Trends in US mortality by region and metropolitan-nonmetropolitan continuum between 1990 and 2015

Irma T. Elo, University of Pennsylvania
Arun Hendi, University of Southern California
Jessica Ho, University of Southern California
Sam Preston, University of Pennsylvania

Short Abstract

Between 1990 and 2010, US life expectancy at birth increased from 78.85 years to 79.45 years for women and from 71.85 years to 76.37 years for men. Since 2010, the United States has experienced the smallest 5-year increase in life expectancy since reliable mortality data have been collected in the United States. This recent stagnation was capped by a 0.1-year decline in overall life expectancy at birth between 2014 and 2015. As a result, the U.S. is losing ground relative to other developed countries. By 2015, female life expectancy at birth was 5.70 years below the world leader, up from 3.00 years in 1990. The respective figures for men were 4.28 and 4.07. At the same time, life expectancy within the United States has grown increasingly disparate with some areas experiencing no or meager gains in life expectancy in the last 25 years, contributing to the poor US performance relative to other developed countries. Using vital statistics and census data, the purpose of this paper is to examine age- and gender-specific mortality trends in the United States between 1990 and 2015 by region and metropolitan-nonmetropolitan continuum and to assess the contribution of cause-specific mortality to trends and differentials in mortality by place of residence.

Extended Abstract

Between 1990 and 2010, life expectancy at birth in the United States increased from 78.85 years to 79.45 years for women and from 71.85 years to 76.37 years for men (Arias 2014; National Center for Health Statistics (NCHS) 1994). Since 2010, the U.S. experienced the smallest 5-year increase in life expectancy since reliable mortality data have been collected. This recent stagnation was capped by a 0.1-year decline in overall life expectancy at birth between 2014 and 2015 (Arias 2014; Xu et al. 2016). As a result, the U.S. is losing ground relative to other developed countries. By 2015, female life expectancy at birth was 5.70 years below the world leader, up from 3.00 years in 1990. The respective figures for men were 4.28 and 4.07 (Ho & Hendi 2017).

At the same time, life expectancy within the U.S. has grown increasingly disparate among states and regions with some areas experiencing no or meager gains in life expectancy in the last 25 years; trends that undoubtedly contribute to the poor US performance relative to other developed countries. For example, during the last decades of the twentieth century, Southern states have experienced much slower declines in mortality than non-Southern states (Ezzati et al. 2008; Fenelon 2013). Within the South the most disadvantaged Census Division is 'South Central' consisting of Alabama, Kentucky, Mississippi, and Tennessee (Fenelon 2013). In addition, the Appalachian region, which consists of all of West Virginia and select counties in Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee and Virginia, has experienced slow mortality improvements relative to other parts of the United States. We estimate that the gap in male life expectancy between the best and most poorly performing Census divisions and Appalachia increased from 3.53 years in 1990 to 5.40 years in 2015. The respective contrast for women were 2.34 and 4.55 (calculations by the authors).

Recent studies focusing on mortality variation by county or a group of counties further demonstrate increasing geographic diversity in U.S. mortality trends. According to Wang et al. (2013), the highest male county-level life expectancy increased from 75.5 years in 1985 to 81.7 years in 2010. The respective figures for women were 81.1 and 85.0 years. At the same time, the lowest county-level male life expectancy stayed below 65 and for women it remained around 73 years. Consistent with prior studies the lowest county-level life expectancies were recorded in the South. As was the case with all-cause mortality, Dwyer-Lindgren et al. (2016) documented substantial county-level disparities in cause-specific mortality for all causes of death with varying geographic patterns by cause. The highest mortality rates from neoplasms and cardiovascular diseases were documented in Southern states and Appalachia, whereas

highest rates from self-harm and interpersonal violence were observed in Southwestern states (see also Mokdad et al. 2017; Roth et al. 2017). Similarly, mortality from chronic obstructive pulmonary disease is high in several Southern and Appalachian counties relative to most of the rest of the country with somewhat more varied geographic patterns from other respiratory diseases (Dwyer-Lindgren et al. 2017). These persistent county-level patterns of high and low mortality have persisted for decades with many of the highest mortality counties concentrated in nonmetropolitan South (Cossman et al. 2007). Thus, since 1990 the U.S. has also witnessed an increasing mortality gap between metropolitan and nonmetropolitan areas with nonmetropolitan areas experiencing much slower mortality decline than metropolitan areas, in part due to mortality trends from two leading causes of adult mortality – heart disease and cancer (Cosby et al. 2008; Cossman et al. 2010).

Factors that have been implicated in the growing mortality disparities include smoking, obesity, leisure time physical activity, access to health care, and socioeconomic disparities (Eberhart and Pamuk 2004; Meit et al. 2014). Fenelon and Preston (2012) estimated that in 2004 at ages 50 and above the fraction of deaths attributable to smoking across states ranged from 11% to 30% among men and from 7% to 23% among women. Furthermore between 1965 and 2004, smoking explained a large fraction (up to over 70%) of the growing gap in male mortality between the worst performing Census division, East South Central consisting of Alabama, Kentucky, Mississippi, and Tennessee, and other US Census divisions, and up to over 50% of the growing gap in female mortality (Fenelon 2013). Other risk factors also show variation across US counties. Shaw et al. (2016), based on the Behavioral Risk Factor Surveillance System, found that residents of nonmetropolitan areas were significantly more likely to report hypertension, poor health status, arthritis, current smoking, and a higher body mass index than residents of metropolitan areas with the largest differences reported for hypertension.

Differences in socioeconomic status between metropolitan and nonmetropolitan areas are also like to play a role. In a recent study, Currie and Schwandt (2016) detailed age-specific trends in mortality by county-level poverty and found increasing inequality in mortality at older ages, whereas Chetty et al. (2016) documented increasing inequality in mortality above age 40 by individual income in 2001-2014 that varied among commuting zones and region of the country. Among low income individuals, there was considerable geographic variation in mortality, which was significantly correlated with smoking prevalence, but surprisingly not with access to medical care, income inequality, or labor force participation.

In this paper, we extend analyses of mortality by region and metropolitan-nonmetropolitan continuum to 2015 by examining age- and gender-specific mortality trends in the United States between 1990 and 2015 and by assessing the contribution of cause-specific mortality to trends and differentials by place of residence. In the cause-specific analyses, we will highlight specific causes or groups of causes that have been implicated in the recent life expectancy decline, causes of death that have public health significance, causes of death that are strongly tied to modifiable health behaviors and those that could be preventable by adequate medical care.

Data

We will use vital statistics data on deaths and Census Bureau population estimates to construct age-specific death rates by sex and geography. We have acquired vital statistics data on deaths with county identifiers from the National Center for Health Statistics (NCHS). Bridged-race-age-sex specific population estimates by county and year are publicly available from the NCHS. We define geographic areas based on a combination of Census geographic divisions and urban/rural status. The nine Census divisions are: New England, Middle Atlantic, South Atlantic, East South Central, East North Central, West South Central, West North Central, Mountain, and Pacific. Our tenth geographic division will be Appalachia, as defined by the Appalachian Regional Commission (Appalachian counties will be included in Appalachia and excluded from overlapping Census divisions) (ARC 2016). We use a 5-category coding of metropolitan-nonmetropolitan continuum. We use the NCHS classification to define metropolitan areas and the United States Department of Agriculture Economic Research Service (USDA, ERS) codes to define nonmetropolitan areas. Our categories are: (1) large central metropolitan counties with 1 million population or more, (2) suburban counties of large metropolitan areas, (3) medium and small metropolitan areas, (4) nonmetropolitan counties adjacent to metropolitan areas, and (5) nonmetropolitan counties not adjacent to metropolitan areas.

Following prior research by Preston and Elo (2014), we will start by coding underlying causes of death into 16 mutually exclusive and exhaustive categories using the International Classification of Diseases ICD-10 (see Appendix Table 1). We will highlight specific causes or groups of causes within the 16 broader categories that are of particular interest. As noted above, we focus on causes of death that have been implicated in the recent life expectancy decline (e.g., cardiovascular disease, chronic lower respiratory disease, Alzheimer's disease, drug overdose); causes of death that have public health significance (e.g., HIV/AIDS, homicide, lung cancer, and cancers for which screening is common such as breast, prostate, and colorectal cancer), causes of death that are strongly tied to modifiable health behaviors (e.g., lung cancer, diabetes, liver

cirrhosis, alcohol-related accidents) and 'medically avoidable mortality'. We expect that many of these causes will be geographically concentrated, and this will be in part due to geographic differentials in socioeconomic conditions and health care resources.

Methods

We will first provide a detailed description of levels and trends in life expectancy in 50 geographic units, 10 regions and 5 metropolitan-nonmetropolitan areas. We will calculate life expectancies using standard demographic methods (Preston et al. 2001).

We will then turn to analyses of the contribution of cause-specific mortality by calculating age standardized crude death rates for each of the 50 geographic units for all causes of death and for each cause-of-death group using the 2010 US population as a standard. We will then assess the contribution of each cause-of-death group to the overall ASCDR in each of our 50 geographic units at a point in time and the contribution of causes-of-death to trends in ASCDR between 1990 and 2015 by region and metropolitan-nonmetropolitan continuum. We will focus on years 1990-1992, 1999-2001, 2009-2011, and 2014-2015.

Preliminary Results

As seen in Figure 1, perhaps the most remarkable gains in life expectancy have taken place in central cities of large metropolitan areas. Between 1990 and 2015, male life expectancy in large metropolitan central cities increased from 70.6 years to 77.4 years, a gain of 6.8 years. The respective figures for women were 78.2 and 82.4, a gain of 4.2 years. By 2015 female life expectancy in large metropolitan central cities (82.4) had caught up with female life expectancy in their suburbs (82.3). In contrast, gains in life expectancy in nonmetropolitan areas, whether or not they were adjacent to metropolitan areas, have been more muted. In 1990, life expectancy in nonmetropolitan areas was higher than in large central city metropolitan areas for both men (71.5-71.8) and women (78.8-79.1), but by 2015 male life expectancy in nonmetropolitan areas lagged behind central city metro areas by about 3 years; the respective figure for women was also about 3 years.

At the same time, both levels and trends in life expectancy at birth by metropolitan-nonmetropolitan continuum varies substantially by region as shown in Table 1 and Figures 2 and 3. As seen in Table 1, largest increases in life expectancy among men between 1990-1992 and 2014-2015 occurred in large central city metro areas, except in Appalachia where the

mortality decline in suburban areas of large metropolitan areas slightly surpassed the mortality decline in central cities. In some regions, these increases were quite substantial, while in other areas they lagged behind. For example, in the Middle Atlantic states male life expectancy in central cities increased by over 9 years, whereas in Appalachia the increase was only about 3 years. In contrast, increases in male life expectancy in nonmetropolitan areas regardless of the region of the country lagged behind those of metropolitan areas.

We document similar regional and metropolitan-nonmetropolitan differences for women, except that the gains in life expectancy were substantially smaller for women than for men, leading to a narrowing of sex differences in life expectancy (Table 1). Furthermore, female life expectancy at birth declined between 1990-1992 and 2014-2015 in nonmetropolitan areas not adjacent to metropolitan areas in Appalachia and in West South Central division. The gains were also small (0.23 years) in East South Central division.

Figures 2 and 3 present the divergence in male and female life expectancy from the US average by region and metropolitan-nonmetropolitan continuum. As seen in Figures 2 and 3, there is considerable variation in mortality by region of residence and metropolitan-nonmetropolitan continuum within each region. For men, we see increasing divergence in mortality in large metropolitan central cities by region of residence, with central cities of large metropolitan areas in the Pacific experiencing a particularly large increase in life expectancy between 1990 and 2015. We document much smaller improvements in the South. At the same time, nonmetropolitan areas in all regions have experienced much slower declines in mortality than large metropolitan central cities or their suburbs, with the Southern nonmetropolitan areas falling further and further behind from the national average.

We see a similar regional variation for women as we did for men with large metropolitan areas experiencing faster declines in mortality than nonmetropolitan areas. Women living in Southern nonmetropolitan areas in particular have seen little or no improvement in life expectancy between 1990 and 2015 and falling further and further behind of other women living in other regions of the country and in the metropolitan South (also see Table 1).

Future Steps

The analyses of cause-of-death contributions will provide evidence for which causes of death are largely responsible for the widening of mortality disparities by region and metropolitan-nonmetropolitan continuum. The results will illuminate the role played by causes of death that

have public health significance, causes of death that are strongly tied to modifiable health behaviors and those that could be preventable by adequate medical care.

References

Appalachian Regional Commission. (2016). Counties in Appalachia. Available online at: https://www.arc.gov/counties.

Arias, E. (2014). United States life tables, 2010. National vital statistics reports; Vol 63 no 7. Hyattsville, MD: National Center for Health Statistics.

Chetty, R., Stepner, M., Abraham, S., Lin, S., et al. 2016. The association between income and life expectancy in the United States, 2001-2014. *JAMA* 315(16):1750-1766.

Cosby, A.G., Neaves, T.T., Cossman, R.E., Cossman, J.S., James W.L., et al. 2008. Preliminary evidence for an emerging nonmetropolitan mortality penalty in the United States. *American Journal of Public Health* 98:1470-1472.

Cossman, J.S., Cossman, R.E., James, W.L., Campbell, C.R., et al. 2007. Persistent clusters of mortality in the United States. *American Journal of Public Health* 97:2148-2150.

Cossman, J.S., James, W.L., Cosby, A.G., & Cossman, R.E., 2010. Underlying causes of the emerging nonmetropolitan mortality penalty. *American Journal of Public Health* 100: 1417-1419.

Currie, J. & Schwandt, H. 2016. Inequality in mortality decreased among the young while increasing for older adults, 1990–2010. *Science* 352(6286):708-12.

Dwyer-Lindgren L., Bertozzi-Villa A., Stubbs R.W., et al. 2016. US county-level trends in mortality rates for major causes of death, 1980-2014. JAMA 316(22):2385-2401.

Dwyer-Lindgren L., Bertozzi-Villa A., Stubbs R.W., Morozoff C., et al. 2017. Trends and patterns of differences in chronic respiratory disease mortality among US counties, 1980-2014. *JAMA* 318(12):1136-1149

Eberhardt, M.S., & Pamuk, E.R. 2004. The importance of place of residence: Examining health in rural and nonrural areas. *American Journal of Public Health* 94: 1692-1686.

Ezzati, M., Friedman A.B., Kulkarni S.C., & Murray C.J.L. 2008. "The reversal of fortunes: Trends in county mortality and cross-county mortality disparities in the United States," *Plos Medicine* 5(4): 557–568.

Fenelon, A. 2013. Geographic divergence in mortality in the United States. *Population and Development Review* 39(4): 611–634

Fenelon, A. & Preston S.H. 2012. "Estimating smoking-attributable mortality in the United States," *Demography* 49(3): 797–818.

Ho, J. Y. & Hendi A. S. 2017. Recent declines in U.S. life expectancy are shared across high-income countries. A manuscript under review.

Meit, M., Knudson, A., Gilbert, T., & Yu, A.T-C., et al,. 2014. The 2014 Update of the Rural-Urban Chartbook. Rural Health Reform Policy Center. University of North Dakota, Grand Forks, ND and NORC Walsh Center for Rural Health Analysis, Bethesda, MD.

Mokdad, A.H., Dwyer-Lindgren, L., Fitzmaurice, C., Stubbs R.W. et al. 2017. Trends and patterns of disparities in cancer mortality among US counties, 1980-2014. *JAMA* 317(4):388-406.

National Center for Health Statistics. 1994. *Vital statistics of the United States, 1990*, Vol. 11. Sec. 6 Life Tables. Washington, DC: Public Health Service.

Preston, S. H., Heuveline, P., & Guillot, M. (2001). *Demography: measuring and modeling population processes*. Oxford: Blackwell Publishers.

Preston, S. H., & Elo, I. T. (2014). Anatomy of a municipal triumph: New York City's upsurge in life expectancy. *Population and Development Review*, 40, 1–29.

Roth, G.A., Dwyer-Lindgren, L.; Bertozzi-Villa A., Stubbs R.W. et al. 2017. Trends and patterns of geographic variation in cardiovascular mortality among US counties, 1980-2014. *JAMA*. 317(19):1976-1992.

Shaw, K.M., Theis, K.A., Self-Brown, S., Roblin, D.W., & Barker, L. 2016. Chronic disease disparities by county economic status and metropolitan classification, Behavioral Risk Factor Surveillance System, 2013. *Preventing Chronic Disease: Public Health Research, Practice, and Policy*. 13: E119.

Wang H., Schumacher A.E., Levitz C.E., Mokdad A.H., & Murray C.J. 2013. Left behind: Widening disparities for males and females in US county life expectancy, 1985-2010. Population Health Metrics. 11(1):8.

Xu, J. Q., Murphy, S. L., Kochanek, K. D., & Arias, E. (2016). Mortality in the United States, 2015. NCHS data brief, no 267. Hyattsville, MD: National Center for Health Statistics.

Figure 1. Life Expectancy at Birth by Sex and Metropolitan-Nonmetropolitan Continuum, United States 1990-2015

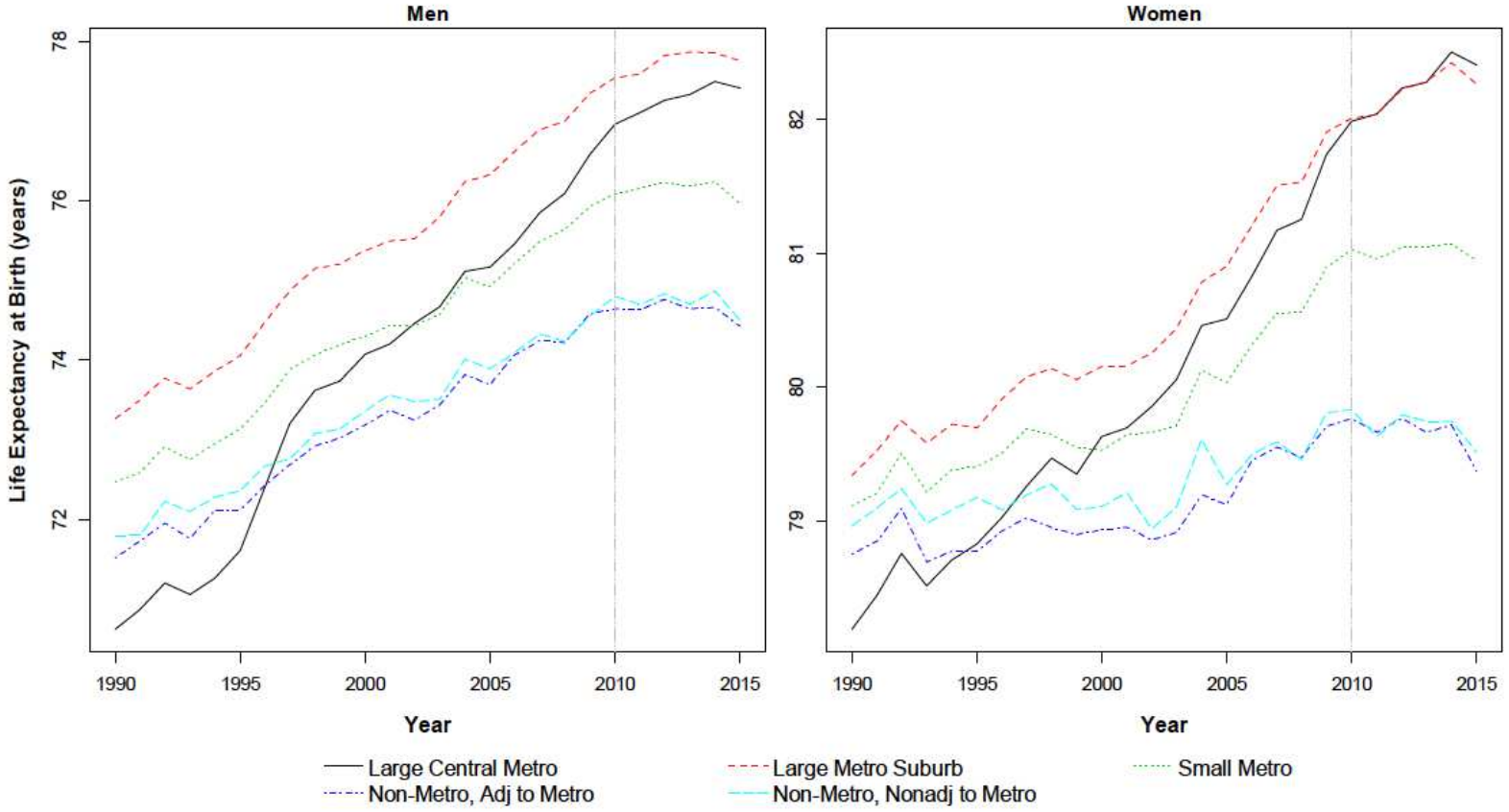
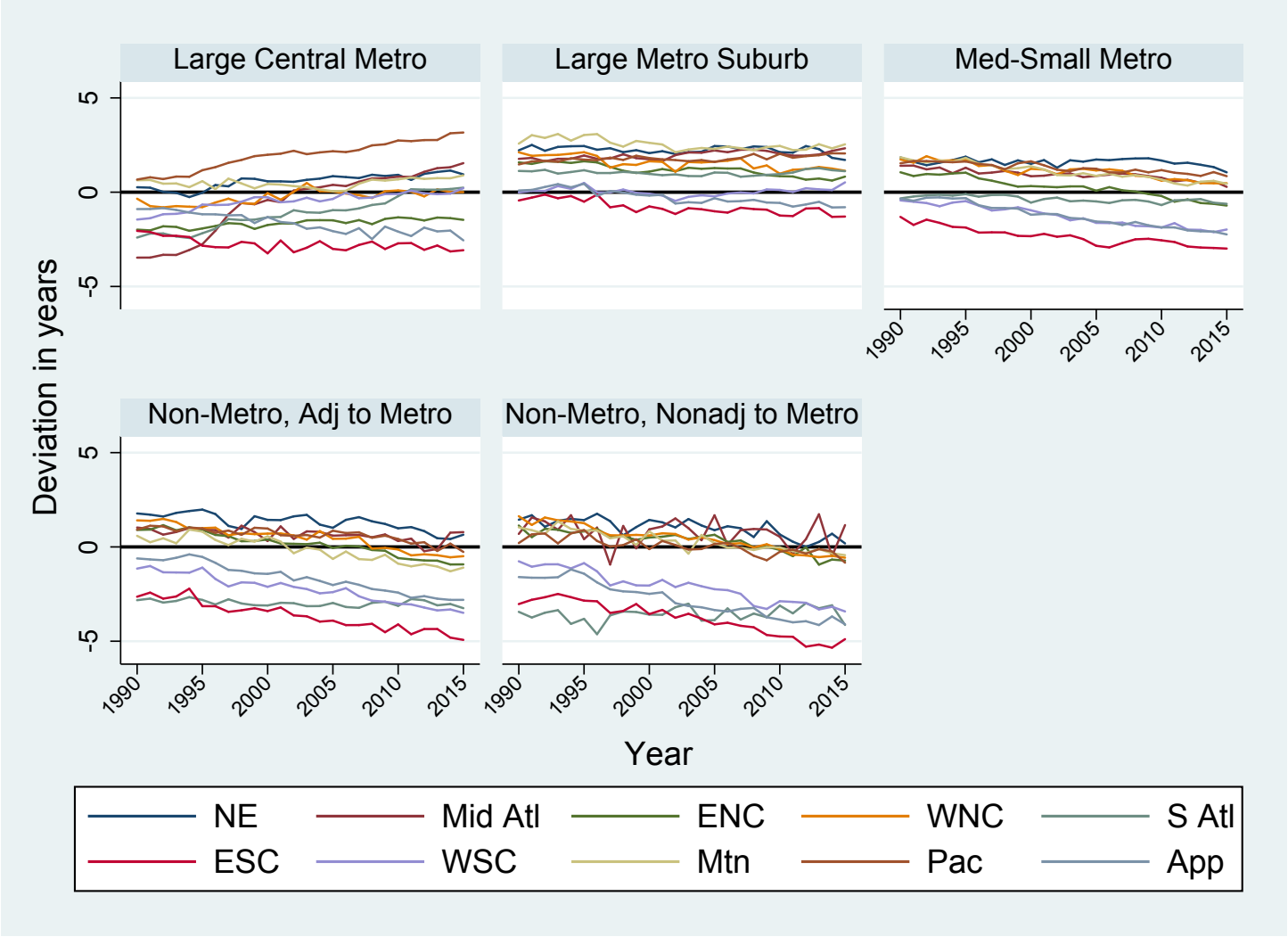


Table 1: Male and Female Life Expectancy at Birth by Region and Metropolitan and Nonmetropolitan Areas, 1990-2015

Region	Large Central City Metro			Large Metro Suburbs			Medium and Small Metro			Nonmetro adjacent to metro			Nonmetro not adjacent to metro		
	1990-1992 (a)	2014-2015 (b)	Δ (b-a)	1990-1992 (a)	2014-2015 (b)	Δ (b-a)	1990-1992 (a)	2014-2015 (b)	Δ (b-a)	1990-1992 (a)	2014-2015 (b)	Δ (b-a)	1990-1992 (a)	2009-2011 (b)	Δ (b-a)
							MALES								
New England	72.25	77.63	5.38	74.38	78.35	3.97	73.70	77.78	4.08	73.77	77.12	3.35	73.47	77.03	3.56
Middle Atlantic	68.65	78.02	9.37	73.81	78.84	5.03	73.41	77.02	3.61	72.95	77.36	4.41	73.28	76.92	3.64
East North Central	70.13	75.16	5.03	73.65	77.31	3.66	73.03	75.92	2.89	73.07	75.66	2.59	72.95	75.89	2.94
West North Central	71.44	76.59	5.15	74.08	77.78	3.70	73.81	77.06	3.25	73.50	76.07	2.57	73.53	76.06	2.53
South Atlantic	69.81	76.79	6.98	73.21	77.73	4.52	71.83	76.00	4.17	69.24	73.45	4.21	68.52	72.97	4.45
Appalachia	71.20	74.29	3.09	72.24	75.78	3.54	71.71	74.42	2.71	71.42	73.78	2.36	70.45	72.69	2.24
East South Central	69.91	73.48	3.57	71.79	75.28	3.49	70.57	73.61	3.04	69.47	71.72	2.25	69.24	71.47	2.23
West South Central	70.74	76.66	5.92	72.11	76.90	4.79	71.57	74.54	2.97	70.90	73.18	2.28	71.16	73.29	2.13
Mountain	72.65	77.40	4.75	74.90	79.02	4.12	73.78	77.11	3.33	72.51	75.39	2.88	72.95	76.20	3.25
Pacific	72.79	79.73	6.94	73.66	78.64	4.98	73.68	77.54	3.86	73.12	76.54	3.42	72.60	76.05	3.45
							FEMALES								
New England	79.53	82.72	3.19	80.35	83.17	2.82	80.07	82.55	2.48	80.13	81.58	1.45	79.71	81.63	1.92
Middle Atlantic	77.29	83.19	5.90	79.52	83.33	3.81	79.57	81.93	2.36	78.99	81.23	2.24	79.04	80.71	1.67
East North Central	77.59	80.63	3.04	79.34	81.67	2.33	79.29	80.56	1.27	79.64	80.47	0.83	79.58	80.64	1.06
West North Central	79.06	81.58	2.52	80.12	82.11	1.99	80.37	81.69	1.32	80.34	80.88	0.54	80.49	80.75	0.26
South Atlantic	78.15	82.21	4.06	79.52	82.51	2.99	78.89	81.20	2.31	77.30	78.82	1.52	76.69	77.95	1.26
Appalachia	78.11	80.08	1.97	78.82	80.47	1.65	78.76	79.49	0.73	78.66	78.88	0.22	78.33	77.74	-0.59
East South Central	77.24	79.32	2.08	78.52	79.89	1.37	77.96	79.12	1.16	77.55	77.40	-0.51	77.28	77.51	0.23
West South Central	78.40	81.41	3.01	78.82	81.24	2.42	78.63	79.77	1.14	78.56	78.21	-0.35	78.56	78.27	-0.29
Mountain	79.71	82.19	2.48	80.26	82.95	2.69	79.97	81.73	1.76	79.39	80.35	0.96	79.42	81.02	1.60
Pacific	79.65	84.32	4.67	79.63	83.06	3.43	79.71	82.27	2.56	79.23	81.36	2.13	79.01	81.34	2.33

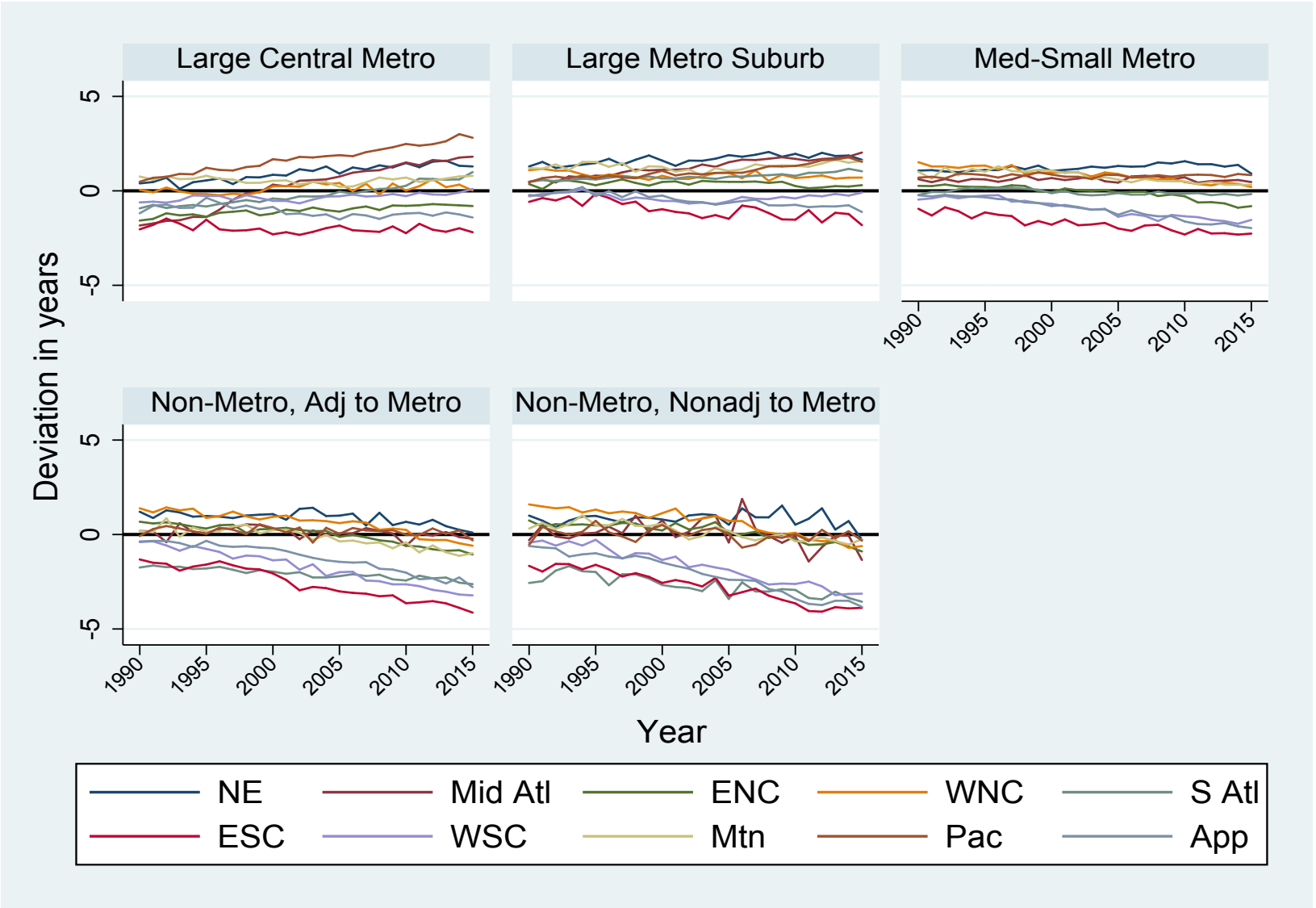
Figure 2. Deviations from US Male Life Expectancy at Birth by Region and Metropolitan-Nonmetropolitan Continuum, 1990-2015



NE = New England; Mid Atl = Middle Atlantic; ENC = East North Central; WNC = West North Central ; S Atl = South Atlantic;

ESC= East South Central; WSC = West South Central; Mtn = Mountain West; Pac = Pacific; App = Appalachia

Figure 3. Deviations from US Female Life Expectancy at Birth by Region and Metropolitan-Nonmetropolitan Continuum, 1990-2015



NE = New England; Mid Atl = Middle Atlantic; ENC = East North Central; WNC = West North Central ; S Atl = South Atlantic;

ESC= East South Central; WSC = West South Central; Mtn = Mountain West; Pac = Pacific; App = Appalachia