Continuity and change in the geography of US longevity

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Introduction

Interest for geographic variations in mortality is fairly recent but there has been growing interest in the issue over the past ten years or so, due to rising inequalities and their implications for public health. Increasing inequalities in the length of life across states and counties since around 1980 are now well documented. However, most studies concentrate on particular age groups (e.g. for older ages, Chetty et al. 2015; NAS 2015; Wilmoth, Boe and Barbieri, 2011), particular causes (e.g., the role of smoking in Fenelon and Preston, 2012), or a relatively short time span (e.g., the 1980s and 1990s in Murray et al., 2006; Ezzati et al., 2008; Kulkarni et al., 2011; the 1990s and 2000s in Currie and Schwandt, 2016a, 2016b, 2018). Our goal in this study is to consider as long a time period as the data allow to look at state-level variations in *both* the level of mortality *and* its year-to-year trend, relying on a cluster analysis to group states together and investigating the contribution of the various age groups and causes of death to the mortality patterns in each cluster.

Data and Methods

We combined data from the state-level life tables published in the United States Mortality DataBase (USMDB, usa.mortality.org, accessed September 23, 2019) with those from the NCHS Mortality Multiple Causes Files for years 1959 through 2016. The NCHS files were processed within a Research Data Center to access geographic identifiers on all US death records. The year 1959 is the first when electronic mortality files are available. The year 2016 is the most recent for which life tables by state are available in the USMDB. We computed cause-of-death fractions from the NCHS files and applied the fractions to the lifetable death rates to produce age-specific mortality rates by sex and cause of death for each US state for years 1959 through 2016. In this initial study, the rates were calculated for 5 very broad cause-of-death categories, namely 1) Infectious and respiratory diseases, 2) Cancer, 3) Cardiovascular diseases, 4) All other diseases, and 5) External causes. Deaths of ill-defined causes were redistributed proportionately over these 5 groupings within each corresponding age group and sex.

As further explained below, we determined that the gap in life expectancy between the worse-off state and the best-off state declined from 1959 through 1984 and increased thereafter. We thus constructed state clusters (classes) of survival patterns over these two periods. The purpose of the analysis is to group states in categories as homogeneous as possible with regard to both the level and the trends in life expectancy at birth during each period under consideration. The technique is designed to minimize intra-class variance and maximize inter-class variance. There are various ways to determine statistically the ideal number. We are still investigating which one is the best for our purpose but for this preliminary version of the study, we decided on 5 clusters.

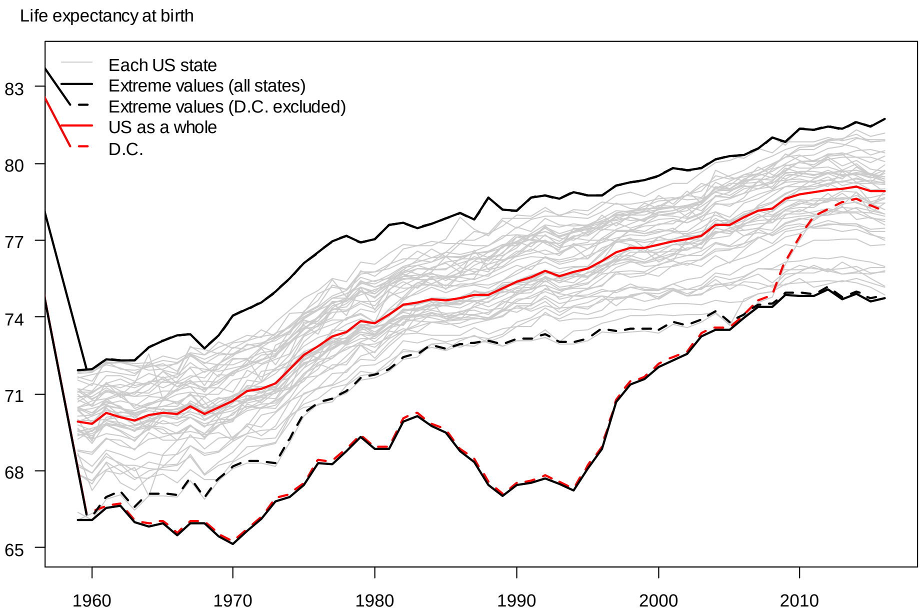
We then examined differences between the pattern of age- and cause-specific mortality within each cluster and the US as a whole for each calendar year using a decomposition technique proposed by Andreev, Begun and Shkolnikov (2002). All calculations were performed with the open-source software R, version 3.3.3. (R Foundation for Statistical Computing, Vienna, 2017).

Results

1. *Convergence and divergence across US states*

Figure 1 shows trends in life expectancy at birth in all 50 states and the District of Columbia (DC). The outlines of the wave (the continuous black line on the figure) show the range of values across all states. The gap in life expectancy between the two extreme states was 5.8 years in 1950, it increased to 11.6 years in 1994 and declined to 7.0 in 2016. However, the pattern of a progressive extension and then compression of the life expectancy spread is entirely driven by a single state, namely DC. Once DC is excluded, the pattern reverses, with a compression of the spread, which declines from 5.6 years in 1959 to 4.9 years in 1984 (which we therefore chose as the breakpoint between the two periods we are considering in our further analyses), followed by an extension, to 7.0 years in 2016. This general trend is well documented. However, previous studies tend to compare snapshots of the inter-state variations in mortality without taking into consideration the role of each individual state in the general pattern of change.

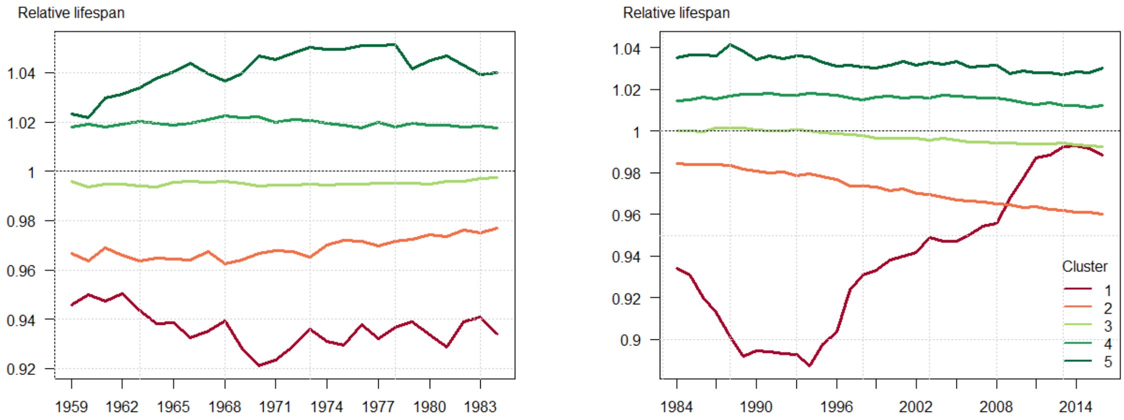
Figure 1. Trends in ife expectancy at birth by state, 1959-2016
Both sexes combined



2. *Mortality trends and differences in five state clusters*

Figure 2 represents the trends in survival for each cluster in relation to each other. It shows a general convergence during the first period under consideration, especially during the 1970s, when the states in the best-off cluster improved more slowly than the US as a whole while those in the two best-off clusters improving faster. The gap between the states in the two intermediate clusters and the US as a whole remained fairly constant throughout the period. The situation changes dramatically during the second period (1984-2016). First, after reaching its lowest relative point in 1994, the bottom cluster rebounds dramatically so that by 2016, it has nearly caught up with the US average. This is the only cluster with a clearly positive trend: by contrast there is a marked deterioration in the relative situation of the second cluster, which progressively diverges from all the other clusters. The third cluster also exhibits a relative deterioration but not as pronounced as the second cluster. As for the 4th and 5th cluster, they remain in a fairly constant position in relation to the US as a whole throughout the period. Increasing geographic inequalities in mortality since the beginning of the 1980s is thus nearly entirely attributable to the states making up the second cluster and, to a much smaller extent, those in the third cluster (see Appendix Table 1 for a full list of states in each cluster during the two study periods).

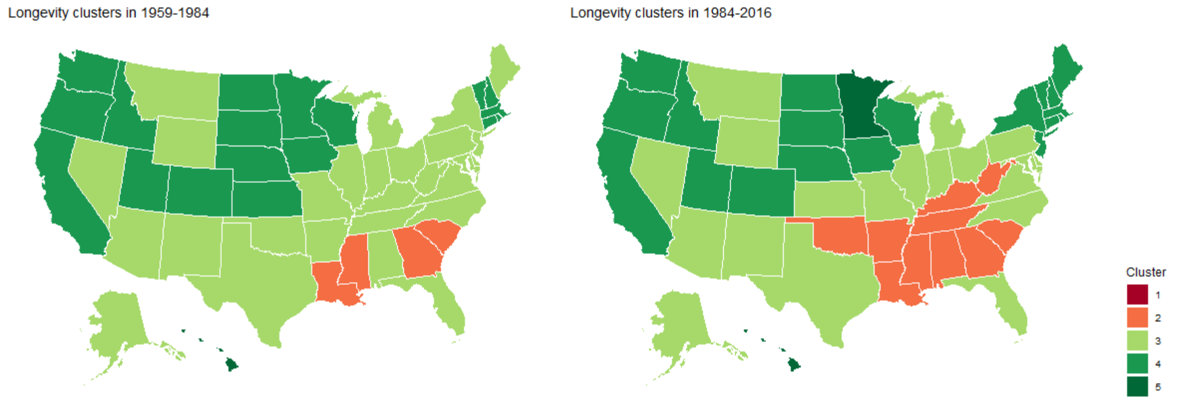
Figure 2. Life expectancy at birth by cluster relative to the US as a whole
Both sexes combined



3. The geography of mortality clusters

Figure 3 provides a cartographic representation of the longevity clusters during the two periods 1959-1984 and 1984-2016. It is difficult to identify the first cluster because it is made up of a single area, the District of Columbia, too small to show up on the maps. Indeed, the trajectory of the District during this last period has been remarkable and unlike any other, with a mortality improvement so quick that the enormous gap (9 years in 1994) in life expectancy with the country average of the1950s had nearly completely disappeared by 2016, in a context of general deterioration in pretty much every other state. By contrast, the second cluster not only fell further away from the national average but it increased in size: during the first time period, the cluster included only 4 states (Georgia, Louisiana, Mississippi, and South Carolina); during the second period, these 4 states were joined by 6 other states (Alabama, Arkansas, Kentucky, Oklahoma, Tennessee, and West Virginia). These 10 states are geographically clustered in the southeast of the country. The two middle clusters remain fairly stable from one period to the next, with one notable exception: in the extreme northeast of the country, the small group of states which belonged to the third cluster in 1959-1984 (made up of Vermont, New Hampshire, Massachusetts, Rhode Island, and Connecticut) expended to include all of the states between Maine in the North, and New Jersey and New York in the South. The fifth cluster, which, like the first one, only included one state during the first period (Hawaii), add another state during the second period (Minnesota).

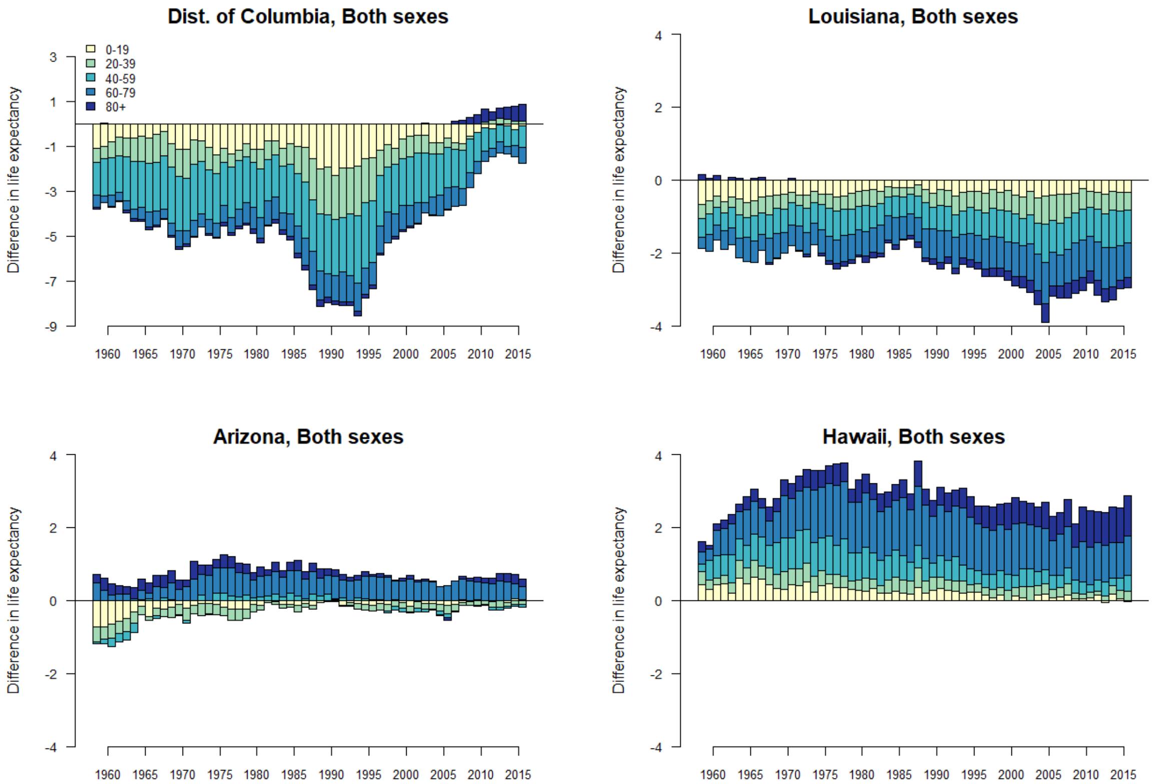
Figure 3. State clusters on life expectancy at birth (Both sexes combined)



4. Age- and cause-of-death patterns

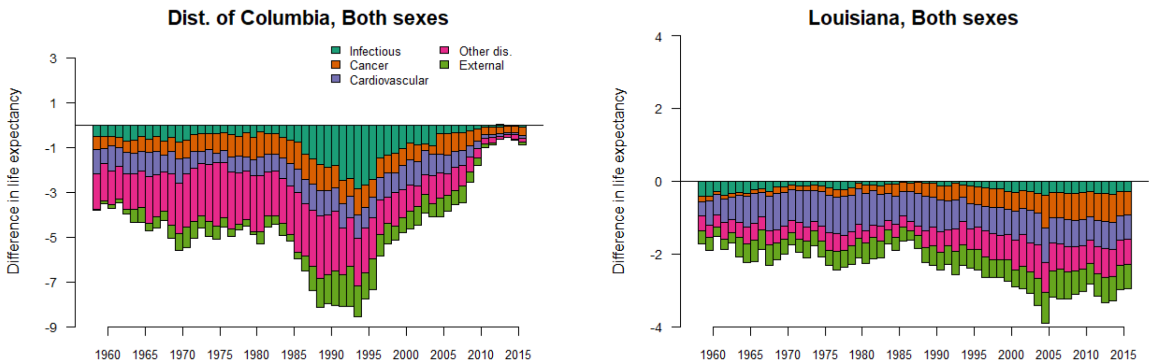
The decomposition by age and cause of the difference in life expectancy at birth between each state and the US as a whole indicates very similar patterns in the first two clusters on the one hand, and in the last two upper clusters on the other, while the middle cluster exhibits a markedly different pattern than the other four. Figures 4 and 5 show how each age group (Figure 4) and each cause-of-death category (Figure 5) contributed to the difference in the length of life between four states and the US as a whole for each calendar year of the entire study period. We selected three states representative of the first two clusters (Louisiana), the middle cluster (Arizona), and the last two clusters (Hawaii). Because of its extraordinary trajectory, we also included the District of Columbia to the graphs. In all clusters but the middle one, all the age groups contributed to the gap in life expectancy, whether negative (DC and Louisiana2) or positive (in Hawaii). One exception is that, in the District of Columbia, mortality in the highest age group (80+ years) improved faster than the national average, by contrast with all other age groups. The other exception is that, in the middle cluster (represented here by Arizona), mortality declined more slowly than the national average in all age groups below age 60 during the 1960s and 1970s but faster at older ages throughout the entire period.

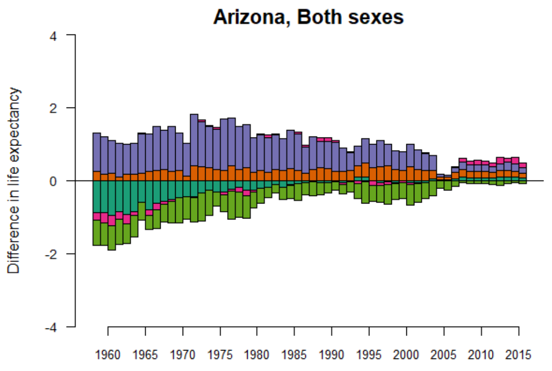
Figure 4. Age group contributions to the difference in life expectancy at birth between each selected state and the US as a whole, Both sexes combined, 1959-2016

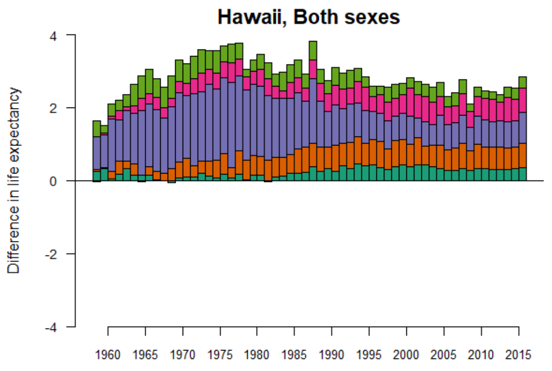


Similarly, all cause-of-death categories have contributed to the negative gap in longevity for the states in the first two clusters and to the positive gap for those in the two upper clusters. Again, Arizona, which exemplifies the situation of all states in the middle cluster, stands out with a negative contribution of causes mostly affecting children and young adults (infectious and respiratory diseases on the one hand, external causes on the other) and a positive contribution of the two leading causes of death (cancer and cardiovascular diseases), which dominate mortality at older ages.

Figure 5. Cause-of-death contributions to the difference in life expectancy at birth between each selected state and the US as a whole, Both sexes combined, 1959-2016







Next steps

In the next few weeks, we will study these patterns more systematically, examine how men and women differ, and review the contribution of causes of death at a finer level of detail (in particular as regards mortality from the conditions of particular public health interest – HIV-AIDS and violence in the 1990s, maternal mortality throughout the second period, and drug overdoses more recently). We will also possibly look at the relationship between mortality and economic trends (in terms of the distribution of income and wealth and rising economic inequalities –see Currie, Schwandt and Thuilliez, 2018) and other factors, such as deindustrialization and incarceration (following up on work by Nosrati et al., 2017) in each cluster.

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Appendix Table 1. State clusters by time period (1959-1984 and 1984-2016), Both sexes combined

Cluster	Period 1959-1984			Period 1984-2016		
1	District of Columbia			District of Columbia		
2	Georgia			Georgia	Arkansas	
	Louisiana			Louisiana	Kentucky	
	Mississippi			Mississippi	Oklahoma	
	South Carolina			South Carolina	Tennessee	
				Alabama	West Virginia	
3	Alabama	Maine	North Carolina	Alaska	Michigan	Pennsylvania
	Alaska	Maryland	Ohio	Arizona	Missouri	Texas
	Arizona	Michigan	Oklahoma	Delaware	Montana Nevada	Virginia
	Arkansas	Missouri	Pennsylvania	Florida	New Mexico	Wyoming
	Delaware	Montana	Tennessee	Illinois	North Carolina	Kansas
	Florida	Nevada	Texas	Indiana	Ohio	
	Illinois	New Jersey	Virginia	Maryland		
	Indiana	New Mexico	West Virginia			
	Kentucky	New York	Wyoming			
4	California	New Hampshire		Maine	Nebraska New	
	Colorado	North Dakota		New Jersey	Hampshire	
	Connecticut	Oregon		New York	North Dakota	
	Idaho	Rhode Island		California	Oregon	
	Iowa	South Dakota		Colorado	Rhode Island	
	Kansas	Utah		Connecticut	South Dakota	
	Massachusetts	Vermont		Idaho	Utah	
	Minnesota	Washington		Iowa	Vermont	
	Nebraska	Wisconsin		Massachusetts	Washington	
					Wisconsin	
5	Hawaii			Hawaii	Minnesota	