Title

Rising Spatial Inequality in Mortality in the United States

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Abstract

Objectives: To examine trends in inequality in life expectancy and age-specific death rates across 40 US spatial units from 1990-2016.

Methods: We use multiple cause-of-death data from vital statistics to estimate the Index of Dissimilarity across metropolitan status and geographic region. We consider trends for 5-year age intervals and examine inequality in cause-specific mortality.

Results: For both sexes, spatial inequality in life expectancy and all-cause mortality above age 25 rose between 2002-04 and 2014-16. Especially noteworthy are divergent trends between large central metropolitan areas on the coasts and non-metropolitan areas in Appalachia and the South. Spatial inequality in mortality from lung cancer/respiratory diseases rose substantially, particularly for older women. Spatial inequality in mortality from the combination of drug overdose/alcohol use/suicide increased at ages 30-34, but declined at ages 50-54 and 70-74. Mortality from screenable cancers, an indicator of the performance of medical systems, showed relatively little spatial disparity.

Conclusions: Spatial inequality in adult mortality increased in recent decades. Policies aimed at encouraging healthy behavior change, expanding access to mental health treatment, and smoking cessation programs in non-metropolitan areas are likely to reduce mortality inequalities.

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Introduction

Where one lives structures the life course in ways that affect length of life and ultimate cause of death. These influences include the quality and accessibility of health services[1], ecological features that affect disease incidence and transmission[2], interpersonal influences on health behaviors like smoking and obesity[3], and major changes in the structure of employment opportunities[4].

One well-documented spatial dimension of mortality is the rural/urban divide. Rural areas, disadvantaged in 1990, had slower subsequent mortality improvements than urban areas so that rural/urban differences in mortality have widened[5-7]. South/Non-South differences have also widened[8]. While studies utilizing these dichotomies are valuable, there is a great deal of spatial variation within each of these broad categories[9,10]. This variation can be captured by a comprehensive index of inequality applied to a more detailed set of spatial units.

In this paper, we take advantage of the huge volume of annual vital statistics produced by the National Center for Health Statistics to investigate the extent of mortality inequality among 40 spatial units over the period 1990-2016. Our units of analysis are combinations of metropolitan status and geographic region that highlight these two separable dimensions. The spatial detail available on several million annual deaths enables us to identify levels and trends in spatial inequality by 5-year age groups for the first time. It also permits a consideration of spatial trends in life expectancy at birth, for which detailed age-specific data are required. To shed light on the social and biomedical processes that contribute to levels and trends in inequality, we examine inequality by cause of death. Changes in geographic patterns of mortality signal whether factors determining health outcomes are converging or diverging across the nation.

Data and Methods

We examine inequality in mortality across 40 spatial units between 1990 and 2016, considering trends in life expectancy at birth and in the Index of Dissimilarity applied to 5-year age intervals. We use age-, sex-, and county-specific data on annual deaths and underlying cause of death from Multiple Cause of Death files provided by the National Center for Health Statistics (NCHS). We estimate person-years of exposure using Census population estimates by age, sex, and county.

We classify counties into 40 spatial units (Appendix Table 1), consisting of 10 broad geographic regions, each of which is further divided into 4 metropolitan statuses. Our 10 geographic regions include the 9 Census divisions, as well as Appalachia, as defined by the Appalachian Regional Commission. Appalachian counties, which include all of West Virginia and counties from 12 other states, are excluded from their overlapping Census regions.

We determine a county's metro status using the Economic Research Service (ERS) classification, which was modified by NCHS[11]. Metro status consists of 4 categories: large central metros, large metro suburbs (hereafter "suburbs"), small metros, and non-metropolitan areas. To maintain consistency over time, we use the counties' metropolitan category as of 2013. We begin by examining trends in life expectancy at birth in the 40 spatial units. Life expectancy at birth is the expected length of life for a newborn subject for all of his or her life to the age-specific death rates of a particular period and spatial unit. It is calculated using standard methods[12] and takes account of both the death rate and the growth rate of the population at ages 85+[13].

Our primary measure of spatial inequality is the Index of Dissimilarity (ID), defined as:

$$ID = 0.5 \sum_{i=1}^{40} | d_i - n_i |$$

where d_i is the percentage of deaths and n_i the percentage of the population in spatial unit i. We pool data into three three-year periods (1990-1992, 2002-2004, and 2014-2016) and focus primarily on the period between 2002-04 and 2014-16 when trends in US mortality were especially problematic[10]. The index is interpretable as the minimum percentage of deaths that would have to be reallocated within that age interval to equalize the spatial distributions of deaths and population[14,15].

The ID is a relative measure of inequality rather than an absolute one because it is scale-invariant; all death rates could be multiplied by the same factor without changing the value of the measure[15]. Relative measures are used roughly four times more frequently in health research than absolute measures[16].

In addition to calculating the index for all causes of death, we also consider levels and trends in inequality for specific cause-of-death categories. We focus on nine mutually exclusive and exhaustive cause-of-death categories:

- Breast, prostrate, cervical, and colorectal cancers;
- Circulatory diseases;
- Drug overdose, alcohol-related causes, and suicide;
- HIV/AIDS;
- Homicide;
- Lung cancer and respiratory diseases;
- Other external causes; and
- All other causes

The ICD-9 and ICD-10 codes for these causes are listed in Appendix Table 2. The list above includes three categories which are combinations of several causes. First, we aggregate screenable cancers—breast, prostate, colorectal, and cervical—to create an indicator of access to and quality of health services. A large percentage of deaths from these cancers can be prevented by timely diagnosis and proper treatment[17-20]. We also consider the role of a category that combines alcohol-attributable deaths, drug overdoses, and suicides. This aggregate, often termed "deaths of despair", has been hypothesized to play a key role in the recent adverse US mortality trends[10]. We use ICD-9 and ICD-10 codes recommended by CDC, which are not identical to those used by Case and Deaton (2017). Finally, we combine lung cancer and respiratory diseases to serve as an indicator of the mortality effects of smoking. In 2014-2016, age-standardized death rates from lung cancer and respiratory diseases at ages 25-64 were correlated at 0.86 for females and 0.88 for males across the 40 units.

Results

Levels and Trends in Spatial Inequality in Life Expectancy at Birth

Figure 1 shows trends in life expectancy at birth for the 40 spatial units during 1990-2016. Based on the mean life expectancy of males and females, we identify four outliers, labeled in Figure 1 and used in subsequent analyses: large central metropolitan areas in the Pacific region, which had the highest life expectancy in 2016; large central metropolitan areas in the Mid-Atlantic region, which had the greatest gain in life expectancy over the period 1990-2016; non-metropolitan areas in the East South Central region, which had the lowest life expectancy in 2016; and non-metropolitan areas in Appalachia, which had the smallest gain in life expectancy over the period.

Figure 1 also presents data on one indicator of inequality, the variance in life expectancy at birth among the 40 units. Between 1990 and 2016, the variance among women tripled. Among men, the variance was relatively constant between 1990 and 2003, and increased by a factor of

1.42 between 2003 and 2016. Inequality among males exceeded that among females throughout the period.

Figure 2 plots each unit's life expectancy in 2003 and 2016, with points falling above the diagonal line indicating an increase over time. The Figure shows that areas with higher life expectancies in 2003 experienced, on average, larger gains in life expectancy between 2003 and 2016. The slope of the relationship between the two life expectancies implies that, among women, each incremental year of life expectancy in 2003 was associated with an additional gain of 0.31 years of life expectancy by 2016. Among men, the additional gain was 0.11 years.

Figure 2 shows that areas that gained the most years of life over the period were primarily large central metropolitan areas and their suburbs. By 2016, the seven highest life expectancies for women and the eight highest for men belonged to these categories. The smallest gains were experienced by non-metropolitan areas, which solidified their position as the highest mortality category. In 2016, the four lowest life expectancies for women and four of the five lowest for men were observed in non-metropolitan areas. One exception to the good performance of large central metropolitan areas were those in the East South Central region, which ranked in the bottom five life expectancies in 2016 for both men and women.

Levels and Trends in Spatial Inequality in All-Cause Mortality by Age

Life expectancy at birth combines death rates at all ages into a single index. In order to shed light on inequality levels and trends by age, we apply the Index of Dissimilarity to death rates in 5-year age groups among the 40 spatial units. Table 1 presents results for 1990-92, 2002-04, and 2014-16. For both sexes, the age-pattern of inequality peaks in the age interval 25-39 and declines steadily thereafter. Early to mid-adulthood is clearly associated with the greatest regional disparity in survival.

Trends in levels of inequality vary by age and sex. At the peak ages for males, inequality declined sharply between 1990-92 and 2002-04 while it rose at older ages. The relatively small change in inequality in male life expectancy between 1990 and 2003 shown in Figure 1 was clearly a product of offsetting trends at younger vs older adult ages.

For both sexes, inequality rose between 2002-04 and 2014-16 at all ages above 25. The increase was particularly sharp among women, consistent with Exhibits 1 and 2. Below age 10, inequality rose for both sexes between 1990-92 and 2014-16, although trends are less distinct in the second half of the period for females. For the remaining analyses, we focus on adult mortality.

To provide detail on the regional mortality patterns producing these changes in inequality, Appendix Figure 1 presents trends in age-specific all-cause death rates at ages 30-34, 50-54, and 70-74. Using colored trend lines, we distinguish the four outlier areas identified earlier. The remaining 36 regions are represented in gray to give a visual impression of trends over the period.

At ages 30-34, the huge reduction in the ID between 1990-92 and 2002-04 among males is clearly led by large central metropolitan areas in the Mid-Atlantic region. This grouping includes New York City, where massive declines in mortality from HIV/AIDS and homicide between 1990 and 2000 at these ages were key factors in an extremely rapid gain in life expectancy[21]. By 2014-16, large central metropolitan areas in the Mid-Atlantic had among the lowest mortality levels at ages 30-34. Large central metropolitan areas in the Pacific also showed substantial mortality gains relative to other areas. For both sexes, non-metropolitan areas in

Appalachia and East-South Central had among the highest death rates by 2014-2016. Mortality at ages 30-34 has been rising in both regions since 2000.

The story is similar at ages 50-54 (Appendix Figure 1). After increases beginning around 2000, death rates in non-metropolitan areas in Appalachia and the East South Central region finished the period higher than those in any other regional grouping. Large central metropolitan areas in the Pacific and Mid-Atlantic regions enjoyed systematic mortality reductions throughout the period. The dispersion in female mortality rates at ages 50-54 rose throughout this period. Regional mortality trends at ages 70-74 (Appendix Figure 1) are similar, with disparities that widen over time more for women than for men.

Levels and Trends in Spatial Inequality by Cause of Death and Age

The ID for all causes combined is a product of inequalities in the underlying causes of death, the distribution of causes, and interactions among the causes. Table 2 shows the ID for the nine causes of death, as well as for all causes, in 2002-04 and 2014-16. As above, we distinguish three age groups: 30-34, 50-54, and 70-74. We do not present results when there are fewer than 1,000 deaths in a cause-sex-age-period grouping.

Among males aged 30-34 and 50-54, HIV/AIDS and homicide, two causes of death with strong behavioral risk factors, exhibit the greatest inequality. The high ID values are a product of exceptionally high death rates from these causes in large central metropolitan areas. Large central metropolitan areas in the East South Central region (Kentucky, Tennessee, Alabama, Mississippi) stand out as especially hazardous with respect to these causes (results not shown).

In contrast, Table 1 shows very low inequality among screenable cancers. At ages 50-54 and 70-74 for both sexes, screenable cancers have the lowest or second lowest ID of any cause in both 2002-04 and 2014-16, ranging from 3.5% to 7.1%. The relative spatial equality of mortality from this disease category reduced spatial inequality from all causes combined; removing deaths from this cause in Appendix Table 3 raises the all-cause ID, especially for women.

Consistent with Figure 3, Table 1 shows that inequality in all-cause mortality rose at all three ages for both sexes between 2002-02 and 2014-16. The increases were larger for women than for men.

Ages 30-34. At ages 30-34, drug/alcohol/suicide mortality experienced the largest increase in cause-specific inequality among males and the second largest increase among females. For men, the entire increase in inequality in deaths from all cases is attributable to drugs/alcohol/suicide; if we remove these deaths and recalculate the ID, the value is basically unchanged at 9.72% in 2002-04 and 9.71% in 2014-16 (Appendix Table 3). For women, the removal of these deaths reduces the increase in the all-cause ID from 2.43 to 1.88 percentage points, or by 23%.

Ages 50-54 and 70-74. In contrast, inequality in drugs/alcohol/suicide among the older adults in Table 1 declined more than for any cause. Declines were especially pronounced among women. By 2014-16, the relative spatial equality of drug/alcohol/suicide deaths suppresses the all-cause ID for both sexes at both age intervals (Appendix Table 3).

The largest *increases* in cause-specific inequality at ages 50-54 and 70-74 occurred for lung cancer/respiratory diseases. For women at ages 50-54, inequality increased more for this category than for any other cause of death for either sex at any age; the ID for this category rose from 6.9% in 2002-04 to 16.6% in 2014-16.

Appendix Figure 2 shows trends in mortality from lung cancer/respiratory disease at ages 50-54 in the 40 units. Among males, death rates since 2000 are high and relatively flat in non-metropolitan East South Central and Appalachia, while death rates decline steadily in large central metropolitan Pacific and Mid-Atlantic regions. Among women, the four outlier areas begin with similar death rates from this category in 1990 and diverge rapidly thereafter; mortality falls in the two large central metropolitan regions and actually rises in the two non-metropolitan regions. Smoking-related diseases are an important contributor to the rise in inequality from all causes combined; if their death rates were set at zero throughout the period, the rise in ID between 2002-04 and 2014-16 would be reduced by 48% for men and 55% for women (Appendix Table 3).

Discussion

We have shown in Figure 3 that spatial inequality in mortality declines steadily with age above ages 35-39. One possible explanation for that decline is that causes of death with low levels of inequality, like screenable cancers, become more prominent as age advances relative to causes that are associated with behavior and exhibit more dispersion such as homicide, HIV/AIDS, and deaths from drugs/alcohol/suicide. That this is not a completely satisfactory answer is suggested by the fact that nearly all cause-of-death categories themselves show declines in inequality with increasing age in Table 1. Such declines are consistent with environmental influences on mortality that become less important relative to aging influences as age advances. For example, the classic Makeham[22] age pattern of mortality consists of two additive terms, one of which is age-independent and represents environmental influences, while the other represents aging influences and increases exponentially with age. If the age-dependent terms are constant from area to area while the environmental terms vary, relative differences in mortality will decline with age.

Although we document rising spatial inequality in mortality at most ages, trends vary by cause of death. We chose screenable cancers as an indicator of the quality of medical care since a large percentage of deaths from breast, prostate, colorectal, and cervical cancers can be prevented by timely diagnosis and proper treatment. The low spatial inequality in mortality from screenable cancers is one indicator that the quality of medical services is not a large source of regional disparity, at least relative to other factors at work. This result is consistent with Chetty et al.'s[23] finding that life expectancy for individuals in the lowest quartile of income was not spatially correlated with measures of access to health care.

Given the coincidence of extraordinary increases in mortality from drugs/alcohol/suicide and the increases in spatial inequality in mortality that we have documented, one might expect the two phenomena to be closely related. While this category did contribute substantially to rising inequality at ages 30-34, geographic convergence occurred for this category at ages 50-54 and 70-74. One must look elsewhere for explanations of spatial divergence at these ages, which are responsible for many more deaths.

Smoking is clearly one of the important explanations. Because smoking prevalence has declined in the United States, it may seem surprising that smoking has a large effect on mortality inequality at older ages. But trends in smoking prevalence are highly differentiated by geography, especially for women. The first national survey of US smoking behavior in 1955 showed that the prevalence of current smoking among women in urbanized areas of 1+ million was 27.8%, compared to only 9.4% in rural farm areas[24]. Women in the West were most likely to smoke and those in the Midwest and South least likely. The metropolitan and regional patterns are now reversed. In 2013-14, rural women were much more likely to smoke than urban women[25] and women in the Midwest and South had the highest prevalence of current cigarette smoking[26]. It is clear that the trend lines for smoking prevalence by metropolitan status and region have crossed sometime during the past 60 years. Appendix Figure 2, which shows little differentiation in women's mortality rates from lung cancer and respiratory diseases among our four outliers in 1990 and rapid dispersion thereafter, helps to locate the approximate period of that cross-over.

Among men, differences in smoking prevalence by metropolitan type and region were much smaller in 1955 than among women; the regional range was only 45.2% to 47.4%[24]. By 2005, the West and Northeast had lower smoking prevalence than the Midwest and the South[25]. The faster decline in male smoking in the West and Northeast is reflected in their much more rapid mortality declines from lung cancer and respiratory diseases. Consistent with our results, Chetty et al.[23] conclude that smoking prevalence is one of the strongest spatial correlates of life expectancy for low-income individuals.

Our findings regarding spatial inequality in US mortality are echoed in international comparisons. We find that spatial inequality in mortality is greatest in early to mid-adulthood. These are also the ages at which the US ranks most poorly relative to other OECD countries[27]. Our findings indicating the important role of smoking in US spatial inequality echo the result of a large international study of mortality at ages 50+, which concludes that the history of heavy smoking in the US is the single most important factor in producing the large US disadvantage in life expectancy at age 50[28]. And one area in which we find spatial mortality inequalities to be quite small, screenable cancers, is consistent with the US having the best trends among OECD countries in breast and prostate cancer mortality, a ranking that has been attributed to exceptionally aggressive screening and treatment in the US[29].

Rising spatial inequality in US mortality is coincident with rising mortality differentials by education and income. The mortality patterns that we describe may also be connected to other spatial patterns. Many writers have referred to increasing social and cultural bifurcation between "coastal elites" and residents in "the heartland"[30]. Our results indicate that mortality trends also adhere to this bifurcation. Among the increasing inequalities that characterize life in modern America, one of the most consequential is surely inequality in the length of life itself.

Public Health Implications

The Healthy People 2020 initiative identifies eliminating health disparities and creating environments that promote good health as primary goals for improving public health. Spatial inequality in adult mortality has been increasing in recent decades, with coastal and metropolitan areas performing better than non-coastal and non-metropolitan areas. Inequality is highest at the young adult ages, suggesting a need for greater focus on prevention and care for people in their 20s and 30s, including expanding access to substance abuse treatment and addressing the risk factors for drug abuse and suicide. Much of the increasing inequality at the younger adult ages is due to the rise in drug, alcohol, and suicide mortality, but the increase at the middle and older ages is instead attributable to smoking-related diseases. Policies aimed at encouraging healthy behavior change and expanding access to mental health treatment and smoking cessation programs are likely to improve mortality in non-metropolitan areas and to reduce mortality inequalities at the middle and older ages. Such programs are sorely lacking in many rural parts of the country.

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Table 1. Index of Dissimilarity[a] by cause of death at three ages, 2002-04 and 2014-16.

	Cause of death	2002-2004 30-34 y.	2002-2004 50-54 y.	2002-2004 70-74 y.	2014-2016 30-34 y.	2014-2016 50-54 y.	2014-2016 70-74 y.	Change (2014-2016) - (2002-2004) 30-34 y.	Change 50-54 y.	Change 70-74 y.
Males	HIV/AIDS	28.0	33.6	--[b]	--	25.6	--	--	-8.0	--
	Homicide	22.4	21.9	--	19.9	20.2	--	-2.4	-1.8	--
	Lung cancer, resp.	--	10.7	6.2	--	16.0	9.1	--	5.3	2.9
	External	14.8	12.4	8.5	15.5	12.6	7.8	0.6	0.2	-0.7
	Circ disease	11.4	9.3	5.3	11.3	10.0	6.7	-0.1	0.7	1.5
	Alz, mental, nervous system	10.5	7.7	5.9	13.2	9.3	6.0	2.7	1.6	0.2
	All other	7.5	6.8	3.6	9.2	8.1	4.2	1.7	1.3	0.6
	Drug, alcohol, suicide	8.2	9.9	10.8	13.1	7.3	9.0	5.0	-2.6	-1.8
	Screenable cancers[a]	--	6.9	3.7	--	7.1	4.4	--	0.2	0.7
	All causes	8.3	7.6	4.1	9.3	8.4	5.5	1.0	0.8	1.5
Females	HIV/AIDS	39.8	42.6	--	--	--	--	--	--	--
	Homicide	15.5	--	--	16.7	--	--	1.1	--	--
	Lung cancer, resp	--	6.9	4.2	--	16.6	8.6	--	9.7	4.4
	External	18.2	12.9	7.7	19.1	14.0	7.8	0.9	1.1	0.1
	Circ disease	13.3	12.4	5.7	16.5	13.6	7.6	3.2	1.2	1.9
	Alz, mental, nervous system	--	7.0	6.9	16.3	10.8	7.4	--	3.8	0.5
	Drug, alcohol, suicide	11.3	13.5	18.4	14.3	9.4	14.1	2.9	-4.1	-4.3
	All other	8.4	6.4	3.3	10.1	8.4	4.9	1.7	2.0	1.6
	Screenable cancers[c]	8.3	4.0	3.7	7.0	4.3	3.5	-1.3	0.2	-0.2
	All causes	9.2	6.6	3.6	11.7	9.4	5.9	2.4	2.8	2.2

Sorted from largest to smallest at age 50-54 in 2014-2016.

a. Minimum percentage of deaths that would have to be reallocated in an age interval to equalize the spatial distribution of deaths and population.

b. Causes with less than 1,000 deaths in each age, sex, and period group are excluded.

c. Screenable cancers include breast, prostrate, colorectal, and cervical cancers.

Figure 1. Trends in life expectancy at birth in 40 spatial units,1990-2016

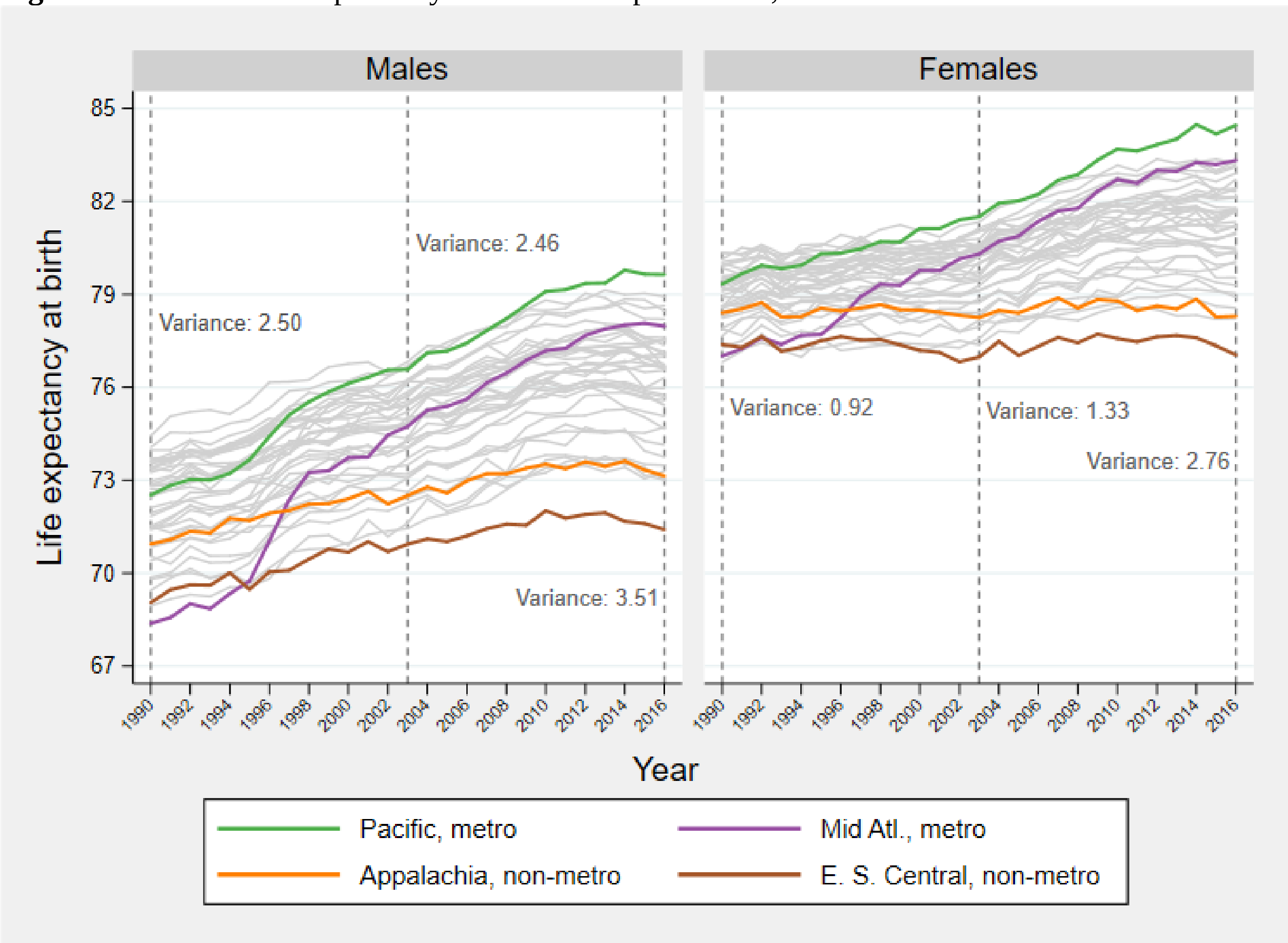
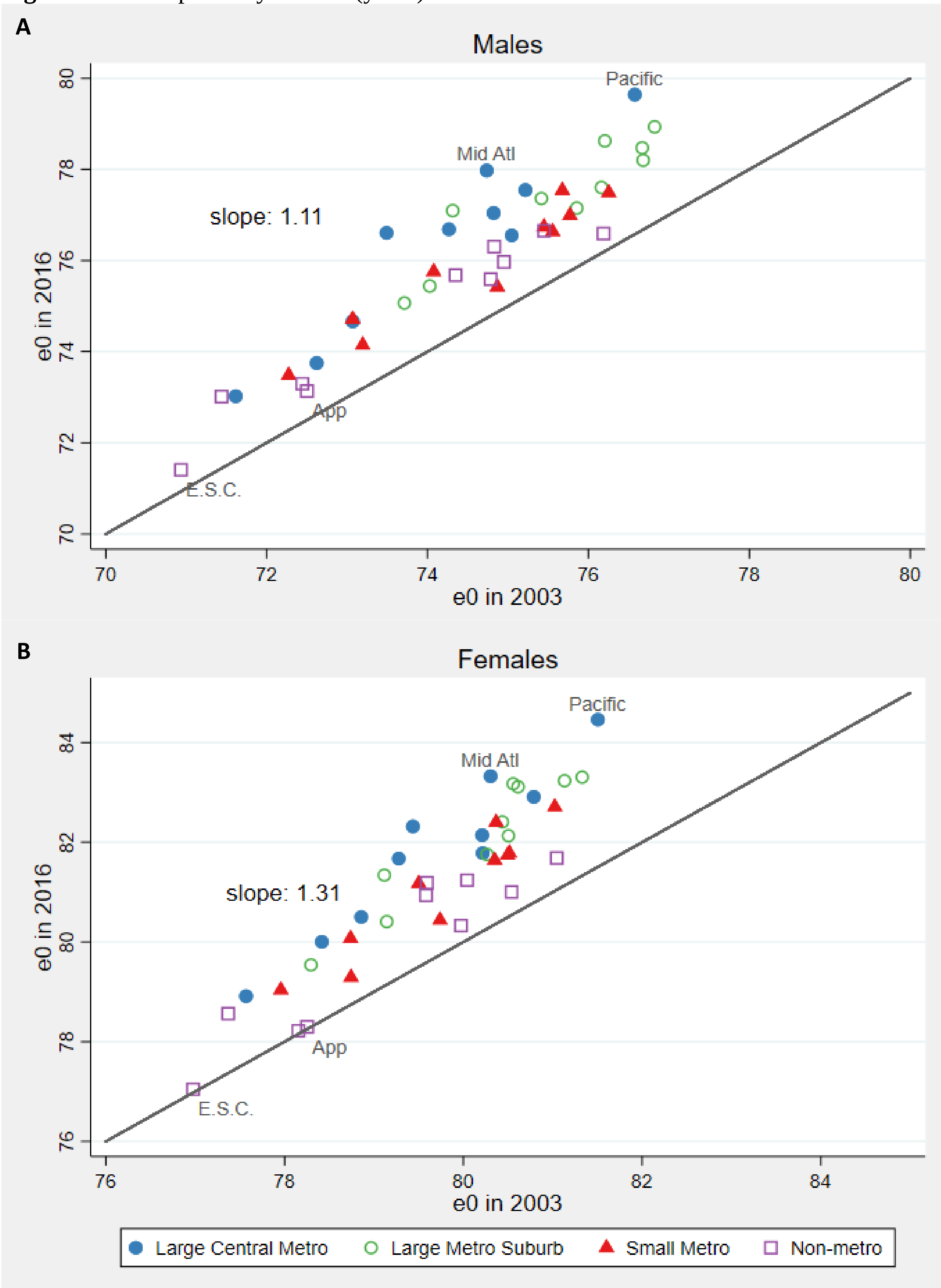
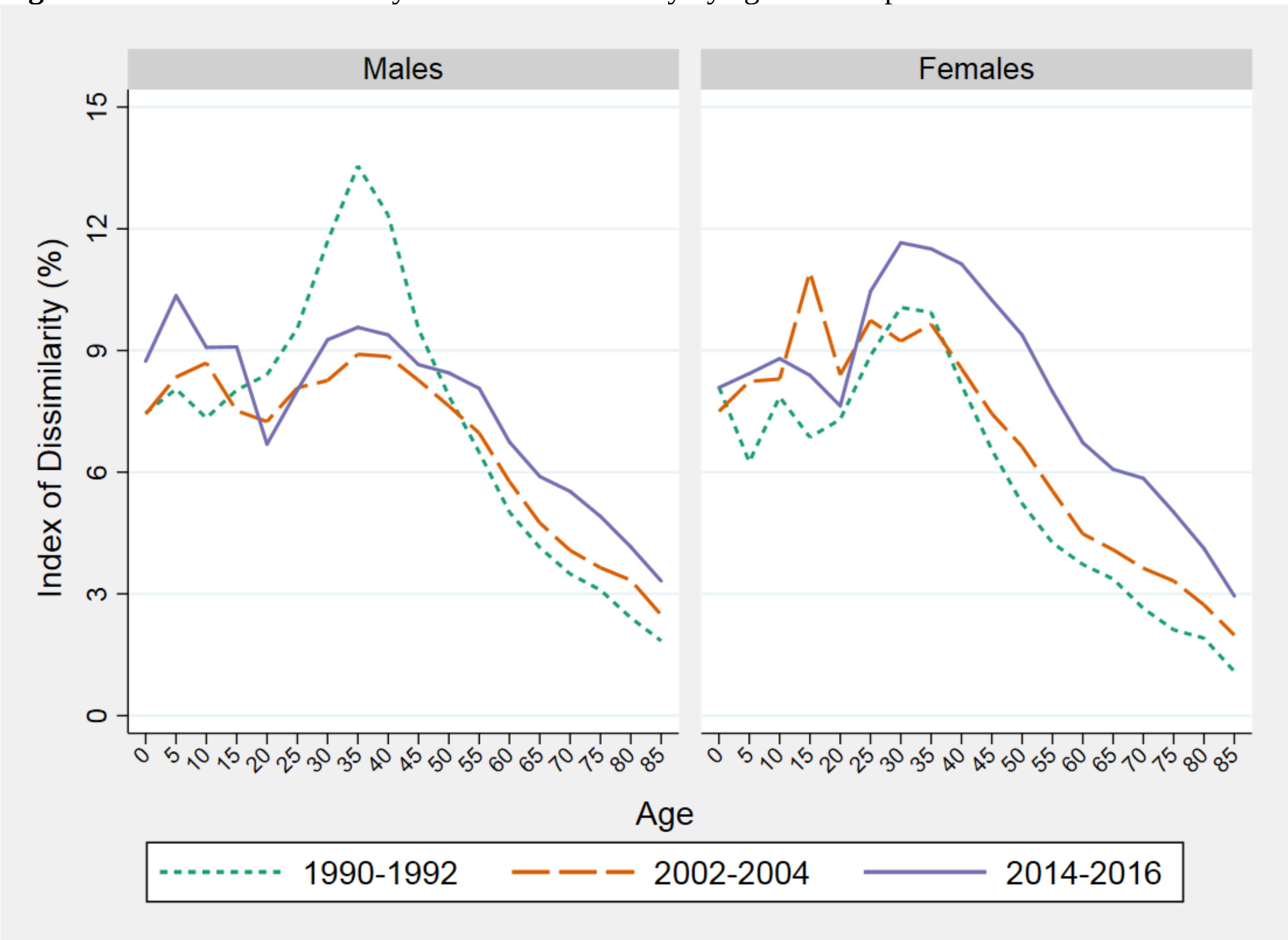


Figure 2. Life expectancy at birth (years) in 2003 and 2016.



App: Appalachia; E.S.C.: East South Central; Mid Atl: Mid Atlantic.

Figure 3. Index of Dissimilarity in all-cause mortality by age in three periods.



Appendix Table 1. Definitions of region and metropolitan status.

Region	New England (CT, ME, MA, NH, RI, VT)
	Middle Atlantic (NJ, NY, PA)
	East North Central (IL, IN, MI, OH, WI)
	West North Central (IA, KS, MN, MO, NE, ND, SD)
	South Atlantic (DE, DC, FL, GA, MD, NC, SC, VA)
	East South Central (AL, KY, MS, TN)
	West South Central (AR, LA, OK, TX)
	Mountain (AZ, CO, ID, MT, NV, NM, UT, WY)
	Pacific (AK, CA, HW, OR, WA)
	Appalachia[a]
Metro Status[b]	Large central metro (counties of MSAs with a population of at least 1 million, including counties that contain all or a part of the area's inner cities)
	Large metro suburb (surrounding counties of large central metro)
	Medium & small metro (counties with MSAs of 50,000-999,999 population)
	Non-metropolitan areas

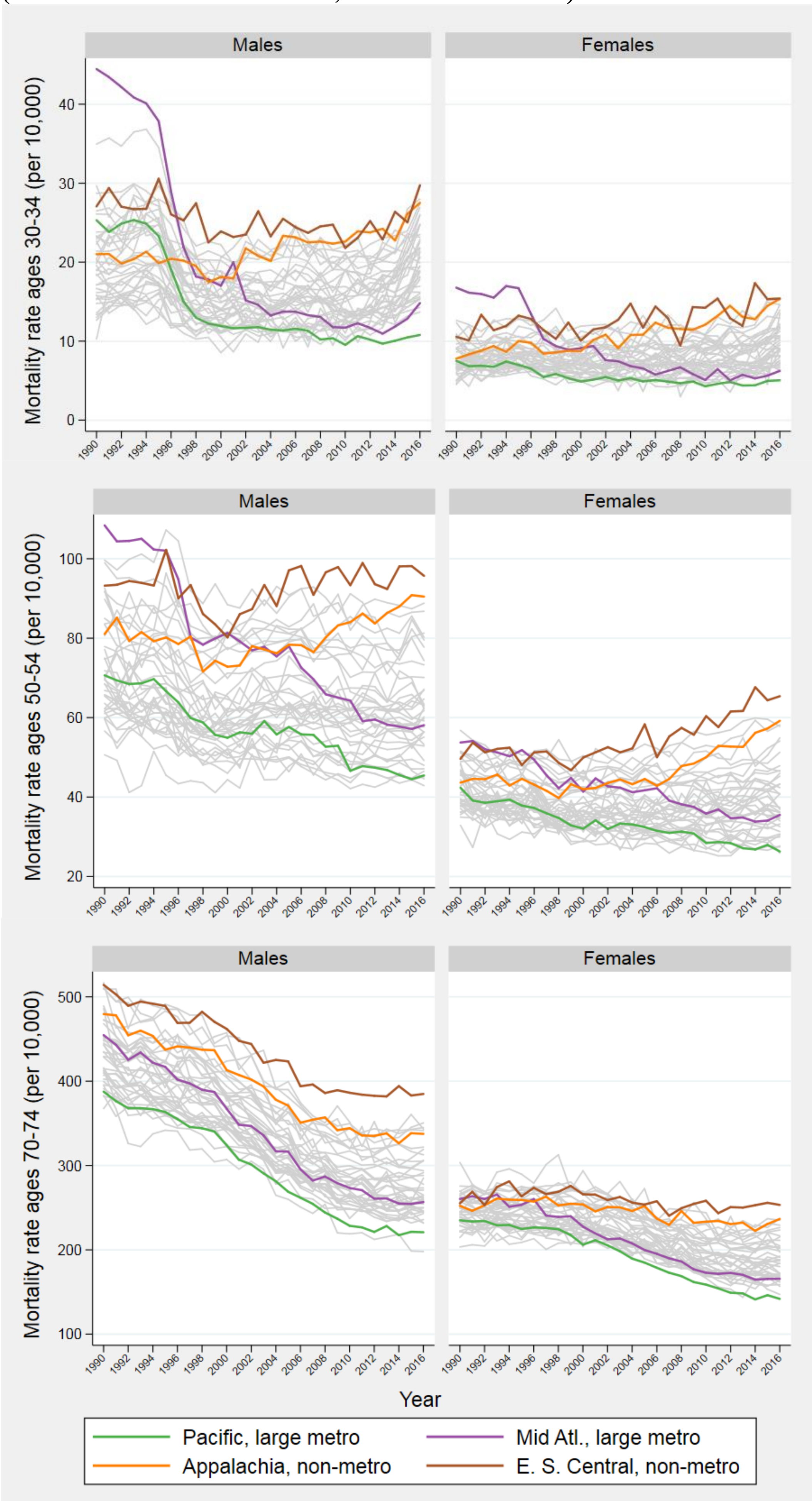
MSA: Metropolitan Statistical Area.
a. As defined by the Appalachian Regional Commission and used by Elo et al. (2018). Appalachia includes all of WV and certain counties in AL, GA, KY, MD, MS, NY, NC, OH, PA, SC, TN, and VA. These counties are excluded from their overlapping census divisions.
b. Based on the NCHS urban-rural classification scheme (1).

Appendix Table 2. Cause of death classifications.

Cause of death	ICD-9	ICD-10
Breast, prostate, colorectal, and cervical cancers	174-175, 180, 185, 153-154	C50, C53, C61, C18–C21
Circulatory diseases	390-459 (excluding 425.5)	I00–I99 (excluding I42.6)
Drug overdose, alcohol-related causes, and suicide	E850–E858, E860, E950-E959, E962, E980.0–E980.5, 291, 303, 305.0, 357.5, 425.5, 535.3, 571.0-571.3, 790.3	E24.4, F10, G31.2, G62.1, G72.1, I42.6, K29.2, K70, K85.2, K86.0, R78.0, X40–X45, X60–X85, Y10–Y15, Y870.0
HIV/AIDS	042-044	B20–B24
Homicide*	E960-E969 (excluding E962)	X86–Y09, Y87.1
Lung cancer and respiratory diseases (excl. influenza and pneumonia)	162, 460-519 (excluding 480-487)	C33, C34, J00–J98 (excluding J09–J18)
Mental and nervous system disorders, including Alzheimer's Disease	290-389 (excluding 291, 303, 305.0, 357.5)	F01–F99 (excluding F10), G00–G98 (excluding G31.2, G62.1, G72.1)
Other external causes	E800-E999 (excluding E850–E858, E860, E950–E969, E980.0–E980.5)	V01–Y89 (excluding X40-X45, X60-Y15, Y87.0-Y87.1)
All other causes	001-289 (excluding 042-044, 174-175, 180, 185, 153-154), 520-799 (excluding 535.3, 571.0-571.3, 790.3)	A00–E90 (excluding B20–B24, C33, C34, C50, C53, C61, C18–C21, E24.4), G99, H00–H93, J09-J18, J99, K00–R99 (excluding K29.2, K70, K85.2, K86.0, R78.0), U00–U99, Y90–Y98

* Except assault by drugs, medicaments, and biological substances, which is included in drug overdose.

Appendix Figure 1. All-cause mortality rates at three ages.
(E. S. Central=East South Central; Mid Atl=Mid Atlantic)



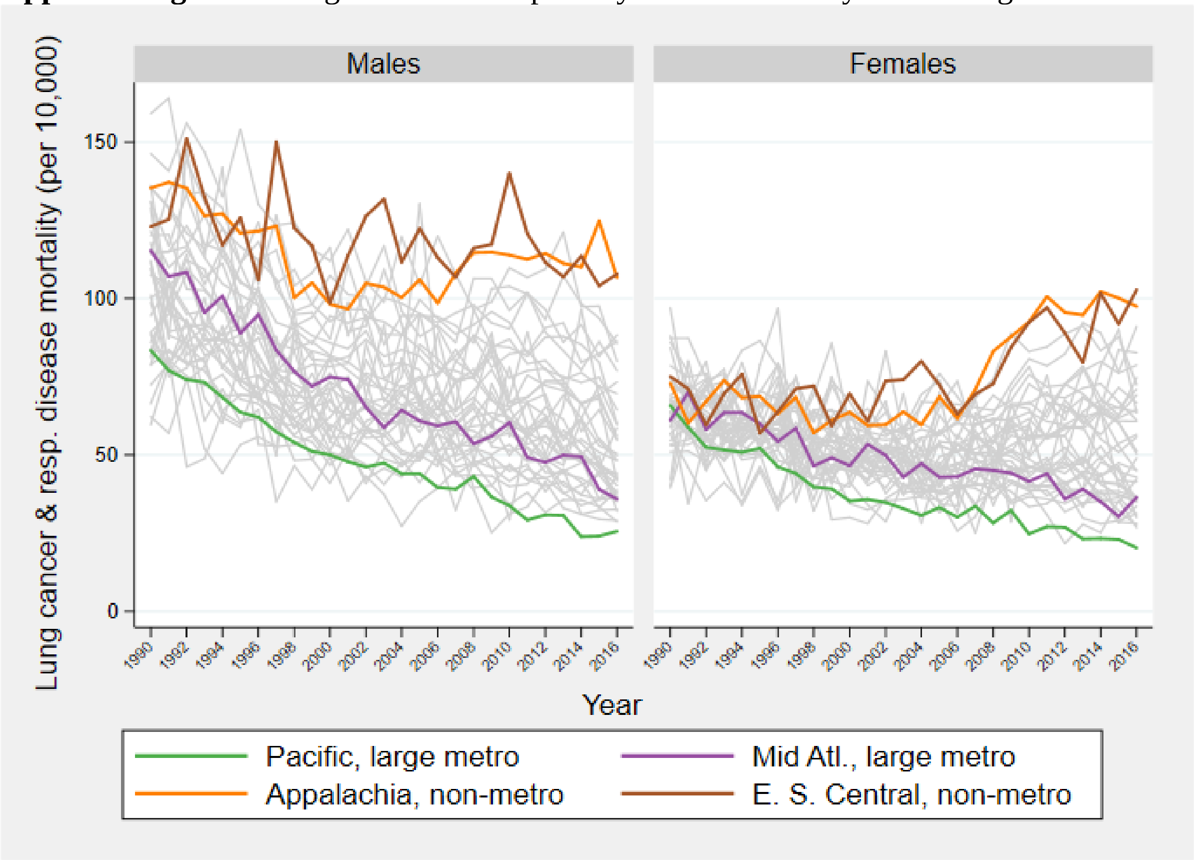
Appendix Table 3. Index of Dissimilarity in all-cause mortality with select causes removed.

	Cause removed	2002-2004 30-35 y.	2002-2004 50-54 y.	2002-2004 70-74 y.	2014-2016 30-35 y.	2014-2016 50-54 y.	2014-2016 70-74 y.
Males	Lung cancer, resp.	--	7.48	3.99	--	7.91	4.88
	Circ. disease	8.30	7.03	3.92	9.27	8.07	5.21
	External	8.16	7.77	4.06	9.05	8.25	5.53
	Homicide	7.85	7.52	--	9.94	8.46	--
	Alz, mental, nervous system	8.40	7.69	4.10	9.26	8.46	5.57
	Screenable cancers[a]	--	7.67	4.17	--	8.55	5.69
	HIV/AIDS	8.04	7.28	--	--	8.60	--
	All other	9.05	8.11	4.49	9.40	8.73	6.28
	Drugs, alcohol, suicide	9.72	8.34	4.18	9.71	9.36	5.68
	None (all-cause ID)	8.26	7.63	4.07	9.27	8.45	5.53
Females	Lung cancer, resp.	--	6.86	3.86	--	8.52	5.45
	Circ. disease	9.05	5.08	3.23	11.25	8.61	5.55
	External	8.91	6.72	3.63	11.08	9.25	5.85
	Alz, mental, nervous system	--	6.80	3.60	11.51	9.35	5.80
	Homicide	9.20	--	--	11.69	--	--
	HIV/AIDS	9.12	6.39	--	--	--	--
	Drugs, alcohol, suicide	10.25	7.19	3.70	12.13	9.94	5.96
	All other	10.17	6.95	3.88	12.40	9.98	6.50
	Screenable cancers[a]	9.50	7.18	3.77	12.09	10.20	6.09
	None (all-cause ID)	9.23	6.63	3.63	11.66	9.38	5.85

Sorted from smallest to largest ID with cause removed at age 50-54. A smaller new ID indicates that had there been no inequality in deaths from that given cause, inequality in all-cause mortality would have been lower. Causes with less than 1,000 deaths in each age, sex, and period group are excluded.

a. Screenable cancers include breast, prostrate, colorectal, and cervical cancers.

Appendix Figure 2. Lung cancer and respiratory disease mortality trends at ages 50-54.



E. S. Central: East South Central; Mid Atl: Mid Atlantic.