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Trends In The Black-White Life Expectancy Gap Among US States, 1990–2009

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ABSTRACT **Nationwide differences in US life expectancy trends for blacks and whites may mask considerable differences by state that are relevant to policies aimed at reducing health inequalities. We calculated annual state-specific life expectancies for blacks and whites from 1990 to 2009 using age-specific mortality counts and census-based denominators. Nationally, the black-white difference in life expectancy at birth shrank during the period by 2.7 years for males (from 8.1 to 5.4 years) and by 1.7 years for females (from 5.5 to 3.8 years). We found considerable variation across states in both the magnitude of the life expectancy gap (approximately fifteen years) and the change during the past two decades (about six years). Decomposition analysis showed that New York made the most profound contribution to reducing the gap, but less favorable trends in a number of states, notably California and Texas, kept the gap from shrinking further. Large state variations in the pace of change in the racial gap in life expectancy suggest that state-specific determinants merit further investigation.**

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Life expectancy continues to rise in the United States for all major population groups.[1] However, the aggregate data obscure important variations at the subnational level.[2–5]

Racial and ethnic inequalities in life expectancy, especially those between blacks and whites, remain a vital issue for policy makers. This is not only because inequalities reflect the cumulative effects of disadvantage in disease risk factors and medical interventions across the life course,[6,7] but also because there is near-universal agreement that such inequalities are preventable.[8] The national black-white gap in life expectancy at birth continues to narrow over time.[9,10] Nonetheless, the gap's persistence represents inadequate progress toward social justice in health.[11]

African American populations are highly concentrated across states. The 2010 census revealed that in twenty-one of the fifty states the black population is at least 10 percent of the total. Mississippi has the largest proportion of blacks (37 percent), and Connecticut has the smallest (10 percent).[12] The census also reported that in eighteen states the black population is greater than 1 million. Of these, New York has the largest population of blacks (3.1 million), and Tennessee has the smallest (1.1 million).

The national life expectancy gap between blacks and whites at any given time is a function of the individual state-specific gaps and the racial distribution across states. Similarly, changes in the overall national life expectancy gap result from the combined effect of each of the state-specific changes in the gap and changes in the racial distribution across states. As a result, the national black-white gap could be shrinking because of stronger growth in life expectancy among blacks in each state or because of migration to states with smaller black-white life expectancy inequalities.[13,14]

Moreover, much of American social and health

policy is set at the state level, and there is wide variation across states in health systems and forms of economic intervention. Thus, understanding state-specific trajectories is an essential step toward explaining the patterns seen in the aggregate trends.

The estimation of state-specific inequality in black-white life expectancy is hampered by the number of states with very small black populations and, thus, very small numbers of age-specific black deaths. This problem necessitates some kind of smoothing procedure in order to obtain reasonable estimates in cases where the data are sparse.[15]

Narzleen Bharmal and coauthors evaluated state-specific racial differences in life expectancy by pooling several years of data (1997–2004), but they excluded eleven states that had too few events for stable models.[5] Such pooling could mask important trends. For example, between the late 1990s and late 2000s the United States experienced rising rates of deaths from unintentional drug poisoning—trends that affected whites to a greater extent than blacks.[16] If these trends also differed by state—and there is strong evidence of state variation in drug poisoning mortality[16]—pooling mortality data could hide important state variations in the black-white life expectancy gap.

In this article we used data from a broader range of years (1990–2009) to estimate annual state-specific inequalities in life expectancy at birth between blacks and whites for all fifty states and the District of Columbia. We estimated these trajectories separately for males and females because previous work has indicated that the causes of changes in the black-white gap differ for males and females.[9,10,17] Our estimates allow an understanding of temporal changes, an assessment of how the racial gap has evolved over time from state to state, and an assessment of which states have contributed most to changes in the racial gap during this twenty-year period.

We used Bayesian smoothing methods that stabilized rates and allowed the calculation of 95 percent credible interval estimates (a credible interval is the Bayesian analogue to a traditional confidence interval) for categories with small black populations. This allowed us to make the first comprehensive depiction of changing state-level racial inequalities in life expectancy over an extended period of time, with important implications for national trends.

Study Data And Methods

DATA The data source for this study was the National Vital Statistics System. The system, which is maintained by the National Center for Health Statistics (NCHS), collects information on all deaths occurring in the United States each year. For the fifty states and the District of Columbia, we calculated state-specific all-cause mortality rates for infants, children ages 1–4, and the remaining five-year age categories (up to ages 85 and older) from 1990 to 2009 for black and white males and females. We extracted the data using software from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program,[18] for which the NCHS provides the underlying mortality data and population estimates.[19]

We did not restrict our analysis to non-Hispanics because data on mortality by ethnicity are not considered to be reliable for all states during this period.[20] However, we conducted a sensitivity analysis for states reported to have reliable mortality data by ethnicity.[21] Five states (Idaho, Montana, North Dakota, South Dakota, and Vermont) with very small black populations were excluded from the analysis (approximately 0.1 percent of the total US black population).[12] Results are therefore shown for the remaining forty-six states (including the District of Columbia), which we refer to as the "national" sample.

We used data for nineteen age categories,[22] forty-six state entities, two races, two sexes, and twenty years. Thus, there were 69,920 crude mortality rates that could be calculated from the data. However, given the small black populations in many states, these crude estimates suffer from a lack of precision. We used a Bayesian extension of standard life-table methods to estimate life expectancy at birth in each state and year for four race-sex groups: black females, white females, black males, and white males.

STATISTICAL METHODS To calculate life expectancies, we obtained denominator counts from the Census Bureau.[23] We modeled the number of deaths in each state-age-sex-race category in each year using Poisson regression, with the size of each group as an offset term in the regression.

The NCHS reports zero counts for deaths when, for a given group (for example, black males ages 15–19 in Wyoming in 2001), no deaths have been reported. However, for reasons of confidentiality, the NCHS suppresses the number of deaths if the count is 1–9.[24] For these categories (12.9 percent of all 69,920 state-age-sex-race observations), we imputed the unobserved count using a truncated Poisson regression to accommodate the fact that the true number of deaths was censored (for the complete specification of the model, see the online Appendix).[25]

Furthermore, because mortality rates were less stable in categories that had a small number of deaths (for example, in places with relatively

The surveillance of average life expectancy trends and social inequalities is a prime public health objective.

small populations or where death rates were very low), we opted to smooth all state-age-sex-race death rates across years using a conditional autoregressive prior specification. This specification allowed the death rates for each state-age-sex-race group to be smoothed toward the rate in adjacent years. For example, the death rate for black men ages 35–39 in New Hampshire in 2003 was smoothed using data for those in 2002 and 2004 to provide a more stable estimate.

We then used Markov chain Monte Carlo methods to obtain state-specific annual mortality rates for each race by sex and age. We converted the mortality rates from this model to risks and then used standard demographic methods to calculate life expectancy at birth.[26] Specifically, we used 10,000 samples from the posterior distribution of each category-specific rate to compute life expectancies. We used the mean of these 10,000 samples as the point estimate for life expectancy for blacks and whites in each state, and we used the 2.5th and 97.5th percentiles of the distribution to estimate precision.

To assess regional variation, we combined the estimates for the change in the gap in each state using an inverse-variance weighted fixed effects meta-analysis. We tested for heterogeneity within and across census divisions using Cochran's Q statistic.[27]

LIMITATIONS Several limitations to our study are worth noting. We did not restrict our sample to non-Hispanics because of data reliability concerns. Thus, our results might not necessarily be applicable to non-Hispanic populations. However, our sensitivity analysis for states considered to have reliable reporting of ethnicity on death certificates was consistent with the estimates for Hispanics and non-Hispanics combined. If anything, we may have underestimated the magnitude of the decline in the life expectancy gap between non-Hispanic blacks and non-Hispanic whites because increasing numbers of Hispanics have contributed to greater life expectancy improvement among whites than among blacks.

To stabilize mortality rates, we implemented Bayesian models that borrowed information on mortality rates for each state-age-sex-race category from adjacent years. As a result, estimated changes over time could be less pronounced and thus more conservative. However, there is evidence that the use of Bayesian methods for life expectancy estimation in smaller samples leads to improvements over more traditional life-table methods.[28]

Study Results

Point estimates and 95 percent credible intervals (CIs) for black and white life expectancy at birth and the black-white life expectancy gap for each state in 1990 and 2009 are given in Appendix Exhibits 1 and 2.[25] The trend in the black-white gap and its CI for each state are shown in Appendix Exhibits 3 and 4[25] for males and females, respectively.[29]

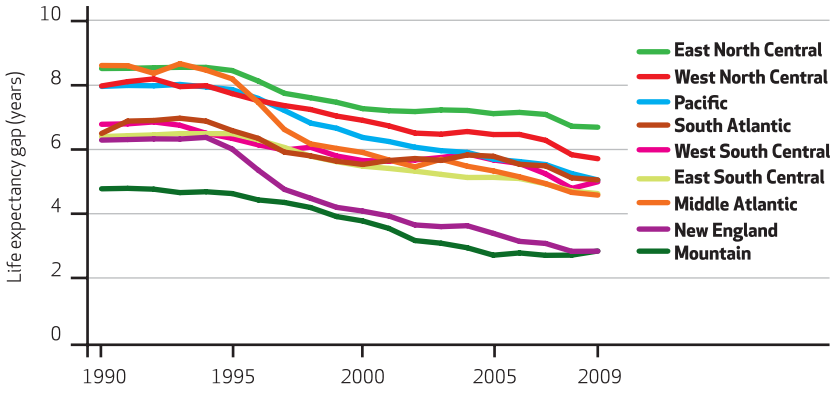
During the twenty-year study period, the national life expectancy gap (weighting each state by its total black and white population) between blacks and whites shrank by 2.7 years for males (from 8.1 years in 1990 to 5.4 years in 2009; Appendix Exhibit 1), and by 1.7 years for females (from 5.5 years to 3.8 years; Appendix Exhibit 2). The estimated state-specific racial gap in life expectancy among males in 1990 ranged from 14.4 years (95% CI: 13.3, 15.4) in the District of Columbia to 0.0 years (95% CI: −5.2, 5.3) in New Hampshire. Both Alaska and Hawaii actually showed a black advantage for males in 1990, but these gaps were very imprecisely estimated (Appendix Exhibit 1).[25] For females, the District of Columbia and New Hampshire also had the largest (10.4 years; 95% CI: 9.5, 11.2) and smallest (1.2 years; 95% CI: −3.9, 6.2) gaps, respectively, in 1990.

In 2009, despite overall improvement at the national level, the enormous racial gap in the District of Columbia remained almost completely unchanged for both males (+0.4 years; 95% CI: −1.1, 1.8) and females (+0.2 years; 95% CI: −1.1, 1.6). Life expectancy there remained dramatically more unequal than in every other state.

The largest decrease in the gap for males occurred in New York (−5.6 years; 95% CI: −6.0, −5.1), largely because of a dramatic increase in black life expectancy, from 63.9 years to 75.4 years. This was a gain of 11.5 years; the national average gain was 6.5 years. For females, the biggest improvement in the gap was observed in Wyoming (−4.1 years), but it was estimated with substantial imprecision (95% CI: −11.8, 1.3). Stronger and more reliably estimated

EXHIBIT 1

Trends In The Black-White Life Expectancy Gap For Males, By Census Region, 1990–2009



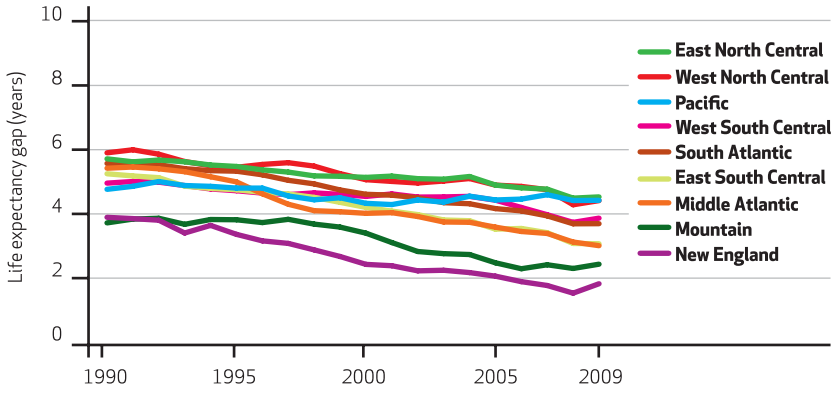
SOURCE Authors' analysis of data from the National Vital Statistics System and the Census Bureau.
NOTE Regional estimates were calculated as weighted averages, with each state weighted by the inverse of the variance of its black-white life expectancy gap in each year.

gains among females were seen in New Jersey, New York, Oregon, and Rhode Island.

Exhibits 1 and 2 show estimates of trends in the black-white life expectancy gap in each of the nine census divisions for males and females, respectively (for a map of the divisions, see Appendix Exhibit 5).[25] These trends illustrate the considerable variation in both levels and trends in the gap (the state-specific trends for both sexes are shown in Appendix Exhibits 6 and 7,[25] respectively). The Middle Atlantic and New England areas showed stronger declines in the black-white life expectancy gap for males during the mid- to late 1990s, compared to other areas. The pace of decline in the gap for females was more similar across areas, except the Pacific division, where the trend was essentially flat.

EXHIBIT 2

Trends In The Black-White Life Expectancy Gap For Females, By Census Region, 1990–2009



SOURCE Authors' analysis of data from the National Vital Statistics System and the Census Bureau.
NOTE Regional estimates were calculated as weighted averages, with each state weighted by the inverse of the variance of its black-white life expectancy gap in each year.

Exhibit 3 shows point estimates and measures of precision for the change in the black-white gap in each census division, along with heterogeneity statistics (the complete forest plots and additional statistical information are given in Appendix Exhibits 8, 8A, and 9).[25] New England and the Middle Atlantic showed greater-than-average declines in the gap for males (approximately 3–4 years), whereas declines were smaller than average in the East and West South Central (less than 2 years). For females the pattern was largely similar to that for males, with large improvements coming in the Middle Atlantic and New England, but it was dissimilar in that the East South Central region showed a larger-than-average decline in the gap.

For males we found evidence of heterogeneity in the gap among states within every division (all $p \leq 0.01$), with the exception of the East South Central (Cochran's $Q = 2.92$; degrees of freedom $= 3$; $p = 0.40$) and Mountain ($Q = 4.20$; df $= 5$; $p = 0.51$) areas (Exhibit 3). For females we also found considerable heterogeneity within most census divisions.

Among the states with large black populations, New York was notable for its particularly dramatic decline in the gap for both sexes. This is in stark contrast to California, which began the period with roughly the same magnitude of inequality as New York but which maintained a roughly constant gap, decreasing by only about a year for males and not at all for females. However, this was not because California showed little improvement in life expectancy. Blacks and whites showed similar above-average increases in life expectancy in California (about 3.5 years for females and 5.0 years for males; see Appendix Exhibits 10 and 11).[25] This reinforces the fact that the changes in the black-white life expectancy gap may arise from various combinations of changes in the component rates. Other relatively large states with poorer improvements in the black-white gap for males included Ohio and Wisconsin.

The pattern for females was somewhat different, but here again New York was the best-performing large state. California registered virtually no change in the life expectancy gap among females during the study period. One state, Wisconsin, had a significantly larger gap for females in 2009 than it did in 1990 (an increase of 1.57 years; 95% CI: 0.64, 2.47).

A simple decomposition analysis of the change in the national gap (described in detail in the Appendix)[25] found that for males and females, respectively, 96 percent (2.6 years) and 98 percent (1.6 years) of the decrease in the black-white life expectancy gap was attributable to differen-

EXHIBIT 3

Changes In The Black-White Life Expectancy Gap, By Census Division, 1990–2009

	Change in the black-white life expectancy gap			Tests of heterogeneity within census division	
Sex and region	Years	95% CI	Weight	*p* value	% of variance[a]
MALES					
New England	−3.32	(−3.97, −2.66)	2.46	0.01	69.70
Middle Atlantic	−4.20	(−4.49, −3.91)	13.05	<0.01	97.60
East North Central	−1.85	(−2.10, −1.59)	16.79	<0.01	94.20
West North Central	−2.22	(−2.72, −1.72)	4.36	<0.01	86.10
South Atlantic	−2.87	(−3.06, −2.67)	28.58	<0.01	89.30
East South Central	−1.80	(−2.10, −1.49)	11.56	0.40	0.00
West South Central	−1.76	(−2.04, −1.47)	13.33	<0.01	82.90
Mountain	−1.98	(−2.67, −1.29)	2.25	0.51	0.00
Pacific	−1.37	(−1.75, −1.00)	7.62	<0.01	76.30
Overall	−2.45	(−2.55, −2.34)	100.00	<0.01	92.20
FEMALES					
New England	−2.04	(−2.68, −1.40)	2.36	0.58	0.00
Middle Atlantic	−2.46	(−2.73, −2.19)	13.50	<0.01	94.80
East North Central	−1.16	(−1.40, −0.93)	17.30	<0.01	94.30
West North Central	−1.41	(−1.87, −0.95)	4.59	<0.01	79.40
South Atlantic	−1.76	(−1.95, −1.58)	27.80	<0.01	82.00
East South Central	−2.11	(−2.40, −1.82)	11.72	0.01	73.40
West South Central	−1.07	(−1.34, −0.80)	13.37	0.22	32.60
Mountain	−1.21	(−1.91, −0.51)	1.98	0.88	0.00
Pacific	−0.33	(−0.69, 0.04)	7.38	0.05	57.10
Overall	−1.57	(−1.67, −1.48)	100.00	<0.01	86.60

SOURCE Authors' analysis of data from the US National Vital Statistics System and the US Census Bureau. **NOTES** Summary estimates were calculated using inverse-variance weighted fixed effects meta-analysis. States with more precise estimates were given greater weight. CI is confidence interval. Note that in the text, "CI" refers to "credible interval." [a]Within each division attributable to heterogeneity across states (I^2).

tial changes in life expectancy instead of differential migration. This suggests that migration played almost no role in decreasing the national black-white life expectancy gap.

Because faster mortality declines among blacks were the chief reason for the decline in the national life expectancy gap, we present below only the results of our state-specific decomposition for counterfactual mortality changes. Appendix Exhibits 12 and 13[25] show, for males and females, respectively, the contribution of each state to the change in the national black-white gap from 1990 to 2009.

States are rank-ordered on the vertical axis by their observed twenty-year change in black life expectancy. When we weighted states by their total black and white populations, the observed national change in the black-white life expectancy gap was −2.7 years for males and −1.6 years for females, and the plotted point for each state along the horizontal axis is the counterfactual national change in the gap that would have been observed had blacks and whites in that state experienced the national average trends in life expectancy growth.

New York was a clear outlier for both males and females. For example, Appendix Exhibit 12[25] shows a value of −2.5 for New York, indicating that if it had experienced the national average life expectancy growth for whites (0.25 percent per year) and blacks (0.48 percent per year) instead of its actual growth rates (0.40 percent and 0.83 percent, respectively), the national black-white gap for males would have declined by only 2.5 years instead of 2.7 years.

In contrast, the observed life expectancy growth rates for white and black males in California were 0.35 percent and 0.46 percent, respectively. The faster-than-average white life expectancy growth coupled with just average black life expectancy growth is why California kept the national black-white gap from declining even further than it did.

The extreme contributions of New York and California are readily evident for both sexes. To a lesser extent than New York, Florida, Illinois, and New Jersey also played important roles in reducing the black-white gap. In contrast, Alabama, Louisiana, and Mississippi kept the national black-white gap from falling by more than it would have otherwise.

A sensitivity analysis of state trends in the

black-white gap restricted to non-Hispanics largely confirmed the results for Hispanics and non-Hispanics combined (for estimates for states considered to have reliable reporting in 1990 and 2009, see Appendix Exhibits 14 and 15).[25] Restricting the sample to non-Hispanics led to a slightly larger reduction in the overall gap (2.9 years for males compared to 2.7 years for all ethnicities, and 1.8 versus 1.7 years for females; Appendix Exhibits 13 and 14, compared to Appendix Exhibits 1 and 2).[25] This is primarily a result of smaller improvements in life expectancy for whites when Hispanics were excluded.

Discussion

Racial differences in life expectancy can be difficult to interpret because the same inequality may arise from a multitude of black and white life expectancies. The study of changes in inequalities over time is even more challenging, since the gap can increase when both groups experience rising life expectancy, and it can decrease even if both groups experience falling life expectancy. For example, both black and white males in the District of Columbia gained nearly ten years of life expectancy from 1990 to 2009, yet the life expectancy gap there remained constant at nearly fifteen years and easily remains the largest among the states.

Nonetheless, the surveillance of average life expectancy trends and social inequalities is a prime public health objective[30] and is necessary for the assessment of progress toward health equality. Our analysis provides a high-resolution picture of the evolution of black-white racial mortality inequalities during the past two decades. This is the first article to detail these values by state and year, with formal assessments of imprecision. Our results depict considerable heterogeneity across states in their trajectories of improvement and raise many important questions about the origins of these patterns in state policies, migration patterns, and the geographic patterns of important risk factors.[31–33]

For instance, New York City has experienced substantial improvements in homicide[34] and HIV/AIDS mortality during the past two decades.[35] These trends have disproportionately benefited blacks in absolute terms and may go some way toward explaining the much larger change in black life expectancy in New York. Samuel Preston and Irma Elo attribute these improvements largely to local policies, particularly to the aggressive identification of and treatment for people with HIV/AIDS.[36] They also provide evidence that reductions in drug- and alcohol-related deaths contributed substantially to New York City's large rise in life expectancy during the past two decades.

The pattern in New York is in stark contrast to that in California, which experienced notably strong declines in tobacco use during past decades[37] and has outpaced the nation in declines in heart disease and smoking-attributable mortality.[38,39] These gains may have differentially benefited whites relative to blacks when compared to progress in other states. Detailed trends on cause-specific mortality will help shed light on this question.

There was no area in which males or females experienced a decrease in life expectancy. However, improvements were sufficiently uneven that the black-white gap worsened in some places (notably among females in Wisconsin), even as mortality rates were falling. The explanations for these divergent patterns rest on a myriad of social, economic, and demographic shifts, in addition to policy differences and the legacy of historical inequalities that have not been quickly resolved. For example, the District of Columbia continues to have the largest magnitude of racial difference in life expectancy of any area, despite the fact that the District's population experienced a profound demographic shift during the study period—from being nearly 70 percent black in 1990 to being only about 50 percent black in 2009.

The diversity of state-specific trajectories in the black-white life expectancy gap suggests important avenues for investigating potential causes of and solutions to racial inequalities in health. Considerable previous work has focused on the lifetime exposure of blacks and whites to substantially different economic and environmental conditions, largely structured through residential segregation.[40,41] These factors should be investigated at the state level, but national socioeconomic trends do not correlate well with the continued declines in the black-white life expectancy gap.

For example, trends in the black-white income and wealth gaps during the study period were generally unfavorable—particularly for black males, who experienced the strongest life expectancy gains—and there is little evidence of black progress in homeownership or full employment.[42,43]

It is also difficult to reconcile patterns in residential segregation with our results. There were larger decreases in segregation in the Mountain and Pacific regions, where we found smaller (though less precise) decreases in the black-white life expectancy gap. However, there has been some black-white convergence in educational attainment. Recent estimates of widening life expectancy differences by education[44] suggest that state differences in black-white educa-

Future work should probe deeper into these patterns by examining the age-specific mortality rates and primary causes of death.

tion inequalities could play some role in explaining divergent state trends.

Race-specific state trends in environmental risk factors for major causes of mortality are likely avenues for further investigation, but few studies have assessed state trends by race. A recent study[45] on state trends from 2001 to 2010 in preventable cardiovascular mortality found that all states showed declines. However, progress was slowest across Appalachia and in much of the East and West South Central regions. These areas were where we found slower progress in reducing the black-white gap. They were also among the areas that performed worst in increasing life expectancy for both blacks and whites. This may suggest that inadequate progress in reducing cardiovascular risk factors and access to treatment are negatively affecting both races.

The strengths of our study include the use of complete population data, which eliminated the need for sampling, and the use of statistical smoothing to increase stability and allow for a greater number of estimates than have been reported previously. We also accounted statistically for the censored values of small counts and reported uncertainty intervals for the change in life expectancy gaps over time.

Future work should probe deeper into these patterns by examining the age-specific mortality rates and primary causes of death. The end of the period of high HIV/AIDS mortality occurred during our study period. In addition, homicide rates have declined substantially in many areas. Both of these changes are known to make important contributions to the narrowing of the racial gap.[10] State-level policies regarding policing, sentencing, and laws related to illicit drugs have also changed importantly during our observation period. This has led to dramatic shifts in incarceration rates, which may also have important impacts on mortality-rate inequalities.[46]

A detailed examination of these patterns by state and time has not yet been conducted, but it should be an obvious next step. This must naturally involve the intense scrutiny of states that have remarkable patterns of change, such as California, the District of Columbia, New York, and Wisconsin.

The heterogeneous gains across southern states should also be a target of further inquiry. These areas include large numbers of blacks and whites, make important contributions to the national statistics, and have unique stories to tell. ■

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Appendix material for: **Harper S, MacLehose RF, Kaufman JS. Trends in the Black-White Life-Expectancy Gap among US States, 1990-2009. Health Aff 2014**

Statistical Methods

To calculate life expectancies we obtained denominator counts from US Census Populations with Bridged Race Categories estimates (http://www.cdc.gov/nchs/nvss/bridged_race.htm). We modeled the number of deaths, *D*, in each category using Poisson regression:

$$D_{s,r,g,a,y} \sim Poisson\left(O_{s,r,g,a,y}\, e^{\lambda_{s,r,g,a,y}}\right)$$

where subscripts refer to state = *s*, race = *r*, gender = *g*, age = *a* and year = *y* sub-groups. The $O_{s,r,g,a,y}$ are the observed counts from the US National Vital Statistics System for each state-race-gender-age-year group. The $\lambda_{s,r,g,a,y}$ are estimates of the log mortality rate in each category.

The NCHS reports zero cell counts, but for reasons of confidentiality it suppresses all counts if the value lies in the interval 1-9.[1] For these categories (approximately 12.9% of all categories), we imputed the unobserved cell count using a truncated Poisson regression to accommodate the censoring:

$$D_{s,r,g,a,y} \sim Poisson\left(O_{s,r,g,a,y}\, e^{\lambda_{s,r,g,a,y}}\right) I_{(D_{s,r,g,a,y})}\left(1, U_{s,r,g,a,y}\right)$$

where $U_{s,r,g,a,y}$ is the smaller of 9 and the population size for that category ($O_{s,r,g,a,y}$). The term $I_{(D_{s,r,g,a,y})}\left(1, U_{s,r,g,a,y}\right)$ is an indicator variable taking the value of 1 for values of $D_{s,r,g,a,y}$ between 1 and $U_{s,r,g,a,y}$ and 0 otherwise.

Because mortality rates tended to be unstable in categories that had a small number of deaths, we opted to smooth all category-specific rates across years using a conditional autoregressive prior:

$$\lambda_{s,r,g,a,y=0} \sim N(-4,10)$$

$$\lambda_{s,r,g,a,y} | \lambda_{s,r,g,a,y-1} \sim N\left(\lambda_{s,r,g,a,y-1}, \sigma_r^2\right), for\ y > 0$$

$$\sigma_r^2 \sim InvGammma(0.01,0.01)$$

This prior specification allows the category-specific rates to be smoothed toward adjacent years. The degree of smoothing is determined by the race-specific hyper-prior, σ_r^2. Smaller values of σ_r^2 imply that the rates in each category from year to year look similar and thus a greater degree of smoothing.

We fit the model above using Markov Chain Monte Carlo (MCMC) methods implemented in *OpenBUGS*,[2] called from *R* (version 2.7.2). For each model we discarded the first 1,000 iterations of the Markov chain to accommodate a burn-in period and allow the chain to approach the posterior distribution. After the burn-in period, an additional 1,000,000 iterations were run and every 100th iteration was retained for analysis, resulting in 10,000 samples from the posterior distribution of $\lambda_{s,r,g,a,y}$ for each state, race, gender, age and year category. These samples were retained for use in the decomposition analysis (described below). Convergence was assessed via visual inspection of trace plots.

We used mortality rate estimates from this model to calculate life expectancies by converting rates to risks, and we used standard methods[3] to compute the life expectancy at birth. Specifically, we used 10,000 samples from the posterior distribution of each category-specific rate to compute life expectancies. We used the mean of these 10,000 samples as the point estimate for life expectancy, and computed the posterior interval estimate using the 2.5th and 97.5th percentiles of the distribution.

Decomposition Analysis

As noted above, the overall gap in life expectancy between blacks and whites is a function of two quantities that may change over time: 1) the black-white life expectancy gap within each state, and 2) the population size in each state. Since the overall black-white gap could decline via either a declining black-white gap in each state or migration/population growth in states with lower black-white gaps, we performed a simple decomposition analysis to quantify these two components of change. We used the following decomposition formula:[4,5]

$$\Delta Gap = \sum_s \left[\left(\overline{l_s^w}\Delta p_s^w\right) - \left(\overline{l_s^b}\Delta p_s^b\right)\right] + \left[\left(\Delta l_s^w \overline{p_s^w}\right) - \left(\Delta l_s^b \overline{p_s^b}\right)\right]$$

where the superscripts *w* and *b* refer to whites and blacks, l_s represents life expectancy in state *s*, p_s represents the proportion of the national population of each racial group that live in state *s*. The overbar indicates an average of 1990 and 2009 values, and Δ is the difference between 1990 and 2009 values. The first term holds black and white life expectancy at their average values over the entire period and estimates the impact of changes in population growth. The second term holds population growth constant at average values and estimates the impact of changes in black and white life expectancy.

While this formula provides an overall decomposition into life expectancy vs. population growth effects it does not provide an estimate of the contribution of each state to the change in the national black-white gap.[6] To do so, for each state we kept the life expectancy in 1990 at the observed level, but replaced the 2009 life expectancy that would have been observed if the state had experienced the same growth in life expectancy as all states combined. Under this counterfactual scenario, both the average life expectancy and change in life expectancy were recomputed for that state. We then estimated the national change in the black-white life

expectancy gap under this counterfactual scenario. This procedure was repeated separately for each state to see which states made the largest contribution to the overall decline in the gap.

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Appendix Exhibit 1. Life expectancy at birth for black and white men by state, 1990 and 2009.

	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
Alabama	64.3	71.2	6.9	(6.5,7.3)	68.1	73.0	4.9	(4.5,5.2)	3.9	1.8	-2.0	(-2.6,-1.5)
Alaska	73.9	73.2	-0.6	(-3.8,2.5)	75.1	77.0	1.9	(-1.5,4.4)	1.3	3.7	2.5	(-1.8,5.8)
Arizona	67.8	73.1	5.3	(4.4,6.2)	74.9	77.9	3.0	(2.1,3.8)	7.1	4.8	-2.3	(-3.6,-1.0)
Arkansas	64.1	71.5	7.4	(6.8,7.9)	67.8	73.5	5.6	(5.1,6.1)	3.7	2.0	-1.8	(-2.5,-1.0)
California	65.7	72.4	6.7	(6.4,7.0)	72.1	77.7	5.6	(5.3,5.8)	6.4	5.2	-1.1	(-1.6,-0.7)
Colorado	68.9	73.9	5.0	(4.1,5.8)	73.8	77.4	3.6	(2.9,4.4)	4.9	3.6	-1.3	(-2.4,-0.2)
Connecticut	66.4	74.4	8.0	(7.2,8.7)	74.0	77.8	3.8	(3.0,4.5)	7.6	3.4	-4.2	(-5.3,-3.2)
Delaware	65.7	73.0	7.3	(6.3,8.3)	71.8	76.0	4.2	(3.3,5.2)	6.1	3.1	-3.0	(-4.4,-1.7)
District of Columbia	57.4	71.8	14.4	(13.3,15.4)	66.0	80.8	14.7	(13.7,15.7)	8.6	9.0	0.4	(-1.1,1.8)
Florida	64.3	73.2	9.0	(8.6,9.3)	72.4	77.2	4.7	(4.4,5.0)	8.2	3.9	-4.2	(-4.7,-3.8)
Georgia	64.1	71.5	7.4	(7.0,7.7)	71.1	75.4	4.3	(4.0,4.6)	7.0	3.9	-3.0	(-3.5,-2.6)
Hawaii	82.1	73.7	-8.5	(-18.9,-2.0)	83.7	75.3	-8.4	(-18.8,-2.8)	1.5	1.6	0.1	(-10.4,9.6)
Illinois	62.0	72.7	10.8	(10.4,11.1)	69.4	76.9	7.5	(7.2,7.8)	7.4	4.1	-3.3	(-3.8,-2.8)
Indiana	65.5	72.3	6.8	(6.3,7.3)	69.8	74.9	5.2	(4.7,5.7)	4.3	2.6	-1.6	(-2.3,-0.9)
Iowa	67.6	74.0	6.4	(5.3,7.6)	71.0	76.8	5.8	(4.8,6.8)	3.4	2.8	-0.6	(-2.1,0.8)
Kansas	66.7	73.7	7.0	(6.2,7.8)	69.7	76.0	6.3	(5.5,7.0)	3.1	2.3	-0.8	(-1.9,0.3)
Kentucky	66.3	71.0	4.7	(4.1,5.2)	69.9	73.2	3.3	(2.8,3.9)	3.5	2.2	-1.3	(-2.1,-0.6)
Louisiana	63.6	71.2	7.6	(7.2,8.0)	68.1	73.8	5.7	(5.3,6.1)	4.5	2.6	-1.9	(-2.4,-1.3)
Maine	70.7	73.1	2.4	(-0.7,5.9)	71.9	76.1	4.2	(1.2,6.9)	1.2	2.9	1.8	(-2.7,5.3)
Maryland	65.0	73.2	8.2	(7.8,8.6)	71.1	76.7	5.6	(5.3,6.0)	6.1	3.5	-2.6	(-3.1,-2.1)
Massachusetts	68.4	73.5	5.1	(4.4,5.8)	75.2	77.6	2.4	(1.7,3.0)	6.8	4.1	-2.7	(-3.7,-1.8)
Michigan	63.8	73.0	9.2	(8.9,9.6)	68.9	76.2	7.3	(6.9,7.6)	5.1	3.2	-1.9	(-2.5,-1.4)
Minnesota	66.7	74.7	8.0	(7.0,9.1)	73.7	78.5	4.7	(3.7,5.7)	7.0	3.8	-3.3	(-4.8,-1.8)

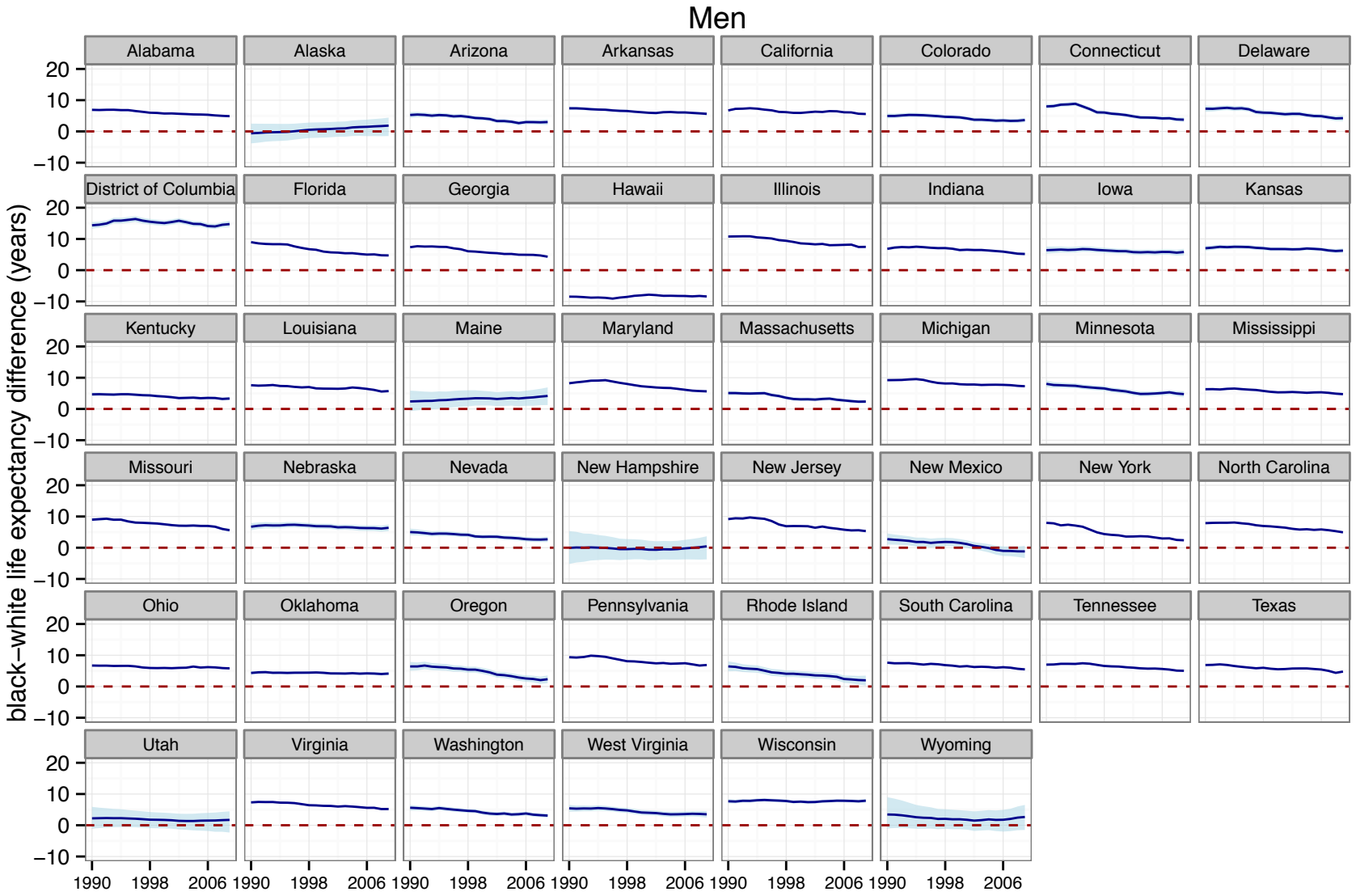
	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
Mississippi	64.5	70.8	6.3	(5.9,6.7)	68.1	72.8	4.7	(4.3,5.1)	3.5	2.0	-1.6	(-2.2,-1.0)
Missouri	63.4	72.3	9.0	(8.5,9.5)	69.4	75.0	5.6	(5.1,6.1)	6.0	2.7	-3.4	(-4.1,-2.7)
Nebraska	67.1	73.8	6.7	(5.6,7.9)	70.6	77.0	6.4	(5.3,7.4)	3.5	3.2	-0.3	(-1.9,1.2)
Nevada	66.4	71.4	5.0	(4.0,6.1)	72.2	74.9	2.7	(1.8,3.5)	5.8	3.5	-2.3	(-3.7,-0.9)
New Hampshire	73.8	73.8	0.0	(-5.2,5.3)	77.0	77.4	0.5	(-3.7,3.7)	3.2	3.7	0.5	(-6.3,6.1)
New Jersey	64.1	73.3	9.2	(8.7,9.6)	72.3	77.6	5.3	(4.9,5.7)	8.2	4.3	-3.8	(-4.4,-3.3)
New Mexico	70.2	72.9	2.7	(1.0,4.6)	76.5	75.3	-1.2	(-3.3,0.6)	6.3	2.3	-3.9	(-6.7,-1.4)
New York	63.9	71.8	8.0	(7.7,8.2)	75.4	77.8	2.4	(2.1,2.7)	11.5	5.9	-5.6	(-6.0,-5.1)
North Carolina	64.4	72.3	7.9	(7.5,8.2)	70.6	75.5	4.9	(4.6,5.2)	6.2	3.3	-2.9	(-3.4,-2.5)
Ohio	65.9	72.6	6.7	(6.4,7.1)	69.5	75.3	5.8	(5.5,6.1)	3.6	2.7	-0.9	(-1.4,-0.4)
Oklahoma	67.2	71.5	4.3	(3.8,4.9)	69.1	73.2	4.1	(3.6,4.7)	1.9	1.7	-0.2	(-1.0,0.6)
Oregon	66.9	73.3	6.4	(5.0,7.9)	74.3	76.6	2.3	(1.1,3.5)	7.4	3.3	-4.1	(-6.0,-2.2)
Pennsylvania	63.4	72.7	9.4	(9.0,9.7)	69.0	75.9	6.9	(6.5,7.2)	5.7	3.2	-2.5	(-3.0,-2.0)
Rhode Island	67.1	73.6	6.4	(4.9,8.0)	74.6	76.6	2.0	(0.3,3.5)	7.5	3.0	-4.5	(-6.9,-2.2)
South Carolina	64.2	71.8	7.6	(7.2,8.0)	69.5	75.0	5.5	(5.1,5.9)	5.4	3.2	-2.1	(-2.7,-1.6)
Tennessee	64.2	71.2	7.0	(6.6,7.4)	68.8	73.8	5.0	(4.6,5.4)	4.6	2.6	-2.0	(-2.6,-1.4)
Texas	65.1	72.0	6.9	(6.6,7.2)	71.2	76.0	4.8	(4.5,5.0)	6.1	4.0	-2.1	(-2.5,-1.7)
Utah	72.8	75.0	2.2	(-1.1,5.9)	76.5	78.2	1.7	(-2.3,4.5)	3.7	3.2	-0.5	(-6.3,3.4)
Virginia	65.7	73.0	7.3	(7.0,7.7)	71.5	76.7	5.2	(4.9,5.5)	5.9	3.7	-2.1	(-2.6,-1.6)
Washington	68.2	73.8	5.6	(4.7,6.5)	74.2	77.3	3.1	(2.4,3.8)	6.0	3.4	-2.5	(-3.7,-1.4)
West Virginia	65.3	70.7	5.4	(4.4,6.5)	68.7	72.2	3.5	(2.5,4.5)	3.4	1.5	-1.9	(-3.4,-0.5)
Wisconsin	66.3	73.9	7.7	(7.0,8.4)	69.5	77.3	7.9	(7.2,8.5)	3.2	3.4	0.2	(-0.8,1.1)
Wyoming	70.0	73.4	3.4	(-1.0,9.0)	72.7	75.4	2.7	(-1.5,6.5)	2.8	2.0	-0.8	(-7.5,4.3)
Weighted Average	64.5	72.6	8.1		71.0	76.4	5.4		6.5	3.8	-2.7	

Appendix Exhibit 2. Life expectancy at birth for black and white women by state, 1990 and 2009.

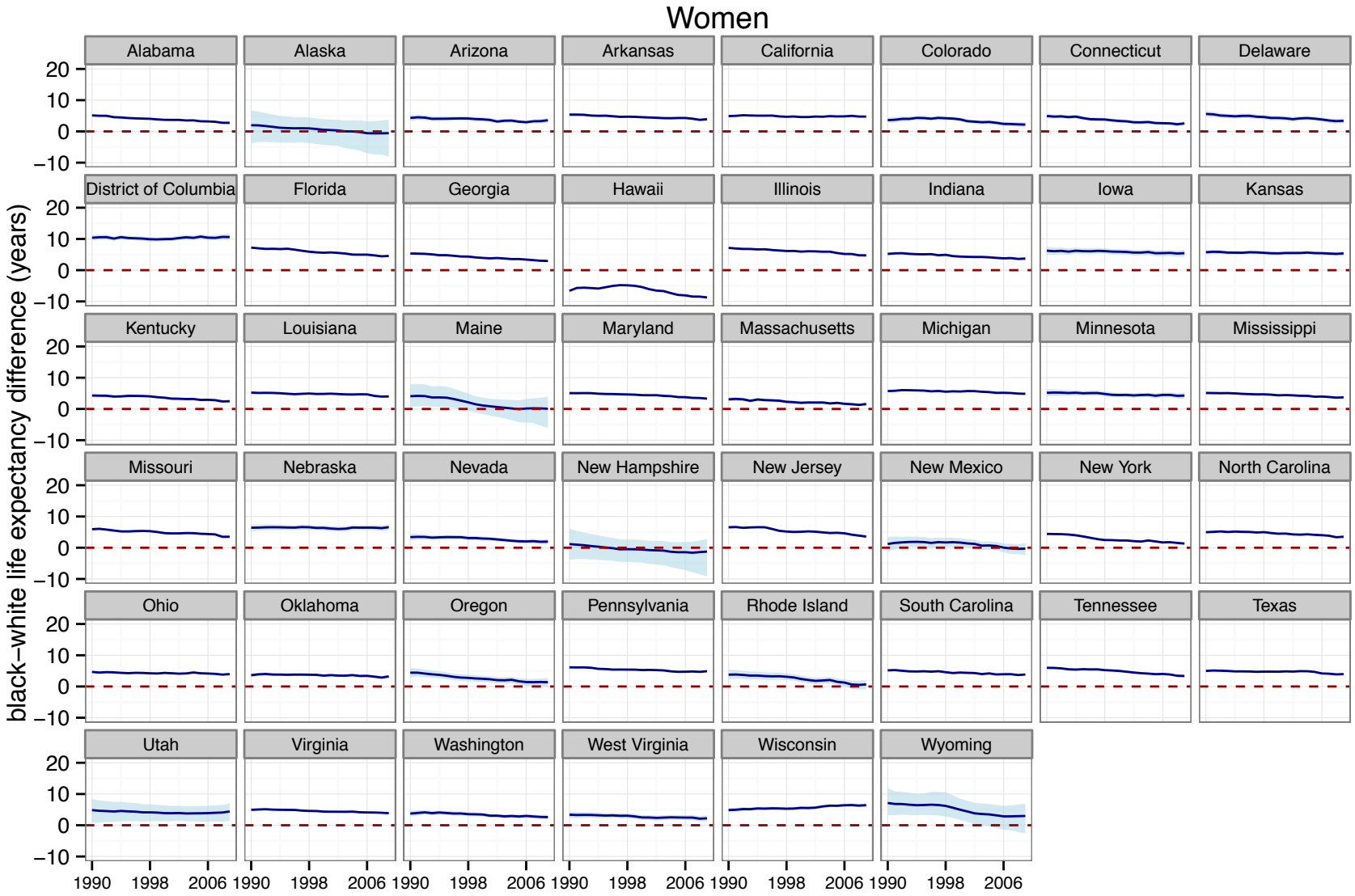
	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
Alabama	73.6	78.7	5.1	(4.8,5.5)	75.9	78.6	2.7	(2.4,3.1)	2.3	-0.1	-2.4	(-2.9,-1.9)
Alaska	78.0	80.0	2.0	(-3.8,6.7)	82.0	81.5	-0.6	(-8.1,3.7)	4.0	1.4	-2.6	(-11.4,3.6)
Arizona	75.8	80.1	4.3	(3.4,5.2)	79.2	82.8	3.6	(2.8,4.4)	3.5	2.7	-0.7	(-2.0,0.5)
Arkansas	73.5	78.9	5.4	(4.9,5.9)	75.3	79.2	3.9	(3.4,4.4)	1.7	0.3	-1.5	(-2.2,-0.8)
California	74.3	79.1	4.9	(4.6,5.2)	77.8	82.6	4.8	(4.5,5.0)	3.6	3.4	-0.1	(-0.5,0.2)
Colorado	76.5	80.1	3.6	(2.6,4.6)	79.7	81.8	2.2	(1.3,3.0)	3.2	1.8	-1.4	(-2.7,-0.2)
Connecticut	75.6	80.5	4.9	(4.2,5.7)	79.8	82.3	2.6	(1.9,3.2)	4.2	1.8	-2.4	(-3.4,-1.4)
Delaware	73.2	78.8	5.6	(4.7,6.5)	77.5	80.9	3.4	(2.6,4.2)	4.3	2.1	-2.2	(-3.5,-0.9)
District of Columbia	71.2	81.6	10.4	(9.5,11.2)	75.5	86.1	10.6	(9.6,11.6)	4.3	4.5	0.2	(-1.1,1.6)
Florida	73.5	80.7	7.2	(6.9,7.6)	78.6	83.1	4.6	(4.3,4.8)	5.1	2.4	-2.7	(-3.1,-2.2)
Georgia	73.7	79.0	5.3	(5.0,5.7)	77.4	80.4	3.0	(2.7,3.2)	3.7	1.3	-2.4	(-2.8,-1.9)
Hawaii	86.2	79.6	-6.6	(-21.5,2.0)	91.6	82.9	-8.7	(-25.7,-0.7)	5.4	3.2	-2.1	(-21.2,14.3)
Illinois	72.1	79.3	7.1	(6.8,7.5)	76.9	81.6	4.7	(4.4,5.0)	4.8	2.4	-2.4	(-2.8,-2.0)
Indiana	73.8	79.0	5.2	(4.7,5.7)	76.4	80.1	3.7	(3.2,4.2)	2.6	1.1	-1.5	(-2.2,-0.8)
Iowa	74.5	80.7	6.2	(5.0,7.5)	76.2	81.7	5.4	(4.3,6.5)	1.7	0.9	-0.8	(-2.5,0.8)
Kansas	74.5	80.3	5.7	(5.0,6.5)	75.6	81.0	5.4	(4.7,6.1)	1.1	0.7	-0.4	(-1.4,0.6)
Kentucky	74.0	78.3	4.3	(3.7,4.9)	76.1	78.6	2.5	(1.9,3.0)	2.2	0.3	-1.8	(-2.6,-1.0)
Louisiana	73.3	78.5	5.2	(4.9,5.6)	75.6	79.6	4.0	(3.7,4.4)	2.3	1.1	-1.2	(-1.7,-0.7)
Maine	75.5	79.6	4.1	(0.6,8.0)	80.9	81.0	0.1	(-6.2,4.0)	5.4	1.4	-4.0	(-11.7,1.0)
Maryland	74.1	79.2	5.1	(4.7,5.4)	78.1	81.4	3.3	(3.0,3.6)	4.0	2.2	-1.8	(-2.3,-1.3)
Massachusetts	76.8	79.9	3.1	(2.4,3.8)	80.9	82.4	1.6	(0.9,2.2)	4.1	2.5	-1.5	(-2.4,-0.6)
Michigan	73.4	79.1	5.7	(5.4,6.1)	76.1	81.0	4.8	(4.5,5.2)	2.7	1.8	-0.9	(-1.3,-0.4)
Minnesota	75.8	81.0	5.2	(4.0,6.3)	78.9	83.2	4.3	(3.2,5.2)	3.1	2.2	-0.9	(-2.5,0.6)

	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
Mississippi	73.6	78.8	5.1	(4.7,5.5)	75.4	79.1	3.7	(3.3,4.1)	1.8	0.4	-1.4	(-2.0,-0.8)
Missouri	73.5	79.4	5.9	(5.5,6.4)	76.7	80.3	3.5	(3.1,4.0)	3.3	0.9	-2.4	(-3.1,-1.8)
Nebraska	74.1	80.5	6.4	(5.3,7.5)	75.1	81.7	6.6	(5.6,7.5)	1.1	1.2	0.2	(-1.2,1.5)
Nevada	74.8	78.2	3.4	(2.3,4.4)	77.8	79.7	1.9	(1.1,2.8)	3.0	1.5	-1.4	(-2.8,-0.1)
New Hampshire	78.8	79.9	1.2	(-3.9,6.2)	83.5	82.3	-1.2	(-9.1,2.8)	4.7	2.3	-2.4	(-12.2,3.6)
New Jersey	72.8	79.3	6.5	(6.1,7.0)	78.7	82.2	3.6	(3.2,3.9)	5.9	2.9	-3.0	(-3.5,-2.4)
New Mexico	78.6	79.8	1.2	(-1.2,3.5)	81.4	81.1	-0.3	(-2.3,1.5)	2.9	1.4	-1.5	(-4.6,1.3)
New York	74.5	78.9	4.4	(4.1,4.7)	81.3	82.6	1.3	(1.1,1.6)	6.8	3.7	-3.1	(-3.5,-2.7)
North Carolina	74.6	79.6	5.0	(4.6,5.3)	77.2	80.7	3.5	(3.2,3.8)	2.6	1.1	-1.4	(-1.9,-1.0)
Ohio	74.2	78.9	4.7	(4.3,5.0)	76.4	80.4	4.0	(3.7,4.3)	2.2	1.5	-0.7	(-1.1,-0.2)
Oklahoma	74.6	78.2	3.6	(3.0,4.2)	75.4	78.6	3.2	(2.7,3.8)	0.8	0.4	-0.4	(-1.2,0.4)
Oregon	75.2	79.6	4.4	(3.0,5.9)	79.7	81.1	1.4	(-0.1,2.7)	4.5	1.5	-3.0	(-5.2,-1.0)
Pennsylvania	73.1	79.2	6.1	(5.8,6.5)	76.4	81.3	4.9	(4.6,5.2)	3.3	2.0	-1.2	(-1.7,-0.8)
Rhode Island	76.2	79.9	3.8	(2.2,5.4)	81.0	81.6	0.7	(-1.0,2.1)	4.8	1.7	-3.1	(-5.5,-1.0)
South Carolina	73.9	79.0	5.2	(4.7,5.6)	76.8	80.6	3.8	(3.5,4.2)	2.9	1.6	-1.3	(-1.9,-0.8)
Tennessee	73.0	78.9	6.0	(5.6,6.4)	76.0	79.3	3.4	(3.0,3.7)	3.0	0.4	-2.6	(-3.2,-2.1)
Texas	74.5	79.4	5.0	(4.7,5.3)	77.1	81.1	4.0	(3.7,4.2)	2.6	1.6	-1.0	(-1.4,-0.6)
Utah	76.0	80.8	4.8	(0.8,8.4)	77.7	82.1	4.4	(1.4,6.9)	1.7	1.3	-0.4	(-5.0,3.7)
Virginia	74.5	79.5	4.9	(4.6,5.3)	77.6	81.4	3.9	(3.6,4.2)	3.0	2.0	-1.1	(-1.6,-0.6)
Washington	76.0	79.8	3.7	(2.8,4.7)	78.9	81.5	2.6	(1.8,3.4)	2.8	1.7	-1.1	(-2.3,0.1)
West Virginia	74.7	78.0	3.4	(2.4,4.4)	75.6	77.8	2.2	(1.2,3.2)	0.9	-0.2	-1.1	(-2.5,0.2)
Wisconsin	75.4	80.2	4.9	(4.1,5.6)	75.7	82.2	6.4	(5.8,7.0)	0.4	2.0	1.6	(0.6,2.5)
Wyoming	72.5	79.6	7.1	(3.2,11.9)	77.3	80.3	3.0	(-2.6,7.0)	4.8	0.6	-4.2	(-11.8,1.3)
Weighted Average	73.9	79.4	5.5		77.6	81.4	3.8		3.7	2.0	-1.7	

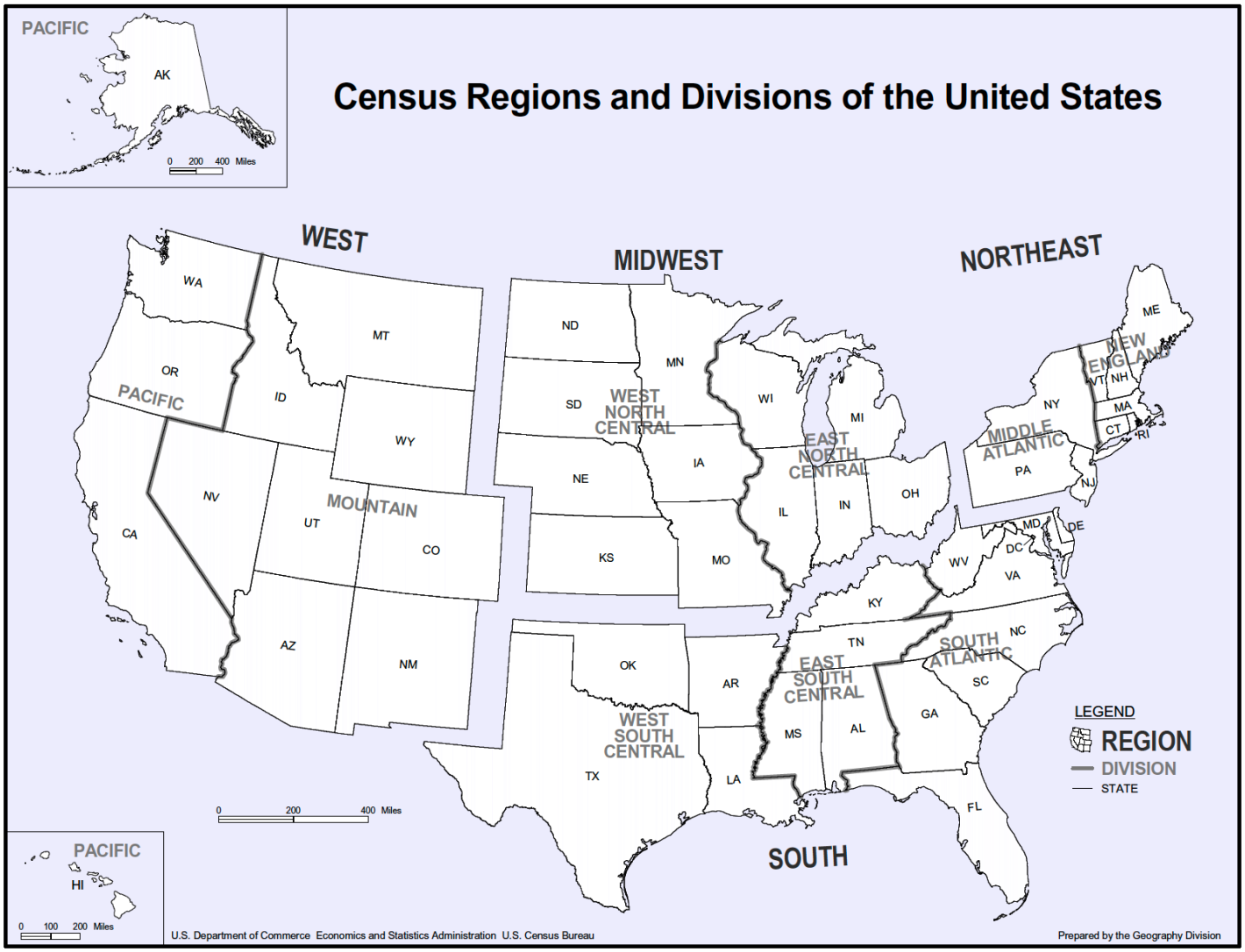
Appendix Exhibit 3: Trend in Black-White Life Expectancy Gap (in years) by State, with 95% Credible Interval (light blue shading), Men



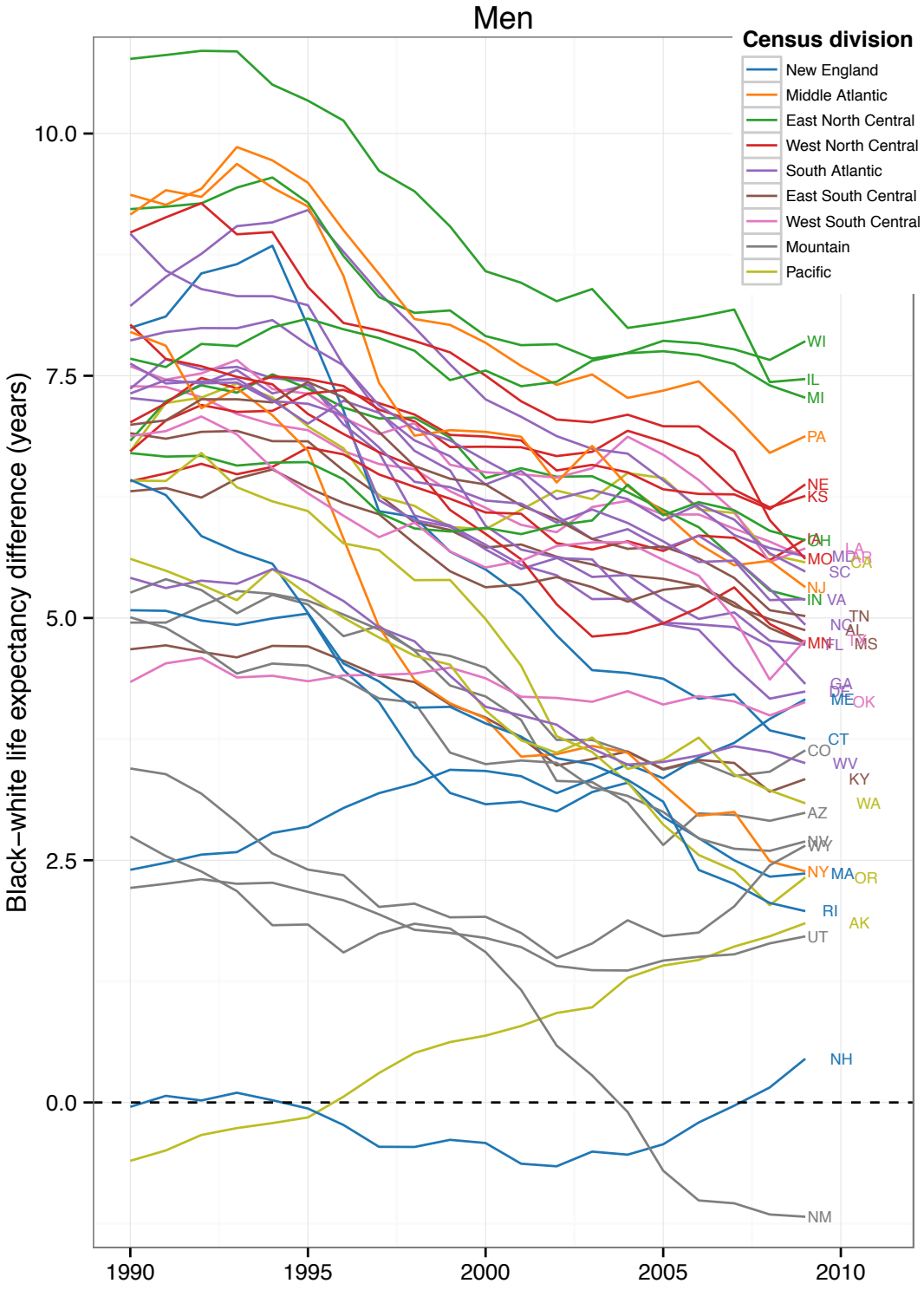
Appendix Exhibit 4: Trend in Black-White Life Expectancy Gap (in years) by State, with 95% Credible Interval (light blue shading), Women



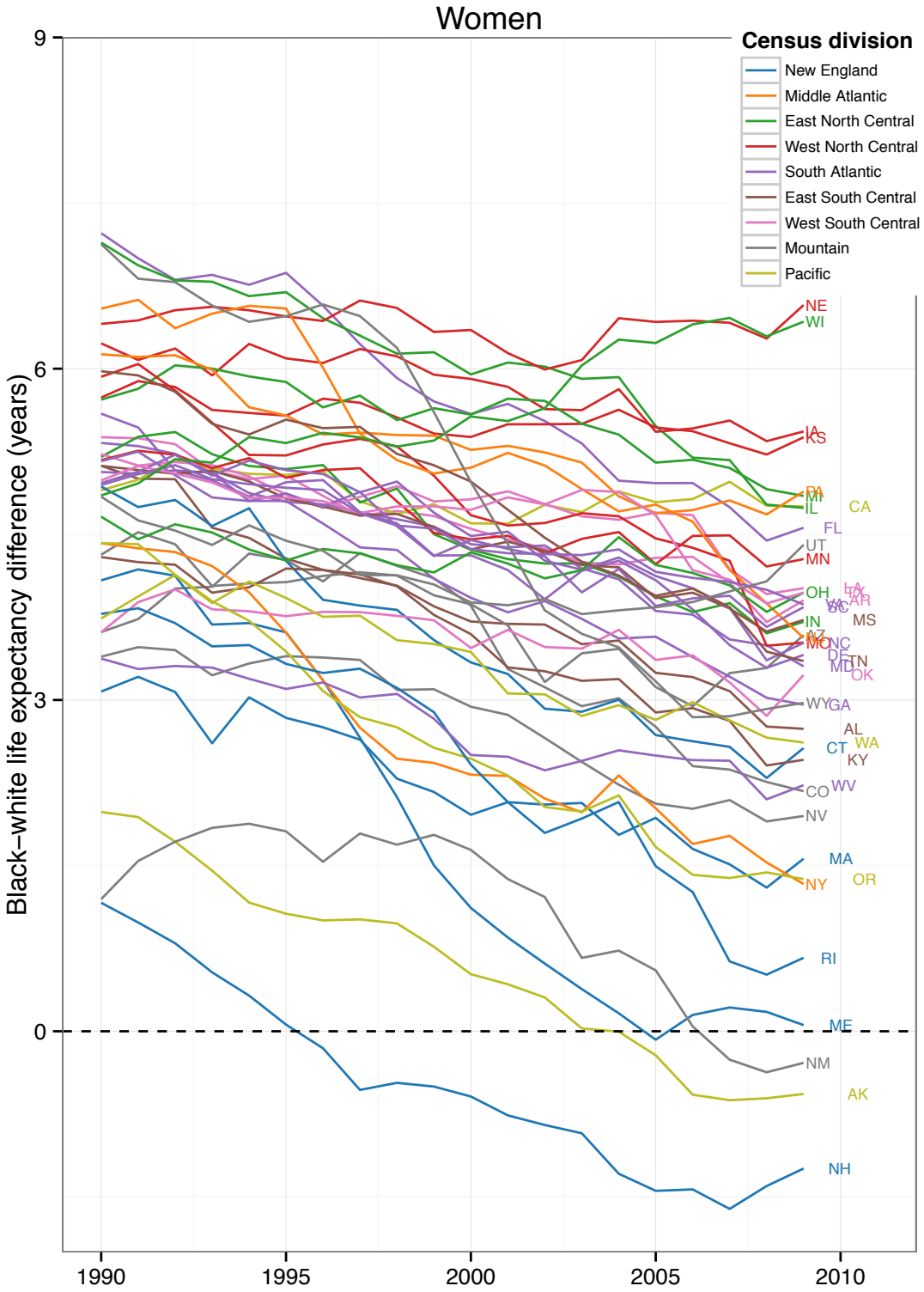
Appendix Exhibit 5: US Census Division Geography (Available at: http://www.census.gov/geo/maps-data/maps/pdfs/reference/us_regdiv.pdf). Accessed 18 Sep 2013.



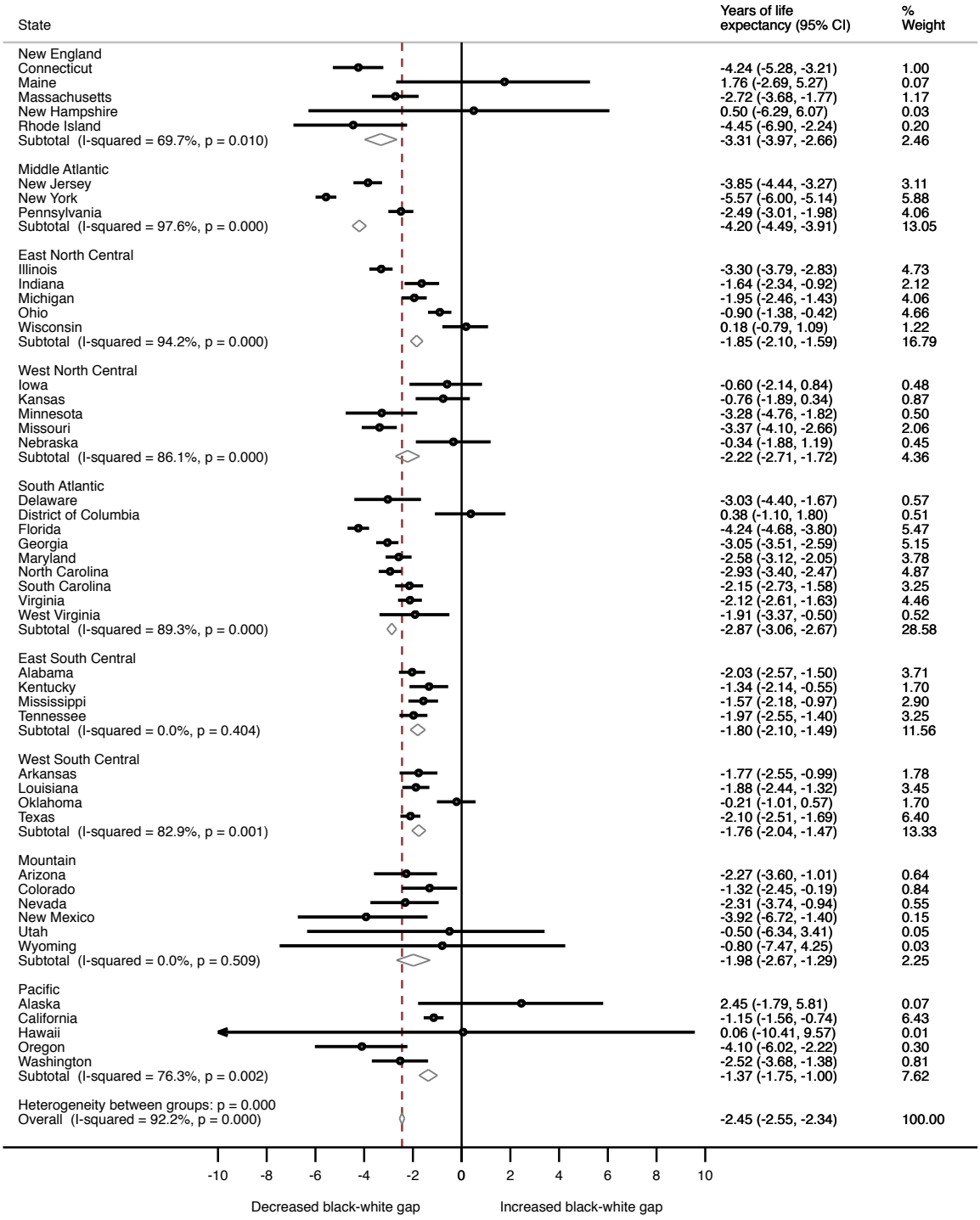
Appendix Exhibit 6: State-Specific Trends in the Black-White Life Expectancy Gap from 1990 to 2009 for Men, Grouped by Census Region. Note: Hawaii and Washington, DC are not shown because they fall outside of the graphed scale.



Appendix Exhibit 7: State-Specific Trends in the Black-White Life Expectancy Gap from 1990 to 2009 for Women, Grouped by Census Region. Note: Hawaii and Washington, DC are not shown because they fall outside of the graphed scale.



Appendix Exhibit 8: State-specific change in the Black-White Life Expectancy Gap for Men, 1990-2009.
Note: Summary estimates are calculated using inverse-variance weighted fixed effects meta-analysis.



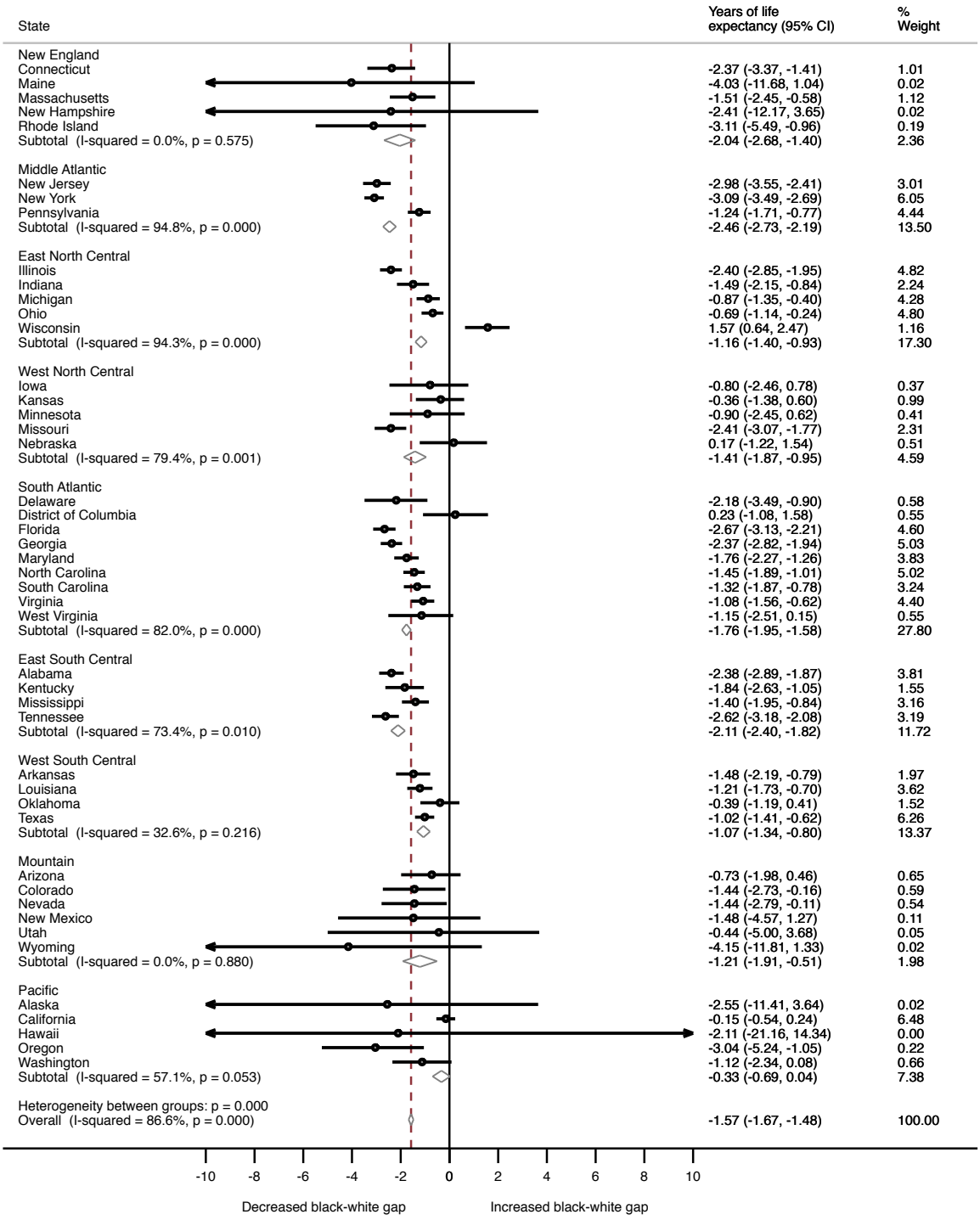
Appendix Exhibit 8A

Change in the Black-White Life Expectancy Gap by Census Division, 1990-2009

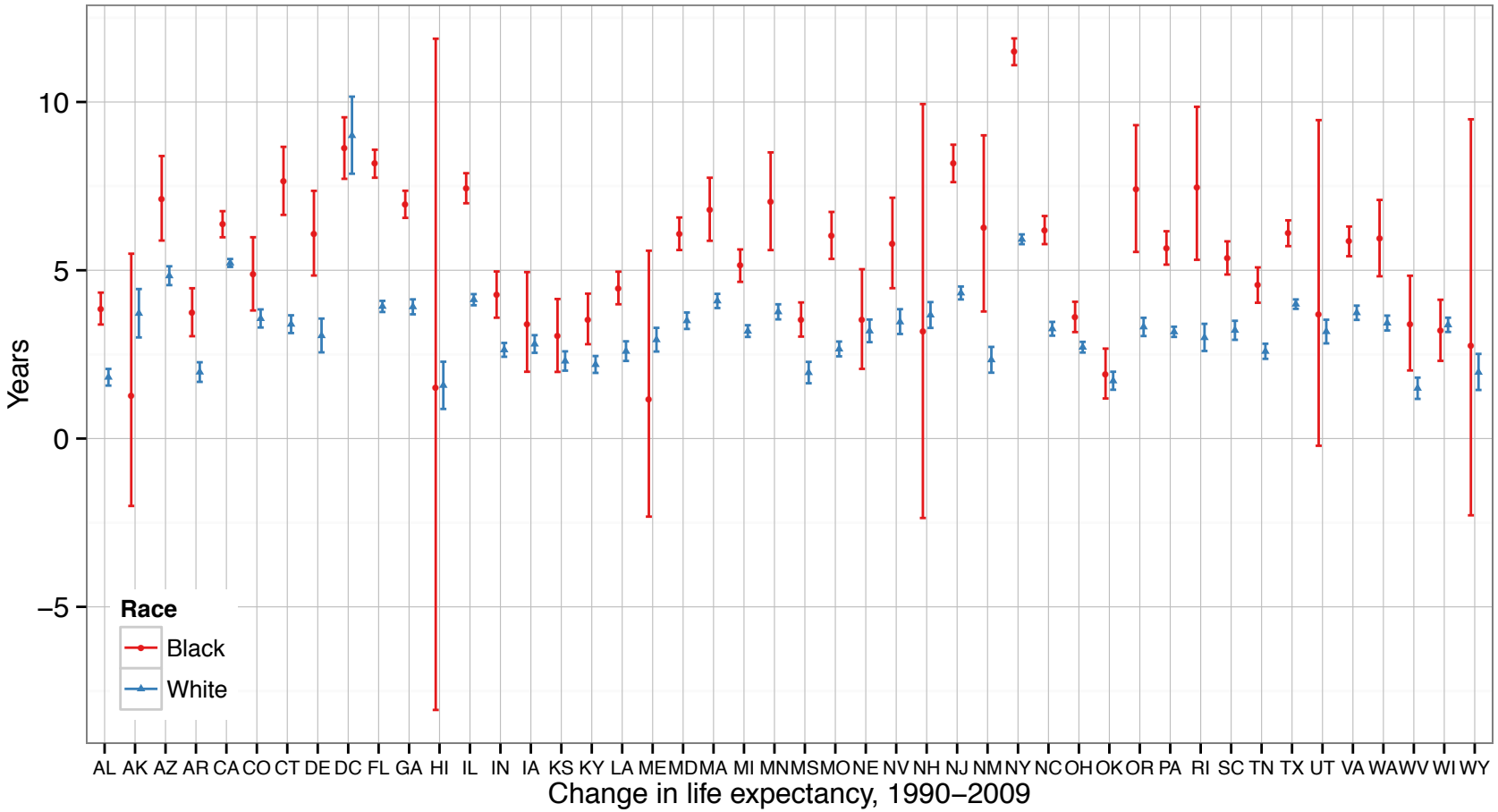
	Change in the black-white life expectancy gap			Tests of heterogeneity within Census division			
	Years	(95% CI)	Weight	Cochran's *Q*	Degrees of freedom	*p-value*	I^2
Men							
New England	-3.32	(-3.97, -2.66)	2.46	13.19	4	0.01	69.70%
Middle Atlantic	-4.20	(-4.49, -3.91)	13.05	83.24	2	0.00	97.60%
East North Central	-1.85	(-2.10, -1.59)	16.79	69.39	4	0.00	94.20%
West North Central	-2.22	(-2.72, -1.72)	4.36	28.72	4	0.00	86.10%
South Atlantic	-2.87	(-3.06, -2.67)	28.58	74.76	8	0.00	89.30%
East South Central	-1.80	(-2.10, -1.49)	11.56	2.92	3	0.40	0.00%
West South Central	-1.76	(-2.04, -1.47)	13.33	17.58	3	0.00	82.90%
Mountain	-1.98	(-2.67, -1.29)	2.25	4.28	5	0.51	0.00%
Pacific	-1.37	(-1.75, -1.00)	7.62	16.86	4	0.00	76.30%
Overall	-2.45	(-2.55, -2.34)	100.00	575.4	45	0.00	92.20%
Women							
New England	-2.04	(-2.68, -1.40)	2.36	2.9	4	0.58	0.00%
Middle Atlantic	-2.46	(-2.73, -2.19)	13.50	38.53	2	0.00	94.80%
East North Central	-1.16	(-1.40, -0.93)	17.30	70.28	4	0.00	94.30%
West North Central	-1.41	(-1.87, -0.95)	4.59	19.38	4	0.00	79.40%
South Atlantic	-1.76	(-1.95, -1.58)	27.80	44.53	8	0.00	82.00%
East South Central	-2.11	(-2.40, -1.82)	11.72	11.29	3	0.01	73.40%
West South Central	-1.07	(-1.34, -0.80)	13.37	4.45	3	0.22	32.60%
Mountain	-1.21	(-1.91, -0.51)	1.98	1.77	5	0.88	0.00%
Pacific	-0.33	(-0.69, 0.04)	7.38	9.32	4	0.05	57.10%
Overall	-1.57	(-1.67, -1.48)	100.00	335.17	45	0.00	86.60%

Source: Authors' analysis of data from the US National Vital Statistics System and the US Census Bureau. Note: Summary estimates are calculated using inverse-variance weighted fixed effects meta-analysis. States with more precise estimates are given larger weight. Cochran's *Q* tests the null hypothesis that the change in the black-white life expectancy gap is the same across states within a division. I^2 is the percentage of variation within each division attributable to heterogeneity across states.

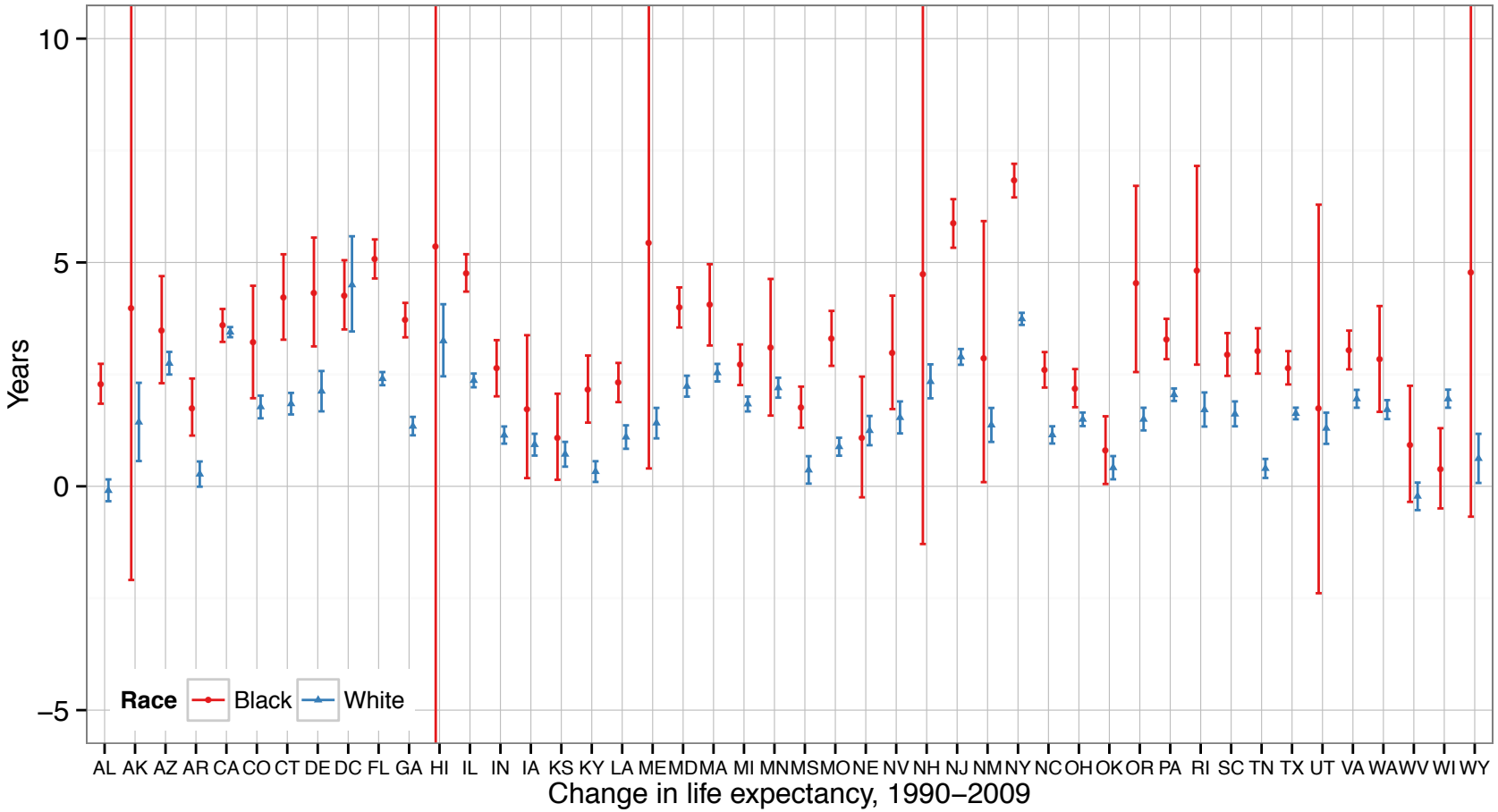
Appendix Exhibit 9: State-specific change in the Black-White Life Expectancy Gap for Women, 1990-2009. Note: Summary estimates are calculated using inverse-variance weighted fixed effects meta-analysis.



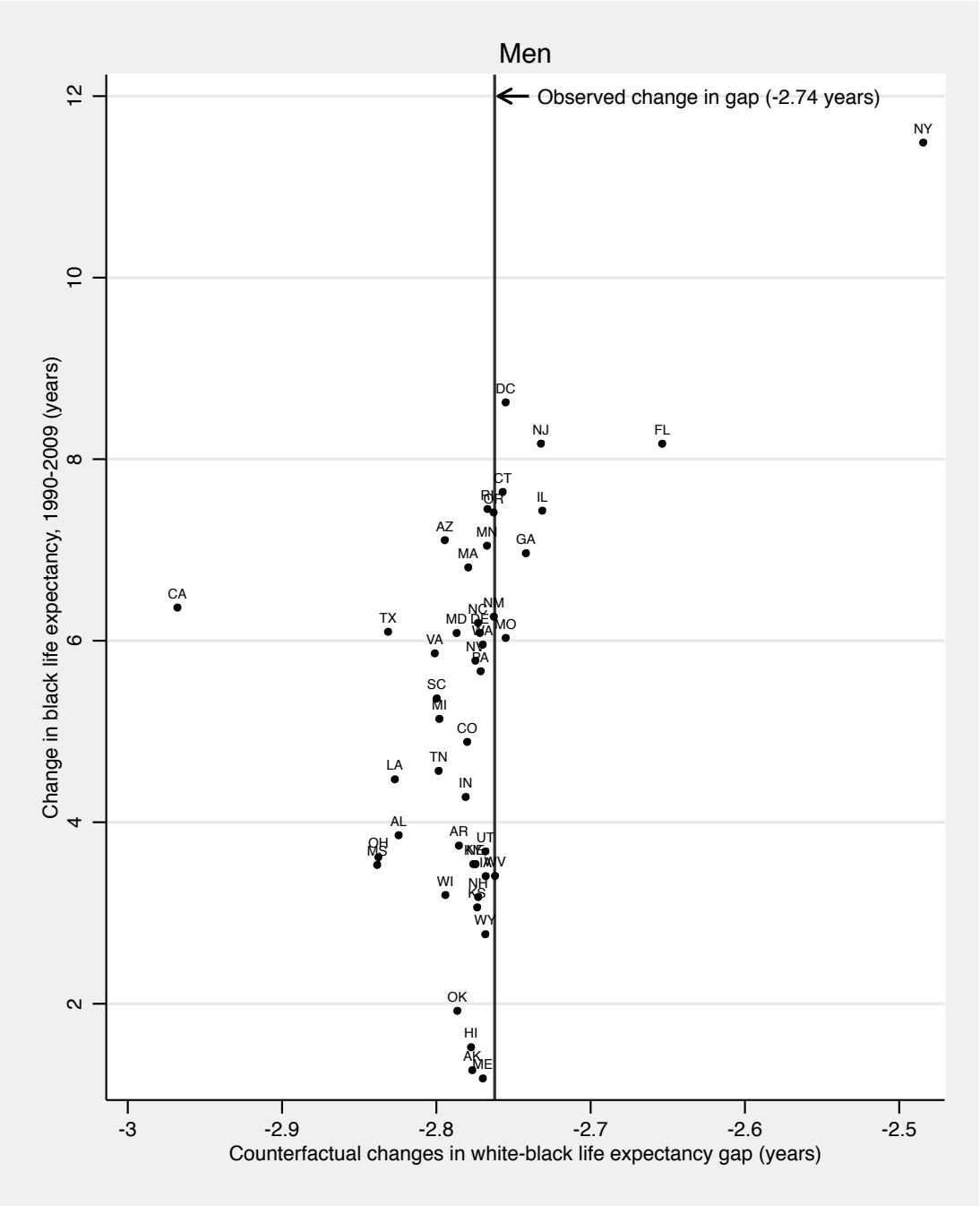
Appendix Exhibit 10: Change in Life Expectancy at Birth for Black and White Men, 1990-2009



Appendix Exhibit 11: Change in Life Expectancy at Birth for Black and White Women, 1990-2009

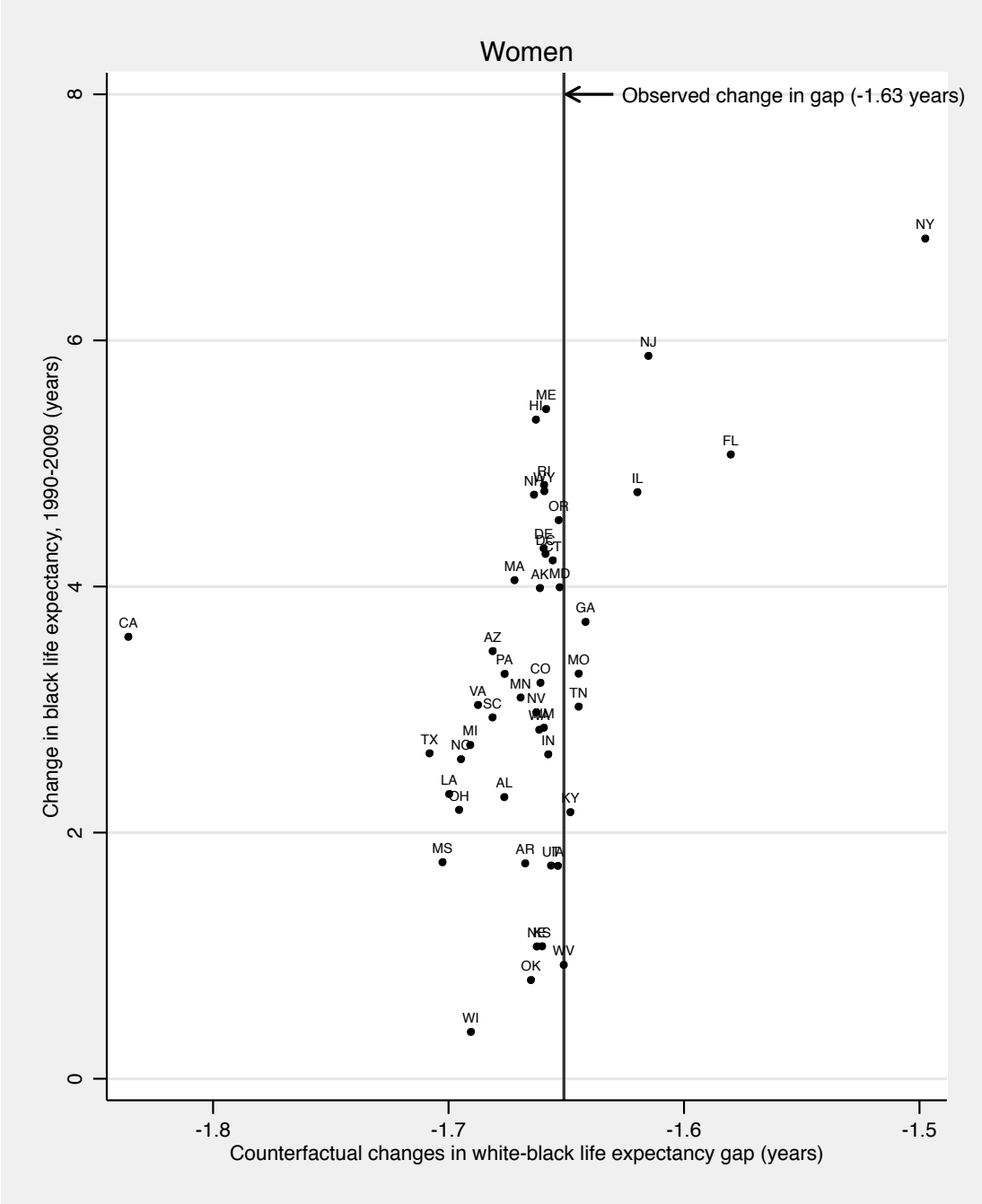


Appendix Exhibit 12: Contribution of each State to the Change in the Black-White Life Expectancy Gap from 1990 to 2009 for Men.



Note: States are ranked from top to bottom by the 20-year change in black life expectancy (vertical axis). The observed national average 20-year change in the black-white life expectancy gap was -2.77 years. The point for each state plotted along the horizontal axis is the deviation from this national average that would have been observed had that state experienced the national average black and white life expectancy growth rather than the observed black and white life expectancy growth.

Appendix Exhibit 13: Contribution of each State to the Change in the Black-White Life Expectancy Gap from 1990 to 2009 for Women.



Note: States are ranked from top to bottom by the 20-year change in black life expectancy (vertical axis). The observed national average 20-year change in the black-white life expectancy gap was -1.63 years. The point for each state plotted along the horizontal axis is the deviation from this national average that would have been observed had that state experienced the national average black and white life expectancy growth rather than the observed black and white life expectancy growth.

Appendix Exhibit 14. Life expectancy at birth for non-Hispanic black and white men by state, 1990 and 2009.

	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
Alabama	64.4	71.2	6.8	(6.5,7.2)	68.0	72.9	4.9	(4.5,5.2)	3.6	1.7	-2.0	(-2.5,-1.4)
Alaska	72.8	73.3	0.5	(-2.4,3.5)	74.3	76.8	2.5	(-1.5,4.4)	1.5	3.5	2.1	(-2.1,5.5)
Arizona	67.1	73.2	6.1	(5.1,7.0)	73.7	77.6	4.0	(2.1,3.8)	6.6	4.5	-2.1	(-3.4,-0.8)
Arkansas	64.2	71.6	7.4	(6.8,8.0)	67.7	73.1	5.4	(5.1,6.1)	3.6	1.6	-2.0	(-2.8,-1.2)
California	64.9	72.4	7.4	(7.1,7.8)	71.2	77.1	5.9	(5.3,5.8)	6.2	4.7	-1.5	(-1.9,-1.1)
Colorado	68.3	74.2	5.8	(5.0,6.7)	73.1	77.6	4.6	(2.9,4.4)	4.7	3.5	-1.3	(-2.4,-0.2)
District of Columbia	57.2	71.6	14.4	(13.3,15.5)	66.0	81.0	14.9	(13.9,16.0)	8.9	9.4	0.5	(-1.0, 2.0)
Delaware	65.6	73.0	7.4	(6.4,8.4)	71.7	76.0	4.3	(3.0,4.5)	6.1	3.0	-3.1	(-4.4,-1.7)
Florida	64.0	73.0	9.0	(8.7,9.3)	71.9	76.4	4.5	(3.3,5.2)	7.9	3.4	-4.5	(-5.0,-4.0)
Georgia	64.1	71.6	7.4	(7.1,7.8)	70.9	74.9	4.0	(13.7,15.7)	6.8	3.4	-3.4	(-3.9,-3)
Hawaii	79.2	73.8	-5.4	(-13.0,0.0)	80.8	74.9	-5.8	(4.4,5.0)	1.6	1.1	-0.5	(-8.8,6.9)
Illinois	62.1	72.8	10.7	(10.3,11)	69.4	76.5	7.1	(4.0,4.6)	7.3	3.7	-3.6	(-4.1,-3.1)
Indiana	65.4	72.3	6.9	(6.4,7.4)	69.7	74.9	5.2	(-18.8,-2.8)	4.2	2.5	-1.7	(-2.4,-1)
Iowa	67.4	74.0	6.6	(5.5,7.8)	70.6	76.7	6.2	(7.2,7.8)	3.1	2.7	-0.4	(-2.0,1.0)
Kansas	66.7	74.0	7.3	(6.5,8.1)	69.6	75.9	6.3	(4.7,5.7)	2.8	1.8	-1.0	(-2.1,0.1)
Kentucky	66.5	71.1	4.6	(4.1,5.2)	69.7	73.1	3.4	(4.8,6.8)	3.3	2.0	-1.2	(-2.0,-0.4)
Maryland	65.9	73.3	7.4	(7.0,7.8)	70.9	76.4	5.6	(5.2,5.9)	5.0	3.2	-1.8	(-2.4,-1.3)
Massachusetts	67.2	73.7	6.5	(5.8,7.2)	73.5	77.7	4.2	(5.5,7.0)	6.3	4.0	-2.3	(-3.2,-1.3)
Michigan	63.7	73.2	9.5	(9.1,9.9)	68.9	76.2	7.4	(2.8,3.9)	5.2	3.0	-2.1	(-2.7,-1.6)
Missouri	63.4	72.4	9.0	(8.5,9.5)	69.3	74.9	5.6	(5.3,6.1)	5.9	2.5	-3.4	(-4.1,-2.7)
Nebraska	66.9	73.9	7.0	(5.9,8.2)	70.2	76.9	6.7	(1.2,6.9)	3.3	3.0	-0.4	(-2.0,1.1)
Nevada	66.0	71.2	5.2	(4.2,6.3)	71.3	73.8	2.5	(5.3,6.0)	5.2	2.6	-2.7	(-4.1,-1.3)
New Jersey	63.7	73.5	9.8	(9.3,10.2)	71.3	77.3	6.0	(1.7,3.0)	7.6	3.8	-3.7	(-4.4,-3.1)

	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
New Mexico	69.6	73.8	4.2	(2.4,6.1)	74.0	75.9	1.9	(6.9,7.6)	4.5	2.1	-2.3	(-5.1,0.1)
New York*	64.2	73.7	9.5	(9.2,9.8)	73.8	77.9	4.2	(3.7,5.7)	9.6	4.2	-5.4	(-5.8,-4.9)
North Carolina	64.4	72.3	7.9	(7.6,8.3)	70.4	75.3	4.9	(4.3,5.1)	6.0	3.0	-3.0	(-3.5,-2.5)
Ohio	65.9	72.6	6.7	(6.3,7.0)	69.3	75.3	5.9	(5.1,6.1)	3.4	2.7	-0.8	(-1.3,-0.3)
Oregon	66.5	73.3	6.8	(5.3,8.2)	73.4	76.4	3.0	(5.3,7.4)	6.9	3.1	-3.8	(-5.7,-1.9)
Pennsylvania	63.1	72.8	9.7	(9.3,10.1)	68.6	75.9	7.3	(1.8,3.5)	5.5	3.1	-2.4	(-3,-1.9)
Rhode Island	65.3	73.8	8.4	(6.8,10.1)	72.1	76.5	4.4	(-3.7,3.7)	6.8	2.8	-4.0	(-6.4,-1.8)
South Carolina	64.1	71.8	7.7	(7.2, 8.1)	70.3	74.9	4.7	(4.3,5.1)	6.1	3.2	-3.0	(-3.6,-2.4)
Tennessee	64.5	71.4	6.9	(6.5,7.4)	68.6	73.7	5.1	(4.9,5.7)	4.2	2.3	-1.9	(-2.5,-1.3)
Texas	65.0	72.0	7.1	(6.7,7.4)	70.9	75.3	4.4	(-3.3,0.6)	6.0	3.3	-2.7	(-3.1,-2.2)
Utah	71.2	75.1	3.9	(0.9,7.3)	74.0	78.1	4.1	(2.1,2.7)	2.8	3.0	0.2	(-4.6,3.6)
Washington	68.0	73.9	5.9	(5.0,6.8)	73.8	77.1	3.3	(4.6,5.2)	5.8	3.2	-2.6	(-3.7,-1.4)
West Virginia	65.3	70.7	5.4	(4.4,6.5)	68.6	72.1	3.6	(5.5,6.1)	3.3	1.4	-1.8	(-3.3,-0.4)
Wisconsin	66.1	73.9	7.8	(7.1,8.5)	69.1	77.2	8.2	(3.6,4.7)	3.0	3.4	0.4	(-0.5,1.3)
Wyoming	69.0	73.4	4.4	(-0.3,10.1)	72.2	75.4	3.2	(1.1,3.5)	3.2	2.0	-1.2	(-7.8,3.8)
Weighted Average	64.4	72.8	8.4		70.7	76.2	5.5		6.3	3.4	-2.9	

*Note: The estimate in the 1990 column for New York is from 1994, the first year it was considered to have reliable mortality by non-Hispanic status.

Appendix Exhibit 15. Life expectancy at birth for non-Hispanic black and white women by state, 1990 and 2009.

	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
Alabama	73.7	78.8	5.1	(4.8,5.5)	75.8	78.6	2.7	(2.4,3.1)	2.1	-0.2	-2.3	(-2.8,-1.8)
Alaska	77.0	80.0	3.1	(-3.8,6.7)	80.5	81.3	0.8	(-5.8,4.6)	3.6	1.3	-2.3	(-10.2,3.4)
Arizona	75.3	80.1	4.8	(3.4,5.2)	78.1	82.6	4.5	(3.7,5.2)	2.8	2.6	-0.3	(-1.5,0.9)
Arkansas	73.5	78.9	5.4	(4.9,5.9)	75.2	79.0	3.8	(3.3,4.2)	1.7	0.0	-1.6	(-2.3,-1.0)
California	73.6	78.9	5.2	(4.6,5.2)	77.1	81.9	4.8	(4.5,5.1)	3.5	3.1	-0.5	(-0.9,-0.1)
Colorado	75.9	80.1	4.3	(2.6,4.6)	78.8	81.9	3.1	(2.2,3.9)	2.9	1.8	-1.2	(-2.5,0.1)
District of Columbia	71.1	81.4	10.3	(9.5,11.2)	75.5	85.5	10.0	(9.1,11.1)	4.4	4.1	-0.3	(-1.6,1.0)
Delaware	73.2	78.8	5.6	(4.2,5.7)	77.5	81.0	3.4	(2.6,4.3)	4.4	2.2	-2.2	(-3.5,-0.9)
Florida	73.2	80.3	7.1	(4.7,6.5)	78.0	82.5	4.4	(4.1,4.7)	4.9	2.1	-2.7	(-3.2,-2.3)
Georgia	73.7	79.1	5.4	(9.5,11.2)	77.3	80.0	2.7	(2.5,3.0)	3.6	1.0	-2.6	(-3.1,-2.2)
Hawaii	82.9	79.7	-3.2	(6.9,7.6)	87.9	82.4	-5.5	(-19.5,1.3)	5.0	2.7	-2.3	(-18.4,11.4)
Illinois	72.3	79.3	6.9	(5.0,5.7)	77.0	81.4	4.4	(4.1,4.7)	4.6	2.1	-2.5	(-3.0,-2.1)
Indiana	73.8	79.0	5.2	(-21.5,2.0)	76.3	80.1	3.7	(3.2,4.2)	2.6	1.1	-1.5	(-2.2,-0.8)
Iowa	74.4	80.7	6.4	(6.8,7.5)	75.9	81.6	5.8	(4.6,6.9)	1.5	0.9	-0.6	(-2.2,1.0)
Kansas	74.6	80.6	6.0	(4.7,5.7)	75.5	80.9	5.4	(4.7,6.1)	0.9	0.3	-0.6	(-1.7,0.4)
Kentucky	74.1	78.3	4.2	(5.0,7.5)	76.0	78.5	2.5	(2.0,3.0)	2.0	0.2	-1.8	(-2.6,-1.0)
Maryland	75.0	79.2	4.2	(3.8,4.6)	77.9	81.1	3.2	(2.9,3.5)	2.9	1.9	-1.0	(-1.5,-0.5)
Massachusetts	75.8	79.9	4.2	(5.0,6.5)	79.4	82.4	3.1	(2.5,3.6)	3.6	2.5	-1.1	(-2.0,-0.2)
Michigan	73.3	79.3	5.9	(3.7,4.9)	76.1	81.0	4.9	(4.6,5.3)	2.7	1.7	-1.0	(-1.5,-0.5)
Missouri	73.4	79.4	5.9	(4.9,5.6)	76.6	80.2	3.5	(3.1,3.9)	3.2	0.8	-2.4	(-3.1,-1.8)
Nebraska	73.9	80.6	6.6	(0.6,8.0)	74.8	81.6	6.8	(5.8,7.8)	0.9	1.1	0.2	(-1.2,1.6)
Nevada	74.5	77.9	3.4	(4.7,5.4)	77.0	78.8	1.8	(1.0,2.6)	2.5	0.9	-1.6	(-3.0,-0.4)
New Jersey	72.6	79.4	6.8	(2.4,3.8)	77.8	81.9	4.1	(3.7,4.4)	5.3	2.5	-2.8	(-3.3,-2.2)

	1990				2009				Change, 2009-1990			
	Black	White	Gap	95% CI	Black	White	Gap	95% CI	Black	White	Gap	95% CI
New Mexico	77.1	79.9	2.8	(5.4,6.1)	78.8	81.0	2.2	(0.4,3.9)	1.7	1.1	-0.6	(-3.3,1.9)
New York*	74.1	79.7	5.6	(4.0,6.3)	79.9	82.6	2.7	(2.4,3.0)	5.7	2.9	-2.9	(-3.3,-2.5)
North Carolina	74.6	79.5	5.0	(4.7,5.5)	77.1	80.6	3.5	(3.2,3.8)	2.5	1.0	-1.5	(-1.9,-1)
Ohio	74.2	78.9	4.6	(5.5,6.4)	76.3	80.3	4.1	(3.8,4.4)	2.0	1.5	-0.6	(-1,-0.1)
Oregon	74.9	79.5	4.7	(5.3,7.5)	78.9	80.9	2.0	(0.6,3.3)	4.0	1.4	-2.6	(-4.8,-0.7)
Pennsylvania	72.9	79.2	6.3	(2.3,4.4)	76.0	81.2	5.2	(4.9,5.5)	3.1	2.0	-1.1	(-1.6,-0.7)
Rhode Island	74.5	80.0	5.5	(-3.9,6.2)	79.2	81.5	2.3	(0.6,3.9)	4.7	1.5	-3.2	(-5.7,-1.0)
South Carolina	73.8	79.0	5.2	(4.7,5.6)	77.4	80.6	3.3	(2.9,3.6)	3.5	1.6	-1.9	(-2.5,-1.4)
Tennessee	73.1	79.0	5.8	(6.1,7.0)	75.8	79.2	3.4	(3.0,3.8)	2.7	0.3	-2.4	(-3.0,-1.9)
Texas	74.4	79.4	5.0	(-1.2,3.5)	76.8	80.4	3.6	(3.3,3.8)	2.5	1.0	-1.5	(-1.8,-1.0)
Utah	74.1	80.8	6.7	(4.1,4.7)	75.4	82.0	6.6	(3.9,8.9)	1.3	1.1	-0.2	(-4.1,3.2)
Washington	75.9	79.8	3.9	(4.6,5.3)	78.5	81.4	2.8	(2.0,3.6)	2.6	1.6	-1.0	(-2.3,0.2)
West Virginia	74.7	78.0	3.4	(4.3,5.0)	75.5	77.7	2.3	(1.3,3.2)	0.8	-0.3	-1.1	(-2.4,0.2)
Wisconsin	75.2	80.2	5.0	(3.0,4.2)	75.5	82.1	6.7	(6.1,7.2)	0.3	1.9	1.7	(0.8,2.6)
Wyoming	71.3	79.7	8.3	(3.0,5.9)	75.8	80.2	4.4	(-0.5,8.6)	4.4	0.5	-3.9	(-11.0,1.5)
Weighted Average	73.7	79.4	5.7		77.3	81.2	3.9		3.6	1.8	-1.8	

*Note: The estimate in the 1990 column for New York is from 1994, the first year it was considered to have reliable mortality by non-Hispanic status.