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Geographic Divergence in Mortality in the United States

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Life expectancy at birth in the United States (both sexes combined) 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 countries in Western Europe. Especially after age 50, mortality in the US remains substantially higher than in countries with similar levels of economic development, an unfavorable trend that has emerged in the past few decades (Crimmins, Preston, and Cohen 2010).¹ Despite spending more per capita on health care than any other peer country, the health performance of the United States is comparatively poor, especially among older adults aged 50 to 80 (Ho and Preston 2010). A recent National Academy of Sciences panel was charged with identifying why US adult mortality is so high relative to its peers (Crimmins, Preston, and Cohen 2010). Although a number of causes were identified, the relatively poor health status of the United States remains a problem that American health policy has not sufficiently addressed.

Levels of health and mortality are far from homogeneous across subpopulations in the United States. The experience of the country as a whole does not necessarily reflect the experience of individual subgroups. Health and mortality vary in a number of dimensions including race/ethnicity, socioeconomic status, sex, and geography. Geographic inequalities in adult mortality in the US appear to be greater on average than in Western Europe (Wilmoth, Boe, and Barbieri 2010). Along with varying mortality levels, regions within the US also have vastly different experiences in terms of environmental exposures, disease control, medical treatment and care, and behavioral risk (Geronimus et al. 1996; Hayward, Pienta, and McLaughlin 1997).

Since the mid-twentieth century, the sections of the US with particularly high mortality have become increasingly concentrated in space and clustered in the South. The standard South US census region includes all states south of the Mason–Dixon line and westward to Texas and Oklahoma. The most disadvantaged region of the South is the so-called Central South, containing Alabama, Kentucky, Mississippi, and Tennessee. This region is distinctive for experiencing a large health and mortality disadvantage as well as relatively high poverty (Fenelon and Preston 2012). The southern disadvantage in resources is a more longstanding pattern; southern states that are more highly dependent on agriculture have been slower to rebound from economic recessions (Slesnick 1993; Tickamyer and Duncan 1990). As a result, poverty and rural isolation have historically had more profound effects on social and economic opportunities in the South among both whites and blacks (Friedman and Lichter

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¹In terms of life expectancy at birth, the US currently ranks 29th in the world (Crimmins, Preston, and Cohen 2010). In terms of mortality after age 50, the US ranks 15th out of 21 developed countries among men and 17th among women (Preston, Gleit, and Wilmoth 2010b).

1998). Although regional differences in poverty have narrowed, some of the enduring disadvantages of southern states may reflect the institutionalization of black inequality (Karnig and McClain 1985). In contrast to economic inequality, the southern disadvantage related to health and mortality is a more recent occurrence. The current southern mortality disadvantage reflects diverging trends between the southern states and states in the Northeast, West, and Midwest over the second half of the twentieth century (Ezzati et al. 2008). In the early to mid-2000s, adult mortality rates in many southern states were 30–40 percent higher than top performers in other regions, particularly the 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.²

This article seeks to explain the considerable geographic realignment in adult mortality that occurred in the US since 1965. Identifying the specific consequences of residing in a particular region for a person's health and life expectancy is analytically difficult. Instead, the analysis examines the aggregate divergence in mortality between the southern states and states with more favorable mortality experience. The article also highlights the contribution of cigarette smoking to the increasing disadvantage of the southern states. Using US vital statistics between 1965 and 2004, the article compares observed mortality trends across states to trends in a 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.

Geographic differences in health

The public health and epidemiological literatures contain a multitude of studies demonstrating poorer health and mortality outcomes in the southern US, a pattern that is observed with respect to many measures of health and well-being (Devesa et al. 1999; Jemal et al. 2005; Wilmoth, Boe, and Barbieri 2010; Mansfield et al. 1999). The large literature on the “stroke belt” indicates the extent to which specific cardiovascular diseases are especially concentrated in this region (Howard 1999; Lanska and Kuller 1995). Although the southern disadvantage characterizes most states in the South census region, the phenomenon is particularly focused in the Central South: Alabama, Kentucky, Mississippi, and Tennessee. Rural counties in these four states are especially disadvantaged (Eberhardt and Pamuk 2004; Ezzati et al. 2008), with many of the economic hardships of the 1970s and 1980s having pronounced effects on rural well-being.

Over the second half of the twentieth century, the increasing concentration of mortality disadvantage in southern states was exceptional. The maps in Figure 1 show the changing alignment of states 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 been geographically uneven. In 1965, the states with the highest mortality were not particularly concentrated in space; the worst-off states (Rhode Island, Alaska, Delaware, Pennsylvania, and New Hampshire) were spread across geographic regions. By the 2000s,

²These gaps are similar to the corresponding differences between the United States and the top performers among other developed countries; the US trails Japan by 3.2 years of expected life at age 50.

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 widened considerably. In 1965, for example, California and Kentucky had very similar expectation of life at age 50, around 20 years for men. While remaining life expectancy for men in California increased steadily over the next four decades, to nearly 30 years in 2004, men in Kentucky experienced only a modest increase, to 26 years in the same year. Kentucky is not alone among southern states in falling behind other regions over the past 40 years; the 13 worst-off states were geographically contiguous in 2004. 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, Richards, and Cutler 2008).

The realization that specific regions of the country are falling further behind is absent in policy discussions of health disparities. Although geographic location is mentioned by the *Healthy People 2020* goals as one dimension of health inequality in the US, significantly more attention is paid to differences in health outcomes between rural and urban residents, with less focus on region or state of residence. The large differences in health and mortality outcomes across US regions reflect differences in sociodemographic, behavioral, environmental, and institutional factors (Murray et al. 2006). 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 and Neidert 2006). Although southern states have experienced socioeconomic disadvantage throughout this 40-year period, it is unknown to what extent this affects health performance relative to other regions (Ezzati et al. 2008).

As chronic and degenerative diseases have come to dominate American morbidity and mortality over the past several decades, the potential role of health-related behavior in individual health status has risen (Cutler et al. 2011). 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 and Lleras-Muney 2006; Goldman and Smith 2002; Pampel, Krueger, and Denney 2010). At the individual level, a portion of the socioeconomic differences in health is purported to reflect gradients in the availability of information about the risks and benefits of various health behaviors (Cutler and Lleras-Muney 2010). Some of the differences in the understanding and application of health information may also reflect 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 they weigh health-related evidence in terms of costs and benefits. It is not clear whether place of residence, in particular, influences behavior or whether place is a marker for underlying determinants of behavioral norms and diffusion (Duncan, Jones, and Moon 1993). Social policy interventions aimed at improving health behaviors must rely on motivating individual action to foster behavioral or attitudinal change and improve population health (Cutler 2004). Behaviors such as cigarette smoking pose substantial challenges for public policy.

Cigarette smoking and mortality

Cigarette smoking is the single greatest cause of preventable deaths in many developed countries. Knowledge of the dangers of smoking emerged in the 1950s and became widespread in the 1960s, particularly with the release of the Surgeon General's report on tobacco (US Surgeon General 1964). At the individual level, tobacco has been linked to mortality from numerous causes, including cardiovascular diseases, stroke, many cancers, and chronic respiratory conditions (Doll et al. 2004). The magnitude of excess risk depends jointly on the duration and intensity of cigarette use (Thun et al. 1995). Rates of cigarette smoking in the US increased starting in the first half of the twentieth century (Forey et al. 2002), although there is a notable difference by sex in smoking trends. Men began smoking widely in the early to mid-twentieth century, consuming more cigarettes than women in the 1940s, 1950s, and 1960s. Men's lung cancer rates rose substantially, peaking in the early 1980s, and declined thereafter (Jemal, Cho, and Tarone 2001). Smoking prevalence among women reached a peak later, with declines much less pronounced than for men. Rates of lung cancer among women reached a peak in the early 2000s (Burns et al. 1997).³

As smoking initiation rates dropped precipitously and smoking cessation rates rose across American cohorts following the 1960s (*ibid.*), the mortality burden of smoking declined for men and leveled off for women. Although the prevalence of smoking has declined in all states, southern states, particularly Kentucky, have maintained high levels of smoking while other states, especially those in the West, have kept smoking prevalence relatively low over the past several decades (CDC 2009). Regional differences in the onset of smoking declines in the United States have produced large geographic disparities in lung cancer (Devesa et al. 1999). This growing gap in smoking behavior likely produced widespread inequalities in health and mortality.

Data and methods

Data

US mortality data for this article come from vital statistics for the period 1965–2004. The National Center for Health Statistics (NCHS) releases mortality micro-data as part of Multiple Cause-of-Death (MCD) public-use files, which contain demographic and geocoded information on all deaths occurring within the US and to US residents. Causes of death are coded according to the International Classification of Disease (ICD), with lung cancer being the principal cause of interest. Data from 1965–67 refer to the 7th revision (ICD7); 1968–70 refer to ICD8; 1970–98 refer to ICD9; and 1999–2004 refer to ICD10. State population data come from US decennial census enumerations and US Census Bureau intercensal estimates. State-specific deaths refer to state of residence as opposed to state of occurrence.⁴ Using this specification, all individuals included in the denominator of the death rate also have the potential to be included in the numerator, preserving the logic of a traditional demographic rate.

³At the peak, close to 50 percent of US adult men were current smokers. During the same period, smoking prevalence was closer to 30 percent among adult women. In 1965, Americans consumed roughly 11 cigarettes per day per adult (Forey et al. 2009).

⁴This is the preferred procedure used by NCHS in calculating decennial state life tables. The vast majority of deaths occur to individuals in their state of residence.

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, mortality experience is examined at two levels of aggregation: 1) states—this includes the 50 states but excludes the District of Columbia, and 2) divisions—the US Census Bureau established nine Census divisions taking into account geographic and cultural regions. Table 1 presents the classification of the 50 states. The division of interest here is the Central South.

Measuring geographic divergence in mortality

The geographic divergence in mortality refers to the changing gap in the age-standardized all-cause death rate between the South and the comparison geographic units. Death rates for ages 50+ standardized to the 2000 US population age structure are calculated in each year and each geographic unit by sex. Age 50 is chosen as the beginning age because smoking-related mortality occurs almost exclusively in the age group 50 and higher and because recent research indicates that mortality above age 50 is responsible for the majority of international differences in life expectancy (Crimmins, Preston, and Cohen 2010). (Mortality at all ages is considered in the Appendix.) Between 1965 and 2004, the geographic pattern of adult mortality in the US changed considerably. The most notable trend is the increasing gap between the Central South and states in the Northeast, Upper Midwest, and West. In order to measure the magnitude of this divergence, age-standardized death rates are compared over two 20-year periods: 1965–85 and 1985–2004. Mortality divergence over the period x to $x+20$ is calculated as

$$divergence^{obs} = (ASDR^i(t_2) - ASDR^j(t_2)) - (ASDR^i(t_1) - ASDR^j(t_1))$$

where $ASDR^i(t)$ is the all-cause age-standardized death rate in state or division i and year t and $ASDR^j$ is the age-standardized death rate in the comparison state j . The mortality divergence simply represents the change in the difference in the death rate between geographic units over a 20-year period between t_1 and t_2 .

Indirect estimation of the impact of smoking

Smoking-attributable mortality is estimated using an indirect method developed by Preston, Gleit, and Wilmoth (2010a). The model uses lung cancer as a reliable “indicator” of the population-level impact of smoking, a recognition that is key to indirect methods for estimating smoking-attributable mortality (Preston, Gleit, and Wilmoth 2010a; Peto et al. 1992). The model extrapolates smoking’s impact to all-cause mortality using the statistical relationship between mortality from lung cancer and mortality from all other causes of death across geographic units. The original model coefficients were estimated across developed countries. Fenelon and Preston (2012) adapted the model to the US context, using the re-estimated coefficients across US states and attributing a substantial fraction of regional disparities in mortality to smoking.

An examination of the differential effect of cigarette smoking across states and regions is problematic because reliable survey data on cigarette smoking are largely unavailable for subnational populations before the mid-1980s and the 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 a powerful indicator because its etiology is intricately linked to smoking. In the US more than 90 percent of lung cancer deaths among men and more than 80 percent among women result from cigarette smoking (Fenelon and Preston 2012). The benefit of the indirect approach is that lung cancer implicitly accounts for the cumulative nature of the relationship between cigarette smoking and mortality (Peto et al. 1994; Haldorsen and Grimsrud 1999). Because smoking typically begins in adolescence while the health effects are not observed until middle age, survey-based reports of smoking behavior may not accurately reflect the eventual mortality burden. The indirect approach produces national estimates of smoking-attributable mortality that are very similar to those using survey-based methods without relying on individual-level smoking data or assumptions about the relationship between reported smoking behavior and eventual mortality (Preston, Gleit, and Wilmoth 2010a; Malarcher et al. 2000).

Contribution of smoking to the divergence

The contribution of smoking to geographic divergence in mortality is examined using counterfactual scenarios in which mortality attributable to smoking is removed. This allows one to observe how trends in geographic differences in mortality would be expected to change in the absence of the impact of smoking:

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

The superscript *obs* refers to the observed data and the asterisk 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. The percentage contribution of smoking refers to the size of the contribution relative to the overall magnitude of the mortality divergence. The next section examines geographic divergence across two periods, 1965–85 and 1985–2004, as well as over the entire period.

Geographic divergence in adult mortality

Adult mortality rates diverged substantially across geographic regions between 1965 and 2004. However, most of the observed divergence reflects relatively slow progress against mortality in many of the southern states. Figure 2 shows trends in the age-standardized death rate (ages 50 and above) for ten states between 1965 and 2004. The graph includes five southern states (Alabama, Kentucky, Louisiana, Mississippi, Tennessee) and five states (California, Connecticut, Iowa, Minnesota, South Dakota) 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 ten states begin the period with similar mortality experience; the split between the groups occurs early and widens substantially by

the end of the period. By 2004, the southern states have mortality rates 30–40 percent higher than rates in the comparison states. Among women, the divergence occurs later, beginning in the 1980s and 1990s, but leads to a sizable difference in the 2000s.

The pattern is similar at the Census division level (see Figure 3). The top line indicates the mortality level for the Central South division, and the other lines refer to New England, Middle Atlantic, Upper Midwest, Mountain West, and Pacific divisions, labeled according to mortality level in 2004. Again among men, all divisions begin the period with similar mortality experience but diverge considerably; the magnitude of the divergence ranges from about 500 to 1,200 deaths per 100,000. New England and Middle Atlantic states exhibit mortality declines that are 75–90 percent larger over this period compared to the Central South. One should note the degree of similarity in mortality rates among the comparison divisions, especially later in the period, while the Central South remains a significant outlier. Among women, 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 increasing inequality between the South and the rest of the United States is clearly shown by comparing mortality in 1965 and 2004. Figure 4 plots the relationship between the age-standardized death rate in 1965 and the same measure in 2004. The x-axis denotes age-standardized (to year 2000) death rates in the period 1965–69; the y-axis denotes the same measure in the period 2000–04. High-mortality states in 1965–69 are on the right side of the scatter. States with high mortality in 2000–04 are at the top of the scatter. For men, ten southern states (shown in the oval) in 1965 show variation in mortality but are not disadvantaged relative to other states. By 2004, a cluster of high mortality is evident in a large inequality between these ten states (visible at the top of the cluster in the oval) and the remaining 40 states. The resulting inequality between the South and the rest of the US is also significant for women.

The role of cigarette smoking

Geographic divergence in smoking-attributable mortality closely tracks corresponding divergence in all-cause mortality. Figure 5 shows trends in the death rate from smoking-attributable causes by Census division. Over this period, the comparison divisions experienced more favorable trends in smoking-attributable mortality than the Central South. The Central South peaks later and at a significantly higher death rate than the other divisions, indicating a greater and more persistent burden of smoking. Men 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, 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 and stabilize or decline thereafter.

Table 2 quantifies the contribution of smoking to the divergences in Census divisions observed in Figure 3. The contribution is calculated for the divergence between the Central South and each of the other divisions for the periods 1965–85 and 1985–2004. Although

these 20-year periods are used for parsimony, considering individual years does not change the substantive results of the analysis. For men, most divisions show larger divergence during the early period, with substantial divergences occurring for New England, the Middle Atlantic, and the Mountain West. Smoking explains at least 50 percent of the divergence of each division in the early period, including nearly all of the divergence for the Pacific. 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 percent of the divergence of the Pacific, 47 percent of the divergence of the Upper Midwest, and around 15 percent of the divergence of New England and the Middle Atlantic.

A similar pattern exists at the state level (see Table 3). The comparisons are presented for the five southern states with the highest mortality in 2004 and five comparison states in other divisions. For men, the period considered is 1965–85, since these years exhibit the largest divergence. Of the southern states, Kentucky shows the largest divergence from the comparison states, particularly Connecticut and South Dakota. Smoking appears to have a noticeably high burden in Kentucky, consistent with that state's history of sustained heavy smoking (CDC 2009). Relative to Kentucky, smoking explains 81 percent, 59 percent, and 72 percent of the divergence for California, Connecticut, and Minnesota, respectively. For women, the period considered is 1985–2004. Smoking makes a substantial contribution to state-level divergence for women as well, particularly with respect to Kentucky. Relative to that state, it explains 66 percent, 48 percent, and 55 percent of the divergence of California, Connecticut, and Minnesota. The age profile of smoking-attributable mortality has likely changed over the 40-year period, although the contribution of smoking to state and regional divergence in mortality is robust to this change.

Smoking and residual factors

Previous work demonstrated that regional differences in the impact of cigarette smoking contribute to disparities in mortality, explaining as much as 50 percent of the current life expectancy disadvantage of the southern states among men (Devesa et al. 1999; Jemal, Cho, and Tarone 2001; Fenelon and Preston 2012). The present study demonstrates that smoking also largely contributed to the emergence of this disadvantage over the last four decades. Among men, smoking explains as much as 75 percent of the divergence between the Central South and other US regions. 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. One question that arises is whether smoking is an independent contributor to the growing disadvantage of the South or whether smoking is only one (perhaps the most virulent) of many interrelated factors that have altered the determinants of health in the southern states compared to states in other regions.

Cigarette smoking may represent one critical piece of a broader cultural, socioeconomic, and behavioral puzzle that has implications for numerous health-related behaviors and outcomes. Obesity may be another piece of this puzzle, given that the impact of widespread obesity has been larger in southern states (Wang and Beydoun 2007). The contribution of obesity will be

concentrated in the latter part of the period, since the rise in obesity prevalence began only the 1980s and 1990s (Flegal et al. 2005). Geographic divergence in obesity may thus explain a significant fraction of the growing disadvantage of the South between 1985 and 2004. There is less certainty, however, regarding the mortality impact of obesity than there is with regard to smoking (Mehta and Chang 2009). It is also possible that declines in smoking in some places have led to a rising burden of obesity, although this notion is more controversial (Flegal 2007).

Limitations

The limitations of this study largely relate to the methods used to estimate the impact of cigarette smoking. 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. The method rests on the contention that lung cancer is a reliable indicator of cigarette smoking across populations (Preston, Gleit, and Wilmoth 2010a). One primary concern in applying indirect estimation to subnational populations such as states is the assumption that smoking is responsible for the vast majority of state variation in lung cancer mortality. Factors other than cigarette smoking may lead to geographic variation in lung cancer, biasing estimates of the impact of smoking. Other factors may include pollution, mining, and asbestos inhalation (Samet et al. 2009; Thun et al. 2008). Although direct evidence that smoking is the primary determinant of state differences in lung cancer mortality is difficult to obtain, research on trends indicates that smoking is the main factor leading to change in lung cancer over time and across populations (Rosenbaum, Sterling, and Weinkam 1998; Peto et al. 1992). While other factors may lead to some bias in estimates of the impact of smoking, they are not expected to be large (Preston, Gleit, and Wilmoth 2010a). The innovators of the indirect method also demonstrate the validity of smoking-attributable mortality estimates over long periods of time (Preston, Gleit, and Wilmoth 2010a). Despite potential sources of uncertainty, the broad applicability of the indirect method makes it an appropriate choice for populations with little available data on cigarette smoking. Existing estimates of smoking prevalence at the state level, which begin in the 1980s, tend to confirm a higher burden of smoking in the southern states.

An additional consideration is whether the composition of state populations may have some effect on geographic patterns of health and mortality. States differ substantially in their racial composition, and differential mortality of racial groups may obscure geographic analyses. Indeed, racial composition helps to explain some differences between states, but it does not account for the overall geographic pattern of southern disadvantage. The pattern looks much the same when considering only the white population (Fenelon and Preston 2012). The same appears to be true for the divergent trends. The mortality experience of whites in the South has shown a similar divergence from whites in other parts of the United States. The results also appear robust to patterns of internal migration (see Appendix), consistent with previous work at the county level (Ezzati et al. 2008).

Conclusion

There has been an increasing concentration of health and mortality disadvantage in the American South since the mid-twentieth century. States with the least favorable mortality trajectories during this period were located almost exclusively in the South, while states in the Northeast, Upper Midwest, and West performed relatively well. The poorest-performing southern states were Alabama, Kentucky, Louisiana, Mississippi, and Tennessee. This process reflects a wider trend of diverging mortality experience among regions within the US, with gaps between the South and more-advantaged parts of the country growing to more than 30 percent 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, a trend also observed at the national level (Rostron and Wilmoth 2011). In contrast to the *Healthy People 2020* goal of eliminating health and mortality disparities based on geographic location, the past 40 years have seen a substantial widening of geographic disparities in mortality. The results of this study are consistent with similar studies focusing on the county level (Ezzati et al. 2008) and with studies documenting the rising gap between the United States and other developed countries (Crimmins, Preston, and Cohen 2010).

The analysis finds both direct and indirect evidence for the contribution of smoking to this divergence in mortality in the US. First, direct adjustment for smoking-attributable mortality across US states and regions demonstrates that the widening gap in the mortality impact of smoking between the South and other parts of the country was a major determinant of mortality trends over this period. Second, the differential timing of the divergence for men and women provides indirect evidence for the role of smoking. The smoking epidemic occurred earlier for men than for women, and men experienced a greater peak burden of smoking (Pampel 2002). Accordingly, the geographic divergence for men occurred earlier, largely between 1965 and 1985, with a smaller divergence observed between 1985 and 2004. Women exhibit no consistent mortality divergence until the mid-1980s, with the largest divergence occurring in the 1990s and early 2000s.

Some of the geographic pattern in the burden of smoking may reflect variation in access to relevant health information between places and over time. Widespread socioeconomic deprivation in the South may be compounded by a corresponding deprivation in health-related information and in knowledge of the health risks of cigarette smoking. Although support for this notion is 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 in 1995, 27 states have followed with bans that include all enclosed public spaces, and many others have legislation that limits or forbids smoking in workplaces and restaurants (Rodu, Peiper, and Cole 2012). The remaining ten states with no statewide ban on smoking are nearly all located in the South. State taxes on tobacco products also remain low in the Central South states compared to states with more favorable trends in the burden of smoking, especially those in New England (CDC 2011). Indeed, smoking bans and cigarette taxes tend to limit the prevalence of smoking (Chaloupka 1999; Wasserman et al. 1991), and their absence may partially explain persistent smoking in the southern states. These states have been less successful at translating emerging information about health risks into effective policies (Viswanath et al. 2010).

A final consideration concerns international health comparisons and the shortfall of US life expectancy with respect to other developed countries. During the period considered here, in which the South fell behind much of the rest of the United States, the US as a whole 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, with smoking identified as a principal factor in the US shortfall (Crimmins, Preston, and Cohen 2010; Preston, Gleit, and Wilmoth 2010b). The temporal correspondence between these trends makes two lessons particularly clear. The first is that simple comparisons between the United States and countries in Europe ignore and obscure the wide variation in health and mortality within both the US and Europe (Wilmoth, Boe, and Barbieri 2010). 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 and Shkolnikov 2001). The second lesson is that the disadvantage of the American South and the disadvantage of the US in the international context may have similar causes. The findings of this analysis support evidence that smoking contributed to the underperformance of the United States (Preston, Gleit, and Wilmoth 2010b). The high mortality burden of smoking in the US appears to be at least partially driven by the persistence of smoking in many of the southern states (Fenelon and Preston 2012). Thus, the narrowing of geographic inequalities in health and mortality within the United States emerges as an important public policy goal both in itself and as a step toward improving the country's performance in an international context.

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Appendix

Mortality trends at subnational levels of aggregation always have the potential to be affected by patterns of internal migration. Bias in estimates of mortality can occur if health status is correlated with migration (Palloni and Ewbank 2004). Migrants may have better underlying health characteristics, which will improve the observed mortality profile of receiving states and lead to higher observed 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). Table A1 presents selected demographic and health characteristics of origin and destination states using decennial census micro-data samples. Characteristics are weighted by the relative in-out migration flows for each state, since census respondents report both current state of residence and state of residence five years earlier. 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 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 large shifts in mortality during this period (Ezzati et al. 2008).

The choice to consider mortality above age 50 reflects the role of this age group in international variation in life expectancy. However, divergent trends between states are identical when all ages and all causes of death are considered, indicating that mortality above age 50 is also responsible for the majority of cross-state variation in life expectancy.

The patterns are also not driven by state differences in racial composition. Additional results available upon request.

Although cigarette smoking is a primary contributor to regional divergence in mortality, it is unclear whether it should be interpreted as an independent factor or as merely one dimension of a broad health-related puzzle. Additional analyses (not shown) indicate that the geographic pattern of the contribution of smoking to the divergence is strongly correlated with the pattern of the contribution of residual factors. This indicates that broader social processes may in fact be responsible both for trends in cigarette smoking and for trends in other unmeasured factors. Indeed, it appears the southern states have shown only limited improvement with respect to both smoking-related and non-smoking-related causes of mortality.

TABLE A1

Differences between origin and destination states of interstate migrants in the US, 1975–2000

	1975–80		1985–90		1995–2000	
	Origin ^a	Destination ^b	Origin	Destination	Origin	Destination
Mortality						
Total adult death rate (per 1,000) ^c	20.3	20.0	18.3	18.2	16.9	16.9
Lung cancer death rate (per 1,000)	1.1	1.1	1.3	1.3	1.2	1.2
Percent intercensal mortality decline ^d	14.8	14.8	9.0	8.8	6.7	6.0
Demographics (adults over 18)						
Median age	40.9	40.8	42.5	42.7	44.9	45.0
Percent male	47.2	47.4	47.1	47.0	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	61.0	59.0	59.1
Income and occupation						
Median income (US\$)	6,952	6,889	12,954	13,014	19,471	19,367
Duncan's Socioeconomic Index ^e	30.0	29.9	31.7	31.7	32.4	32.3
Education						
Percent completing high school	67.8	67.8	77.9	77.7	83.0	82.8
Percent with bachelor's degree	13.9	13.9	16.7	16.7	20.2	19.9

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.

SOURCE: US Census Public-Use Microdata 5% Samples 1980, 1990, 2000 (available from IPUMS).

FIGURE 1.

Age-standardized mortality by state, 1965 and 2004

NOTES: States classified into quintiles. Darker shades represent higher death rates. Death rates are standardized using year 2000 age structure.

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 by sex at ages 50 and above in five southern states and five other states, 1965–2004

NOTES: Age-standardized all-cause death rates (ASDR) by state standardized to US age structure in 2000. States are labeled according to their level of mortality in 2004.

SOURCE: Same as Figure 1.

FIGURE 3.

Diverging trends in all-cause mortality by sex at ages 50 and above in the Central South and five other geographic divisions, 1965–2004

NOTES: Age-standardized all-cause death rates (ASDR) by geographic division standardized to US age structure in 2000. State-division classifications shown in Table 1.

SOURCE: Same as Figure 1.

FIGURE 4.
 Realignment of US mortality by sex and state, 1965–2004
 SOURCE: Same as Figure 1.

FIGURE 5.

Smoking-attributable mortality trends by sex at ages 50 and above in selected geographic divisions, 1965–2004

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

SOURCE: Same as Figure 1.

TABLE 1

Classification of states in nine geographic divisions

Division	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, Nevada, New Mexico, Utah, Wyoming
Pacific	Alaska, California, Hawaii, Oregon, Washington

NOTES: 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: US Census Bureau.

TABLE 2

Contribution of smoking to geographic divergence in mortality by sex and geographic division, 1965–2004

	1965–85		1985–2004		1965–2004	
	Divergence ^a	Percent due to smoking ^b	Divergence	Percent due to smoking	Total divergence	Percent due to smoking
Men						
New England	741.8	50	466.4	30	1,208.2	42
Middle Atlantic	524.3	73	515.6	35	1,039.9	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						
New England	203.9	–2	365.9	23	569.8	14
Middle Atlantic	260.6	–2	463.2	26	723.8	16
South Atlantic	3.2	–174	198.6	39	201.8	35
Western South	–241.7	–5	50.7	78	–191.0	–27
Great Lakes	149.1	–4	273.9	27	423.0	16
Upper Midwest	40.4	106	168.7	33	209.0	47
Mountain West	–117.4	–53	180.4	47	62.9	234
Pacific	–148.0	16	385.6	40	237.6	56

^a 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.

^b 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 percent indicate that, in the absence of smoking, one would expect mortality convergence instead of divergence. A negative contribution of smoking reflects a convergence in smoking-attributable mortality between the Central South and the comparison division over the period.

TABLE 3
Contribution of smoking to diverging trends in mortality by sex, selected states 1965–2004

Central South state relative to comparison state	California		Connecticut		Iowa		Minnesota		South Dakota	
	Divergence ^a	Percent due to smoking ^b	Divergence	Percent due to smoking	Divergence	Percent due to smoking	Divergence	Percent due to smoking	Divergence	Percent due to smoking
Men 1965–85										
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										
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

^a Divergence refers to the change in the mortality disadvantage of the Central South state relative to the comparison state in deaths per 100,000 between 1965 and 1985 for men and 1985 and 2004 for women.

^b 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 percent indicate that, in the absence of smoking, one would expect mortality convergence instead of divergence.