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Are There Place-Based Disparities in Mortality Risk? Findings From Two Longitudinal Studies

Olivia E. Atherton
Department of Psychology, University of Houston

Objective: Most work on place-based (e.g., rural–urban) health disparities has been conducted with population-level data, which is limited in its capacity for causal inferences about *individuals* and *lifespan health*. The present study leverages individual-level longitudinal data, spanning up to 29 years, to understand how rurality–urbanicity predicts risk for all-cause mortality; whether these associations hold above and beyond socioeconomic status (SES); and whether the association between rurality–urbanicity and mortality risk varies by sex, SES, race, ethnicity, and partner status. ***Method:*** The present preregistered study uses data from two large longitudinal studies of U.S. Americans (Health and Retirement Study and Midlife in the United States; total $N = \sim 55{,}000$), who reported on their sociodemographic characteristics, had their addresses linked to geographical indicators (i.e., rural–urban continuum codes), and have data from the National Death Index regarding the vital status and survival time. ***Results:*** Using Cox proportional hazards regression models, findings showed that suburban and rural residents were at a 12% and 18% greater risk for earlier mortality compared to urban residents in Health and Retirement Study, but the associations between rurality–urbanicity and mortality risk were nonsignificant in Midlife in the United States. The longitudinal associations between rurality–urbanicity and mortality risk were largely independent of SES. Finally, there was only one statistically significant interaction effect, suggesting the strength and direction of the association between rurality–urbanicity and mortality risk was largely the same across sociodemographic subgroups. ***Conclusions:*** There is tentative evidence suggesting that rurality–urbanicity is an important social determinant of longevity, over and above other sociodemographic factors. Future studies should explore how to promote longer and healthier lives among rural residents.

Public Significance Statement
People who reside in rural, suburban, and urban areas of the United States experience different opportunities and challenges when it comes to healthcare access, proximity to amenities like fitness centers and grocery stores, and exposure to pollution, all of which impact longevity. The present research contributes to our understanding of how residing in rural, suburban, and urban areas of the United States is associated with how long people live. Findings suggest that people who reside in rural areas tend to have, on average, two fewer years of life than people who reside in urban areas, highlighting a pressing need to identify how to promote longer and healthier lives among rural residents.

Keywords: place-based, rurality, mortality, longitudinal, social determinants of health

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As of 2021, approximately 46 million U.S. Americans, or 20% of the population, live in rural areas (Dobis et al., 2021). Compared to urban counties, rural counties have higher rates of the leading contributors of death including Alzheimer's disease and related dementias, cardiovascular diseases, stroke, chronic lower respiratory disease, kidney disease, unintentional injuries, and suicide (Cross et

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Olivia E. Atherton https://orcid.org/0000-0001-5766-6901
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Olivia E. Atherton served as lead for conceptualization, data curation, formal analysis, visualization, writing–original draft, and writing–review and editing.
Correspondence concerning this article should be addressed to Olivia E. Atherton, Department of Psychology, University of Houston, 3695 Cullen Blvd., Room 126, Houston, TX, 77004, United States. Email: oeatherton@uh.edu

al., 2021; Garcia et al., 2017; Ho & Franco, 2022; Singh & Siahpush, 2014). Extant population-level research suggests that rural counties have higher premature death rates than urban counties; however, little-to-no work has leveraged individual-level longitudinal data to examine the extent to which rurality–urbanicity confers lifespan risk for all-cause mortality. Using data from two longitudinal studies of aging (total $N = \sim$55,000 U.S. adults), the present study sought to fill this gap by addressing three research questions:

Research Question 1: To what extent does rurality–urbanicity impact risk for all-cause mortality?

Research Question 2: Are the associations between rurality–urbanicity and risk for mortality independent of socioeconomic status (SES)?

Research Question 3: Does the strength of the associations between rurality–urbanicity and mortality vary as a function of sociodemographic characteristics (i.e., sex, race, ethnicity, SES, partner status)?

Conceptualizing Place-Based Disparities: Rurality–Urbanicity and Its Impact on Lifespan Health

The Socioecological Model of Health (e.g., Bronfenbrenner, 1979) and Life Course Theory (Elder, 1998) together suggest that individual health is impacted by various biological factors, social contexts, and psychological characteristics across the lifespan. Where people live is one such place-based context that can affect biopsychosocial functioning, health, and longevity. Although there are over 15 operationalizations of rurality and urbanicity (e.g., Cromartie & Bucholtz, 2008; J. C. Long et al., 2021; U.S. Census Bureau, 2010), two common features characterize rural versus urban places: (a) population count and (b) (non)adjacency to a metropolitan area (USDA Economic Research Service, 2019). Apart from differences in the sheer number of people located in rural versus urban areas, rural areas also tend to have reduced access to healthcare providers and services (Douthit et al., 2015; Gong et al., 2019; Johnston et al., 2019; Weinhold & Gurtner, 2014), fewer healthy amenities such as grocery stores and gyms (Losada-Rojas et al., 2021; Patterson et al., 2004), and worse water quality and air pollution (Hendryx et al., 2010; Strosnider et al., 2017; Zhang et al., 2023). For example, health professional shortages account for approximately 40% of the difference in preventable deaths across rural and urban areas (Johnston et al., 2019), and fine particulate matter (PM2.5; known to increase the risk for dementia) is most heavily emitted from agricultural sources and wildfires, which are more common in rural areas (Zhang et al., 2023). Furthermore, these environmental disadvantages are independent of polygenic risk for health problems (Davidson et al., 2022) and pose notable constraints on individuals' capacity to engage in health-promoting behaviors like going to the doctor, exercising, and eating/drinking healthy (Matthews et al., 2017). Moreover, prior research has shown that people who live in rural areas tend to have lower levels of psychological well-being and higher levels of neuroticism (Atherton et al., 2023). Thus, the confluence of structural and biopsychosocial factors may lead individuals in urban (vs. rural) areas to develop better (or worse) health as they get older. These individual-level processes may then feed into population-level health disparities, with rural counties showing worse health outcomes than urban counties.

Rural Mortality Penalty Versus Rural Mortality Advantage

The vast majority of prior work has used population-level data to characterize the county-level death rates between rural and urban areas. In the early 1900s, urban areas in the United States were more dangerous for one's health given poor sanitation and the risk of contracting infectious diseases in densely populated areas (Haines, 2001). However, by the 1940s–1950s, the ramifications of urban living on health and longevity were minimized due to public health and infrastructure changes. The resources dedicated to improving health in metropolitan areas came at a cost to health infrastructure in rural areas. Since the 1960s, the age-adjusted mortality rates (per 100,000 population) have been significantly higher in rural areas compared to urban areas (Cross et al., 2021; Singh & Siahpush, 2014). Furthermore, this disparity has widened over time: mortality rates have steadily declined in urban areas since 1969, whereas the mortality rates in rural areas have remained constant (or not declined as rapidly), a pattern commonly referred to as the rural mortality penalty (Cossman et al., 2010; Cross et al., 2021; W. L. James, 2014; Singh & Siahpush, 2014). In fact, the 1990s were a notable inflection point for rural–urban health disparities, with the rural penalty in mortality rates almost tripling from 1999 to 2019 (Cross et al., 2021). Furthermore, rural–urban differences in age-adjusted mortality rates are not due to the specific operationalization of rurality (W. L. James et al., 2022) nor confounding by other social determinants of health including race, education level, and poverty, suggesting that there are true "place-based" differences in death rates (Cosby et al., 2019; but see A. S. Long et al., 2018). Moreover, as rural areas become urbanized and are reclassified as such, their age-adjusted mortality rates drop suggesting that there are health advantages associated with urban infrastructures (Brooks et al., 2020). However, population-level data are limited in their capacity for drawing causal inferences about individual health and identifying how rurality–urbanicity confers risk for mortality longitudinally within persons. Although insufficient for causal inference on its own, individual-level data have the potential to strengthen causal inference compared to population-level data because rural–urban, sociodemographic, and mortality data are collected from the same individuals, which then permits conclusions about individuals rather than counties and allows for investigations of how rural–urban residence interacts with other social determinants of health (e.g., SES, race) to impact longevity.

To date, there are only two studies that have leveraged individual-level longitudinal data to study the associations between rurality–urbanicity and risk for mortality in the United States and both have found evidence for a rural mortality advantage. Smith et al. (1995) used data from the National Longitudinal Mortality Study to understand whether all-cause mortality risk differs by degree of urbanization among adults aged 55 years and older from 1979 to 2011. In contrast to studies with county-level data, they found that the risk of death was highest among those living in central cities, whereas the risk of death was lowest for those living in rural areas, though the protective effects of rural areas weakened with increasing age. Additionally, Yang et al. (2021) used longitudinal data from the Americans' Changing Lives study (1986–2011) and showed that after accounting for age and sex, rural residents have a lower risk of death than those living in central cities. The discrepancy in findings regarding rural–urban differences in mortality risk across population-level and individual-level data is peculiar, especially considering that researchers do find longitudinal associations between rurality and individuals' risk for various age-related diseases, such as Alzheimer's disease (Glauber, 2022). However, some research has shown that convergence across different rural–urban measures and their predictive validities of health outcomes vary quite widely (J. C. Long et al., 2021). Taken together, the current literature suggests we know relatively little about how rural–urban disparities in risk for mortality unfold longitudinally, and the extent to which individual- and population-level patterns converge.

Intersectionality of Rurality–Urbanicity and Other Sociodemographic Factors

Compared to other social determinants of health, rurality–urbanicity has been relatively understudied (Lutfiyya et al., 2012). This is potentially, in part, due to the misconceptions that: (a) rural areas in the United States are monolithic groups that are synonymous with low SES and being White (Rowlands & Love, 2021) and (b) SES is the prevailing fundamental cause of health and mortality (Phelan et al., 2010). However, these misconceptions have hindered scientific research because not all rural places are the same in terms of socioeconomic distribution, with some areas being highly homogeneous in terms of education and income, whereas others have more inequality (Butler et al., 2020). Likewise, while the rural Midwest is largely comprised of White Americans, the rural south is largely comprised of Black individuals and Tribal Nations, and the rural west and southwest regions are largely comprised of Hispanic/Latinx individuals (Rowlands & Love, 2021). Moreover, rural America has become more racially and ethnically diverse over the last decade (Rowlands & Love, 2021) and tends to overrepresent older adults (Cromartie, 2018). As a result of the sociodemographic diversity of people who live in rural and urban areas, it is necessary to adopt an individual-level intersectional lens to understand longevity (Afifi et al., 2022; Cole, 2009; Crenshaw, 1989). That is, there is a pressing need to consider how various intersections of privilege and oppression impact risk for all-cause mortality across the lifespan, as this will tell us for whom the associations between rurality–urbanicity and risk for mortality are evident.

It is well established that people with fewer socioeconomic resources, Black individuals, men, and people without a partner/spouse have lower life expectancies (Baciu et al., 2017; Heron, 2019; Jia & Lubetkin, 2020; Ruiz et al., 2018). However, we know relatively little about how these sociodemographic factors intersect with rural–urban residence to increase or decrease the risk for all-cause mortality within persons. The majority of empirical research has been done at the intersection of the rurality–urbanicity and socioeconomic factors using population-level data (e.g., Gong et al., 2019). Some researchers have suggested that rurality–urbanicity accounts for negligible variance in death rates after accounting for county-level median income and percentage of poverty (A. S. Long et al., 2018), whereas others have suggested they have independent and interactive effects, with counties that have the highest percentage of poverty and percentage of rural showing the highest mortality penalty (Cosby et al., 2019). Further underscoring this intersectional lens, some research has shown that the rural mortality penalty is exacerbated for Black Americans compared to White Americans (W. James & Cossman, 2017). Although there is a mortality penalty for both Black and White Americans in rural areas (compared to urban areas), the worst rural regions for White individuals are still better than the best rural regions for Black individuals for age-adjusted mortality rates, possibly because of differential access to healthcare. For the remaining sociodemographic characteristics (i.e., sex, partner status), it is likely that there are additive effects, such that if a person lives in a rural area and is a man or does not have a partner/spouse, they will be at highest risk for all-cause mortality, but there is no empirical research on this topic. No prior studies have leveraged individual-level data to examine the interactive effects of rurality–urbanicity and SES, race, sex, and partner status on risk for all-cause mortality. The present study aims to fill these gaps.

Method

The present study was preregistered. The preregistration, a document with deviations from the preregistration, and the R code for the present study can be found on the Open Science Framework: https://osf.io/wnrbj/. Due to the use of deidentified secondary data, the University of Houston Institutional Review Board determined this research to be exempt (Protocol: STUDY00003824).

Participants and Procedure

The present study used longitudinal data from two national probability samples that have been linked to geographical indicators and National Death Index records: Midlife in the United States (MIDUS; Brim et al., 2004) and the Health and Retirement Study (HRS; Sonnega et al., 2014). For MIDUS, all available cohorts with rural–urban and mortality data were included in this investigation, which included the core sample (1995–1996), the Milwaukee sample (2005–2006), and the refresher samples (2011–2014). For HRS, due to refreshment cohorts throughout the study period, participants could have varying baseline measurement occasions; data from all available unique participants from 1992 to 2020, who had at least one measurement occasion of rural–urban and mortality data, were included in this investigation. Details regarding the MIDUS and HRS studies are publicly available at https://www.icpsr.umich.edu/web/ICPSR/series/203 and https://hrs.isr.umich.edu/about, respectively. Table 1 contains a summary of the MIDUS and HRS sample characteristics for the present study.

Measures

Rurality

For both MIDUS and HRS, participants' addresses were linked to U.S. Department of Agriculture Economic Research Service rural–urban continuum codes (RUCCs) to characterize the extent to which they reside in urban or rural areas. RUCCs represent whether an address in a given county is considered urban, suburban, or rural in relation to its population count and (non)adjacency to a metro area. These characteristics are represented on a 0–9 scale in 1993 and a 1–9 scale in 2003 and 2013 (e.g., 0 or 1 = *counties in metro areas of 1 million population or more*; 9 = *completely rural or less than 2,500 urban population, not adjacent to a metro area*).[1] Participants' baseline addresses were linked to the most proximal assessment of RUCCs. In MIDUS, the core sample

[1] 2013 RUCC are not directly comparable with the codes prior to 2000 because of the new methodology used in developing the 2000 metropolitan areas. See the Documentation here: https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/documentation/. The 1993 codes are only different such that: 0 = *central counties of metro areas of 1 million population or more*; and 1 = *fringe counties of metro areas of 1 million population or more*. The remaining 2–9 categories are the same as what is indicated in 2003 and 2013. Thus, for 1993, "0s" were recoded as "1s" to be on a comparable scale to the 2003 and 2013 RUCCs, ranging from 1 to 9.

Table 1
MIDUS and HRS Sample Characteristics

Descriptive	MIDUS	HRS
Total analytic *N*	11,780	42,430
Follow-up time	22 years	29 years
Median baseline age (range)	47 years (20–85)	56 years (<23–101+)
% female	52	56
Race		
White	79%	73%
Black	16%	19%
Other race	6%	8%
Ethnicity (Hispanic/Latinx)	4%	12%
Median education level	6 (“some college”)	12 years
Median household income	$73,478	$54,889
% married/partnered	67	72
Rurality–urbanicity		
Urban	81%	80%
Suburban	12%	13%
Rural	6%	7%
Geographical region		
Northeast	—	17%
Midwest	—	23%
South	—	41%
West	—	19%
% deceased	19	42
Median survival time	226 months	158 months

Note. MIDUS = Midlife in the United States; HRS = Health and Retirement Study. Median household incomes are scaled in 2014 USD for MIDUS and 2020 USD for HRS.

was linked to 1993 RUCCs, the Milwaukee sample was linked to 2003 RUCCs, and the refresher sample was linked to 2013 RUCCs to be consistent with their respective baselines. For HRS, participants' baseline assessments occurred from 1992 to 2018. As a result, baseline assessments that occurred from 1992 to 1998 were linked to 1993 RUCCs; baseline assessment years 2000–2008 were linked to 2003 RUCCs; and baseline assessment years 2010–2018 were linked to 2013 RUCCs. Consistent with Atherton et al. (2023), rurality–urbanicity was recoded to be trichotomous (otherwise, referred to as “3-RUCC”) such that RUCCs 1–3 (urban) were coded as 0, RUCCs 4–6 (suburban) were coded as 1, and RUCCs 7–9 (rural) were coded as 2.[2]

Mortality

In both MIDUS and HRS, vital status and death month/year were primarily obtained from administrative linkage to National Death Index (NDI) records. The MIDUS core and Milwaukee samples were linked to NDI through 2020, and the MIDUS refresher samples were linked to NDI through 2018. Any remaining decedent cases after 2020 and 2018 were identified by staff via longitudinal sample maintenance and online tracing. For HRS, participants were linked to NDI through 2020 and any remaining decedent cases were identified by staff via next-of-kin reports. Two variables were used to model risk for mortality: vital status (0 = *alive/censored*, 1 = *dead*) and survival time in months (death month/year—baseline assessment month/year). For participants who were still alive at the end of follow-up, the maximum possible number of months in the study was entered and censored in analyses.

Sociodemographic Factors

In both samples, several sociodemographic covariates were included: baseline age, sex (female, male), race (White, Black, other race/multiracial), ethnicity (non-Hispanic/Latino, Hispanic/Latino), spouse/partner status (no partner, married/partnered), and SES (average composite of *z*-scored household income and education level). For both MIDUS and HRS, participants could only endorse a single racial group or indicate that they identified as multiracial. For MIDUS, the highest education level was self-reported and ranged from 1 (*no school/some grade school*) to 12 (*PhD, EdD, MD, DDS, LLB, LLD, JD, or other professional degrees*). Household income was comprised of the sum (in U.S. dollars) of wages, pension, social security, and other sources, which were self-reported by participants. For HRS, education level was assessed as the number of years in school, ranging from 0 (*no formal education*) to 17 (*postcollege*). Household income was comprised of the sum (in U.S. dollars) of participants' and their spouses' self-reported earnings, pensions and annuities, social security, unemployment and

[2] Originally, the preregistration stated the 9-RUCC would be the primary operationalization, and the 3-RUCC would be the sensitivity analysis operationalization. However, 3-RUCC variable was used as the primary operationalization because: (a) conceptually, U.S. Americans think about their geographical residence as either rural, suburban, or urban (Bucholtz et al., 2020; Short Gianotti et al., 2016); (b) prior work has established the convergent validity of operationalizing “rural” as RUCCs 7–9 (J. C. Long et al., 2021; Streeter et al., 2020) and the predictive validity of 3-RUCC for various health outcomes (Atherton et al., 2023; Joseph et al., 2015; Segel & Lengerich, 2020; Wang et al., 2013; Zuniga & Lango, 2018); (c) conceptually and statistically, a 9-category RUCC analyzed as a “continuous” variable has untenable assumptions including that each of the nine scale points are equally distanced and conceptually different from one another; and (d) statistically, using 9-category RUCC as a categorical (or continuous) variable poses methodological problems due to the skewed/non-normal distribution and the small sample sizes at the rural end of the scale, as noted by a biostatistician who consulted on the analytic approach (see Figure S1–S2); 3-RUCC has higher statistical power for the present analyses.

workers' compensation, other government transfers, household capital income, and other income in the last calendar year.[3]

Statistical Analyses

Analyses were conducted in R (Version 4.2.1; R Core Team, 2022) using the R packages tidyverse (v1.3.2; Wickham et al., 2019), haven (v2.5.1, Wickham et al., 2022), psych (v2.2.9; Revelle, 2021), sjmisc (v2.8.9, Lüdecke, 2018), survival (v3.3.1, Therneau, 2022), survminer (v0.4.9, Kassambara et al., 2021), and adjustedCurves (v.0.10.1, Denz et al., 2023). To answer the present research questions, a series of Cox proportional hazards regression models were conducted within each data set. Time-to-incident was modeled as a function of vital status (alive/censored or deceased) and survival time (in months), with baseline age as a covariate. Time-to-death was right-censored for participants who were still living at the final assessment. Time-to-death was regressed on rurality–urbanicity for Research Question 1, and then both rurality–urbanicity and SES for Research Question 2. For the first step of Research Question 3, each sociodemographic characteristic (i.e., sex, race, ethnicity, SES, partner status) was entered as a predictor (in separate models), along with rurality–urbanicity. Then, in a second step, interaction terms between rurality–urbanicity and sociodemographic characteristics (e.g., Rurality–Urbanicity × Sex) were entered into their respective models. Exact hazard ratios (HR), *p* values, and 95% confidence intervals (CI) are reported. *p* values less than .05 and CIs that do not contain 1 are interpreted as statistically significant.

Results

Descriptive Statistics and Proportional Hazards Assumption

Table 1 shows descriptive statistics for rurality–urbanicity, vital status, survival time, and demographic characteristics. The vast majority of MIDUS and HRS participants live in urban, metropolitan areas whereas fewer participants live in rural areas (Figures S1 and S2 in the online supplemental materials show distributions of the full 9-RUCC). Nineteen percent of the MIDUS sample and 42% of the HRS sample were deceased at follow-up (median survival times = 226 months/18.8 years and 158 months/13.2 years, respectively). Table S1 in the online supplemental materials shows descriptive statistics for the urban, suburban, and rural groups separately in MIDUS and HRS.

The proportional hazards assumption posits that the hazard function for all levels of exposure is the same over time. If the proportional hazards assumption is violated, then the association between the violating predictor and risk for mortality differs across time. Table S2 in the online supplemental materials shows that five sociodemographic covariates (SES, race, ethnicity, partner status) in MIDUS and all variables in HRS violate the proportional hazards assumption.

To inspect the degree of violations and impact on results, several steps were taken. First, the Schoenfeld residuals were plotted for all violating predictors in MIDUS and HRS (see Figures S3 and S4 in the online supplemental materials). As shown, most proportional hazard violations were small in magnitude; even slight deviations from proportional hazards will be statistically significant due to the large sample sizes and high statistical power to detect violations (Austin, 2018). Second, additional models were conducted to account for proportional hazard violations through timesplitting and stratification, which are two different ways of handling hazard violations. Timesplit models involve computing an interaction term between the violating predictor and the calculated start time using the Greg package (Gordon & Seifert, 2020). Many of the timesplit models would not converge, likely because the deviations from proportional hazards were very small and/or there were small group sizes for the rural group in particular (see Tables S3–S8 in the online supplemental materials). Stratified analyses involve stratifying the Cox regression models by the violating covariate to allow the hazard functions to differ. As shown in Tables S3–S8 in the online supplemental materials, the associations between rurality–urbanicity and risk for mortality did not change in terms of statistical significance or effect size magnitude when stratifying by violating predictors. Thus, all subsequent models assume proportional hazards because: (a) stratifying by the violating predictors did not change the associations between rurality–urbanicity and mortality risk and (b) the main research questions involve testing the main and moderating effects of sociodemographic factors, which cannot be estimated if models are stratified by such factors.

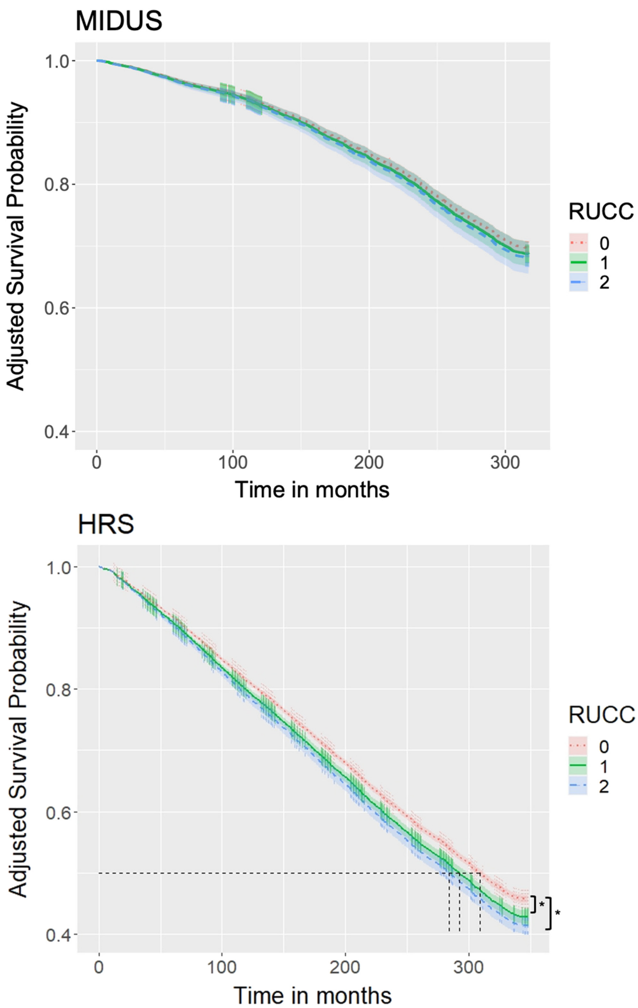
Main and Moderating Effects on Mortality Risk

Figure 1 depicts age-adjusted survival curves for the associations between rurality–urbanicity and survival probability in MIDUS and HRS. MIDUS participants who lived in urban, suburban, and rural areas did not differ in their risk for mortality; however, HRS participants who lived in suburban and rural areas were at 12% and 18% greater risk of earlier mortality, respectively, compared to participants who lived in urban areas. On average, individuals who lived in rural areas were more likely to die approximately 2 years earlier than individuals who lived in urban areas (median survival quartiles = 284 months for rural and 309 months for urban). Figure 2 shows forest plots of exact HRs, 95% CIs, *p* values, and sample sizes of the main effects of rurality–urbanicity and other sociodemographic factors on risk for mortality (see Tables S9–S20 in the online supplemental materials for full model results). People who had fewer socioeconomic resources, who identified as Black, were male, and did not have a partner/spouse were at higher risk for earlier all-cause mortality. Additionally, Hispanic/Latinx individuals were at a *lower* risk for mortality, compared to White individuals, in HRS.

Tables S11–S20 in the online supplemental materials show the moderating effects of each sociodemographic factor on the association between rurality–urbanicity and mortality risk. Out of 10 possible interactions across studies, there was one statistically significant interaction between rurality–urbanicity and race in HRS. Individuals who identified as an other race/multiracial and who lived in suburban areas were 37% more likely to die earlier than multiracial/other race individuals who lived in urban areas (see Figure 3; HR = 1.37, 95% CI [1.10, 1.71], $p < .01$).

[3] Because MIDUS and HRS participants had markedly different baseline years (ranging from 1992 to 2020 across studies), baseline household incomes were transformed to ensure comparability across participants within study. For MIDUS participants, household incomes were translated into 2014 U.S. dollars, which was the latest possible year that a participant could have a baseline assessment. For HRS participants, household incomes were translated into 2020 U.S. dollars, which was the latest possible year that a participant could have a baseline assessment. Conversion values were taken from the U.S. Bureau of Labor Statistics inflation calculator found at: https://www.bls.gov/data/inflation_calculator.htm.

Figure 1
Age-Adjusted Survival Curves for Rurality–Urbanicity in MIDUS and HRS



Note. 0 = *urban*. 1 = *suburban*. 2 = *rural*. The dotted lines indicate the median survival times for each group. There were no estimated median survival times for MIDUS because at least 50% of each RUCC group were not dead. Proportional hazards are assumed. MIDUS = Midlife in the United States; HRS = Health and Retirement Study; RUCC = rural–urban continuum codes. See the online article for the color version of this figure.

Preregistered Sensitivity Analyses

First, when including all sociodemographic covariates as simultaneous predictors in the model, the main effects of rurality–urbanicity on risk for all-cause mortality remain the same in terms of magnitude and statistical significance in MIDUS and HRS (see Table S21 in the online supplemental materials). Second, all research questions were reanalyzed to determine whether the main and moderating effects hold when analyzing rurality–urbanicity as a continuous variable (ranging from 1 to 9) instead of a trichotomous categorical variable. Tables S9–S20 in the online supplemental materials show that all main and moderating effects hold in terms of statistical significance and nonsignificance in both MIDUS and HRS. Notably, the HRs for continuous 9-RUCC predicting mortality risk in HRS are smaller (1.02–1.03) compared to the categorical 3-RUCC. Additionally, the continuous 9-RUCC was a statistically significant predictor of mortality risk in MIDUS when the main effects of sex, race, and partner status were in the models, but not in the absence of covariates or when SES, ethnicity, and the moderating effects of sex and partner status were in the models. Moreover, although the *p* values were below .05 in some models for 9-RUCC in MIDUS, the 95% CIs were very close to 1 (and only statistically significant when going out to three decimal places).

Nonpreregistered Exploratory Analyses

First, because a notable number of HRS participants are sampled from the same households, the Cox regression models were rerun while clustering by household to account for the dependency in the data and estimate robust standard errors. All main and moderating effects remain the same in terms of magnitude and statistical significance (see Tables S22–S27 in the online supplemental materials). Second, exploratory analyses were conducted to examine the main and moderating effects of geographical regions (Northeast, Midwest, South, and West).[4] Table 1 and Table S1 in the online supplemental materials show descriptive statistics of geographical regions. Table S28 in the online supplemental materials shows the main and moderating effects of geographical regions. Participants who lived in the U.S. South were at a higher risk of mortality (HR = 1.15, 95% CI [1.10–1.20], $p < .01$). There were no statistically significant interactions between rurality–urbanicity and geographical region, though the main effect of suburban on mortality risk became nonsignificant when including the regional interaction terms in the model. Third, follow-up analyses were conducted to examine education level and household income separately. Tables S29 and S30 in the online supplemental materials show the main and moderating effects of education level and household income in MIDUS and HRS. Higher education levels and household incomes reduced the risk for mortality in MIDUS (HRs = 0.78–0.82, $ps < .01$) and HRS (HRs = 0.63–0.88, $ps < .01$). There were no statistically significant interaction effects, except for an interaction between rurality–urbanicity and household income in MIDUS (see Figure S5 in the online supplemental materials). At high-income levels, rural participants had the greatest risk of death compared to their urban counterparts, whereas at low-income levels, urban participants had the greatest risk of death compared to rural participants. Fourth, additional analyses were conducted with the MIDUS data to separate the "other race" category into the racial groups that comprise it, resulting in racial categories for White, Black, Native American or Alaskan Native, Asian or Pacific Islander, multiracial, and other. Table S31 in the online supplemental materials shows the main and moderating effects; these results should be interpreted with caution because the group sizes are small and some of the moderation effects could not be estimated.

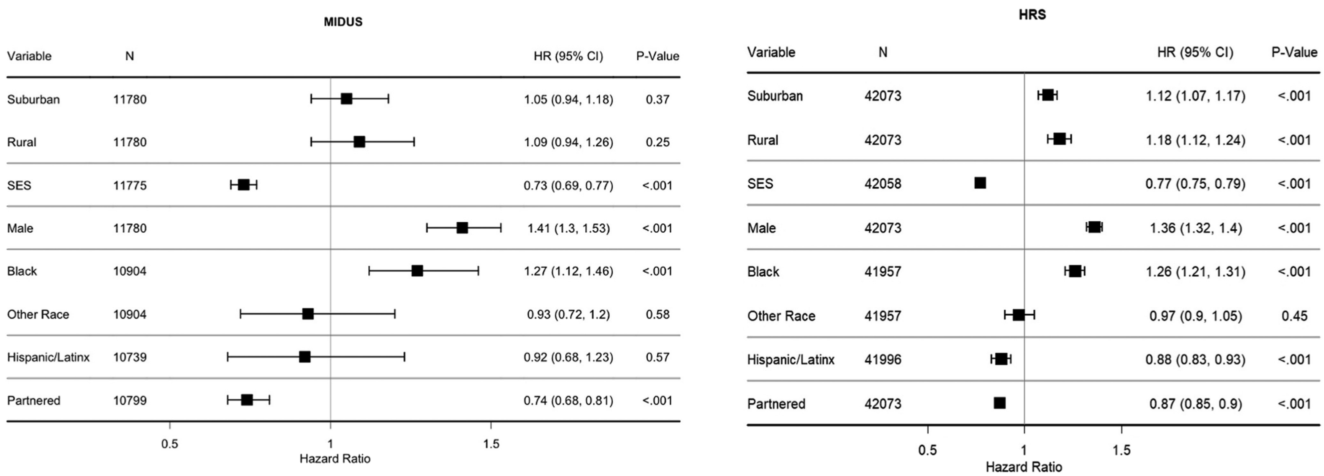
Discussion

For the last 70 years, rural areas have continually showed worse health when compared to urban areas, and these gaps are widening

[4] MIDUS does not allow researchers to work with geographical region data because their study policies consider it a geographical identifier that poses risks for participant confidentiality.

Figure 2

Forest Plots of Effect Sizes of Rurality–Urbanicity and Sociodemographic Characteristics on Mortality Risk in MIDUS and HRS



Note. The reference groups are urban, female, White, non-Hispanic/Latinx, and not partnered/married. Proportional hazards are assumed. MIDUS = Midlife in the United States; HRS = Health and Retirement Study; CI = confidence interval.

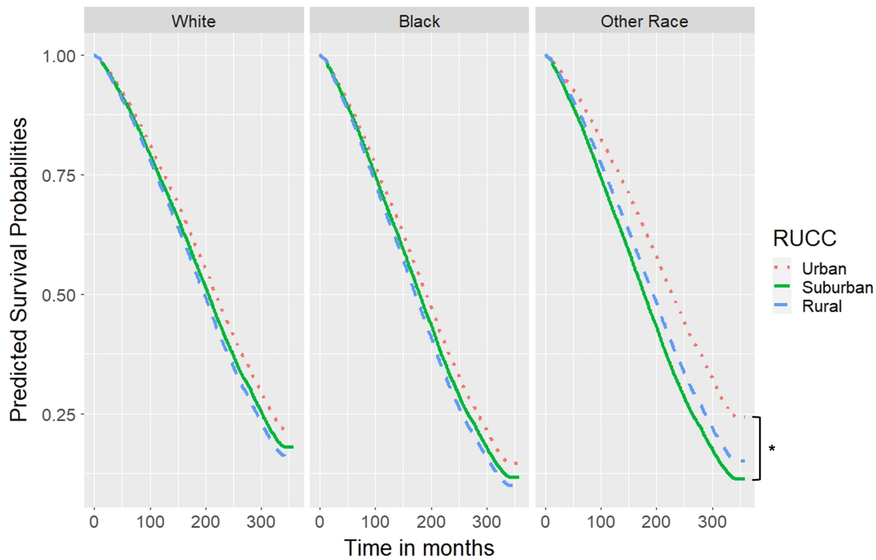
at a population level. Using two large longitudinal datasets of approximately 55,000 U.S. Americans, the present study investigated for whom rurality–urbanicity predicts risk for all-cause mortality; whether these associations were independent of SES; and whether the associations between rurality and urbanicity varied by SES, sex, race, and partner status. There are four key takeaways from this research, which have theoretical and practical implications for future research and health policy.

First, there is tentative evidence to suggest that rurality confers risk for all-cause mortality. Although no statistically significant differences in mortality risk were observed in MIDUS, the HRS data showed that individuals who lived in suburban and rural areas were 12% and 18% more likely to die earlier than individuals who lived in urban areas. Roughly, this translates to rural Americans dying 2 years earlier than urban Americans, on average. Theoretically, these findings are aligned with both Socioecological Models of Health (Bronfenbrenner, 1979) and Life Course Theory (Elder, 1998), suggesting that where we live in adulthood is associated with risk for death. This is likely due to a cascade of experiences, where people who live in rural areas have reduced access to healthcare services, gyms, healthy food, transportation, and broadband internet, which in turn leads to poorer health and ultimately, premature mortality. It would be beneficial for future research to delve deeper into the developmental processes that feed into population health disparities and to understand how and why rural adults experience poorer health than urban adults (e.g., Afifi et al., 2022). Likewise, the present research is partially consistent with prior population-level data indicating that there is a rural mortality penalty (Cossman et al., 2010; Cross et al., 2021; W. L. James, 2014; Singh & Siahpush, 2014) and further strengthens our ability to draw causal inferences about the impact of rurality on individuals' risk for mortality. Finally, it is worth noting that the present results stand in contrast to prior longitudinal work suggesting that there is a rural mortality advantage (Smith et al., 1995; Yang et al., 2021), which may be due to measurement differences. Residential location was self-reported by Yang et al. (2021), whereas standard metropolitan statistical areas were used by Smith et al. (1995).

Second, the associations between rurality–urbanicity and mortality risk in HRS were largely independent of SES, which suggests rurality–urbanicity and SES are not synonymous with one another at the individual level and are likely accompanied by unique features that pose a greater risk for (or resilience to) health problems and premature mortality. For example, living in a rural area may pose unique risks for longevity that are separate from SES due to air and water pollutants (e.g., agricultural air toxins, well water usage) that affect rural areas regardless of individuals' education and income levels (Zhang et al., 2023). Likewise, while higher levels of income can afford benefits for purchasing healthy food or gym memberships, people who live in urban areas may not take advantage of those ample opportunities and people who live in rural areas may not have an easily accessible opportunity at all. The separation of rurality–urbanicity and SES in predicting longevity at the individual level differs from population-level work showing a high overlap between rurality–urbanicity and SES at the population level (e.g., Gong et al., 2019). These two patterns of findings can coexist given that heterogeneity is being captured within rural and urban areas at the individual level, whereas heterogeneity is being captured across rural and urban areas at the population level. Given that rural–urban health disparities are a relatively understudied research area, the present study provides a timely opportunity to call for future researchers to consider rural–urban as a social determinant of health and to delineate the pathways in which rurality–urbanicity and SES work together or independently to harm or benefit individuals' health and longevity. By identifying what individuals' residential locations and socioeconomic resources share (or do not share) in predicting health, we will be able to develop more effective prevention and intervention strategies that reduce population health disparities and ensure health equity for all.

Third, across datasets, there were surprisingly few interaction effects among rurality–urbanicity and other key sociodemographic factors such as SES, sex, race, ethnicity, and partner/marital status. Only one statistically significant interaction effect emerged: suburban areas posed a greater risk for mortality for other race/multiracial individuals (in HRS only). It is possible that other race/multiracial individuals are subject to more segregation, racism, discrimination, and

Figure 3
Interaction of Rurality–Urbanicity and Race on Mortality Risk in HRS



Note. Proportional hazards are assumed. HRS = Health and Retirement Study; RUCC = rural–urban continuum codes. See the online article for the color version of this figure.

prejudice in suburban areas than they are in urban areas, which in turn, leads to an increased risk of premature death (e.g., Barnes et al., 2008). However, interpreting effects with an "other race/multiracial" category is challenging because this group is comprised of people who hold many different racial identities, including multiracial, Asian, Native Hawaiian or Pacific Islander, Alaskan Native, or Native American. All of these racially identified groups tend to have their own cultural belief systems, norms, and values and tend to show differential relations to health outcomes. MIDUS and HRS do not permit robust investigations of each of these racial groups separately because the sample sizes are too small. As a result, there is a dire need to increase the representation of racially diverse groups in large longitudinal studies of aging—a need that is beginning to be filled with the HRS international sister studies through the Gateway to Global Aging Network. Likewise, as shown in the supplemental material, the MIDUS and HRS studies overrepresent White U.S. Americans in rural areas (∼85%–93%), despite White Americans comprising only ∼76% of rural areas nationwide. As a result, the interaction effects between rurality–urbanicity and race and ethnicity are likely to be underestimated in the present study. Future research should aim to collect longitudinal samples that have adequate demographic representation to understand how rurality–urbanicity intersects with other sociodemographic factors, like race and ethnicity, to predict health and longevity.

Fourth, the present findings between rurality–urbanicity and mortality risk largely held when accounting for proportional hazard violations, using a continuous measure of rurality–urbanicity ranging from 1 to 9, controlling for all sociodemographic factors simultaneously, separating SES into education level and income, and accounting for clustering by household and variation by geographical region in HRS. Although there were some sociodemographic factors (i.e., SES, race, ethnicity, and partner status in both data sets) that violated the proportional hazard assumption, the associations between rurality–urbanicity and mortality risk did not differ whether we statistically accounted for these violations or not. Nonetheless, future research should investigate the processes that underlie why the associations between some sociodemographic factors and mortality risk are not constant over time, as doing so may inform interventions aimed at targeting potentially sensitive periods. The largest and most consistent discrepancies in the findings were between MIDUS and HRS participants, with rurality–urbanicity being a significant predictor of mortality risk in HRS but not MIDUS. Compared to HRS participants, the majority of MIDUS participants were still alive at the final assessment (∼81%) and were, on average, younger by almost a decade. As a result, the effect sizes for MIDUS may be underestimated because the vast majority of participants were still living at the final assessment. This is also evidenced by the fact that median survival times could not be estimated for each of the RUCC groups in MIDUS because the survival curve did not reach .50 (i.e., at least 50% of each group had not died). Thus, some caution is warranted in overinterpreting null associations in MIDUS given its methodological limitations, as well as overinterpreting significant associations in HRS given they did not replicate in MIDUS.

Limitations

The present study has several limitations. First, the use of individual-level data strengthens causal inferences compared to population-level data. However, individual-level data are insufficient for causal inference on their own; and thus, future research should aim to implement causal inference methodologies (e.g., difference-in-difference or target trail emulation methods; Hernán et al., 2022; Tchetgen et al., 2024) to strengthen inferences from observational data. Second, the present study leveraged rural–urban continuum codes as geographical indicators of rurality–urbanicity. However, given that there are over 15 operationalizations of rurality–urbanicity (Cromartie & Bucholtz, 2008; U.S. Census Bureau, 2010) and not all measures have the same predictive validity (J. C. Long et al., 2021; but see W. L. James et al., 2022), it will be important for future research to test whether the present results replicate with other measures of rurality–urbanicity. Likewise, most prior investigations either examine dichotomized rural–urban continuum codes or a continuous measure ranging from 1 to 9, whereas the present study operationalizes as 3-RUCC. Prior work demonstrates that quantifying "rural" as RUCCs 7–9 has convergent validity with other definitions of rural (J. C. Long et al., 2021; Streeter et al., 2020) and the 3-RUCC operationalization has predictive validity for various health outcomes (Atherton et al., 2023; Joseph et al., 2015; J. C. Long et al., 2021; Segel & Lengerich, 2020; Wang et al., 2013; Zuniga & Lango, 2018). However, 3-RUCC has yet to be psychometrically validated, and future research should empirically investigate the validity of the 3-RUCC operationalization for characterizing urban, suburban, and rural areas. Third, because prior work with these datasets has shown that the stability of residential location over time is quite high in these samples (Atherton et al., 2023), the present study only examined how baseline rurality–urbanicity predicted risk for all-cause mortality. However, "baseline" in these samples occurs in midlife, so the presented associations may be confounded by early life/childhood rural–urban locations or residential mobility from early life to midlife. It is critical for future research to explore how migration and residential mobility patterns either increase or decrease individuals' risk for mortality from early life to old age, in order to fully test the Life Course Perspective. Datasets that start earlier in the life course, such as the National Longitudinal Studies of Youth or the Wisconsin Longitudinal Study, may be better suited to address these questions. Fourth, the measures of some sociodemographic covariates are imperfect and may show differential findings with more nuanced indicators. For example, although SES was examined as a composite, as well as with education level and household income separately, there are other factors that comprise SES such as occupational prestige. Last, although the data sets used are large, they are still limited in terms of within-country representation and cross-country generalizability. Indeed, the sample representativeness of MIDUS and HRS within rural and urban areas tends to overrepresent White U.S. Americans, and underrepresent Black, Hispanic/Latinx, Asian and Pacific Islander, and Native American Tribal Nations and Alaskan Natives, many of whom occupy a notable portion of rural areas in the United States. It is necessary for large longitudinal studies of aging to work toward being more inclusive of underrepresented racial-ethnic groups. Furthermore, MIDUS and HRS do not administer questions about gender identity (only sex), and the vast majority of participants are heterosexual (84%–93%), which limits the capacity to examine how rurality–urbanicity intersects with gender identity and sexual orientation to impact risk for mortality. The exclusion of underrepresented groups from large longitudinal studies like MIDUS and HRS necessarily affects the conclusions that can be drawn about for whom rurality–urbanicity affects mortality risk in the United States. Moreover, although rural areas across the globe have some common features, such as a lack of access to services and transportation, there are likely many factors that differentiate rural areas in the United States from rural areas in other countries. It will be critical for future research to identify the universal and culturally specific aspects of rural and urban areas to fully promote global health and longevity.

Conclusion

The present study tentatively suggests that rural living increases individuals' risk for premature mortality, such that rural Americans die 2 years earlier than urban Americans, on average. And, these associations are largely independent of SES and other key sociodemographic factors like sex, race, ethnicity, and partner/marital status. However, some discrepancies in results were identified across the two longitudinal data sets. Practically, this work has broader implications for place-based health policy: rural areas are long overdue in receiving the infrastructures necessary for health equity. If we can identify when, how, and why rural–urban disparities in health and longevity unfold, then we will be able to develop intervention efforts and implement policy changes to help rural Americans live longer and healthier lives.

Resumen

Objetivo: La mayor parte de los trabajos sobre las disparidades en la salud entre las zonas rurales y urbanas se han realizado con datos a nivel de población, cuya capacidad de inferencias causales sobre las personas y la salud a lo largo de la vida es limitada. El presente estudio aprovecha los datos longitudinales a nivel individual, que abarcan hasta 29 años, para comprender cómo la ruralidad-urbanidad predice el riesgo de mortalidad por todas las causas; si estas asociaciones se mantienen por encima y más allá del nivel socioeconómico; y si la asociación entre ruralidad-urbanidad y riesgo de mortalidad varía según el sexo, el nivel socioeconómico, la raza, el origen étnico y la condición de pareja. ***Métodos:*** El estudio presente pre-registrado utiliza datos de dos grandes estudios longitudinales de estadounidenses (HRS y MIDUS; *N* total = ∼55,000), que informaron sobre sus características sociodemográficas, tenían sus direcciones vinculadas a indicadores geográficos (es decir, códigos de continuo rural-urbano) y tienen datos del Índice Nacional de Mortalidad sobre el estado vital y el tiempo de supervivencia. ***Resultados:*** Utilizando modelos de regresión de riesgos proporcionales de Cox, los hallazgos mostraron que los residentes suburbanos y rurales tenían un riesgo 12% y 18% mayor de mortalidad temprana en comparación con los residentes urbanos en HRS, pero las asociaciones entre ruralidad-urbanidad y riesgo de mortalidad no fueron significativas en MIDUS. Las asociaciones longitudinales entre ruralidad-urbanidad y riesgo de mortalidad fueron en gran medida independientes del nivel socioeconómico. Finalmente, solo hubo un efecto de interacción estadísticamente significativo, lo que sugiere que la fuerza y dirección de la asociación entre ruralidad, urbanidad y riesgo de mortalidad fue en gran medida la misma en todos los subgrupos sociodemográficos. ***Conclusiones:*** Existe evidencia tentativa que sugiere que la ruralidad-urbanidad es un determinante social importante de la longevidad, por encima de otros factores sociodemográficos. Los estudios futuros deberían explorar cómo promover vidas más largas y saludables entre los residentes rurales.

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