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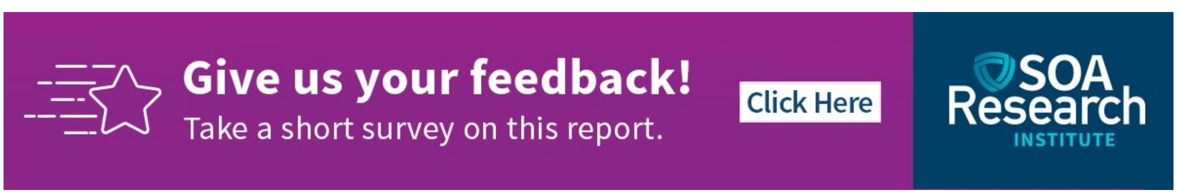

Longevity Disparity across Communities in the United States

Lijia Guo[1], Ph.D., ASA, MAAA

Abstract

Studies on geographic inequalities in life expectancy in the United States have generally focused on single-level analyses of aggregated data at state or county level. Less is known about how socioeconomic conditions and neighborhood-level disadvantage may intersect to contribute to longevity disparity. Reports on COVID-19 mortality variations in small areas within counties further highlighted the needs on community-level analysis.

This paper aims to study how longevity varies by communities and what are the socioeconomic and other community characteristics associate with longevity disparity across US. We used publically available government databases and developed models that identified socioeconomic factors for estimating life expectancy while accounting for other characteristics. The models are developed at the census tract level which reflects the community characteristics more accurately.

Our analysis indicated that US residents in communities of less socially vulnerable have experienced larger gains in life expectancy than those live in socially vulnerable communities. In addition, we found an inverse relations of longevity disparity to the community risks to natural disasters, an indication of increasing longevity risks associated with climate change. Differences in life expectancy may be explained in part by demographics and economic conditions, as well as access to healthcare and community resilience to natural disasters. This findings might have implications in managing longevity risk of insurance portfolios for health, retirement, and property casualty. Our analysis on how socioeconomic factor impact the longevity most at younger ages, could help identify specific policies needed to reduce the longevity disparities cross communities.

Keywords: Longevity inequality, social vulnerability index, natural hazard risk, national risk index, COVID-19, climate change

Introduction

Despite gains in life expectancy during much of past decades, large disparities in life expectancy continue to exist in the United States between subgroups of the population. Research has been done to understand the factors contribute to longevity risks, and how historical mortality trends varied by geographical regions. Ezzati, etc. 2008 analyzed trends in county mortality and cross-

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The opinions expressed and conclusions reached by the author are her own and do not represent any official position or opinion of the US Government Accountability Office.

county mortality disparities in the United States. Barbieri, 2021 reported interstate variations in mortality and found that the magnitude of disparities in mortality has increased slightly for men but much more significantly for women between 1959 and 2018 in the United States.

Socioeconomic disparities in longevity have been documented. Sasson, 2016 studied trends in life expectancy and lifespan variation by educational attainment in US from 1990–2010. Brønnum-Hansen, 2017 studied socially disparate trends in lifespan variation that linked income and mortality based on nationwide Danish register data. Permanyer, 2018 found longevity and lifespan variation by educational attainment in Spain from 1960 to 2915. Loures, etc. 2019 reported mortality variations in US by education level.

Mariotto, 2018 analyzed mortality differences by race, geography, and socio-economic status to more accurately measure relative cancer survival and life expectancy patterns in the United States. Crairns, etc. 2019 looked small area mortality in England and developed a Longevity Index for England that focuses on mortality and uses a range of predictive variables to explain the differences in mortality and life expectancy between small neighborhoods. Barbieri, 2022 construct a Socioeconomic Index by groupings of U.S. counties based on their socioeconomic characteristics using 2000 Census data and found growing socioeconomic inequalities in mortality by US counties.

Moss, etc. 2021 found that area-level measures are often used to approximate socioeconomic status when individual-level data are not available. However, no national studies have examined the validity of these measures in approximating individual-level socioeconomic status.

Until recently, studies on geographic inequalities in life expectancy in the United States have mostly focused on single-level analyses of aggregated data at state or county level. Boing, etc. 2020 studied life expectancy disparity by partitioning the variations across three geographic scales: states, counties, and census tracts and found that more than three-fourths of the total variation in life expectancy is attributable to census tracts. This indicates that population inequalities in longevity are primarily a local phenomenon, and there is a need for greater precision and targeting of local geographies in public policy discourse.

This study applied a different approach. We examined the longevity inequality across US census tracts. Instead of constructing our own socioeconomic index, we used public available socioeconomic measures used by health inequity research and disaster management professionals. This paper aims to study how longevity varies by communities and what are the socioeconomic and other community characteristics associate with longevity disparity across US at the census tract level.

Data and Methods

The data used for this analysis are all publically available government databases, including small-area Life Expectancy (LE) Estimates and community social vulnerability index from Centers for Disease Control and Prevention (CDC), the National Risk Index from Federal Emergency Management Agency (FEMA), and American Community Survey data from U.S. Census Bureau.

The U.S. Small-area Life Expectancy Estimates Project[2] (USALEEP) produced estimates of life expectancy at birth for most of the census tracts in the United States for the period 2010-2015. In addition, it also produced the abridged (see Arias, 2018) period life tables for 2010-2015 that were calculated to generate the life expectancy estimates for each census tract.

CDC and Agency for Toxic Substances and Disease Registry (ATSDR) created the Social Vulnerability Index[3] (SVI) to help public health officials and emergency response planners identify and map the communities that will most likely need support before, during, and after a hazardous event. SVI indicates the relative vulnerability of every U.S. Census tract. SVI ranks census tracts on 15 social factors, including unemployment, minority status, and disability, and further groups them into four related themes. Thus, each tract receives a ranking for each Census variable and for each of the four themes, as well as an overall ranking. The final SVI is a composite score of the following four sub index, each measures different aspects of social vulnerability:

- Socioeconomic – SVI_THEME1,
- Household Composition & Disability - SVI_THEME2,
- Minority Status & Language - SVI_THEME3,
- Housing Type & Transportation - SVI_THEME4.

FEMA developed the National Risk Index[4] (NRI) to help illustrate the United States communities (for each United States county and Census tract) that most at risk for 18 natural hazards. The NRI provides relative risk index scores and ratings based on data for expected annual loss due to natural hazards, social vulnerability, and community resilience. A community's risk score describes its relative position among all other communities at the same level for a given component. All scores are constrained to range of 0 (lowest possible value) to 100 (highest possible value). For each of 18 hazard types, a risk score is developed using the following three components:

- a natural hazards component (Expected Annual Loss),
- a consequence enhancing component (Social Vulnerability),
- a consequence reduction component (Community Resilience).

The overall community risk score is a combination of the risk scores for all 18 hazard types.

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[2] National Center for Health Statistics. 2018. Available from: https://www.cdc.gov/nchs/nvss/usaleep/usaleep.html

[3] CDC/ATSDR Social Vulnerability Index. Available from: https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

[4] For more information on the National Risk Index data, see https://www.fema.gov/flood-maps/products-tools/national-risk-index

Both SVI and NRI used social, economics, and demographics data from the American Community Survey[5] (ACS) developed by Census along with other data. ACS data, published by Census annually, is the premier data source for detailed population and housing information about our nation and it helps local officials, community leaders, and businesses understand the changes taking place in their communities. The following are some of the datasets included in ACS data:

- Median household income,
- Percent of population aged over 65,
- Percent of female population,
- Percent of minority population,
- Percent of households with limited English language proficiency,
- Percent of labor force unemployed,
- Percent of mobile homes,
- Percent of owner-occupied housing units,
- Percent of persons below poverty,
- Percent of single parent households, and
- Percent of population without health insurance.

We examined factors that influence the life expectancy for all ages, including the advanced ages. We first linked life expectancy estimates to the ACS community socioeconomic and demographic data, the CDC SVI data, and FEMA community risk of natural disasters.

We then performed multivariate analysis and developed generalized linear models that identified associations of community risks, socioeconomic and demographic factors with the life expectancy while accounting for other census tract characteristics. These models estimated the strength of the relationship between each community characteristic and longevity while holding each of the other characteristics constant. For example, our models allowed us to determine whether communities with high social vulnerability had significantly different longevity risks than communities with low social vulnerability, for communities that were otherwise similar in terms of other community characteristics included in our analysis.

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[5] ACS data are available from Census: https://www.census.gov/programs-surveys/acs

The models are developed at the census tract[6] level which reflects the community characteristics more specifically. Statistical significance was assessed at the 0.05 level.

Results

Life Expectancy at birth

We first looked how life expectancy at birth varies across census tracts and how the variations of life expectancy at birth associated with the area socioeconomic, and risk levels.

The results of our analysis indicate how longevity was associated with communities' natural disaster risk and social vulnerability, as shown in tables 1 below. Table 1 lists the parameter analysis of maximum likelihood estimate (MLE) for predicting the life expectancy at birth, where the direction (positive or negative) and magnitude of statistical association is determined by the coefficient estimates for the effects. The p-value indicates the degree of statistical significance of the coefficient estimates. Overall, our analysis shows that there are statistically significant associations between the life expectancy at-birth and the communities' risk to natural disasters and to the social vulnerability levels of the communities.

Table 1: Effects for Estimating Life Expectancy At-Birth (2010 - 2015)

Explanatory Variable	Parameter Estimate	Standard Error	t Value	p Value
Intercept	84.252	0.0704	1196.19	<.0001
Percent of Female	0.039	0.0012	31.47	<.0001
Percent of Black or African American	-0.041	0.0002	-176.93	<.0001
Percent Lack of High School Diploma	-0.058	0.0007	-86.00	<.0001
Percent Labor Force Unemployed	-0.161	0.0012	-133.61	<.0001
Percent without Health Insurance	-0.032	0.0008	-40.47	<.0001
Percent of Owner Occupied Housing	0.010	0.0003	37.18	<.0001
Social Vulnerability Score	-0.183	0.0015	-124.99	<.0001
Risk Score of Natural Disasters	-0.008	0.0004	-18.45	<.0001

Our analysis shown that the longevity inequality for new born: areas with higher social vulnerability tend to have lower life expectancy, when control all other factors. The longevity inequality also linked to the level of natural disaster risks and other community characteristics as well. More specifically, they show the following:

- Communities with higher levels of socioeconomic vulnerability and underserved populations had lower life expectancy at birth than communities with lower social

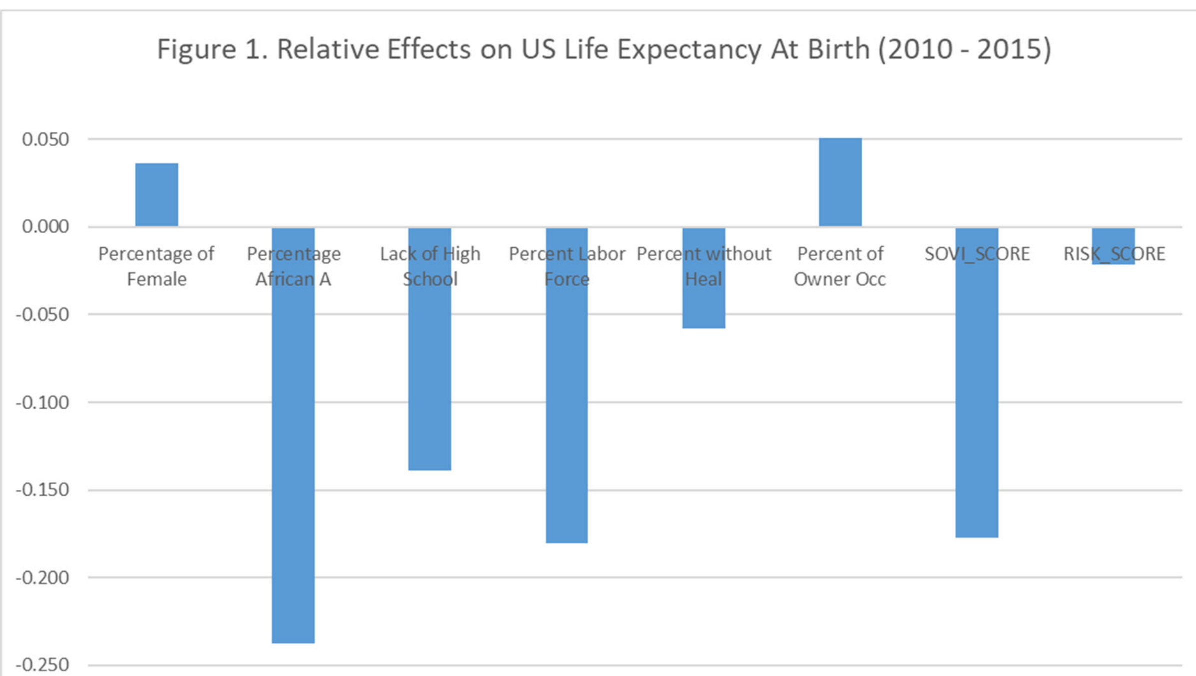
[6] U.S. Census Tracts are small, relatively permanent statistical subdivisions of a counties whose borders follow geographic features, such as streams, highways, railroads, and legal boundaries and that generally contain between 1,200 and 8,000 people. There 84,414 census tracts in US as of March 2022.

vulnerability and underserved populations, as indicated by the results for explanatory variables Social Vulnerability Score in table 1.

- Communities with higher portion of African American population had lower life expectancy at birth than communities with lower portion of female in the community, as indicated by the results for explanatory variable Percent of Black or African American in table 1
- Communities with higher risks of natural disasters had lower life expectancy at birth than communities with lower risks of natural disasters, as indicated by the results for explanatory variable Risk Score of Natural Disasters in table 1.
- Communities with higher portion of uninsured population had lower life expectancy at birth than communities with lower portion of uninsured, as indicated by the results for explanatory variable Percent without Health Insurance in table 1.
- Communities with higher portion of female population had higher average life expectancy at birth than communities with lower portion of female in the community, as indicated by the results for explanatory variable Percent of Female in table 1

On average, life expectancy at birth for female American is about 5 years higher than male life expectancy at birth in recent years. In our analysis, however, the effect of percent of woman in the community is not a prediction or driver of the female life expectancy. Instead, it shown the association of the gender to the life expectancy, along with other variables included in the multivariate analysis.

Figure 1 below shown the relative relationship of socioeconomic, demographic, natural disasters to the longevity risks.



Life Expectancy as People Aging

While we found significant associations of socioeconomic and other community characteristics to the life expectancy at birth, we also found that the correlations of socioeconomic factors such as income, education, and homeownership to life expectation decrease as people aging, as shown in figure 2.

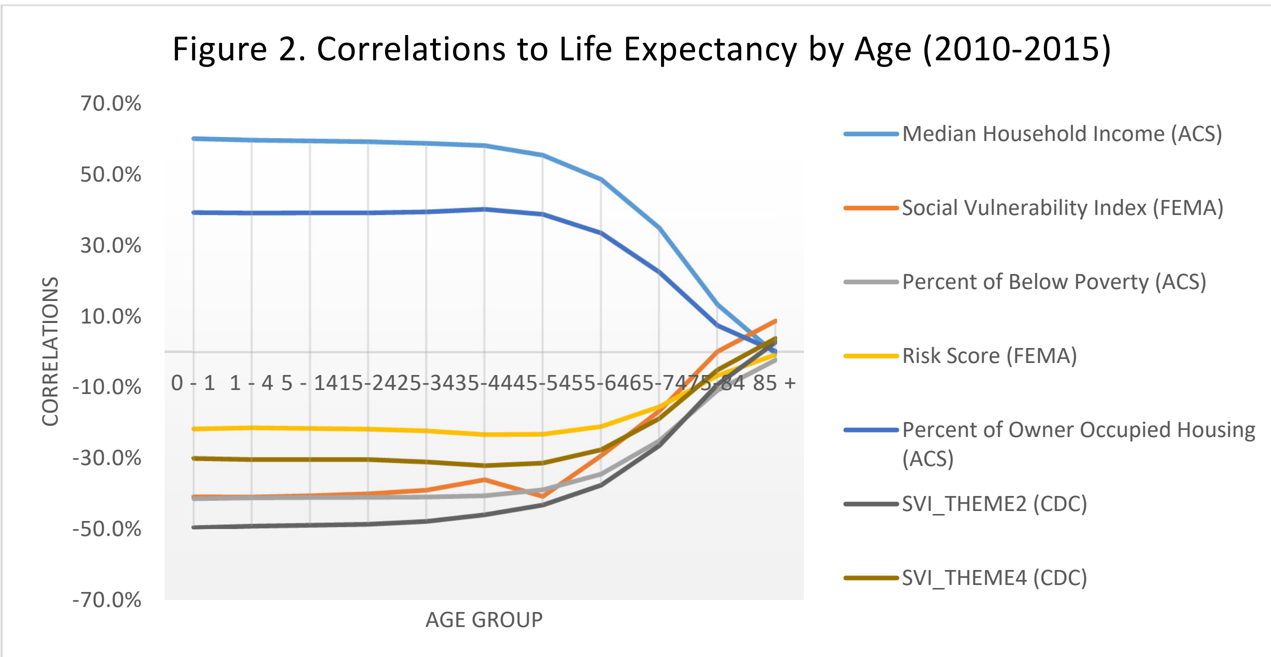


Figure 2. Correlations to Life Expectancy by Age (2010-2015)

The correlations of income, homeownership, and social vulnerability in general to life expectation decreases as people aging, which indicates that the longevity for older people with higher income/wealth is due to cumulated effects of high income/wealth before retirement. Those with higher longevity risks are also associated higher level of social vulnerability before retirement.

Discussion

Gender and Race

It is well known that women generally has lower longevity risk and research (see Barbieri, 2022) has shown that both male and female mortality are linked to socioeconomic status at state and county level. USALEEP doesn't provide gender specific life mortality data and our model did not include gender as an explanatory variable. We found, the associations of gender and race to the average life expectancy for new born as shown in table 1. We also examined gender and racial disparity for life expectancy as people aging and found that women and Africa Americans are also associated with extra (lower for women and higher for Africa Americans) longevity risks for all age groups, as shown in table 2 below.

Table 2: Effects for Estimating Life Expectancy by Age Group (2010 - 2015)				
Explanatory Variable	**Parameter Estimate**	**Standard Error**	**t Value**	**p Value**
Intercept	11.644	0.0628	185.49	<.0001
Age Group 0 - 1	70.949	0.0191	3718.2	<.0001
Age Group 1 - 4	70.580	0.0191	3698.85	<.0001
Age Group 5 - 14	66.704	0.0191	3495.74	<.0001
Age Group 15-24	56.833	0.0191	2978.42	<.0001
Age Group 25-34	47.359	0.0191	2481.92	<.0001
Age Group 35-44	38.007	0.0191	1991.84	<.0001
Age Group 45-54	28.789	0.0191	1508.72	<.0001
Age Group 55-64	20.161	0.0191	1056.55	<.0001
Age Group 65-74	12.259	0.0191	642.45	<.0001
Age Group 75-84	5.306	0.0191	278.05	<.0001
Age Group 85 +	0.000			
Percent of Female	0.072	0.0011	63.93	<.0001
Percent of African American	-0.046	0.0002	-251.2	<.0001
Social Vulnerability Score	-0.235	0.0011	-215.92	<.0001

Note that we only showed percent of Africa American population in table 2, including the complete race and ethnicity measures in the analysis could provide a more comprehensive understanding of longevity inequality across communities.

Urban/Rural

While this analysis didn't address rural area longevity disparity directly, there are variables (such as population, number of housing units and number of household in any given census tract) in our data that reflect rural/urban status of communities. Longevity risk is higher for communities in the rural area with similar socioeconomic and demographic characteristics, as indicated by explanatory variable Number of Households of in Table 3 below.

Table 3: Effects for Estimating Life Expectancy by Age Group (2010 - 2015)				
Explanatory Variable	**Parameter Estimate**	**Standard Error**	**t Value**	**p Value**
Intercept	7.242	0.01910	379.2	<.0001
Age Group 0 - 1	70.949	0.02042	3474.2	<.0001
Age Group 1 - 4	70.580	0.02042	3456.12	<.0001
Age Group 5 - 14	66.704	0.02042	3266.34	<.0001

Age Group 15-24	56.833	0.02042	2782.97	<.0001
Age Group 25-34	47.359	0.02042	2319.05	<.0001
Age Group 35-44	38.007	0.02042	1861.13	<.0001
Age Group 45-54	28.789	0.02042	1409.71	<.0001
Age Group 55-64	20.161	0.02042	987.22	<.0001
Age Group 65-74	12.259	0.02042	600.29	<.0001
Age Group 75-84	5.306	0.02042	259.8	<.0001
Age Group 85 +	0.000			
Risk Score of Natural Disasters	-0.062	0.00041	-150.53	<.0001
Number of Households	0.001	0.00001	130.85	<.0001

Future study could include using rural/urban as an explanatory variable in the analysis of longevity inequality.

Climate Change

Millions of Americans have been impacted by natural disasters each year. Climate change affects global temperature and precipitation patterns. These effects, in turn, influence the frequency and intensity of extreme environmental events, such as wild fires, hurricanes, heat waves, floods, droughts, and storms (see Sousounis, 2021). FEMA NRI is a composite risk score that measures up to 18 nature hazard for communities across the nation. The associations we found of the FEMA risk score to the longevity risk indicate that the climate change could have increasing impacts on the longevity inequality across the country.

COVID-19

Many researchers has reported how populations facing socioeconomic disadvantage have experienced a higher overall burden of COVID related deaths (see Blair A., 2022). Wrigley-Field, 2020 found that COVID-19 mortality and excess mortality in Minnesota were concentrated in disadvantaged neighborhoods, where members of racial and ethnic minority groups across the state live in less advantaged neighborhoods than White people. Given the socioeconomic disparity in Covid-19 related mortality, the current Covid-19 pandemic can have only worsened longevity inequality in US and further investigation and remediation are needed.

Limitations of the Analysis

This study is intended to better understand differences in longevity between populations, using the publically available data sources. This analysis studies the relationships of community (at the US census tract level) characteristics for which there are data available; there could be other characteristics not identified that could be related to longevity that are not identified in the analysis. Moreover, there could be other characteristics that are related to the factors identified and the outcomes that could be driving some of the relationships. For example, there could be other unmeasured factors that may be correlated with both social vulnerability and the longevity risks. Also, some of the characteristics could be correlated with others, which would reduce the precision of the estimates, and we would be less likely to find statistically significant relationships. This analysis relies on data from US government agencies. Some of the data in this analysis are based on statistical estimates from sample surveys and indices that were developed by FEMA and CDC using data from the American Community Survey and other sources. Like all sample surveys, these estimates are subject to sampling error.

Conclusions

Our analysis shown that US residents in communities of less socially vulnerable have experienced larger gains in life expectancy than those live in socially vulnerable communities. In addition, we found an inverse relations of longevity disparity to the community risks to natural disasters, an indication of increasing longevity risks associated with climate change. Differences in life expectancy may be explained in part by demographics and economic conditions, as well as access to healthcare and community resilience to natural disasters. This findings might have implications in managing longevity risk of insurance portfolios for health, retirement, and property casualty. Our analysis on how socioeconomic factor impact the longevity most at younger ages, could help identify specific policies needed to reduce the longevity disparities cross communities.

Our study shows that the use of publically available data for community characteristics at census tract can provide more insights on estimating longevity, improve comparisons of longevity risk at the neighborhood level, and better illustrate longevity disparities. We hope our findings could facilitate debates and actions on how to tackle mortality inequality. Future research included impact of pandemics, the climate change risks on longevity inequality.

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