrower. By age 85, the absolute difference in years expected pain-free, for males and females, is merely a small fraction of a year and non-significant.

Table 3 shows relative differences in pain expectancy across age, sex, and rural-suburban-urban residence. Again, estimates are shown for rural areas as well as net differences between rural and suburban or urban areas. Full results are provided in Supplemental Table S2. The findings are somewhat like what is shown in Table 2, but urban-rural differences in severe pain are now evident and statistically significant for those at age 55. That is, because life expectancy is lower in rural areas in comparison to urban areas, these rural residents live a significantly larger percentage of life with severe pain, even though the absolute years lived with severe pain are similar across areas. For instance, at age 55 males in rural areas live 20.3% of life with severe pain, while the percent is 1.3 and 2.8 percentage points lower in suburban and urban areas respectively. Females of that age in rural areas expect 29.6% of life with severe pain, and the percentage is 1.4 and 3.3 percentage points lower in suburban and urban areas respectively.

Rural males and females at age 55 also expect significantly lower percentages of pain-free life than their urban counterparts. For example, rural males at age 55 expect to live 65.2% of their remaining life pain-free while their suburban and urban counterparts can expect 2.6 and 4.7 percentage points more. The rural-urban disparity is a little less pronounced for females than males, where urbanites age 55 an advantage over their rural counterparts of 3.1 net percentage points. The relative findings indicate that rural-urban differences become reversed by age 85, where urban males and females expect lower percentages of pain-free life and higher percentages of life with milder pain.

3.3. Regional differences in pain expectancies

Table 4 adds the regional dimension. The top panel shows absolute results in rural areas and net differences with suburban or urban areas. The bottom panel shows relative estimates and percentage point differences. Specific estimates of absolute and relative pain expectancies, 95% confidence intervals as well as results for milder pain and severe pain are provided in Supplemental Tables S3 and S4. We find that the urban and suburban advantage over rural areas is fairly consistent exist across regions. An exception is that rural-urban differences in the Midwest are relatively smaller and often non-significant. In contrast, the rural South is particularly disadvantaged. For example, males at age 55 in rural South expect only 14.1 years of pain-free life; fewest among all residence/region groups. Like the non-regional findings, differences decrease to being non-significant at age 85.

The patterns shown for relative pain expectancies are similar, with a few discrepancies. Those in the South, especially rural South, have relatively low total life expectancy compared to other areas. But, with respect to the percent of life pain-free, it is not always less than those in other regions. For instance, for males at 70, the lowest percentage of pain-free life is found in rural Northeast, at 63.2 while it is 67.0 in the rural South. For the oldest old age 85, the rural-urban differences are sometimes reversed with suburban and urban residents expecting lower percentages of pain-free life. In addition, there are some large rural-urban differences in pain-free life in the Northeast.

4. Discussion

This study is among very few that examine how rural-urban health disparities are reflected in pain outcomes (Carter and Dean, 2021; Singh and Siahpush, 2014b). Using health expectancy methods, which capture dynamics of health change in older ages together with mortality, we compared expected years of life without pain, with milder pain, and with severe pain for males and females at ages 55, 70, and 85 living in urban, suburban, and rural areas and across regions. The results show relatively consistent and significant rural disadvantages in absolute and relative pain expectancies in comparison to urban and often in comparison to suburban residents. There are also some variations in this general finding depending upon age, sex, and region.

The presentation of results for people at ages 55, 70 and 85 provide a range across earlier and later old age. For people at age 55, those in rural areas not only expect shorter life but also a lower percentage of remaining years free of pain, and a higher percentage of life with severe pain, compared to those in urban and suburban areas. This is consistent with previous findings of a rural disadvantage in life expectancy, pain, and pain-related conditions like arthritis and obesity (Boring et al., 2017; Cohen et al., 2017; Dahlhamer et al., 2018; Singh and Siahpush, 2014b). Some of the mechanisms, as previous literature points out, may include lower education and fewer economic resources for rural residents compared to urban counterparts, as well as deficits in the availability and quality of healthcare services (Keyes et al., 2014; Lutfiyya et al., 2013; Yaemsiri et al., 2019).

However, we find that as people reach the upper older age of 85, the differences by urban-suburban-rural residence are greatly diminished and may even reverse. We can postulate several possible explanations for this. First, rural older adults may report pain more conservatively, which may be a function of having to rely on fewer physical health practices and having lower health expectations (Clayton et al., 1994; Magilvy and Congdon, 2000). Another explanation is selection. Life expectancy is shorter in rural than in urban areas (Singh and Siahpush, 2014b), which makes it less likely that rural older adults will survive until the oldest-old ages, especially if they suffer from painful health conditions. Therefore, by age 85, rural and urban people look more equal. There is also a selective migration of better-off older adults to amenity-rich rural destinations (Glasgow and Brown, 2012). Lastly, rural areas have some strengths that favor the aging process, such as stronger informal ties and social support, religious or spiritual sources, and lifestyle factors (Hash et al., 2018; Henning-Smith et al., 2022). Rural older adults are more likely to age in place than their urban counterparts due to strong place attachment (Bacsu et al., 2014; Erickson et al., 2012), which could enhance health, or at least perceived health. Future research is needed to understand the mechanisms of how rural-urban pain disparities change in older ages.

Similar to previous findings on rural-urban differences in life expectancy and mortality rate (Singh and Siahpush, 2014a, 2014b), our results also show that the rural-urban disparities in both total life expectancy and pain expectancies are larger and more significant for males than for females. Previous studies suggest several disadvantages of rural males compared to females, which could lead to a larger gap. There is an overwhelmingly larger share of rural males participating in manual labor occupations such as rural farming and mining compared to rural females (Smith and Trevelyan, 2019), which sometimes leads to health conditions that associate with pain (Case and Deaton, 2005; Gutin and Hummer, 2020). Rural males also receive poorer clinical care services than rural females, possibly because of lower health literacy and patient activation (Burkhart et al., 2020; MacCarthy et al., 2022). Moreover, the traditional and conservative rural culture may reinforce gender norms that females are often the primary healthcare decision-makers and thus could better navigate their own health while males are more reluctant to seek medical help (Burkhart et al., 2020; Galdas et al., 2005; MacCarthy et al., 2022).

Bringing the region into discussion, the findings show that people in the rural South generally have the shortest years of pain-free life, which is consistent with previous evidence on health disadvantages of the rural South (Martin et al., 2005; Miller and Vasan, 2021). These findings echo previous literature on the geography of chronic pain showing the deep South and the West are “hotspots” of pain (Zajacova et al., 2022). Rural-urban differences are particularly pronounced in the Northeast and the South areas, and less so in the Midwest and West. These idiosyncrasies suggest that in addition to documenting rural-urban disparities in absolute and relative life with and without pain, our study is highlighting heterogeneity across regions. This in turn indicates the importance of localized policies targeting areas.

The study has several limitations. First, as discussed previously, the simple self-assessed pain measure used in HRS cannot capture complex facets of pain, such as the location, duration, and management. Self-reporting also may differ across population groups. For example, some health conditions that particularly affect the oldest old population, such as those linked to cognitive decline, will affect pain reporting (Scherder et al., 2009). Nonetheless, self-report remains the most common way to measure pain, and only large scale population-level data, such as the HRS, are suitable for health expectancy analyses. Second, we only used the publicly available HRS rural-urban measure based on the Beale rural-urban codes. While we are not able to replicate the entire analysis using restricted HRS data, we did sensitive analysis for the baseline rural, suburban and urban pain prevalence using different cut-offs of the Beale codes and different rural-urban measures such as the National Center for Health Statistics (NCHS) rural-urban scheme, Urban Influence Code, and Rural-Urban Commuting Area (RUCA) codes (results available upon request) and found consistent rural disadvantages compared to urban areas. However, the 3-group-categorization of rural-urban may mask some heterogeneity in rural areas. Since rural areas in the U.S. are diverse regionally in natural environments, socioeconomic conditions, population size and composition, history, and culture that may shape the aging processes, the experiences of older adults in health transition and health management are very different in different rural communities (Glasgow and Brown, 2012; James, 2014). Future research is needed to use more refined rurality or urbanicity measures to examine people's pain outcomes by residence. Lastly, the study did not include a race/ethnicity dimension. Given that rural-urban health disparities also vary significantly across race/ethnicity groups (Probst et al., 2020), this suggests further research is needed to understand how this interacts this with rurality in shaping pain expectancies.

Contributing to the ongoing discussions on rural-urban health inequality and the geographic distribution of pain, this paper provides the first analysis of rural-suburban-urban disparities in pain that quantifies the years one expects to live with and without pain. A male at age 55 who lives in rural areas can expect to live nearly 2 years fewer in total life and 2.4 years fewer in pain-free life than a 55-year-old male living in urban areas. A female at that age 55 in rural areas can expect to live 1.2 fewer total years and 1.5 fewer pain-free years than her counterpart in urban areas. This translates into a substantial difference in quantity of life for males and females, and at times an even greater disparity in relative years or quality of life. In turn, it suggests a need for more healthcare resources in rural areas and medical professionals to understand and improve the functional ability and quality of life for rural residents. The rural-urban disparity is most evident and robust for those living in Northeast and South U.S., indicating significant heterogeneities across regions and suggesting targeted and localized policies. The findings also call for more research on the interactions between rurality and other predictors of pain. Further research is also needed to disentangle the mechanisms through which residential environments impact older people's pain experiences, with an aim of better understanding and perhaps ameliorating the alarming rising prevalence of pain in the country (Zimmer and Zajacova, 2020).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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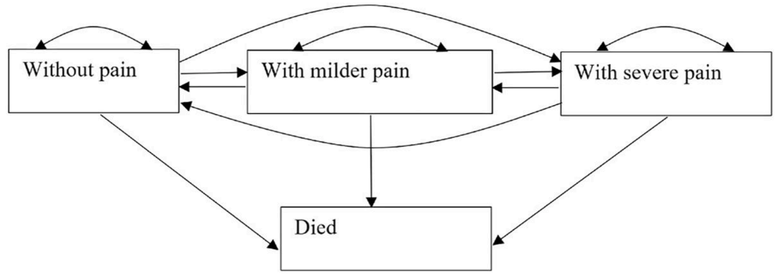

Fig. 1.

States and transitions estimated in the multistate life tables.

Table 1

Weighted descriptive statistics of subsamples according to baseline rural-urban residence and regions.

		Urban	Suburban	Rural	t-test results[a]
Total	Baseline status				
	Without pain (%)	72.2	70.6	69.2	c
	Milder pain (%)	9.6	11.1	9.4	a, b
	Severe pain (%)	18.2	18.3	21.4	b, c
	Female (%)	55.6	56.2	55.1	
	Mean age (SD)	67.1	67.6	67.4	a
	N (respondents)	8689	3995	5476	
Northeast	Baseline status				
	Without pain (%)	72.4	70.3	68.7	
	Milder pain (%)	8.9	11.7	8.9	
	Severe pain (%)	18.7	18.0	22.4	
	Female (%)	57.3	58.4	54.1	
	Mean age (SD)	68.0	68.9	66.4	b, c
	N (respondents)	1914	759	427	
Midwest	Baseline status				
	Without pain (%)	71.6	71.0	71.6	
	Milder pain (%)	10.1	11.2	10.7	
	Severe pain (%)	18.3	17.8	17.7	
	Female (%)	56.4	58.3	55.9	
	Mean age (SD)	67.4	67.7	68.2	
	N (respondents)	1774	902	1860	
South	Baseline status				
	Without pain (%)	71.6	72.7	68.3	b, c
	Milder pain (%)	10.4	10.4	8.4	c
	Severe pain (%)	18.0	16.9	23.3	b, c
	Female (%)	53.9	54.7	54.7	
	Mean age (SD)	65.9	66.8	67.2	a, c
	N (respondents)	2995	1591	2822	
West	Baseline status				
	Without pain (%)	73.0	66.7	64.1	a, c
	Milder pain (%)	9.1	11.5	9.9	
	Severe pain (%)	17.9	21.7	26.1	a, c
	Female (%)	55.6	53.6	56.1	
	Mean age (SD)	67.6	67.5	66.9	
	N (respondents)	2006	743	367	

[a] *t*-test results among three samples (at 0.05 significance level). a: urban versus suburban; b: suburban versus rural; c: urban versus rural.

Table 2.

Absolute life expectancies showing number of years with and without pain for rural residents, and net differences between rural and suburban or urban residents, by age and sex[a]

Sex and Pain Status	Age	Rural	Suburban-Rural	Urban-Rural
Males				
	55			
Pain-free		15.1	**1.7 (0.9, 2.6)**	**2.4 (1.9, 2.9)**
Milder pain		3.4	−0.1 (−0.4, 0.2)	**−0.2 (−0.4, −0.1)**
Severe pain		4.7	0 (−0.4, 0.5)	−0.3 (−0.6, 0)
Total		23.2	**1.6 (0.9, 2.4)**	**1.9 (1.4, 2.3)**
	70			
Pain-free		8.4	**0.8 (0.4, 1.2)**	**0.8 (0.5, 1.1)**
Milder pain		1.6	0.1 (0, 0.3)	**0.2 (0.1, 0.3)**
Severe pain		2.4	0.2 (0, 0.4)	0.1 (−0.1, 0.2)
Total		12.4	**1.2 (0.7, 1.6)**	**1.1 (0.8, 1.4)**
	85			
Pain-free		3.8	0.2 (−0.2, 0.5)	0.1 (−0.2, 0.3)
Milder pain		0.6	0.1 (0, 0.3)	**0.2 (0.1, 0.3)**
Severe pain		1.0	0.2 (0, 0.4)	0.1 (0, 0.2)
Total		5.4	**0.5 (0.1, 0.9)**	**0.4 (0.1, 0.7)**
Females				
	55			
Pain-free		15.5	**1.0 (0.3, 1.7)**	**1.5 (1.0, 2.0)**
Milder pain		3.3	**0.3 (0.1, 0.6)**	**0.3 (0.1, 0.4)**
Severe pain		7.9	0 (−0.5, 0.6)	**−0.6 (−0.9, −0.2)**
Total		26.7	**1.3 (0.7, 2.0)**	**1.2 (0.8, 1.7)**
	70			
Pain-free		9.0	0.2 (−0.2, 0.6)	**0.3 (0.1, 0.6)**
Milder pain		1.7	**0.2 (0.1, 0.3)**	**0.2 (0.1, 0.4)**
Severe pain		4.2	0.3 (0, 0.6)	0 (−0.2, 0.2)
Total		14.9	**0.7 (0.3, 1.1)**	**0.6 (0.3, 0.9)**
	85			
Pain-free		4.1	−0.2 (−0.4, 0.1)	−0.1 (−0.4, 0.1)
Milder pain		0.7	0.1 (0, 0.2)	0.1 (0, 0.2)
Severe pain		1.8	0.2 (−0.1, 0.4)	0.1 (0, 0.3)
Total		6.6	0.1 (−0.2, 0.4)	0.1 (−0.1, 0.3)

[a]Statistically significant differences (at 0.05 level) are shown in bold.

Table 3

Relative life expectancies showing percentages of remaining years with and without pain for rural residents, and net differences between rural and suburban or urban residents, by age and sex.[a]

Sex and Pain Status	Age	Rural	Suburban-Rural	Urban-Rural
Males				
	55			
Pain-free		65.2	**2.6 (0.2, 5.0)**	**4.7 (3.3, 6.1)**
Milder pain		14.5	**− 1.3 (−2.3, −0.3)**	**− 1.9 (−2.7, −1.1)**
Severe pain		20.3	− 1.3 (− 3.3, 0.7)	**− 2.8 (− 4, − 1.6)**
Total		100	-	-
	70			
Pain-free		67.5	0.4 (− 1.6, 2.4)	1.0 (− 0.4, 2.4)
Milder pain		12.8	0 (− 1.0, 1.0)	0.5 (− 0.3, 1.3)
Severe pain		19.7	− 0.4 (− 2.0, 1.2)	**− 1.5 (− 2.7, − 0.3)**
Total		100	-	-
	85			
Pain-free		70.0	− 2.8 (− 6.3, 0.7)	**− 3.1 (− 5.8, − 0.4)**
Milder pain		11.2	1.2 (− 0.8, 3.2)	**2.8 (1.2, 4.4)**
Severe pain		18.8	1.6 (− 1.3, 4.5)	0.2 (− 2.0, 2.4)
Total		100	-	-
Females				
	55			
Pain-free		57.9	1.0 (−1.2, 3.2)	**3.1 (1.3, 4.9)**
Milder pain		12.5	0.4 (− 0.4, 1.2)	0.2 (− 0.4, 0.8)
Severe pain		29.6	− 1.4 (− 3.4, 0.6)	**− 3.3 (− 4.7, − 1.9)**
Total		100	-	-
	70			
Pain-free		60.2	− 1.2 (− 3.0, 0.6)	0.1 (− 1.7, 1.9)
Milder pain		11.5	0.8 (0, 1.6)	**0.9 (0.3, 1.5)**
Severe pain		28.3	0.4 (− 1.2, 2.0)	− 1.0 (− 2.2, 0.2)
Total		100	-	-
	85			
Pain-free		62.2	**− 3.2 (−6.3, −0.1)**	**− 3.2 (−6.3, −0.1)**
Milder pain		10.5	1.1 (− 0.5, 2.7)	**1.7 (0.5, 2.9)**
Severe pain		27.3	2.1 (− 0.8, 5.0)	1.4 (− 1.0, 3.8)
Total		100	-	-

[a]Statistically significant differences (at 0.05 level) are shown in bold.

Table 4

Absolute and relative pain-free expectancies showing numbers and percentages of years without pain in rural areas by region, age, and sex, and differences with suburban and urban areas.[a]

Number of remaining pain free years						
Sex	**Age**	**Residence**	**Region**			
			Northeast	**Midwest**	**South**	**West**
Male	55					
		Rural	14.8	16.7	14.1	16.0
		Suburban-Rural	2.0 (− 0.2, 4.2)	0.5 (− 0.7, 2.3)	**1.7 (0.3, 3.1)**	**2.1 (0.3, 3.9)**
		Urban-Rural	**3.5 (2.4, 4.6)**	**1.5 (0.3, 2.6)**	**2.7 (1.8, 3.6)**	**1.3 (0.2, 2.4)**
	70					
		Rural	8.2	9.1	7.8	8.5
		Suburban-Rural	**1.4 (0.4, 2.4)**	0.4 (− 0.5, 1.4)	**0.8 (0.1, 1.4)**	**1.2 (0.3, 2.1)**
		Urban-Rural	**1.4 (0.8, 2.0)**	0.5 (− 0.2, 1.1)	**0.9 (0.3, 1.4)**	**0.8 (0.3, 1.4)**
	85					
		Rural	3.7	3.9	3.6	3.9
		Suburban-Rural	0.4 (− 0.3, 1.2)	0.1 (− 0.6, 0.8)	0.2 (− 0.4, 0.7)	0 (− 0.7, 0.8)
		Urban-Rural	0.4 (− 0.1, 0.9)	0.2 (− 0.4, 0.7)	− 0.1 (− 0.5, 0.4)	0 (− 0.4, 0.5)
Female	55					
		Rural	15.4	15.8	15.1	16.1
		Suburban-Rural	**3.6 (2.1, 5.1)**	− 0.1 (− 1.6, 1.4)	**1.4 (0.2, 2.6)**	− 1.2 (− 2.9, 0.4)
		Urban-Rural	**2.1 (1.1, 3.1)**	0.1 (− 1.0, 1.2)	**1.5 (0.6, 2.4)**	**1.9 (0.9, 2.8)**
	70					
		Rural	8.7	9.2	8.7	9.4
		Suburban-Rural	**1.6 (0.8, 2.4)**	− 0.3 (− 1.0, 0.5)	0.4 (− 0.2, 1.0)	− 0.8 (− 1.6, 0.1)
		Urban-Rural	**0.8 (0.3, 1.3)**	− 0.2 (− 0.7, 0.4)	0.4 (− 0.1, 0.9)	0.3 (− 0.2, 0.8)
	85					
		Rural	3.9	4.2	4.0	4.2
		Suburban-Rural	0 (− 0.5, 0.6)	− 0.1 (− 0.7, 0.4)	− 0.1 (− 0.6, 0.4)	− 0.5 (− 1.1, 0.1)
		Urban-Rural	0.1 (− 0.3, 0.5)	− 0.2 (− 0.6, 0.2)	− 0.1 (− 0.5, 0.2)	− 0.3 (− 0.7, 0)

Number of remaining pain free years

Sex	**Age**	**Residence**	**Region**			
			Northeast	**Midwest**	**South**	**West**

Percent of remaining pain-free years

Sex	Age	Residence	Region: Northeast	Midwest	South	West
Male	55					
		Rural	63.7	66.9	64.2	66.4
		Suburban-Rural	3.3 (− 2.8, 9.4)	1.5 (− 3.4, 6.4)	3.0 (− 1.1, 7.1)	1.8 (− 3.1, 6.7)
		Urban-Rural	**9.8 (6.9, 12.7)**	**5.7 (2.8, 8.6)**	**4.9 (2.4, 7.4)**	− 0.7 (− 3.8, 2.4)
	70					
		Rural	63.2	69.3	67.0	66.9
		Suburban-Rural	**6.2 (1.7, 10.7)**	0.1 (− 4.0, 4.2)	− 0.8 (− 3.9, 2.3)	0.9 (− 3.4, 5.2)
		Urban-Rural	**8.7 (6.0, 11.4)**	2.0 (− 0.9, 4.9)	− 0.4 (− 3.1, 2.3)	− 1.3 (− 4.0, 1.4)
	85					
		Rural	59.3	71.6	70.3	68.8
		Suburban-Rural	**11.1 (2.9, 19.3)**	− 2.7 (− 10.5, 5.1)	**− 6.5 (−12.6, −0.4)**	− 2.2 (− 10.6, 6.2)
		Urban-Rural	**10.9 (5.6, 16.2)**	− 1.9 (− 7.6, 3.8)	**− 6.9 (−12.6, −1.2)**	− 3.5 (− 8.8, 1.8)
Female	55					
		Rural	57.4	58.0	58.2	56.1
		Suburban-Rural	**7.6 (3.7, 11.5)**	− 0.2 (− 4.9, 4.5)	1.6 (− 1.7, 4.9)	− 4.2 (− 9.1, 0.7)
		Urban-Rural	**5.2 (2.3, 8.1)**	− 0.3 (− 3.6, 3.0)	**3.3 (0.9, 5.7)**	**5.3 (2.8, 7.8)**
	70					
		Rural	57.6	60.0	61.2	58.9
		Suburban-Rural	**5.8 (2.3, 9.3)**	− 1.4 (− 4.9, 2.1)	− 2.2 (− 5.1, 0.7)	− 4.3 (− 8.2, - 0.4)
		Urban-Rural	**3.5 (1,1, 5.9)**	− 1.0 (− 3.5, 1.5)	− 0.5 (− 2.7, 1.7)	1.2 (− 1.2, 3.6)
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		Rural	57.4	61.0	64.4	62.0
		Suburban-Rural	3.0 (− 3.5, 9.5)	− 1.0 (− 6.9, 4.9)	**− 6.7 (−12.2, −1.2)**	− 5.0 (− 11.7, 1.7)
		Urban-Rural	1.8 (− 2.3, 5.9)	− 1.2 (− 5.7, 3.3)	**− 5.3 (−9.4, −1.2)**	− 4.1 (− 8.2, 0)

[a]Statistically significant differences (at 0.05 level) are shown in bold.