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Socio-Economic Status and Life Expectancy in the United States, 1990-2010: Are We Reaching the Limits of Human Longevity?

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Abstract

This study updates earlier findings regarding changes in the relationship between socio-economic status (SES) and life expectancy (at birth) between 1970 and 1990. In a sample randomly drawn from each of eight of the nine census divisions of the United States, the earlier study found that High SES populations in seven of the eight states gained additional life expectancy over Low SES populations between 1970 and 1990. In the remaining state, the gap between High and Low SES populations found in 1970 narrowed by 1990, but did not disappear. Thus, High SES populations had higher average life expectancy than Low SES populations both in 1970 and in 1990. In the process of conducting this research, it became apparent that the life expectancy gains observed between 1970 and 1990 for both low and High SES populations did not continue from 1990 to 2010. This finding was neither wholly unexpected nor an active focus of the research. However, because the finding fits within the debate on the limits to human longevity, it seemed worthwhile to report it. Thus, the current study offers two major findings. First, the average life expectancy gap between high and Low SES populations found in 1990 has persisted to 2010; second, average life expectancy gains are far less for the Low SES population between 1990 and 2010 than was found for 1970 to 1990; and third, average life expectancy gains for the High SES populations effectively came to a halt between 1990 and 2010. These results have implications for the relationship between social inequality and health outcomes. They also confirm that the United States did not meet one of two key national health policy goals: the elimination of health disparities by 2010.

Keywords

Health outcomes, human longevity, policy goals, health disparities

Background

Using a sample of eight states, Swanson, McGehee and Hoque (2009) found that High SES populations in seven of them gained additional average life expectancy (at birth) between 1970 and 1990 over Low SES populations. In the one state where the gap was narrowed, the High SES populations retained a statistically significant difference over the average life expectancy of the Low SES populations. Thus, the High SES populations in the sample enjoyed higher average life expectancy both in 1970 and 1990 than the Low SES populations.

The years 1970 and 1990 were selected in the initial study because they represented what may be regarded as the "bookends" of a pivotal social policy period in the U. S., where federal support of social welfare programs was at a high point circa 1970 (via the New Deal under Roosevelt and the War on Poverty under Johnson, among other programs), but by 1990 (shortly after the end of the Reagan era) federal support was significantly smaller (Reese 2005, Stockwell, Goza and Balisteri 2005). The decline in federal support during the 1970-1990 period coincided with growing SES inequality in the United States.[1] Weinberg (1996) found, for example, that the distribution of income among households was more equal in 1970, which had a Gini Ratio of .394 than in 1990 when the Gini Ratio reached .428, an increase of nearly 9 percent. The pace of the increase in inequality has not slowed since 1990. By 2010, the Gini Index reached the highest level recorded by the Census Bureau: .469 (DeNavas-Walt, Proctor and Smith 2011). This is nearly a 10 percent increase since 1990.

The years 1990 to 2010 are of interest in that they provide an opportunity to examine the relationship between life expectancy and SES in the face of the continued increase in US income inequality. The current study is basically an update of the earlier study. It uses the same sample of eight states. Thus, we look at changes in life expectancy between 1990 and 2010 for the high and Low SES populations within the same eight states.

Socio-Economic Status (SES) and Life Expectancy[2]

Massey (2007) argues that race and gender form two of the three pillars of the social stratification system in the United States and that SES makes up the third. SES has been linked in many studies to mortality differentials (Congressional Budget Office 2008; Ezzati et al. 2008; Gortmaker and Wise 1997; James and Cossman 2006; Hummer 2005; Kitagawa and Hauser 1973; McGehee 1994; Rogers, Hummer and Nam 2000; Singh and Siahpush 2006; Stockwell 1961; Stockwell 1963; Stockwell and Laidlaw 1977; Stockwell and Wicks 1984; Stockwell, Swanson and Wicks 1987; Stockwell, Swanson and Wicks 1988a; Stockwell, Swanson and Wicks 1988b; Stockwell, Goza and Balisteri 2005; Stockwell, Bedard, Swanson and Wicks 1987; Swanson, McGehee and Hoque 2009). Because of the pervasiveness of the findings, Hummer (2005) postulated that SES differences are fundamental causes of health disparities in the United States, a postulation also made by Link and Phelan (1995).

Life expectancy is arguably the single most important indicator of the general health of a population (Lamb and Siegel 2004), and it has long been documented that variations in life expectancy exist among the broad geographic divisions within the United States, as well as among individual states (Dublin et al. 1949; Glover 1921; Oosse 2003). More recently, these variations have been documented at the county level (Ezzati et al. 2008; Glover 1921, Kulkarni et al. 2011; Oosse 2003; Singh and Siahpush 2006; Swanson, McGehee and Hoque 2009).

Limits to Life Expectancy

There is debate on the limits of human longevity. Some scholars argue that we are on the cusp of a major breakthrough that will dramatically increase life expectancy (de Grey 2002; Kurzweil 2005). Others feel that the historical record suggests that life expectancy will reach 100 years by 2060 (Oeppen and Vaupel 2002). Still others argue that unless aging can be slowed down, continued increases are not likely (Olshansky and Carnes 2009). Intertwined with the debate on the limits of human longevity is the issue of health disparities, particularly along SES and race lines (Ezzati et al. 2008; Kulkarni et al. 2011; Oosse 2003). While it may be the case that a major breakthrough is in our future, there is no evidence to suggest that it has already happened. Neither is there evidence to suggest that we are yet able to slow down aging. Consequently, what can be empirically assessed at this point in time is the argument presented by Olshansky and Carnes (2009) that continued increases are not likely. Thus, as a secondary objective, this paper looks at this argument from the standpoint of the data used in the current study.

Materials and Methods

The states examined in this study are the same as those selected in the earlier study, in which details of the sample design and selection process can be found (Swanson, McGehee and Hoque 2009). The set of states included in the analysis is listed in Table 1 by Census Division.

Table 1. States Included in the Analysis, by Census Division

Census Division	State	Number of Counties*
East North Central	Ohio	88
East South Central	Mississippi	83
Middle Atlantic	Pennsylvania	67
Mountain	Colorado	63
Pacific	Washington	39
South Atlantic	Florida	67
West North Central	South Dakota	66
West South Central	Louisiana*	64

*In Louisiana, parishes are used as county equivalents.

For the same reasons that a regression-based model was used by Swanson, McGehee and Hoque (2009) to estimate life expectancy by county for these eight states in 1970 and 1990, a regression-based technique is used to estimate life expectancy at birth by county for these same eight states in 1990 and 2010.[3] The model used here was constructed using 2000 state-level census and life table data.[4] The 2000 data were used because they represent the mid-point between 1990 and 2010. This follows the procedure used by Swanson, McGehee and Hoque (2009), who used a regression model constructed from 1980 state-level census and life table data that represented the mid-point between 1970 and 1990.

The model used here is defined as:

$$e_o = 78.9 - (1.295{*}CDR) + (.7322{*}P65+) \qquad [1]$$
$$[p<.01] \qquad [p<.01] \qquad [p<.01]$$

$R^2 = .678$
Adj $R^2 = .665$
N = 51
S.E.E. = .879

where

e_o	is life expectancy at birth
CDR	is the Crude Death Rate (expressed as deaths per 1000 population)
P65+	is the percent of the population aged 65 & over

The data used to construct the preceding regression model are taken from 2000 census data (U.S. Census Bureau (No Date 1), 2000 mortality data (Miniño et al. 2002) and 2000 life tables (U.S. Census Bureau 2005).

The model described in Equation [1] was used to estimate 1990 and 2010 life expectancy for all of the counties in each of the eight states shown in Table 1. County level mortality data (in the form of total deaths to residents) needed to estimate 1990 county life expectancy values are taken from 1990 vital statistics reports produced by the U.S National Center for Health Statistics (1994). The 2010 county level mortality data (in the form of total deaths to residents) required to estimate life expectancy in 2010 were provided by the health departments in the each of the eight states. The 1990 total county population data and the population aged 65 years and over for 1990 are from the U.S. Bureau of the Census (1992). The 2010 total county population data and the population aged 65 years and over are taken from the U.S. Census Bureau's "American Factfinder" (http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml).

As was done in the earlier study in regard to 1970 and 1990, county populations are grouped into two sets for 1990 and 2010: (1) Low SES and High SES, based on the 1st and 5th quintiles in regard to median household income. Washington has only 39 counties, so the first and fourth quartiles are used to group its county populations into Low and High SES sets, respectively. Median household income data for 1990 are taken from a special report by the Census Bureau (No Date 2). Because the 1990 census asked for income in the preceding year, the median income data are actually for 1989. The 2010 median household income data are taken from a series of files produced by the US Bureau of Labor Statistics (2011). All 2010 amounts are expressed in 1989 dollars.

In the earlier study, the change in life expectancy between 1970 and 1990 was measured using a dummy variable regression model constructed for each of the two SES populations by state to measure change in life expectancy. This method is also used to measure life expectancy changes between 1990 and 2010. The general form of the model is:

$$e_o = a + b(YR) \qquad [2]$$

where

- e_o is life expectancy in 1990 and 2010 for a given SES population as found from Equation [1]
- a is the intercept (1990 mean life expectancy for the same SES population)
- b is the change in mean life expectancy between 1990 and 2010 for the SES population in question
- YR is a dummy variable for year (YR=0, in 1990; YR=1, in 2010)

The two-tailed test (α=.05) is applied to the slope coefficient, b, in each of the two equations to determine if there is a statistically significant change in life expectancy for the SES population in question. Because there is a positive correlation between life expectancy for each SES population in 1990 and 2010, the standard error is diminished. However, this effect is mediated by the extremely small sample sizes, and the net result is that a given t-test is not highly subject to a Type I error. The null hypothesis is that there is no change (i.e., b=0); and the alternative hypothesis is that there is change (i.e., $b \neq 0$).

In addition to the dummy regression, the (unequal variance) one-tailed t-test is used to assess whether or not a difference in average life expectancy exists between the High and Low SES populations within a given state in 1990 and again in 2010.

As should be clear, the analytical unit consists of a county population classified by SES status (High or Low). Thus, the study follows an "ecological" design. No attempt is made to cross the "group-level/individual-level" boundary, so the analysis itself is not subject to the "ecological fallacy" (Freedman 2002). This follows what was done in the earlier study (Swanson, McGehee and Hoque 2009).

In the original study, Swanson, McGehee and Hoque (2009) discussed several methodological issues that also concern the present study. We reproduce the discussion of these issues here. First, the study uses cross-sectional data at two points in time. This type of analysis is a natural approach given that a period-based measure of life expectancy measure is being used, which is itself cross-sectional in nature. The second issue is comprised of fertility and migration, which along with mortality form the components of population change. All three of these components of population change affect the High and Low SES populations examined here between 1970 and 1990. Migration is particularly salient. The third issue is the social mobility of a given population, where it might be upward or downward. Both of these issues can interact with one another, so it is useful to address them together.

In regard to the second issue, consider that a Low SES (county) population in 1990 could be impacted by migration such that by 2010 this (county) population is no longer in the Low SES group. Similarly, a High SES population in 1990 could be impacted by migration such that it is no longer in this group by 2010. The third issue, social mobility, for a given population can be viewed as a variation on the second issue, whereby it is not the coming and going of people that affect changes in SES but, rather, income changes specific to the population. For example, it could be the case that a major source of employment comes into being in a county subsequent to 1990 that improves the household incomes of the residents. Similarly, a major source of employment in 1990 may no longer be in the county in 2010 and, as such, household incomes are depressed. Finally, it can be through a combination of migration and social mobility that the county populations change in terms of SES groups between 1990 and 2010.

It is for precisely these reasons that the analysis reported here does not attempt to follow a population in a given SES set in 1990 into 2010. Instead, the analysis examines the Low and High SES populations as found at each of the two time points. This is entirely appropriate because the period (cross-sectional) life table needs to be matched with cross-sectional (period) SES groups. By doing this, the analysis remains on track to its goal – the association of SES with a period-based measure of life expectancy. It simultaneously provides a tractable solution to the issue of dealing with temporal effects such as upward and downward social mobility and migration.

Results

The estimated life expectancy values for each of the two SES populations in 1990 and 2010, by county, are given for each state in Tables 2a through 9a and 2b through 9b, respectively.

As just described, two dummy variable regression equations were used to examine change in life expectancy, one for each SES population within each of the eight states in the sample. These equations are found in for each state in tables 2c through 9c, respectively. At the conclusion of this section, dummy regression summaries are shown for all of the counties taken together by SES (n = 218 for Low SES populations and n = 220 for High SES populations). The results for the low and High SES populations are found in Table 10.

Colorado

In Colorado, there appears to be no change in life expectancy for either High SES or Low SES populations between 1990 and 2010. The significance of the slope coefficient (which shows the change in life expectancy) in both cases is $p > .05$.

The T-Test (1 tailed, unequal variance, α =.05) for 1990 finds no statistically significant difference in average life expectancy (e_0) between High and Low SES populations. However, the T-Test results find such a difference in 2010 such that average e_0 for High SES populations (78.95) is higher than average e0 for Low SES populations (76.31), a difference of 2.64 years.

High SES populations gained only a marginal number of additional years (an increase of 0.37 years), while Low SES populations lost 2.46 years between 1990 and 2010.

Table 2a. 1990 and 2010 Life Expectancy at Birth for
Low SES Populations (by Quintile) in Colorado

County	1990 Life Expectancy	County	2010 Life Expectancy
Baca	77.52	Alamosa	75.61
Bent	75.54	Baca	74.93
Conejos	79.76	Bent	74.80
Costilla	79.04	Conejos	76.74
Crowley	80.71	Costilla	84.87
Delta	78.54	Crowley	77.96
Huerfano	78.98	Huerfano	71.18
Las Anima	76.29	Otero	76.92
Otero	76.66	Prowers	73.85
Rio Grande	77.75	Saguache	77.99
Saguache	79.32	San Juan	75.26
Sedgwick	85.18	Sedgwick	75.58
MEAN	78.77	**MEAN**	76.31

Table 2b. 1990 and 2010 Life Expectancy at Birth for
High SES Populations (by Quintile) in Colorado

County	1990 Life Expectancy	County	2010 Life Expectancy
Arapahoe	78.31	Boulder	78.51
Boulder	78.20	Clear Creek	75.21
Clear Creek	78.35	Douglas	79.15
Douglas	78.87	Eagle	79.74
Eagle	78.70	El Paso	78.45
Elbert	77.65	Gardield	78.66
Gilpin	79.51	Gilpin	78.40
Jefferson	77.67	Jefferson	78.36
Moffat	78.44	Park	79.43
Park	79.39	Pitkin	81.71
Pitkin	79.46	Routt	78.64
Summit	79.70	San Miguel	79.44
Teller	77.86	Summit	80.68
MEAN	78.62	**MEAN**	78.95

Table 2c. Dummy Regression and Statistical Test Results: Changes in Life
Expectancy by SES Population in Colorado between 1990 and 2010

SES	a	b	Se(b)	T-score	*P*(b=0)	r^2
Low	78.77	-2.47	1.19	-2.065	> 0.05	.16
High	78.62	0.33	0.46	0.71	> 0.05	.02

Florida

In Florida, average life expectancy increased between 1990 and 2010 for both High and Low SES populations. While the gap between the average life expectancy of Low SES populations and the average life expectancy of High SES populations in FL narrowed between 1990 and 2010, the statistically significant gap found in 1990 remained in 2010.

The T-test (1-tailed, unequal variance, α =.05) finds a statistically significant difference in life expectancy (e_0) between High and Low SES populations in 1990. High SES populations in 1990 had an average e_0 of 76.3 compared to Low SES average e_0 of 72.72, a difference of 3.58 years.

In 2010, the gap narrowed slightly to a difference of 2.76 years, with both High and Low SES populations gaining life expectancy. However, the Low SES population had a greater gain in life expectancy between 1990 and 2010 than the High SES population. The T-test results (1-tailed, unequal variance, α =.05) for 2010 also demonstrate a statistically significant difference in life expectancy, but that the Low SES population gained more ground overall than the High SES population, in that the Low SES population rose to an average e_0 of 77.4 years in 2010 and gained 4.68 years, while the High SES population rose to an average e_0 of 80.16 in 2010 and gained 3.86 years. Although there is still a significant gap of nearly three years between the populations, the average e_0 of the Low SES population is increasing relatively more quickly than that of the High SES population.

Table 3a. 1990 and 2010 Life Expectancy at Birth for Low SES Populations (by Quintile) in Florida

County	1990 Life Expectancy	County	2010 Life Expectancy
Calhoun	72.05	Calhoun	76.51
Dixie	73.31	Columbia	75.99
Franklin	74.24	DeSoto	79.99
Gasden	74.54	Dixie	78.58
Hamilton	75.35	Franklin	76.38
Holmes	72.92	Hamilton	77.21
Jackson	72.93	Hardee	79.32
Levy	70.08	Highlands	82.71
Madison	73.86	Holmes	73.89
Putnam	71.90	Levy	75.94
Sumter	71.66	Madison	76.69
Suwanee	69.86	Putnam	75.60
Washington	72.69	Taylor	77.35
MEAN	72.72	**MEAN**	77.40

Table 3b. 1990 and 2010 Life Expectancy at Birth for
High SES Populations (by Quintile) in Florida

County	1990 Life Expectancy	County	2010 Life Expectancy
Clay	76.45	Clay	77.21
Collier	76.63	Collier	85.72
Duval	73.54	Duval	76.26
Flagler	76.30	Indian River	82.10
Indian River	76.55	Martin	83.32
Martin	79.32	Monroe	78.31
Monroe	74.27	Nassau	78.55
Nassau	73.49	Okaloosa	77.86
Orange	76.87	Palm Beach	81.75
Palm Beach	76.61	St. Johns	79.90
St. Lucie	76.21	Santa Rosa	77.77
Santa Rosa	74.64	Sarasota	83.71
Sarasota	81.01	Wakulla	79.66
MEAN	76.30	**MEAN**	80.16

Table 3c. Dummy Regression and Statistical Test Results: Changes in Life Expectancy by SES Population in Florida between 1990 and 2010

SES	a	b	Se(b)	T-score	*P*(b=0)	r^2
Low	72.72	4.68	0.77	6.03	< 0.001	.60
High	76.30	3.86	1.00	3.87	< 0.001	.38

Louisiana

In Louisiana, there appears to be a gain in average life expectancy for Low SES populations between 1990 and 2010, but no change for High SES populations during the same period. The T-Test results show that High SES populations have higher average life expectancy than Low SES populations in 1990 but not in 2010.

The T-test (1-tailed, unequal variance, α =.05) finds a statistically significant difference in life expectancy (e_0) between High and Low SES populations in 1990. High SES populations in 1990 had an average e_0 of 76.23 compared to Low SES average e_0 of 74.62, a difference of 1.6 years. In 2010, the gap basically disappeared, with High SES populations showing essentially no change from 1990 while Low SES populations showed an increase of 1.74 years. The T-test results (1-tailed, unequal variance, α =.05) for 2010 demonstrate that difference between average life expectancy for the High SES populations and Low SES populations in 2010 is not statistically significant.

Table 4a. 1990 and 201 Life Expectancy at Birth for
Low SES Populations (by Quintile) in Louisiana

Parish	1990 Life Expectancy	Parish	2010 Life Expectancy
Avoyelles	76.19	Beauregard	76.74
Catahoula	76.55	East Baton Rouge	76.50
East Carroll	73.48	East Carroll	73.94
Evangeline	75.02	Iberia	75.53
Franklin	75.31	La Salle	77.07
Madison	70.81	Lafourche	76.14
Natchitoches	75.93	Ouachita	76.16
Red River	75.35	Red River	77.88
Richland	73.45	St. Landry	74.88
St. Helena	74.61	St. Martin	76.47
St. Landry	73.87	Union	75.89
Tensas	73.55	Vermilion	77.05
West Feliciana	75.91	West Baton Rouge	78.48
MEAN	74.62	**MEAN**	76.36

Table 4b. 1990 and 2010 Life Expectancy at Birth for
High SES Populations (by Quintile) in Louisiana

Parish	1990 Life Expectancy	Parish	2010 Life Expectancy
Ascension	75.49	Avoyelles	73.90
Bossier	76.37	Calcasieu	75.47
Calcasieu	75.99	De Soto	75.44
Cameron	77.68	Evangeline	73.92
East Baton Rouge	76.25	Jefferson Davis	74.60
Jefferson	76.12	Lafayette	76.84
La Salle	76.64	Livingston	76.73
Livingston	76.56	Pointe Coupee	77.55
St. Bernard	75.98	St. Helena	73.58
St. Charles	76.65	St. Tammany	76.97
St. John the Baptist	75.95	Tensas	75.86
St. Tammany	76.10	Terrebonne	75.96
West Baton Rouge	75.23	West Feliciana	76.15
MEAN	76.23	**MEAN**	75.61

Table 4c. Dummy Regression and Statistical Test Results: Changes in Life
Expectancy by SES Population in Louisiana between 1990 and 2010

SES	a	b	Se(b)	T-score	*P*(b=0)	r^2
Low	74.62	1.75	1.39	3.19	< 0.05	.30
High	76.23	-0.61	1.00	-1.57	> 0.05	.09

Mississippi

In Mississippi, Low SES populations experienced a gain in life expectancy between 1990 and 2010 while High SES populations experienced a decline between 1990 and 2010. However, the T-Test results show that High SES populations have higher average life expectancy than Low SES populations both in 1990 and in 2010.

The T-test (1-tailed, unequal variance, α =.05) finds a statistically significant difference in life expectancy (e_0) between high and Low SES populations in 1990. High SES populations in 1990 had an average e_0 of 78.14 compared to Low SES average e_0 of 70.49, a difference of 7.65 years. In 2010, the gap narrowed sharply to a difference of only 1.6 years, with High SES populations losing 2.54 years of life expectancy while Low SES populations gained 3.51 years. The T-test results (1-tailed, unequal variance, α =.05) for 2010 demonstrate that the increase in average life expectancy for the Low SES population and the decrease in life expectancy for the High SES population is statistically significant.

Table 5a. 1990 and 2010 Life Expectancy at Birth for Low SES Populations (by Quartile) in Mississippi

County	1990 Life Expectancy	County	2010 Life Expectancy
Bolivar	71.64	Benton	76.44
Claiborne	75.59	Claiborne	74.02
Coahoma	68.77	Coahoma	73.98
Franklin	73.72	Holmes	74.33
Holmes	68.92	Humphreys	73.93
Humphreys	67.87	Issaquena	75.49
Issaquena	63.95	Jeff Davis	73.89
Jefferson	76.83	Jefferson	75.17
Kemper	75.34	Kemper	76.40
Noxubee	71.20	Leflore	73.82
Quitman	65.60	Noxubee	74.47
Sharkey	69.79	Quitman	70.80
Tallahatchie	67.37	Sharkey	73.02
Tunica	61.41	Sunflower	71.48
Walthall	77.55	Tallahatchie	76.81
Wilkinson	72.42	Washington	72.36
Yazoo	70.38	Wilkinson	71.61
MEAN	70.49	**MEAN**	74.00

Table 5b. 1990 and 2010 Life Expectancy at Birth for
High SES Populations (by Quartile) in Mississippi

County	1990 Life Expectancy	County	2010 Life Expectancy
Desoto	80.09	Desoto	77.02
Hancock	82.79	George	72.75
Harrison	78.65	Greene	75.81
Hinds	77.93	Hancock	77.15
Itawamba	77.96	Harrison	76.38
Jackson	79.33	Jackson	76.06
Lamar	78.97	Lafayette	76.16
Lauderdale	74.61	Lamar	77.00
Lee	79.31	Lee	74.46
Lowndes	76.75	Madison	72.90
Madison	77.13	Pearl River	75.36
Pearl River	78.57	Pontotoc	76.90
Pontotoc	76.05	Rankin	77.28
Rankin	81.05	Stone	75.30
Tate	76.94	Tate	75.35
Union	77.99	Union	75.20
Warren	74.16	Warren	74.19
MEAN	78.14	**MEAN**	75.60

Table 5c. Dummy Regression and Statistical Test Results: Changes in Life
Expectancy by SES Population in Mississippi between 1990 and 2010

SES	a	b	Se(b)	T-score	P(b=0)	r^2
Low	70.49	3.51	1.18	2.98	< 0.05	.22
High	78.14	-2.53	0.62	-4.50	< 0.05	.34

Ohio

In Ohio, there appear to be declines in average life expectancy for both High SES and Low SES populations between 1990 and 2010. On average, the High SES population shows a decline of 0.84 years while the Low SES populations show a decline of 1.03 years.

The T-Test results show that High SES populations have higher average life expectancy than Low SES populations, both in 1990 and 2010.

Table 6a. 1990 and 2010 Life Expectancy at Birth for
Low SES Populations (by Quintile) in Ohio

County	1990 Life Expectancy	County	2010 Life Expectancy
Adams	77.82	Adams	74.48
Athens	77.10	Athens	75.90
Brown	77.72	Belmont	74.51
Gallia	77.77	Columbiana	77.07
Guernsey	74.95	Coshocton	76.94
Highland	77.93	Gallia	75.35
Hocking	77.19	Guernsey	75.69
Holmes	79.27	Harrison	75.83
Jackson	74.70	Jackson	73.69
Lawrence	76.42	Jefferson	75.82
Meigs	75.42	Lawrence	75.52
Monroe	79.33	Meigs	75.75
Morgan	78.46	Monroe	76.58
Noble	77.95	Morgan	77.75
Perry	76.06	Noble	77.80
Pike	77.15	Pike	75.81
Scioto	74.57	Scioto	74.48
Vinton	74.90	Vinton	77.25
MEAN	76.93	**MEAN**	75.90

Table 6b. 1990 and 201 Life Expectancy at Birth for
High SES Populations (by Quintile) in Ohio

County	1990 Life Expectancy	County	2010 Life Expectancy
Butler	78.37	Auglaize	76.80
Clermont	78.04	Butler	77.00
Cuyahoga	75.96	Clermont	76.83
Erie	78.04	Delaware	78.29
Franklin	77.16	Fairfield	77.42
Geauga	81.41	Fulton	76.72
Greene	78.70	Geauga	79.23
Lake	79.79	Greene	77.89
Lorain	77.98	Hancock	77.27
Lucas	75.82	Lake	77.14
Medina	79.54	Licking	76.94
Montgomery	77.66	Lorain	76.60
Portage	78.67	Medina	78.01
Stark	77.87	Ottawa	77.54
Summit	77.56	Pickaway	76.41
Trumbull	77.82	Putnam	77.77
Warren	79.46	Union	77.94
Wood	78.59	Warren	77.57
MEAN	78.25	**MEAN**	77.41

Table 6c. Dummy Regression and Statistical Test Results: Changes in Life Expectancy by SES Population in Ohio between 1990 and 2010

SES	a	b	Se(b)	T-score	P(b=0)	r^2
Low	76.93	-1.03	0.45	-2.27	< 0.05	.13
High	71.18	-0.84	0.35	-2.37	< 0.05	.14

Pennsylvania

In Pennsylvania, there appears to be no change in average life expectancy for either High SES or Low SES populations between 1990 and 2010. However, the T-Test results show that High SES populations have higher average life expectancy than Low SES populations both in 1990 and 2010.

The T-test (1-tailed, unequal variance, α =.05) finds a statistically significant difference in life expectancy (e_0) between high and Low SES populations in 1990. High SES populations in 1990 had an average e_0 of 77.7 compared to Low SES average e_0 of 75.16, a difference of 2.54 years. In 2010, the gap narrowed to a difference of 1.29 years, with High SES populations losing just under one year (-0.81 years) of life expectancy while Low SES populations gained just under half a year at 0.44. The T-test results (1-tailed, unequal variance, α =.05) for 2010 show that the average e_0 for the High SES population remains higher than that for the Low SES population and that there is a statistically significant difference.

Table 7a. 1990 and 201 Life Expectancy at Birth for Low SES Populations (by Quintile) in Pennsylvania

Adams	76.29	Bedford	76.88
Bedford	75.72	Cameron	75.87
Blair	74.74	Clarion	76.16
Forest	76.25	Clearfield	75.46
Greene	73.13	Clinton	77.49
Juniata	74.48	Crawford	74.83
Lancaster	76.38	Fayette	73.54
Luzerne	72.71	Forest	76.07
Mifflin	74.66	Jefferson	73.98
Potter	73.58	Lawrence	76.04
Somerset	77.71	Mifflin	76.05
Susquehanna	76.89	Northumberland	75.42
Wayne	74.18	Philadelphia	74.71
Wyoming	75.51	Sullivan	75.89
MEAN	75.16	**MEAN**	75.60

Table 7b. 1990 and 2010 Life Expectancy at Birth for High SES Populations (by Quintile) in Pennsylvania

County	1990 Life Expectancy	County	2010 Life Expectancy
Bucks	77.35	Adams	76.29
Cambria	75.93	Berks	76.32
Carbon	77.33	Bucks	76.53
Crawford	75.76	Butler	75.47
Cumberland	80.38	Chester	77.78
Delaware	77.14	Cumberland	76.45
Fayette	77.80	Dauphin	76.21
Franklin	80.51	Delaware	75.07
Fulton	77.71	Lancaster	77.15
Indiana	75.82	Monroe	77.26
Mercer	78.53	Montgomery	76.96
Pike	79.07	Northampton	76.38
Snyder	76.99	Pike	81.8
Warren	77.47	York	76.72
MEAN	77.70	**MEAN**	76.89

Table 7c. Dummy Regression and Statistical Test Results: Changes in Life Expectancy by SES Population in Pennsylvania between 1990 and 2010

SES	a	b	Se(b)	T-score	*P*(b=0)	r^2
Low	75.16	0.44	0.49	0.91	> 0.05	.03
High	77.70	-0.81	0.58	-1.40	> 0.05	.07

South Dakota

In South Dakota, there appears to be no change in average life expectancy for either High SES or Low SES populations between 1990 and 2010. The T-Test results show that High SES populations have higher average life expectancy than Low SES populations both in 1990 and 2010.

The T-test (1-tailed, unequal variance, α =.05) finds a statistically significant difference in life expectancy (e_0) between high and Low SES populations in 1990. High SES populations in 1990 had an average e_0 of 78.65 compared to Low SES average e_0 of 75.16, a difference of 3.49 years. In 2010, the gap widened to a difference of 4.81 years, with High SES populations gaining less than one year (0.48 years) of life expectancy while Low SES populations lost just under one year at -0.84. The T-test results (1-tailed, unequal variance, α =.05) for 2010 again finds a statistically significant difference in life expectancy with the High SES population having an average of 76.89 years and the Low SES population with an average of 75.60 years.

Table 8a. 1990 and 2010 Life Expectancy at Birth for Low SES Populations (by Quintile) in South Dakota

County	1990 Life Expectancy	County	2010 Life Expectancy
Aurora	74.56	Bennett	76.84
Bennett	74.63	Buffalo	71.70
Buffalo	77.03	Charles Mix	77.64
Charles Mix	77.46	Corson	73.49
Corson	75.75	Dewey	71.45
Dewey	75.61	Gregory	74.49
Douglas	82.45	Jackson*	70.30
Gregory	77.08	McCook	82.16
McPherson	77.77	Mellette	73.22
Mellette	72.13	Perkins	75.36
Shannon	69.84	Shannon	69.96
Todd	69.88	Todd	73.73
Ziebach	72.94	Ziebach	75.85
MEAN	75.16	**MEAN**	74.32

Table 8b. 1990 and 2010 Life Expectancy at Birth for High SES Populations (by Quintile) in South Dakota

County	1990 Life Expectancy	County	2010 Life Expectancy
Beadle	76.79	Brookings	80.06
Brown	77.78	Brown	77.37
Custer	73.74	Edmunds	80.79
Grant	77.40	Hamlin	77.92
Hughes	80.27	Hanson	80.40
Lake	79.68	Hughes	78.66
Lawrence	77.39	Lincoln	78.74
Lincoln	79.73	Meade	79.11
Meade	78.53	Minnehaha	77.84
Minnehaha	78.75	Stanley	80.38
Moody	80.91	Sully	80.10
Pennington	77.94	Turner	79.29
Sully	83.53	Union	78.11
MEAN	78.65	**MEAN**	79.13

Table 8c. Dummy Regression and Statistical Test Results: Changes in Life Expectancy by SES Population in South Dakota between 1990 and 2010

SES	a	b	Se(b)	T-score	P(b=0)	r^2
Low	75.16	-0.84	1.43	-0.63	> 0.05	.02
High	78.65	0.49	0.72	0.67	> 0.05	.02

Washington

In Washington, life expectancy increased between 1990 and 2010 for both High and Low SES populations. While the gap between the average life expectancy of Low SES populations and the average life expectancy of High SES populations in WA narrowed between 1990 and 2010, the statistically significant gap found in 1990 remained in 2010.

The T-test (1-tailed, unequal variance, α =.05) finds a statistically significant difference in life expectancy (e_0) between High and Low SES populations in 1990. High SES populations in 1990 had an average e_0 of 72.78 compared to Low SES average e_0 of 71.12, a difference of 1.66 years. In 2010, the gap narrowed to a difference of 1.21 years, with High SES populations gaining 4.46 years of life expectancy while Low SES populations gained 4.91 years. The T-test results (1-tailed, unequal variance, α =.05) for 2010 demonstrate that increases in life expectancy for both High and Low SES populations are statistically significant.

Table 9a. 1990 and 2010 Life Expectancy at Birth for Low SES Populations (by Quartile) in Washington

County	**1990 Life Expectancy**	**County**	**2010 Life Expectancy**
Asotin	69.67	Asotin	74.54
Columbia	66.49	Ferry	75.70
Grant	72.16	Grays Harbor	74.34
Grays Harbor	69.75	Kittitas	77.50
Kittitas	73.82	Lewis	75.24
Klickitat	71.77	Okanogan	76.18
Okanogan	70.74	Pacific	76.21
Pacific	70.50	Pend Oreille	75.85
Pend Oreille	72.18	Whitman	78.95
Whitman	74.13	Yakima	75.74
MEAN	71.12	**MEAN**	76.03

Table 9b. 1990 and 2010 Life Expectancy at Birth for High SES Populations (by Quartile) in Washington

County	**1990 Life Expectancy**	**County**	**2010 Life Expectancy**
Benton	72.37	Benton	77.04
Clark	71.82	Clark	75.99
Island	73.74	Island	79.20
King	71.85	King	76.40
Kitsap	72.59	Kitsap	76.09
Pierce	71.55	Pierce	75.44
San Juan	75.41	San Juan	81.67
Skamania	72.36	Skagit	76.45
Snohomish	72.70	Snohomish	76.86
Thurston	73.45	Thurston	77.22
MEAN	72.78	**MEAN**	77.24

Table 9c. Dummy Regression and Statistical Test Results: Changes in Life Expectancy by SES Population in Washington between 1990 and 2010

SES	a	b	Se(b)	T-score	*P*(b=0)	r^2
Low	71.12	4.90	0.87	5.93	< 0.001	.66
High	72.78	4.45	0.69	6.43	< 0.001	.70

Discussion

With the exceptions of Colorado and Louisiana, the results found here are consistent with those found in the earlier study (Swanson, McGehee and Hoque 2009) in that six states (Florida, Mississippi, Ohio, Pennsylvania, South Dakota, and Washington) of the eight states analyzed saw High SES populations with the higher average life expectancy levels found in 1990 with them again in 2010. However, fewer states saw High SES populations gain additional years of e_0 over Low SES populations, on average, than was the case from 1970 to 1990. Between 1990 and 2010, only three states saw the High SES populations gain additional years of e_0 over the Low SES populations, on average: Florida, Ohio, and Washington. Between 1970 and 1990, there were seven states (Colorado, Florida, Louisiana, Mississippi, Ohio, South Dakota, and Washington) in which High SES populations gained additional years of life expectancy, on average, over Low SES populations. The only exception in the earlier study was Pennsylvania, where the SES gap in e_0 found in 1970 was narrowed by 1990 because the Low SES populations gained more additional years (6.20) over the High SES populations (4.99), on average.

It is informative to look at the particular ways in which average e_0 increased or decreased within each of the five states where the High SES populations did not gain additional years of e0 over the Low SES populations between 1990 and 2010: Colorado, Louisiana, Mississippi, South Dakota, and Pennsylvania. We start with Colorado. In Colorado, the High SES populations showed no change in average e_0 between 1990 and 2010 from a statistical perspective while Low SES populations showed an average decline of 2.46 years, which was statistically significant. Given this decline it is not surprising that where no gap existed in 1990, one was indicated in 2010.

In Louisiana, the gap between low and High SES populations narrowed due to the Low SES populations gaining in average e_0 between 1990 and 2010 while the High SES populations showed no change. In 1990 a statistically significant difference in average e_0 was found between High and Low SES populations, but in 2010, no statistically significant difference was found.

In Mississippi, the gap between low and High SES populations also narrowed due to the Low SES populations gaining in average e_0 between 1990 and 2010 while the High SES populations showed no change. However, unlike Louisiana, the 1990 statistically significant average e_0 difference found between High and Low SES populations was found again in 2010.

Recall that Pennsylvania is one of only two states (South Dakota, discussed next, is the other one) in which neither the High nor the Low SES populations show a change in average e_0 between 1990 and 2010 from a statistical perspective. Given that there was a statistically significant difference in average e_0 between these two populations in 1990, it is not surprising that a statistically significant difference was found again in 2010.

Like Pennsylvania, South Dakota shows no change in average e_0 for both the High and Low SES populations between 1990 and 2010 from a statistical perspective. Also like Pennsylvania, the statistically significant difference in average e_0 between these two populations for South Dakota in 1990 remained in 2010.

As can be gleaned from the preceding discussion, there are some very different results found for the period between 1990 and 2010 than were found between 1970 and 1990 in the earlier study. Perhaps the most interesting is the number of times a given set of High or Low SES populations showed in increase in e_0 or, more surprisingly, a decline in average e_0. Between 1990 and 2010 High SES populations in five states (Colorado, Louisiana, Mississippi, Pennsylvania, and South Dakota) exhibited no change in average e_0. During the same period, Low SES populations in two states (Pennsylvania and South Dakota) showed no change in average e_0 while in one state (Colorado), a decline was found in average e_0 for a set of Low SES populations. Between 1970 and 1990 average increases in e_0 were found for High SES populations in all of these eight states and for Low SES populations in six of the eight. Florida and South Dakota were the only two states in which the Low SES populations did not show a statistically significant increase in average e_0 between 1970 and 1990. In no case was a decline in average e0 found between 1970 and 1990.

In order to gain another perspective on these results, all of the sample counties were divided into High and Low SES groups and analyzed as a whole. Table 10 shows the dummy regression results for the two SES groups for the period 1990 to 2010 while Table 11 shows the results of two T-Tests (α =.05, one-tailed test, assuming unequal variances) examining the difference in e_0 between the High and Low SES populations, one test in 1990 and the other in 2010.

Table 10. Dummy Regression and Statistical Test Results: Changes in Life Expectancy by SES Population for all Sample Counties between 1990 and 2010

SES	a	b	Se(b)	T-score	*P*(b=0)	r^2
Low	74.52	1.62	0.41	2.86	< 0.01	0.03
High	77.26	0.29	0.31	0.95	> 0.05	0.004

Table 11. T-Test (1-Tailed) Results: Difference in Life Expectancy between High and Low SES Population for all Sample Counties in 1990 and in 2010

Year	High SES e_0	Low SES e_0	T-score	df	*P*	Decision
1990	77.26	74.52	6.67	187	< 0.001	Reject Ho
2010	77.56	75.68	6.21	218	< 0.001	Reject Ho

Table 10 indicates that the Low SES populations show an average increase in e_0 of 1.62 years ($p<.01$) between 1990 and 2010 while the High SES populations show no increase ($p > .05$). However, the statistically significant difference in e_0 found between the two populations in 1990 remains in 2010 (Table 11).

In order to broaden the temporal scope, we examined 1970 and 1990 data in the original study (Swanson, McGehee and Hoque 2009). Table 12 shows the dummy regression results for the two SES groups for the period 1970 to 1990 while Table 13 shows the results of two T-Tests (α =.05, 1-tailed test, assuming unequal variances) examining the difference in e_0 between the High and Low SES populations, one test in 1970 and the other in 1990. Note that the 1990 data from the original study (tables 12 and 13) are different from the 1990 data in the current study (tables 10 and 11) due to the change in the e_0 estimation model that was used in the original study, as discussed earlier in this paper.

Table 12. Dummy Regression and Statistical Test Results: Changes in Life Expectancy by SES Population for all Sample Counties between 1970 and 1990

SES	a	b	Se(b)	T-score	*P*(b=0)	r^2
Low	70.75	3.70	0.32	11.55	< 0.001	.39
High	71.50	4.90	0.29	16.93	< 0.001	.59

Table 13. T-Test (1-Tailed) Results: Difference in Life Expectancy between High and Low SES Population for all Sample Counties in 1970 and in 1990

Year	High SES e_0	Low SES e_0	T-score	df	*P*	Decision
1970	71.50	70.75	1.65	195	< .05	Reject Ho
1990	76.40	74.45	6.55	203	<.001	Reject Ho

Table 12 indicates that the Low SES populations show an average increase in e_0 of 3.70 years ($p<.001$) between 1970 and 1990 while the High SES populations show an average increase of 4.90 ($p < .001$). As expected, given its higher average value in 1970 and the higher average increase in e_0 between 1970 and 1990 for the High SES populations, the statistically significant difference in e_0 found between the two populations in 1970 remains in 2010 (Table 13).

So, we see that the trend for the period from 1970 to 1990 (Table 12) in which High SES populations gained more life expectancy on average over Low SES populations changes rather dramatically in the period from 1990 to 2010 (Table 10), such that Low SES populations gain more average life expectancy than do the High SES populations, which show no increase.

The reasons for these absolute and relative gains by High SES populations during the period from 1970 to 1990 (Table 12) may be due to what is observed by Stockwell, Goza and Balistreri (2005) in regard to high infant mortality rates, namely that income inequality had been increasing in the United States since 1970, an increase that coincided with cutbacks in social welfare programs. However, the lack of both absolute and relative gains by the High SES populations during the 1990-2010 period as shown in Table 10 may suggest something about the limits to life expectancy. It would be logical to assume that the High SES populations would hit such a limit before the Low SES populations, assuming that the latter will ever hit it.

In summary, we find that as of 2010, SES, one of three primary mechanisms of social stratification in the United States (Massey 2007), remains associated with life expectancy disparities in the United States. However, our findings also suggest that life expectancy gains for High SES populations may be coming to an end. If so, this is an interesting turn of events in that we may be coming up against limits to life expectancy in the United States, limits that may not be overcome by additional investments in health care. This may be particularly salient for the Low SES populations. As such, it may be that the gap between High and Low SES populations simply persists into the future. This, of course, is not definitive given the data are from a sample, but it clearly suggests avenues of future research.

These findings are of practical interest because in its "Tracking Healthy People 2010" report, the U. S. Department of Health and Human Services (2000) cites the elimination of health disparities by the end of this decade as one of its two key goals. Clearly, the findings presented here that these disparities persisted between 1990 and 2010 provide evidence that this goal was not met. Moreover, it may be that as Olshansky and Carnes (2009: 738) suggest, we may be bumping up against the expiration period of our "biological warranty." If so, it appears that High SES populations represent the leading edge of this encounter. What about the Low SES populations and the biological warranty? Given the long-term persistence of life expectancy disparities by SES, it may be the case that Low SES populations may not encounter the expiration period of our biological warranty, but instead find they have encountered the "social" expiration date. That is, they have run into an expiration period representing the difference between what may be possible given the level of health care available to High SES populations and what is available to them. If so, this suggests that there are two expiration periods, the one that comes with the biological warranty and the one that serves as a buffer between it and what is possible for Low SES populations, the social warranty.

Shortly before his death in 1969, the pioneering actuary, demographer and biostatistician, Mortimer Spiegelman (1968), wrote that that gender, race, spatial, and SES mortality differentials in the United States had been narrowing since 1940. He concluded his paper by stating that (national) leaders were now responsible for seeing that adequately staffed and functioning health facilities were conveniently accessible to the public in order for these trends to continue. He clearly believed that the country's leadership would shoulder this responsibility because he foresaw that even smaller mortality differentials were in the country's future. Unfortunately, it appears that his optimism was not only misplaced, but given that we may have reached the expiration periods of biological and social warranties, an unrealistic belief about the future trajectory of human longevity.

Endnotes

1. A remarkably similar process occurred in the United Kingdom during approximately the same period that social and spatial health inequalities first narrowed and then widened in the United States. Shaw et al. (1999) found that social and spatial inequalities in health had narrowed in the U.K. between the late 1950s and the early 1980s, but steadily widened since the early 1980s, the latter period coinciding with the Thatcher government.

2. Through this paper we use the term 'life expectancy' to refer to 'life expectancy at birth.'

3. In 2008, Ezzati et al. constructed sex-specific life expectancies for counties for every year from 1961 to 1999. However, they were forced to combine the 3,141 counties into 2,068 units because of the lack of data needed to avoid unstable death rates. This represents about two-thirds (66%) of the total counties. They merged smaller counties with adjacent counties to form units with a total population of at least 10,000 males and 10,000 females. In the study reported here, none of the 537 counties is excluded. All of this is not to say that the regression method is in competition with either a complete or an abridged life table. Clearly, a life table provides much more precise estimates of life expectancy and more information than does a regression based estimate of life expectancy alone, even when, as is the case in the study by Ezzati et al. (2008) only three of the 39 years for which they constructed life tables had census quality population data in the denominators (the remaining years had estimated age-sex specific data). However, where it is neither desirable to merge counties nor possible to create a life table, then the regression estimation method may be preferable, given that, in return, information and precision are sacrificed.

4. The data used to construct the regression model, along with the model itself is available from the corresponding author. It is important to note that the model used in this study provides slightly different estimates of life expectancy in 1990 than does the model used in the earlier study.

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