# Geographic divergences in adult mortality in the United States

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Abstract

Health and mortality experience in the United States varies along many dimensions. Geography is one important dimension that has received little attention in the literature. Although geographic disparities have existed for many decades, trends in the second half of the twentieth century show increased spatial concentration of disadvantaged states in the American South. Analysis of U.S. vital statistics indicates that the relatively poor performance of the southern states is a product of substantial divergence in mortality from states in the Northeast, Upper Midwest, and West over the past 40 years. This article tracks the contribution of regional differences in the progression of the smoking epidemic to these divergent trends. Cigarette smoking appears to be an important factor responsible for widening regional mortality gaps among men and women. The impact of smoking is largest for men between 1965 and 1985 and for women between 1985 and 2004. Among men, smoking is responsible for 50% – 75% of the divergence between the Central South and other Census Divisions. Among women, smoking explains half of the divergence between the Central South and the Upper Midwest and Pacific divisions, and around 20% for the Middle Atlantic and Great Lakes divisions. The analysis also finds that the contribution of smoking to the divergence is associated with the contribution of other factors, suggesting that smoking may be simply one important factor among many in a broad health-related trend. Many of the factors responsible for the U.S. international shortfall in life expectancy may have corresponding impacts on geographic divergences within the United States.

The United States is somewhat exceptional in terms of demographic outcomes in comparison to its European counterparts. Relative to Europeans, Americans get married younger, have more children on average, are less likely to bear children outside of marriage, and are less likely to live together prior to marriage (Lesthaeghe & Neidert 2006). Large-scale societal changes associated with the second demographic transition appear to be delayed in the United States, at least among a large fraction of the population. At same time, a more sinister exceptionalism characterizes U.S. health and mortality performance. Life Expectancy at birth in the United States rose from 70 years in 1965 to nearly 78 years in 2007. While this is a new milestone for low mortality among Americans, the United States lags significantly behind its counterparts in Western Europe. Especially after age 50, mortality in the U.S. remains substantially higher than countries with similar levels of economic development, a troubling trend that has emerged in the past few decades (Crimmins et al. 2010). Despite spending more per-capita on health care than any other peer country, the health performance of the United States is comparatively very poor, especially between ages 50 and 80 (Ho & Preston 2010). A recent National Academy of Sciences panel was charged with the task of identifying why U.S. adult mortality is so high with respect to its developed world peers in terms of health and mortality (Crimmins et al. 2010). Although a number of sources of the U.S. shortfall were identified, the relatively poor health and mortality experience of the United States remains an issue that American health policy has not sufficiently addressed.

It is important to recognize that health and mortality experience across subpopulations in the United States is far from homogeneous. The experience of the U.S. as a whole does not necessarily reflect the experience of individual subpopulations. Within the U.S., health and mortality vary on a number of dimensions including race/ethnicity, socioeconomic status, gender, and geography. Geographic variation represents a particularly fascinating dimension of mortality inequality, but one that has received substantially less attention than the others. Geographic inequalities in adult mortality in the U.S. also appear to be greater on average than in Western European countries (Wilmoth et al. 2010). Along with varying mortality experience, places within the U.S. also have vastly different experiences in terms of environmental exposures, disease control, medical treatment and care, and behavioral risk (Geronimus et al. 1996; Hayward et al. 1997).

Since the mid-twentieth century, U.S. geographic regions with particularly high mortality have become increasingly concentrated in space and clustered in the South. The southern disadvantage in terms of resources is a more longstanding pattern; southern economies that more closely depended on agriculture have been slower to rebound from economic recession cycles (Slesnick 1993; Tickamyer & Duncan 1990). As a result, poverty and rural isolation have historically had more profound effects on social and economic opportunities in the South in both white and black communities (Friedman & Lichter 1998). Although regional differences in poverty have narrowed, some of the enduring disadvantage of southern states may reflect institutionalization of black inequality (Karnig & McClain 1985). In contrast to economic inequality, the southern disadvantage with respect to mortality experience appears to be a more recent pattern. The current southern mortality disadvantage reflects diverging trends in mortality between the southern states and states in the Northeast, West, and Midwest over the latter half of the Twentieth Century (Ezzati et al. 2008). In the early-mid 2000s, adult mortality rates in many Southern states are 30% – 40% higher than top performers in other regions, particularly Pacific Coast, Upper Midwest, and New England. This excess mortality translates into 3-4 fewer expected years of life at age 50 for the states that are worst off.

**Geographic Differences in Health**

It is well known that individuals in the southern United States experience relatively poor health outcomes compared those in to other regions. The public health and epidemiological literatures contain a multitude of studies demonstrating poorer health and mortality outcomes in this region of the country, a pattern that is observed with resect to many different measures of health and well-being (Devesa et al. 1999; Jemal et al. 2005; Wilmoth et al. 2010; Mansfield et al. 1999). The large literature on the "stroke belt" indicates the enormous extent to which specific cardiovascular diseases are especially concentrated in this region (Howard 1999; Lanska & Kuller 1995). Although the southern disadvantage characterizes most states in the generalized "South" census region, the phenomenon is particularly focused in the so-called Central South, in Louisiana, Mississippi, Alabama, Tennessee, and Kentucky. Rural counties in these states are especially disadvantaged (Eberhardt & Pamuk 2004), with many of the economic hardships of the 1970s and 1980s having particularly pronounced effects on rural well-being.

This specific geographic pattern in adult mortality is a relatively recent phenomenon. The maps in Figure 1 show the changing pattern between the 1960s and the mid 2000s. Although all states have experienced reductions in mortality over this 40-year period, the pace of the decline has not been geographically even. In 1965, the states with the highest mortality were not particularly concentrated in space; the worst-off states (Rhode Island, Alaska, Delaware, Pennsylvania, New Hampshire) were fairly widely spread across geographic regions. By the 2000s, however, the southern disadvantage was both evident and widely acknowledged (National Center for Health Statistics 2001). Gaps in adult mortality between the southern states and better-off states in the Northeast, Midwest, and West have grown considerably. For example, in 1965, California and Kentucky had very similar expectation of life at age 50, around 20 years for men.

While life expectancy for California men increased steadily over the next four decades to more than 26 years in 2004, men in Kentucky experienced only a modest increase, to 23 years in 2004. Kentucky is not alone among its southern counterparts in falling behind other regions over the past 40 years; the 11 worst-off states were geographically contiguous. Among women, reductions in mortality over this period were slower than for men. Women in many southern states experienced stagnating mortality decline in the 1980s and 1990s, and some even suffered increases in mortality (Meara et al. 2008).

This troubling realization, that specific regions of the country are falling further behind, appears to be inexplicably absent in policy discussions of health. Although geographic location is mentioned by the *Health People 2020* goals as one focal dimension of health disparities in the US, significantly more attention is paid to differences in health outcomes between rural and urban individuals, with less focus on region or state of residence. In contrast more familiar dimensions such as race, gender, and social class, there is no well-developed framework for conceptualizing geographic disparities in mortality. Descriptive studies are widespread, but there is little empirical research about the underlying mechanisms that produce the observed pattern of regional inequality. Differences in health and mortality outcomes across U.S. regions are large, and reflect differences in large set of sociodemographic, environmental, and institutional processes (Murray et al. 2006). A specific interest in the experience of the southern states is highlighted by the myriad sociodemographic and cultural distinctions that characterize the region over the past several decades. Although socioeconomic disadvantage has undoubtedly grown among southerners over this period, it is unknown how such trends impact health performance relative to other regions (Ezzati et al. 2008). There is evidence that broad cultural shifts in the United States have led to increasingly disparate social and demographic outcomes among regions of the country (Lesthaeghe & Neidert 2006). Such shifts have implications not only for geographic patterns of social and political beliefs, but also for regional differences in demographic behavior associated with family and household formation (Lesthaeghe & Neidert 2009).

As chronic and degenerative disease conditions have come to dominate American morbidity and mortality over the past several decades, the potential role of health-related behavior in individual health outcomes has risen (Cutler et al. 2011). As the importance of health behaviors has grown, it has become increasingly important for individuals to translate a large amount of health-related information into action in order to produce more favorable health outcomes (Cutler & Lleras-Muney 2006; Goldman & Smith 2002). At the individual level, a portion of the socioeconomic gradient in health is purported to reflect gradients in the availability of information about the risks and benefits of various health behaviors (Cutler & Lleras-Muney 2010). It is possible that some portion of differences in processing and application of health information reflects differences in the level of trust in science (National Science Board 2012). The process through which individuals make health decisions depends, to some extent, on how health-related evidence is weighed in terms of costs and benefits. Although no direct empirical evidence supports this notion, geographic regions may differ in the importance given to scientific evidence in shaping health behaviors and attitudes. It is not clear whether place, in particular, impacts behavior or whether place is a marker for more underlying determinants of behavioral norms and diffusion (Duncan et al. 1993). Social policy interventions aimed at improving health behaviors must rely on motivating individual action in order to foster behavioral or attitudinal change and improve population health (Cutler 2004). Behaviors such as cigarette smoking raise important challenges for public policy, since policies must attempt to reduce the risk factor while at the same time recognizing the socioeconomic implications of policies that benefit the most advantaged.

**Cigarette smoking and mortality**

Cigarette smoking is the single greatest cause of premature death in many developed countries. At the individual level, tobacco has been linked to mortality from a wide array of causes of death including cardiovascular diseases, many types of cancers, and chronic respiratory conditions (including chronic obstructive pulmonary disease and emphysema) (Doll et al. 2004). The magnitude of excess risk depends jointly on the duration and intensity of cigarette use (Thun et al. 1995). Knowledge of the individual dangers of the smoking habit emerged in the 1950s and became widespread in the 1960s, particularly with the release of the Surgeon General's report on tobacco (U.S. Surgeon General 1964). Rates of cigarette smoking in the U.S. increased starting in the first half of the twentieth century. Men were first to begin smoking widely, and consumed substantially more cigarettes than women in the 1940s, 1950s, and 1960s. Smoking prevalence among men reached a peak in the 1960s and 1970s nationwide and declined thereafter (Burns et al. 1997). Among women, the peak occurred later.

As smoking uptake rates dropped precipitously and smoking cessation rates rose across American cohorts following the 1960s (Burns et al. 1997), the mortality burden of smoking declined for men and has leveled off for women. But there remain large regional differences in smoking's impact (Adhikari et al. 2009). Regional differences in the timing and severity of the tobacco epidemic in the United States have produced large disparities in lung cancer across places (Devesa et al. 1999). States in the South, particularly Kentucky and West Virginia, have maintained high levels of smoking while other states, particularly in the West, have kept smoking prevalence relatively low over the past several decades. This growing gap in smoking behavior likely produced widespread inequalities in health and mortality.

The goal of this paper is to explain the large and stark geographic realignment in adult mortality that occurred since 1965. The paper compares the pace and magnitude of mortality decline across states and regions, with special attention to the experience of the southern states. Using U.S. vital statistics between 1965 and 2004, I compare observed mortality trends across states to trends in the counterfactual scenario in which the impact of smoking is removed. If smoking is an important contributor, the latter scenario should reveal substantially less divergence in mortality. The paper also examines whether smoking should be interpreted as an independent contributor to the divergence or whether smoking instead reflects a broader behavioral trend in the health and mortality experience of the South.

## Data and Methods

### *Data*

U.S. mortality data come vital statistics for the period 1965 – 2004. The National Center for Health Statistics (NCHS) releases mortality microdata as part of Multiple Cause-of-Death (MCD) public-use files, which contain demographic and georeferenced information on all deaths occurring within the US and to US residents. I tabulate lung cancer and all-cause deaths by sex, state, year, and five-year age groups. Lung cancer is coded according to the International Classification of Disease; data from 1965-1967 refer to the $7^{th}$ revision (ICD7 codes 160-164); 1968-1970 refer to ICD8 (160-163); 1970 – 1998 refer to ICD9 (160-165); and 1999-2004 refer to ICD10 (C33-C34). State deaths refer *state of residence* as opposed to *state of occurrence*. Using this specification, all individuals included in the denominator of the death rate calculation also have the potential to be included in the numerator, thus preserving the logic of a traditional demographic rate. This is the standard procedure used by NCHS in calculating decennial state life tables. State population data come from U.S. decennial census enumerations and U.S. census bureau intercensal estimates.

*Geographic Units Considered*

Beginning in 2005, NCHS no longer provides geographic identifiers below the level of Census region in the public-use version of MCD files. For geographic comparisons, I examine mortality experience at two levels of aggregation:

1) States – this includes the 50 states but excludes the District of Columbia.
2) Divisions – the U.S. census bureau established 9 census divisions taking into account geographic and cultural regions. Table 1 explains how states are classified.

The specific division of interest is the *Central South*, which contains Alabama, Kentucky, Mississippi, and Tennessee. This division is unique for experiencing a large health and mortality disadvantage as well as a high mortality burden of smoking (Fenelon & Preston 2012).

*Measuring Geographic Divergence in Mortality*

I calculate period age-specific death rates for each geographic unit and each year between 1965 and 2004. I calculate death rates for both lung cancer and all causes. I also calculate age-standardized death rates for each geographic unit for ages 50+ standardized to the 2000 US Census population age structure. Between 1965 and 2004, the geographic pattern of adult mortality in the U.S. changed considerably. The most notable trend is the increasing gap between the Central South states and other states in the Northeast, Upper Midwest, and West. In order to measure the magnitude of this divergence, I compare change in age-standardized death rates over two 20-year periods:  1965 – 1985 and 1985 – 2004. Mortality divergence over the period $x$ to $x$+20 is calculated as

$$divergence^{obs} = \left(ASDR^i(x+20) - ASDR^j(x+20)\right) - \left(ASDR^i(x) - ASDR^j(x)\right)$$

where $ASDR^i(x)$ is the all-cause age-standardized death rate in state $i$ and year $x$. The mortality divergence simply represents the change in the difference in the death rate between geographic units over a twenty-year period.

*Indirect Estimation of the Impact of Smoking*

An examination of the differential impact of cigarette smoking across states and regions is problematic because reliable survey data on cigarette smoking are largely unavailable for subnational populations prior to the mid 1980s and 1990s. As a result, any measurement of smoking's impact in prior years must be indirect, relying on the observable consequences of smoking rather than the unobserved prevalence of the habit. Lung cancer is an attractive indicator because its etiology is so intricately linked to smoking behavior. In the U.S. more than 90% of lung cancer deaths among men and more than 80% among women result from cigarette smoking (Fenelon & Preston 2012). As an indicator of smoking, the lung cancer death rate may be superior to survey self-reports of smoking behavior since lung cancer simultaneously accounts for smoking duration and intensity and thus does not require detailed cohort smoking histories (Peto et al. 1994; Haldorsen & Grimsrud 1999). The recognition that lung cancer provides a reliable indicator of the population-level "impact" of smoking is key to indirect methods for estimating smoking attributable mortality (Preston, Glei & Wilmoth 2010a; Peto et al. 1992).

I estimate smoking attributable mortality using an indirect method developed by Preston, Glei, and Wilmoth (2010a). The model extrapolates smoking's impact to all-cause mortality using the observed statistical relationship between mortality from lung cancer and mortality from all other causes of death across geographic units. The original model was estimated across developed countries and was adapted to the U.S. geographic context by Fenelon and Preston (2012). They used the re-estimated coefficients across U.S. states and attributed a substantial fraction of regional disparities in mortality to smoking.

*Contribution of Smoking to the Divergence*

In order to examine the contribution of smoking to geographic divergences, I calculate “counterfactual” mortality scenarios in which mortality attributable to smoking is removed. This allows us to observe how trends geographic differences in mortality would change were it not for the impact of smoking

$$contribution = divergence^{obs} - divergence^{*}$$

The *obs* superscript refers to the observed data and the * refers to the same measure in the absence of smoking-related mortality. To the extent that geographic divergences in mortality are attributable to smoking, the difference between the divergence in the observed data and the divergence in the smoking-absent scenario should be larger. I examine the contribution of smoking to diverging life expectancies in the geographic units across two periods: 1965 – 1985 and 1985 – 2004. I also calculate the contribution of smoking to the divergence over the entire period 1965 – 2004.

## Geographic Divergences

Adult mortality rates diverged substantially across geographic units between 1965 and 2004. However, most of the observed divergence reflects slow progress against mortality in many of the southern states. Figure 2 presents trends in the age-standardized death rate (ages 50 and above) between 1965 and 2004. The graph includes five southern states (Alabama, Kentucky, Louisiana, Mississippi, Tennessee) and five “top performers” (California, Connecticut, Iowa, Minnesota, South Dakota), states from other regions that experienced larger declines in mortality over this period. States are labeled according to their level of mortality in 2004. For men, all 10 states begin the period with rather similar mortality experience; the split between the groups occurs early, and widens substantially by the end of the period. By 2004, the group of southern states exhibits mortality rates 30%-40% higher than those in the “top performer” group. Among women, the divergence occurs later, beginning in the 1980s and 1990s, but leads to a sizeable difference in the 2000s.

The pattern is similar at the division level (Figure 3). The top line is the mortality experience for the Central South division and the other lines refer to New England, Middle Atlantic, Upper Midwest, Mountain West, and Pacific divisions, labeled in order by mortality level in 2004. It is important to note the degree of similarity in mortality experience among the comparison divisions, especially later in the period, while the Central South remains a significant outlier. Again among men, all divisions begin the period with rather similar mortality experience but diverge considerably; the magnitude of the divergence ranges from 180 to 1,200 deaths per 100,000. These differences imply 50% higher magnitude of mortality decline comparison divisions compared to the Central South. Among women, it is evident that the divergence does not begin until later in the period. This widening primarily reflects an extended period of stagnation or even mortality increase among women in the Central South.

**The Role of Smoking**

Geographic divergences in smoking-attributable mortality closely track corresponding divergences in all-cause mortality (Figure 4). Over this period, the comparison divisions experience more favorable trends in smoking-attributable mortality compared to the Central South. The Central South peaks later and at significantly higher level than the other divisions, indicating a greater and more persistent impact of smoking. Men (panel a) exhibit large divergences in the early part of the period, with larger declines in smoking-attributable mortality in the Northeast, Midwest, and West, as compared with the Central South. By 2004, the gap is exceptionally large. Among women (panel b), the divergence is less extreme and begins later. Smoking-attributable mortality in the Central South rises continuously over this period, while other divisions reach a peak in the 1990s.

Table 2 quantifies the contribution of smoking to the division divergences observed in Figure 3. The contribution is calculated for the divergence between the Central South division and each other U.S. division for two periods: 1965 – 1985 and 1985 – 2004. For men, most divisions show larger divergences during the early period, with substantial divergences occurring for New England, the Middle Atlantic, and the Mountain West. Smoking explains at least 50% of the divergence of *each* division in the early period, including nearly all of the divergence for the Pacific division. It also explains sizable fractions in the later period and overall. Smoking makes the largest relative contributions to the divergence of the Western South, Mountain West, and Pacific. For women, the magnitude of divergence and the contribution of smoking are smaller than for men. Smoking is an important factor for several divisions. Overall, it is responsible for 56% of the divergence of the Pacific division, 47% of the divergence of the Upper Midwest, and around 15% of the divergences of New England and the Middle Atlantic.

A similar pattern exists at the state level (Table 3). The comparisons are presented for the five states with the highest and lowest mortality in 2004. For men, the period considered is 1965-1985, since these years exhibit the largest divergence. Kentucky shows the largest divergences with the low-mortality states, particularly Connecticut and South Dakota. Smoking appears to have a noticeably high burden in Kentucky, consistent with its history of sustained heavy smoking (Adhikari et al. 2009). Relative to Kentucky, smoking explains 81%, 59%, and 72%, of the divergence for California, Connecticut, and Minnesota, respectively. For women, the period considered is 1985-2004, since the observed divergence occurs later. Smoking makes a substantial contribution to state-level divergences for women as well, particularly with respect to Kentucky. It explains 66%, 48%, and 55% of the divergences of California, Connecticut, and Minnesota, respectively.

## Smoking and Other Factors

Previous work documents that regional differences in the impact of cigarette smoking contributes to disparities in mortality, explaining as much as 50% of the current life expectancy disadvantage of the southern states among men (Devesa et al. 1999; Jemal et al. 2001; Fenelon & Preston 2012). The current study demonstrates that smoking largely contributes to the emergence of this disadvantage over time. Among men, smoking explains as much as 75% of the divergence between the Central South and other U.S. It is important, however, not to overstate the role of smoking independent of broader cultural, demographic, and socioeconomic shifts that took place over this period. A natural question that arises is whether smoking is an independent contributor to the growing disadvantage of the South or whether smoking merely represents one among many interrelated factors that has altered the determinants of health in the southern states compared to states in other regions.

The scatterplots in Figures 5 and 6 examine whether the contribution of smoking might reflect broader health-related processes. These plots present the changing ranking of states in the level of mortality over the periods of interest (1965-1985 for men, 1985-2004 for women). Figure 6 examines the relationship between the change in the smoking-attributable mortality rank and the change in the all-cause mortality rank in men (Panel a) and women (Panel b). The x-axis represents the change in the rank of each state in the level of smoking-attributable mortality (1 being the lowest attributable-fraction, 50 being the highest). The y-axis denotes change in the all-cause mortality rank. Figure 7 substitutes non-smoking-related mortality for all-cause mortality. The goal of these Figures is to identify the overall contribution of smoking to changing state rankings as well as the relationship between smoking and other "non-smoking" factors that may have contributed to state divergence. The correlations in Figure 6a-b are substantial for both men (r=0.599) and women (r=0.508). When we consider only mortality that is not attributable to smoking in Figure 7 the correlations decline to 0.269 and 0.329, respectively. The relationships in Figure 7 are notable for two reasons. First, since the correlations are decidedly weaker than those in Figure 6, they suggest that a significant portion of the changing mortality ranking of states reflects changes in the impact of smoking. Second, the modest remaining correlations suggest that state-specific trends in smoking-related mortality are related to trends in other factors that are not attributable to smoking. Thus, whatever factors explain the residual of state-by-state divergences, some exhibit the same geographic pattern as cigarette smoking.

## Conclusions

Since the mid-twentieth century, there has been an increasing concentration of health and mortality disadvantage in the American South. States with the least favorable mortality experience came to be located almost exclusively in the South, while states in the Northeast, Upper Midwest, and West performed relatively well. The most heavily affected southern states are Alabama, Kentucky, Louisiana, Mississippi, and Tennessee. This process reflects a wider trend of diverging mortality experience among regions within the U.S., with gaps between the South and more advantaged parts of growing to more than 25% in the mid-2000s. Declines in all-cause mortality between 1965 and 2004 were rather small in southern states; slowdowns occurred first for men and later for women. In contrast to the *Healthy People* goal of eliminating health and mortality disparities based on geographic location, the past 40 years have seen an unprecedented widening of geographic disparities in mortality. The results of this study at the meso-scale are consistent with similar studies focusing on the county level (Ezzati et al. 2008) and with studies documenting the increased gap between to the United States and other OECD countries (Crimmins et al. 2010).

The current analysis finds both direct and indirect evidence for the contribution of smoking to this troubling trend. First, direct adjustment for smoking-attributable mortality across U.S. states and regions demonstrates that growing gaps in the impact of the behavior between the South and other parts of the United States was a major determinant of mortality trends over this period. Despite the methodological issues in interpreting cross-sectional measures, available smoking-prevalence data appear to support the role of smoking (Figure A1). Second, indirect support for the contribution of smoking comes from the differential timing of the divergences for men and women. Since the rise of the smoking epidemic occurred in different periods and to different extremes for men and women, the timing of the divergence among men and women provides important evidence of smoking's contribution. All else being equal, we should expect smoking to contribute to geographic divergences among men earlier than among women. This is precisely what we observe; geographic divergences for men occur primarily between 1965 and 1985 and for women between 1985 and 2004.

As an explanation for diverging regional trends in mortality, cigarette smoking is not necessarily inconsistent with other explanations and the contribution of smoking should not be viewed in isolation. Although smoking appears to be the most important factor explaining geographic divergence in mortality, a portion of the divergence remains unexplained. Although the paper is unable to specify precisely the factors that explain the residual divergence, we can tentatively conclude that some residual factors are *related though not directly attributable to* smoking. The implications of this finding are relatively broad; it is unlikely that cigarette smoking is an independent contributor to the unprecedented mortality divergence between the South and the rest of the United States. Instead, cigarette smoking likely represents one important piece of a broader cultural, socioeconomic, and behavioral puzzle that has implications for myriad health-related behaviors and outcomes. Obesity may be another health-related outcome of these wider processes, since the impact of the obesity epidemic has been larger in southern states (Wang & Beydoun 2007). A central goal of future research should be to develop a more comprehensive understanding of this broader trend, and how it may contribute to future geographic inequalities in health-related performance.

Evidence for a growing regional divide in demographic outcomes has accumulated in recent years. Differences between regions of the country in terms of household structure, family formation, and marriage behavior are well-known, and their relationship to U.S. political alignments was popularized by Lesthaeghe and Neidert (2006; 2009) in their analyses of the second demographic transition. The similarity of their geographic pattern to the geographic pattern in health and mortality is notable. It is not to suggest that the two processes are causally related, but instead whether regional divergence in traditional social and family values and divergence in health may share a broader common cause.

It is possible that some of the geographic pattern in the burden of smoking reflects differences across places in the processing of information about health. Widespread socioeconomic deprivation in the South may be compounded by a corresponding deprivation in health-related information, and knowledge of the health risks of widespread behaviors such as cigarette smoking. Although support for this notion is somehwat speculative, it can help to explain the largely laissez-faire approach to smoking-related policy intervention in the southern states. While California introduced the first statewide smoking ban legislation in 1995, 27 states have followed with bans that include all enclosed public spaces, and many others have bans that impact workplaces and restaurants (Rodu et al. 2012). The remaining 10 states with no statewide ban on smoking are nearly all located in the South. State taxes on tobacco products also remain notoriously low in the Central Southern states compared to states with more beneficial trends in the burden of smoking, especially New England (CDC 2011). Indeed, it remains unclear to what extent smoking bans and cigarette taxes have a causal impact on behavior, but it appears that over the past several decades, Southern states have been less successful at translating emerging information about health risks into effective policy (Viswanath et al. 2010).

This study has limitations. The results are based on an indirect method for calculating mortality attributable to cigarette smoking. The estimates do not reference self-reports of smoking status from representative surveys, and instead refer only to vital statistics. We can be reassured by previous work that documents similar attributable risk estimates with both indirect and survey-based methods (Fenelon & Preston 2012; Malarcher et al. 2000; Rostron 2011). Because lung cancer mortality presumably accounts jointly for smoking prevalence, cigarette consumption, and the number of years spent as a smoker, it is likely to be a more accurate measure of the mortality impact of smoking than self-reported smoking status (Peto et al. 1992). It may perhaps be that lung cancer is a better indicator of smoking in some years compared to others, which will make comparisons over time difficult. There is some evidence that individual disease conditions have different lag times with respect to smoking (Shopland et al. 1991). The innovators of the current indirect method, however, have shown over a relatively long period that this does not bias estimates of smoking-attributable mortality (Preston, Glei & Wilmoth 2010a).

Mortality trends at subnational levels of aggregation always have the potential to be affected by patterns of internal migration. Bias in estimates of mortality experience can occur if health status is correlated with migration behavior. Migrants may have better underlying health profiles which will improve mortality of receiving states and raise mortality in sending states, all else being equal (Ezzati et al. 2008). Migration may also lead to inconsistencies between the enumerated population and the actual population at risk and may distort the components of the age-specific death rate (Tong 2000). Sociodemographic and health characteristics of origin and destination states are shown by census year in Appendix Table A1. Differences between sending and receiving states are slight, with little consistency across categories, suggesting that a healthy migrant effect cannot explain the observed trends. There is also no significant relationship between net interstate migration rates and mortality level[1] throughout the period under consideration. While interstate migration may have altered the geographic pattern of demographic composition in the United States in the past four decades, it is not responsible for the drastic shifts in mortality during this period (Ezzati et al., 2008).

A final consideration concerns international comparisons and the shortfall of U.S. life expectancy with respect to to other developed countries. During the period considered here wherein the South fell behind much of the rest of the United States, the U.S. also fell behind much of the rest of the developed world. As the burden of smoking rose throughout the southern states, the United States sank in the international rankings (Crimmins et al. 2010). The temporal correspondence of these trends makes two important lessons particularly clear. The first is that simple comparisons between the United States and countries in Europe ignores and obscures the incredible variation in health and mortality experience within *both* the U.S. and Europe (Wilmoth et al. 2010). Variation in mortality within the United States belies the notion of a singular unified experience of Americans in recent decades. The experience of some U.S. states over the second half of the 20th century closely resembles many of the low-mortality social democracies in Northern Europe. At the same time, the slowed progress against mortality in the southern United States is not unlike the unfavorable health and mortality experience of Eastern Europe over the past three decades (McKee & Shkolnikov 2001). The second lesson is that both the disadvantage of both the American South as well as the disadvantage of the United States in the international context may ultimately have similar causes. The findings of the current analysis joins evidence that smoking contributed to the underperformance of the United States (Preston, Glei & Wilmoth 2010b). The relatively high mortality burden of smoking in the United States appears to be at least partially driven by the intransigence of smoking in many of the southern states (Fenelon & Preston 2012). Thus narrowing geographic inequalities in health and mortality within the United States can be interpreted as an important public policy goal both in itself and as a step towards improving the international performance of the U.S.

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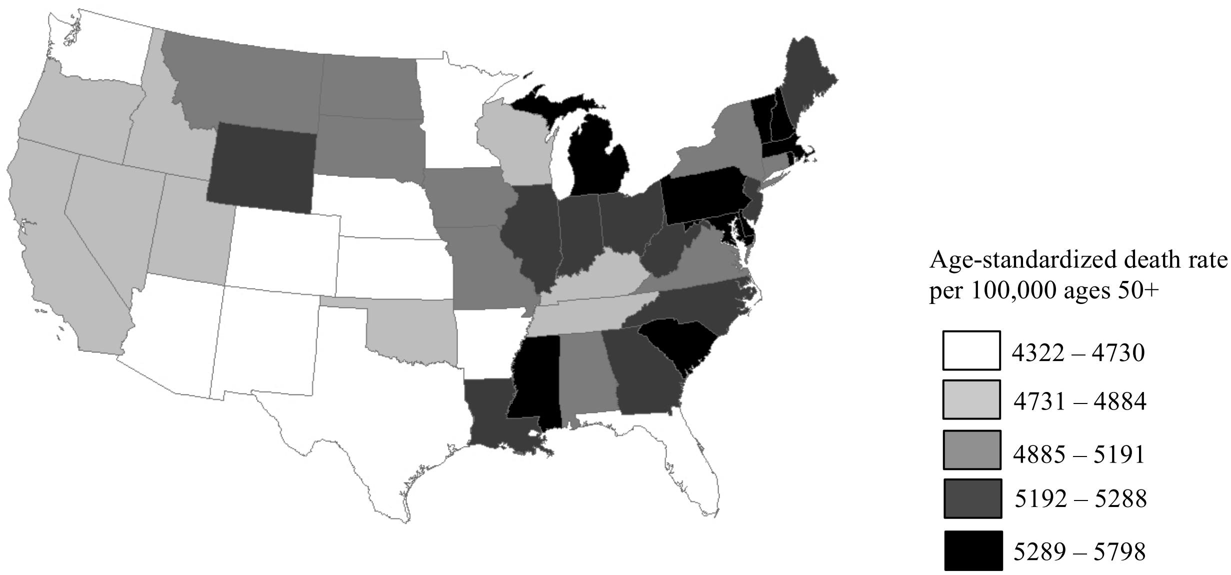
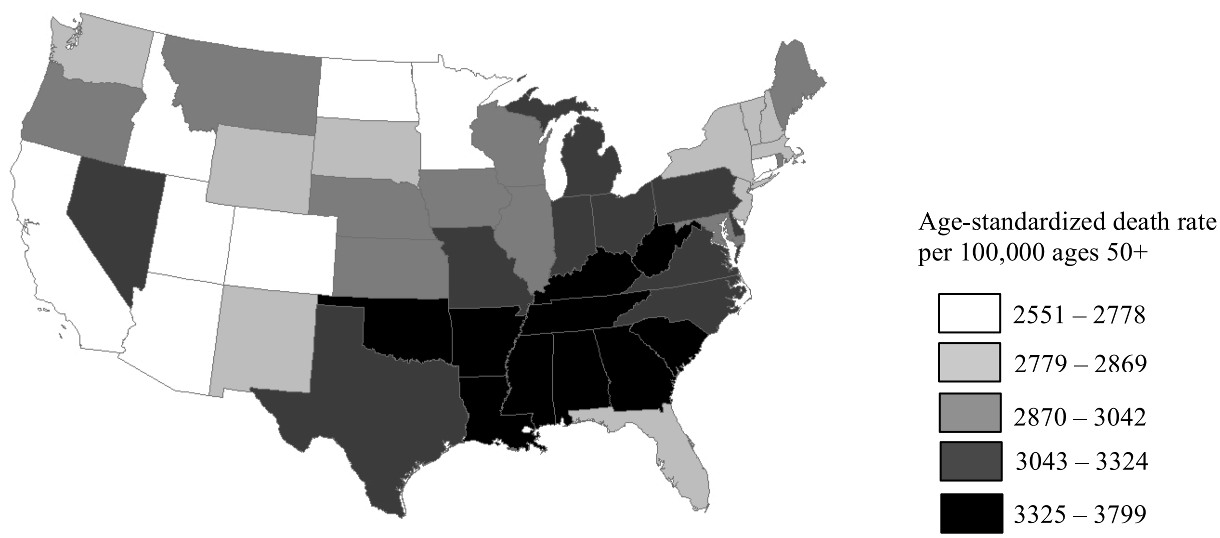
Figure 1: Growing concentration of regional mortality disadvantage in the United States: Age-standardized mortality by state 1965 – 2004

(a) 1965



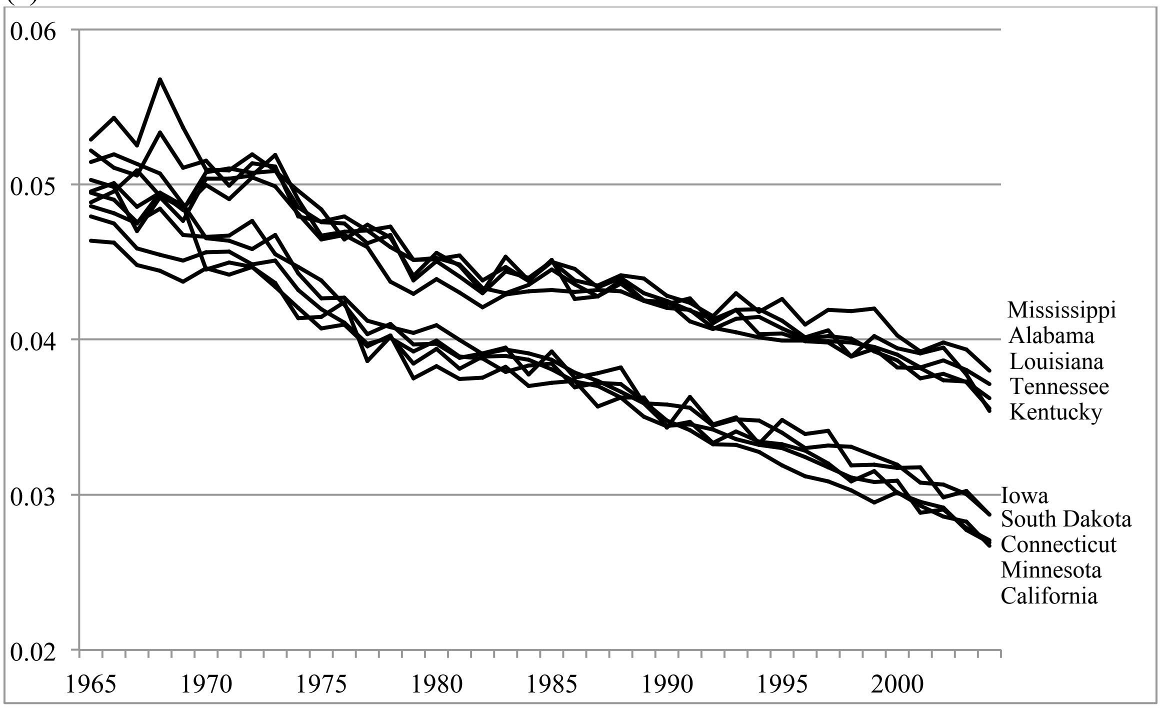

(b) 2004



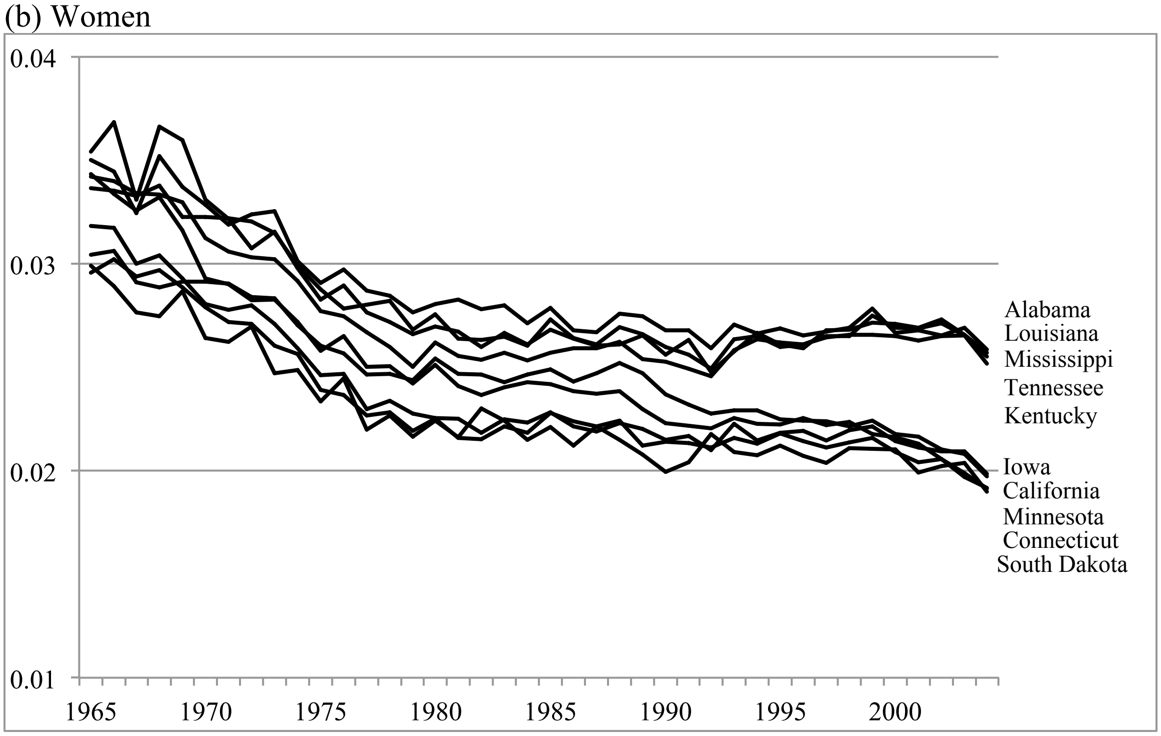

Notes: States classified into quintiles. Darker shades represent high mortality rates. Mortality standardized using year 2000 age distribution.

Source: Author's calculations from National Center for Health Statistics Multiple Cause of Death public use files 1965 and 2004.

Figure 2: Diverging trends in all-cause mortality among selected states: 1965 – 2004
(a) Men



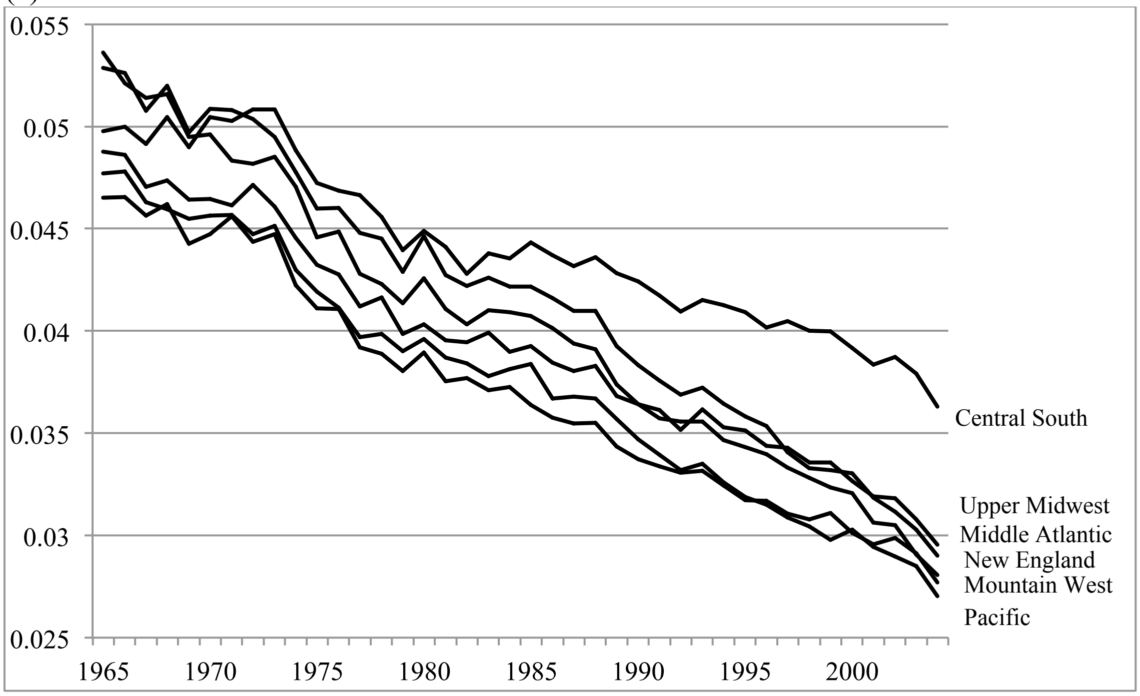

(b) Women



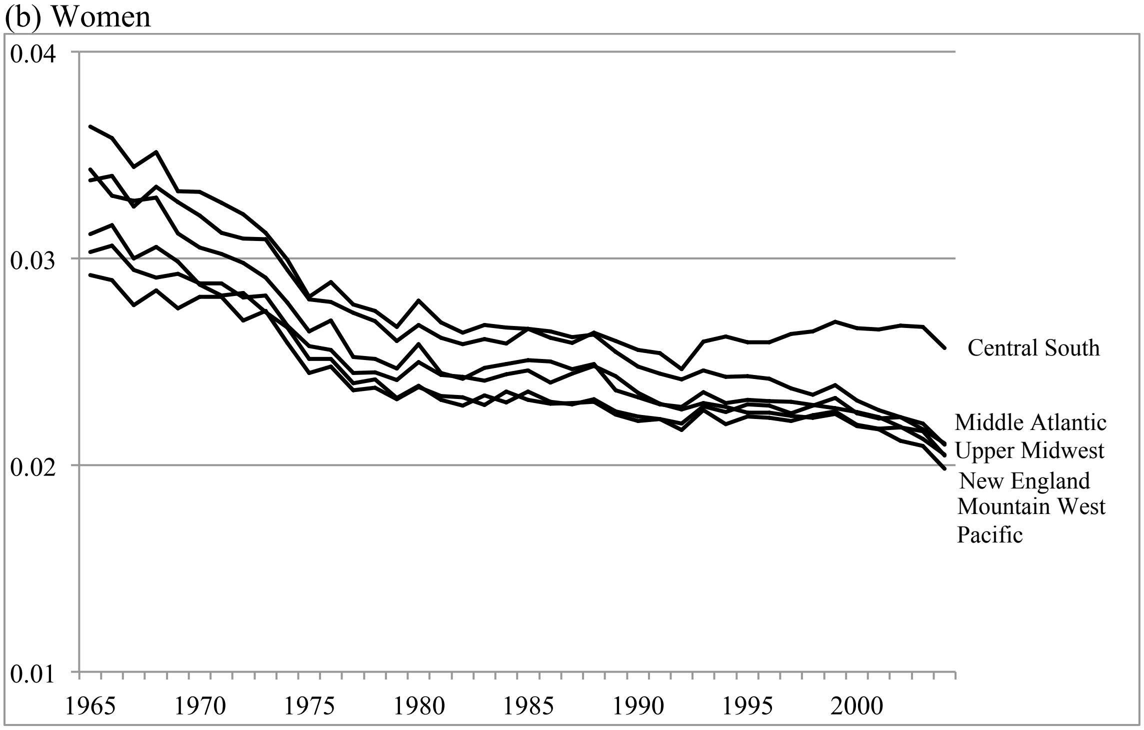

Notes: Age-standardized all-cause death rate by division standardized to U.S. age structure in 2000.
Source: Author's calculations from National Center for Health Statistics Multiple Cause of Death public use files 1965-2004.

Figure 3: Diverging trends in all-cause mortality among selected divisions: 1965 – 2004

(a) Men




(b) Women

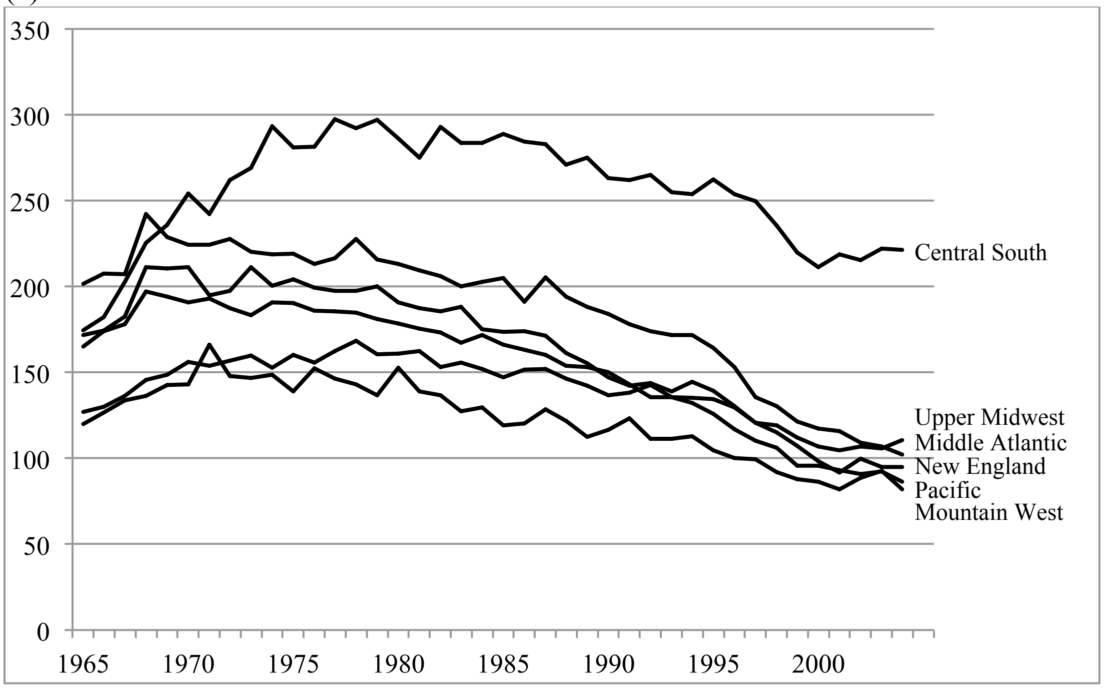



Notes: Age-standardized all-cause death rate by division standardized to U.S. age structure in 2000. State-division classifications shown in Table 1.

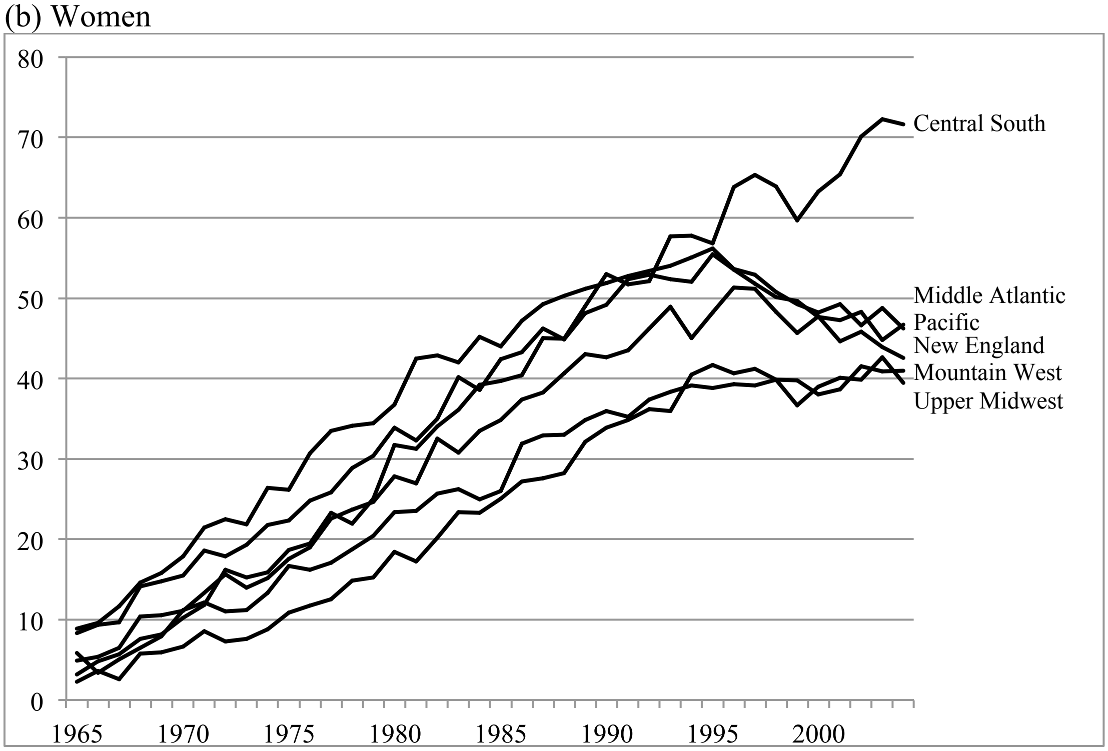
Source: Author's calculations from National Center for Health Statistics Multiple Cause of Death public use files 1965-2004.

Figure 4: Smoking-attributable mortality trends in selected divisions: 1965 – 2004

(a) Men




(b) Women

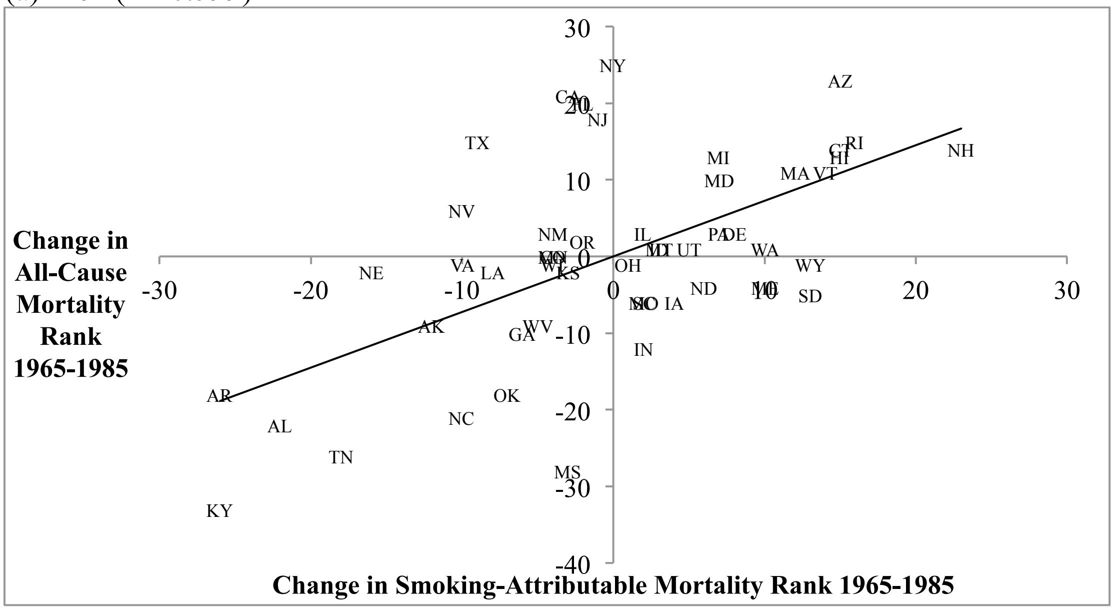



Notes: Age-standardized death rate for smoking-related mortality by division standardized to U.S. age structure in 2000. Death rates are per 100,000. State-division classifications shown in Table 1. Smoking attributable mortality estimated using coefficients from Fenelon and Preston (2012)

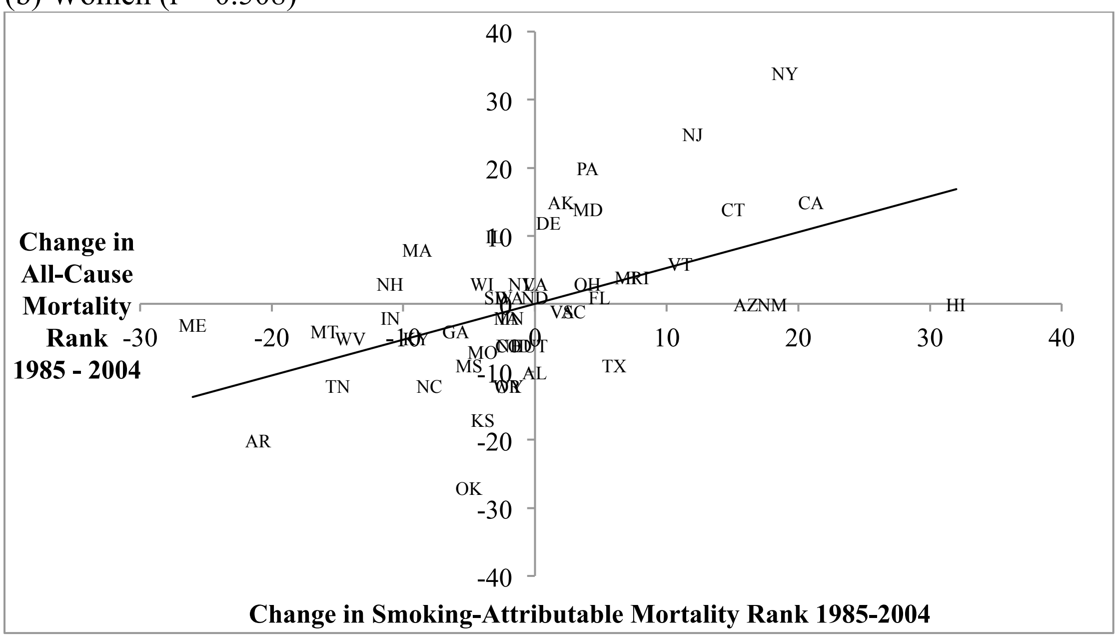
Source: Author's calculations from National Center for Health Statistics Multiple Cause of Death public use files 1965-2004.

Figure 5: Contribution of smoking to changing state-by-state mortality rank among U.S. men 1965-1989. Change in all-cause mortality rank vs. change in smoking-attributable fraction rank

(a) Men (r = 0.599)



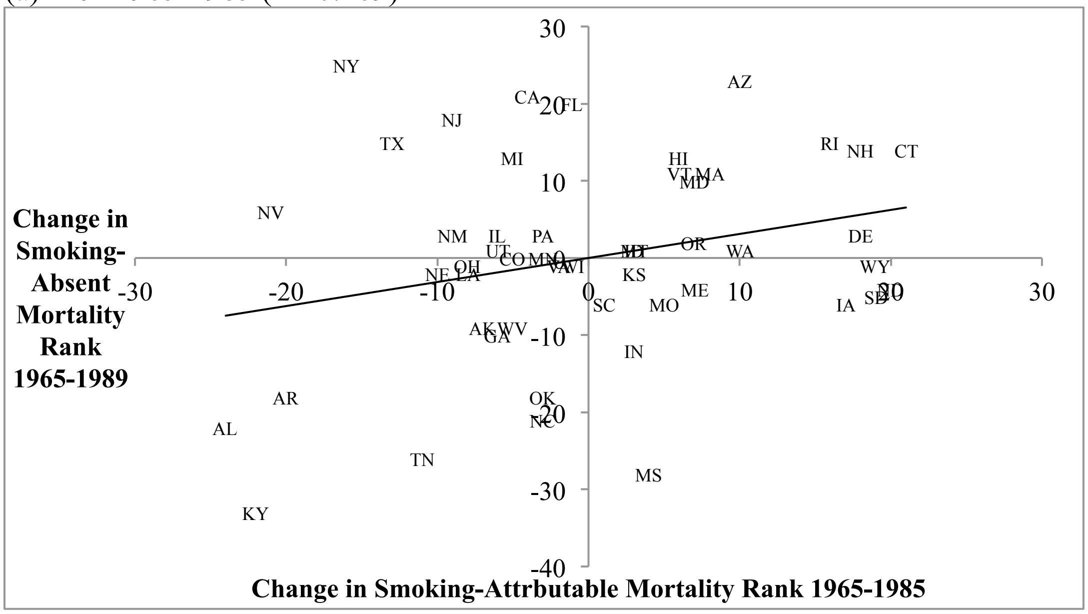

(b) Women (r = 0.508)



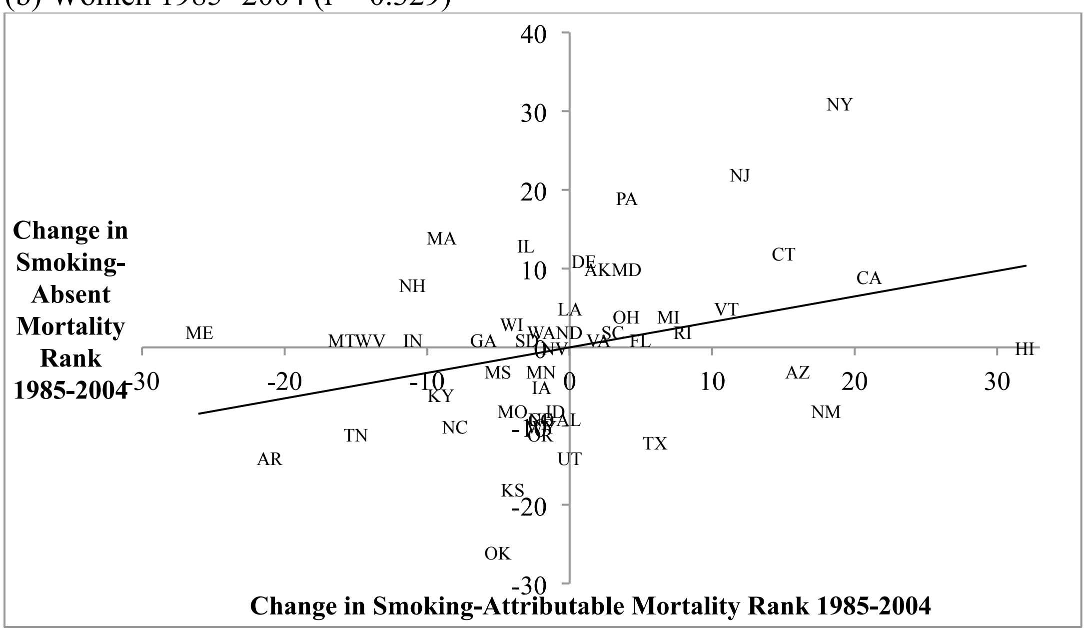

Notes: These graphs represent the relationship between the change in the rank of the 50 states in smoking-attributable mortality fraction (1=lowest attributable fraction, 50=highest) and the change in the all-cause mortality rank between 1965 and 1985 for men and between 1985 and 2004 for women. A positive value indicates mortality improvement relative to other states. A negative value represents poor mortality improvement.

Figure 6: Contribution of smoking to changing state-by-state mortality rank among U.S. men and women. Change in smoking-absent mortality vs. change in smoking-attributable fraction rank

(a) Men 1965-1985 (r = 0.269)




(b) Women 1985- 2004 (r = 0.329)




Notes: These graphs relationship between the change in the rank of the 50 states in smoking-attributable mortality fraction (1=lowest attributable fraction, 50=highest) and the change in the non-smoking-related mortality rank between 1965 and 1985 for men and between 1985 and 2004 for women. A positive value indicates mortality improvement relative to other states. A negative value represents poor mortality improvement. The decline in the correlation from the relationship in Figure 5 to that in Figure 6 reflects the role played by smoking in this process. The remaining correlation in Figure 6 reflects a portion of the change in the geographic pattern of mortality that is related to smoking but not directly attributable to the behavior.

Table 1: U.S. Classification of States in Divisions

| Division[1] | States included |
|---|---|
| New England | Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont |
| Middle Atlantic | New Jersey, New York, Pennsylvania |
| South Atlantic | Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia |
| Central South | Alabama, Kentucky, Mississippi, Tennessee |
| Western South | Arkansas, Louisiana, Oklahoma, Texas |
| Great Lakes | Illinois, Indiana, Michigan, Ohio, Wisconsin |
| Upper Midwest | Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota |
| Mountain West | Arizona, Colorado, Idaho, Montana, New Mexico, Utah, Wyoming |
| Pacific | Alaska, California, Hawaii, Oregon, Washington |

[1] Division labels used here differ from those used by the Census Bureau. The choice of names was intended to represent more familiar terms for these regions.
Source: U.S. Census Bureau

Table 2: Contribution of Smoking to geographic divergence in mortality by division: 1965 - 2004

| | Men | | | | | |
|---|---|---|---|---|---|---|
| | 1965-1985 | | 1985-2004 | | **1965-2004** | |
| | Divergence[1] | % due to smoking[2] | Divergence | % due to smoking | **Total divergence** | **% due to smoking** |
| Central South relative to | | | | | | |
| New England | 741.8 | 50% | 466.4 | 30% | **1208.2** | **42%** |
| Middle Atlantic | 524.3 | 73% | 515.6 | 35% | **1039.9** | **54%** |
| South Atlantic | 397.2 | 64% | 206.8 | 65% | **603.9** | **64%** |
| Western South | 115.8 | 224% | 64.5 | 42% | **180.3** | **159%** |
| Great Lakes | 466.3 | 59% | 303.8 | 34% | **770.1** | **49%** |
| Upper Midwest | 405.6 | 71% | 171.2 | -11% | **576.8** | **46%** |
| Mountain West | 467.7 | 89% | 68.5 | -33% | **536.2** | **73%** |
| Pacific | 386.9 | 98% | 333.1 | 46% | **720.0** | **74%** |
| | Women | | | | | |
| | 1965-1985 | | 1985-2004 | | **1965-2004** | |
| | Divergence[1] | % due to smoking | Divergence | % due to smoking | **Total divergence** | **% due to smoking** |
| Central South relative to | | | | | | |
| New England | 203.9 | -2% | 365.88 | 23% | **569.8** | **14%** |
| Middle Atlantic | 260.6 | -2% | 463.17 | 26% | **723.8** | **16%** |
| South Atlantic | 3.2 | -174% | 198.62 | 39% | **201.8** | **35%** |
| Western South | -241.7 | -5% | 50.69 | 78% | **-191.0** | **-27%** |
| Great Lakes | 149.1 | -4% | 273.89 | 27% | **423.0** | **16%** |
| Upper Midwest | 40.4 | 106% | 168.65 | 33% | **209.0** | **47%** |
| Mountain West | -117.4 | -53% | 180.36 | 47% | **62.9** | **234%** |
| Pacific West | -148.0 | 16% | 385.64 | 40% | **237.6** | **56%** |

[1]Divergence refers to the change in the mortality disadvantage of the Central South division relative to the comparison divisions in deaths per 100,000 over the periods in question. A negative divergence implies that the age-standardized death rate in the comparison division converged to that in the Central South.
[2]Percent of the divergence that is attributable to smoking-related mortality. This percentage reflects the expected decrease in the size of the total divergence in the absence of smoking-related mortality as a fraction of the total divergence. Percentages greater than 100% indicate that, in the absence of smoking, we would expect mortality convergence instead of divergence.

Table 3: Contribution of Smoking to diverging trends in mortality: selected states 1965-2004

| | Men: 1965 - 1985 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | California | | Connecticut | | Iowa | | Minnesota | | South Dakota | |
| | Diverge[1] | % due to smoking[2] | Diverge | % due to smoking | Diverge | % due to smoking | Diverge | % due to smoking | Diverge | % due to smoking |
| Alabama | 370.6 | 98% | 698.9 | 61% | 446.7 | 37% | 339.2 | 84% | 568.8 | 45% |
| Kentucky | 589.2 | 81% | 917.5 | 59% | 665.3 | 42% | 557.7 | 72% | 787.4 | 47% |
| Louisiana | 245.3 | 104% | 573.6 | 56% | 321.4 | 17% | 213.8 | 83% | 443.5 | 33% |
| Mississippi | 164.2 | 247% | 492.5 | 96% | 240.3 | 86% | 132.7 | 248% | 362.4 | 82% |
| Tennessee | 379.6 | 101% | 707.9 | 63% | 455.7 | 40% | 348.1 | 88% | 577.8 | 47% |

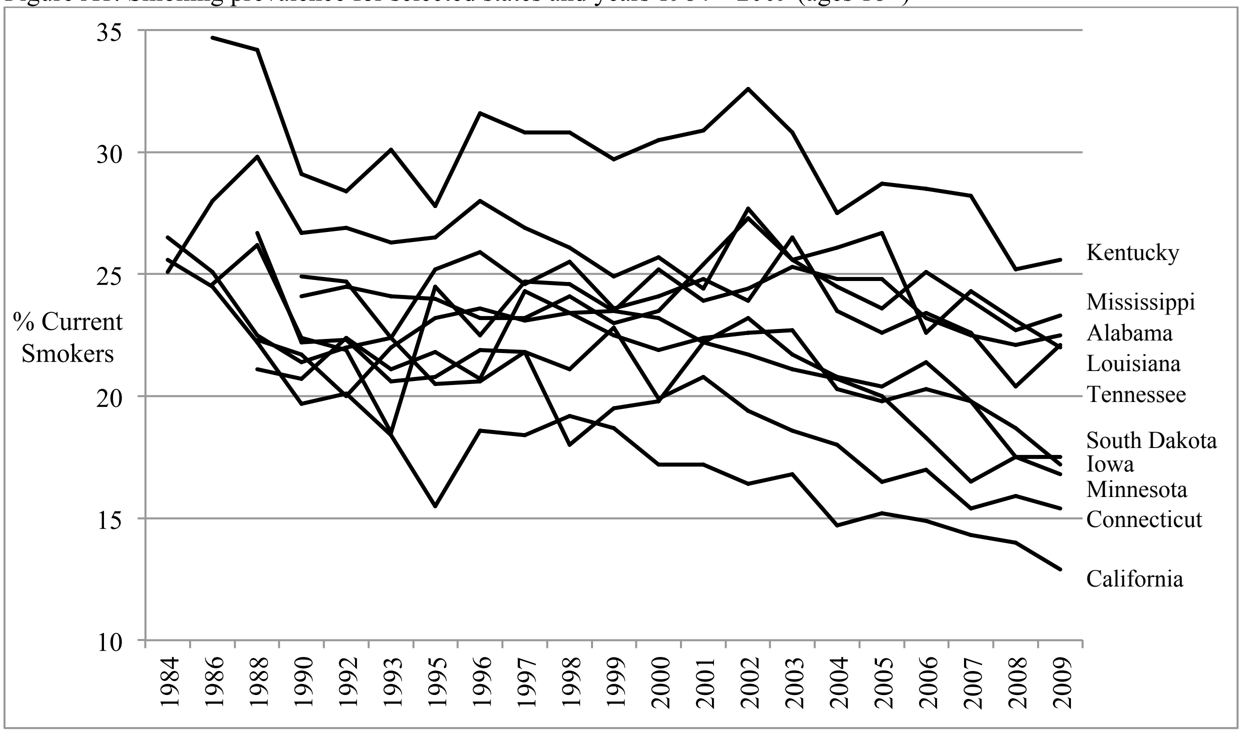
| | Women: 1985 - 2004 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | California | | Connecticut | | Iowa | | Minnesota | | South Dakota | |
| | Diverge[1] | % due to smoking | Diverge | % due to smoking | Diverge | % due to smoking | Diverge | % due to smoking | Diverge | % due to smoking |
| Alabama | 469.3 | 30% | 454.1 | 17% | 248.5 | 6% | 313.3 | 7% | 264.7 | 29% |
| Kentucky | 305.2 | 66% | 290.0 | 48% | 84.5 | 88% | 149.2 | 55% | 100.7 | 136% |
| Louisiana | 318.1 | 39% | 302.9 | 20% | 97.4 | -2% | 162.1 | 3% | 113.5 | 53% |
| Mississippi | 405.3 | 51% | 390.1 | 37% | 184.5 | 43% | 249.2 | 34% | 200.7 | 70% |
| Tennessee | 500.9 | 36% | 485.7 | 24% | 280.1 | 19% | 344.9 | 17% | 296.3 | 39% |

[1]Divergence refers to the change in the mortality disadvantage of the southern state relative to the comparison state in deaths per 100,000 between 1965 and 1985 for men and 1985 and 2004 for women.

[2]Percent of the divergence that is attributable to smoking-related mortality. This percentage reflects the expected decrease in the size of the total divergence in the absence of smoking-related mortality as a fraction of the total divergence. Percentages greater than 100% indicate that, in the absence of smoking, we would expect mortality convergence instead of divergence.

# Appendix

Figure A1: Smoking prevalence for selected states and years 1984 – 2009 (ages 18+)




Source: Centers for Disease Control and Prevention – Behavioral Risk Factor Surveillance System (BRFSS)

Table A1: Differences Between Origin and Destination States of Interstate Migrants in the US: 1975 - 2000

| | 1975 - 1980 | | 1985 - 1990 | | 1995 - 2000 | |
|---|---|---|---|---|---|---|
| Mortality | Origin[a] | Destination[b] | Origin | Destination | Origin | Destination |
| Total Adult Death Rate (per 1,000)[c] | 20.3 | 20 | 18.3 | 18.2 | 16.9 | 16.9 |
| Lung Cancer Death Rate (per 1,000) | 1.13 | 1.12 | 1.3 | 1.31 | 1.15 | 1.16 |
| Percent Intercensal Mortality Decline[d] | 14.8 | 14.8 | 9 | 8.8 | 6.7 | 6 |
| Demographics (of Adults over 18) | | | | | | |
| Median Age | 40.9 | 40.8 | 42.5 | 42.7 | 44.9 | 45 |
| Percent Male | 47.2 | 47.4 | 47.1 | 47 | 47.6 | 47.6 |
| Percent White | 85.8 | 85.8 | 85.3 | 84.7 | 80.3 | 80.4 |
| Percent Black | 10.4 | 10.3 | 9.3 | 9.9 | 10.2 | 10.7 |
| Percent Married | 62.5 | 63.2 | 61.1 | 61 | 59 | 59.1 |
| Income and Occupation | | | | | | |
| Median Income (US Dollars) | 6,952 | 6,889 | 12,954 | 13,014 | 19,471 | 19,367 |
| Duncan's Socioeconomic Index[e] | 30 | 29.9 | 31.7 | 31.7 | 32.4 | 32.3 |
| Education | | | | | | |
| Percent Completing High School | 67.8 | 67.8 | 77.9 | 77.7 | 83 | 82.8 |
| Percent with Bachelor's Degree | 13.9 | 13.9 | 16.7 | 16.7 | 20.2 | 19.9 |

*Source*: US Census Public-Use Microdata 5% Samples 1980, 1990, 2000 (available from IPUMS)
*Note*: Refers to interstate migrants only. Respondents report state of residence currently and state of residence five years ago. International migration is not considered

[a] Denotes average values for non-movers in sending states, weighted by the total number of migrants sent

[b] Denotes average values for non-movers in receiving states, weighted by total number of migrants received

[c] Refers to ages 35 and above in the census year. Age-standardized to US population in 2000

[d] In the ten years preceding the focal census year

[e] A general index of occupational prestige and socioeconomic status ranging from 0 - 100 (Duncan 1961)