

# Monitoring Socioeconomic Disparities in Death: Comparing Individual-Level Education and Area-Based Socioeconomic Measures

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We compared all-cause mortality rates stratified by individual-level education and by census tract area-based socioeconomic measures for Massachusetts (1999–2001). Among persons aged 25 and older, the age-adjusted relative index of inequality was slightly higher for the census tract than for the individual education measures (1.5 vs 1.2, respectively). Only the census tract socioeconomic measures could provide a relative index of inequality (2–3) for deaths before age 25 or detect expected socioeconomic disparities for deaths among persons 65 and older (relative index of inequality = approximately 1.2 vs 0.8 for census tract measures and individual education, respectively). (*Am J Public Health*. 2006;96:2135–2138. doi:10.2105/AJPH.2005.075408)

Population health data stratified by socioeconomic position are critical for monitoring and analyzing health disparities. When individual-level socioeconomic measures are not available, as is often the case with health surveillance data,<sup>1–4</sup> an alternative approach is to use census tract area-based socioeconomic measures to characterize rates in relation to the socioeconomic position of the immediate areas in which people reside.<sup>1,3–6</sup> Moreover, even when individual-level education data are

available (e.g., for death certificates), the public-release census summary files before the 2000 US census did not provide data on educational level cross-tabulated by age, needed for denominators. In this study, we used the newly available 2000 census population counts for education level cross-tabulated by age to report and compare, for the first time, the socioeconomic inequalities in mortality detected with individual-level education data and census tract area-based socioeconomic measures.

## METHODS

We obtained mortality data, including years of individual education,<sup>7</sup> from the state of Massachusetts for the years 1999 to 2001 (N=165 217) and geocoded all deceased persons according to the address on the death certificate. We employed a commercial geocoding firm with known high accuracy<sup>8</sup>; thus, we were able to geocode 97% of the records with certainty to the census tract level. A priori determined categories for individual-level education and the 3 census tract area-based socioeconomic measures (percentage of persons below poverty, percentage of adults aged 25 and older with less than a high-school education, and percentage of adults aged 25 and older with a 4-year college education) are shown in Tables 1 and 2.<sup>3,4</sup>

To calculate age-standardized rates for the population aged 25 and older (Table 1), we used the US year 2000 standard million for ages 25 and older.<sup>9</sup> We used the least deprived group as the comparison group to calculate incidence rate ratios for individual-level education and census tract area-based socioeconomic measures. We could not compute mortality rates by individual-level education for individuals younger than 25 because persons in this age group may not have completed their education, and the requisite person-year data for denominators were not available for persons younger than 18.<sup>10</sup> On the basis of age-standardized rates, we calculated the relative index of inequality, which is a coefficient of linear slope that takes into account the effect estimate of each socioeconomic category weighted by the number of individuals in that category.<sup>11–13</sup> This measure

permits meaningful comparison of health inequalities across diverse socioeconomic measures, even if their proportionate allocation of persons across socioeconomic strata differs.

## RESULTS

Table 1 presents data on deaths, person-years, and age-standardized mortality rates for the population aged 25 and older, by individual-level education and by census tract area-based socioeconomic measure. Table 2 presents the same data for 4 age strata (0–24, 25–44, 45–64, ≥65). The individual-level education and census tract area-based socioeconomic measures had a similar low proportion of missing data (typically less than 3%).

For the population aged 25 and older (Table 1), the degree of socioeconomic inequality in mortality detected with the census tract area-based socioeconomic measures was slightly greater than that detected by the individual-level education measure (relative index of inequality of approximately 1.5 vs 1.2). Additionally, as shown in Table 2, only the census tract area-based socioeconomic measures yielded estimates of socioeconomic inequality for persons younger than 25 (relative index of inequality between 2.3 and 3.0). For persons aged 25 to 44, the magnitude of the relative index of inequality was greater for the individual-level education measure (6.8) compared with the census tract area-based socioeconomic measures (range=3.3–3.7) but was similar for persons aged 45 to 64 (range=2.7–2.9). For persons aged 65 and older, the relative index of inequality was significantly below 1 for individual-level education (0.8) but ranged between 1.2 and 1.3 for the 3 census tract area-based socioeconomic measures.

## DISCUSSION

Our findings suggest that census tract area-based socioeconomic measures such as “percentage of persons below poverty” and individual-level education detect a similar magnitude of socioeconomic inequality for all-cause mortality in the state of Massachusetts

**TABLE 1—Age-Standardized All-Cause Mortality Rates, by Individual-Level Education and Census Tract Area–Based Socioeconomic Measures: Adults Aged 25 and Older, Massachusetts, 1999–2001**

	Deaths	Person-Years <sup>a</sup>	Age-Standardized Mortality Rates, <sup>b</sup> per 100 000	Incident Rate Ratio (95% CI)	Relative Index of Inequality (95% CI)
Individual level: education, y					1.23 (1.21, 1.26)
≥16	22 897	4255	870	1.00	
12–15	103 182	6612	1507	1.73 (1.71, 1.76)	
<12	33 340	1954	1016	1.17 (1.15, 1.19)	
<b>Census tract level</b>					
Percentage below poverty					1.46 (1.44, 1.49)
0.0–4.9	60 356	5416	1096	1.00	
5.0–9.9	48 999	3866	1185	1.08 (1.06, 1.10)	
10.0–19.9	30 098	2140	1390	1.27 (1.25, 1.29)	
20.0–100	18 175	1379	1453	1.33 (1.29, 1.37)	
Percentage adults 25 and older with less than a high-school education					1.53 (1.51, 1.57)
0.0–14.9	88 589	7857	1107	1.00	
15.0–24.9	38 415	2844	1301	1.18 (1.16, 1.21)	
25.0–39.9	21 683	1502	1451	1.31 (1.29, 1.34)	
40.0–100	8941	606	1472	1.33 (1.31, 1.35)	
Percentage adults 25 and older with a bachelor's degree					1.45 (1.43, 1.48)
40.0–100	41 315	3908	1061	1.00	
25.0–39.9	44 963	3744	1172	1.10 (1.08, 1.13)	
15.0–24.9	40 619	3040	1276	1.20 (1.18, 1.22)	
0.0–14.9	30 731	2117	1435	1.35 (1.33, 1.37)	

Note. CI = confidence interval. Percentages missing socioeconomic data for age categories <25, 25–44, 45–64, ≥65, and ≥25 were 100, 1.9, 1.8, 1.9, and 3.4 (for individual education); 2.6, 3.1, 3.0, 3.0, and 3.0 (for census tract poverty, census tract less than high-school education, and census tract college graduate). Person-years for individual-level education were calculated from US 2000 census summary file (SF) 3 (Table PCT025). Person-years for area-based socioeconomic measures were calculated from US 2000 census SF1 (Table P012). Area-based socioeconomic measures were calculated from US 2000 census SF3 (Table P087, % poverty; and Table P037, % with less than high-school education and % with bachelor's degree).

<sup>a</sup>Person-years are in thousands.

<sup>b</sup>Rate is age-standardized according to the US Year 2000 standard population categories consistent with age strata of education level reported in the US 2000 census (with age categories 25–44, 45–64, and ≥65).

for individuals between ages 45 and 64. Census tract area–based socioeconomic measures also uniquely provide evidence of socioeconomic inequality for (1) persons younger than 25 years, for whom education may not yet be completed; and (2) persons aged 65 and older, for whom individual-level education analyses indicated that mortality rates were higher among persons with 12 to 15 years of education than among those with both less than 12 and 16 or more years. However, for persons aged 25 to 44, the magnitude of the

relative index of inequality for the census tract area–based socioeconomic measures, although still large (approximately 3.5), was less than that yielded by the individual-level education (6.8).

Consistent with our results, previous empirical research has reported selective misclassification in education level on death certificates, chiefly because of individuals who did not graduate from high school being reported as having obtained a high-school diploma, especially among persons aged 65

and older.<sup>15,16</sup> The net effect is to deflate the mortality rate among persons with fewer than 12 years of education and inflate it among persons with 12 to 15 years of education.<sup>15</sup> For this reason, the National Center for Health Statistics report *Socioeconomic Status and Health* provided mortality rates by individual education only for individuals between ages 25 and 64.<sup>16</sup> Importantly, studies with self-reported individual-level educational data document socioeconomic inequality in all-cause mortality analogous to that detected with this study's census tract area–based socioeconomic measures.<sup>17</sup>

Census tract area–based socioeconomic measures thus offer 2 advantages over individual-level education data for monitoring socioeconomic inequality in mortality. First, they provide an estimate of effect with decreased misclassification bias for persons aged 65 and older. Second, they can be used validly for persons younger than 25.

Of note, our use of census tract area–based socioeconomic measures is unlikely to be substantially affected by ecological bias, given the similar direction of estimates for the individual and area-based socioeconomic measures and results that are of a comparable magnitude (except for older ages, for which individual data are likely misclassified). From an etiological standpoint, multilevel analyses assessing the relative contribution of individual- and area-level socioeconomic characteristics to social inequities in mortality would be useful.<sup>18–21</sup> Future research also should evaluate whether our findings vary by type of mortality,<sup>22</sup> race/ethnicity, and gender. ■

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This brief was accepted November 15, 2005.

### Contributors

D. H. Rehkopf led the data analysis and writing. L. T. Haughton assisted with data analysis and manuscript preparation. J. T. Chen developed the tools for data analysis and assisted with data analysis. P. D. Waterman

**TABLE 2—Age-Stratified All-Cause Mortality Rates, by Individual-Level Education and Census Tract Area–Based Socioeconomic Measures: Massachusetts, 1999–2001**

	Deaths	Person-Years <sup>a</sup>	Age-Stratified Mortality Rates, per 100 000	Incident Rate Ratio (95% CI)	Relative Index of Inequality (95% CI)
<b>Ages 0–24 y</b>					
Individual-level education, y					...
≥ 16	...	...	...	...	
12–15	...	...	...	...	
< 12	...	...	...	...	
Census tract-level percentage below poverty					2.33 (2.03, 2.67)
0.0–4.9	800	2490	32	1.00	
5.0–9.9	729	1636	45	1.38 (1.25, 1.53)	
10.0–19.9	544	1080	50	1.57 (1.41, 1.75)	
20.0–100	615	1032	60	1.86 (1.67, 2.06)	
Census tract-level percentage of adults 25 and older with less than a high-school education					2.93 (2.55, 3.38)
0.0–14.9	1201	3614	33	1.00	
15.0–24.9	639	1131	49	1.46 (1.33, 1.61)	
25.0–39.9	561	894	63	1.89 (1.71, 2.09)	
40.0–100	287	418	69	2.06 (1.81, 2.35)	
Census tract-level percentage of adults 25 and older with a bachelor's degree					3.03 (2.64, 3.48)
40.0–100	496	1852	27	1.00	
25.0–39.9	662	1656	40	1.46 (1.33, 1.61)	
15.0–24.9	716	1440	50	1.89 (1.71, 2.09)	
0.0–14.9	814	1290	63	2.06 (1.81, 2.35)	
<b>Ages 25–44 y</b>					
Individual-level education, y					6.75 (6.12, 7.45)
≥ 16	1061	2321	46	1.00	
12–15	4723	3066	154	3.37 (3.15, 3.60)	
< 12	1074	603	178	3.90 (3.58, 4.24)	
Census tract-level percentage below poverty					3.34 (3.06, 3.65)
0.0–4.9	1855	2364	78	1.00	
5.0–9.9	1875	1779	105	1.34 (1.26, 1.43)	
10.0–19.9	1559	1073	145	1.85 (1.73, 1.98)	
20.0–100	1482	748	198	2.52 (2.36, 2.70)	
Census tract-level percentage of adults 25 and older with less than a high-school education					3.72 (3.41, 4.07)
0.0–14.9	2969	3545	84	1.00	
15.0–24.9	1738	1363	127	1.52 (1.44, 1.62)	
25.0–39.9	1369	753	181	2.17 (2.04, 2.32)	
40.0–100	695	309	225	2.69 (2.48, 2.92)	
Census tract-level percentage of adults 25 and older with a bachelor's degree					3.63 (3.32, 3.96)
40.0–100	1231	1794	69	1.00	
25.0–39.9	1735	1721	101	1.52 (1.44, 1.62)	
15.0–24.9	1835	1408	130	2.17 (2.04, 2.32)	
0.0–14.9	1970	1047	188	2.69 (2.48, 2.92)	

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assisted with data preparation. S.V. Subramanian assisted with data interpretation. N. Krieger originated the study and assisted with manuscript preparation. All authors helped to conceptualize ideas, interpret findings, and review drafts of the manuscripts.

**Acknowledgments**

This work was funded by the National Institutes of Health (grant 1 R01 HD3685-01) via the National Institute of Child Health and Human Development and the Office of Behavioral and Social Science Research (Principal Investigator, Nancy Krieger). S.V. Subramanian is supported by the National Institutes of Health Career Development Award (1 K25 HL081275 )

We thank Bruce Cohen (Division of Research and Epidemiology, Massachusetts Department of Public Health) for facilitating the conduct of this study with data from the Massachusetts Health Department and for providing helpful comments. We also thank Malena Orejuela Hood (Division of Research and Epidemiology, Massachusetts Department of Public Health) and Charlene Zion (Registry of Vital Records and Statistics, Massachusetts Department of Public Health) for assistance with data handling and preparation.

**Human Participant Protection**

Use of the data in this study was approved by all relevant institutional review boards and human subjects committees at the Harvard School of Public Health and the Massachusetts Department of Public Health.

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TABLE 2—Continued

	Ages 45–64 y				
Individual-level education, y					2.79 (2.65, 2.94)
≥ 16	4356	1478	295	1.00	
12–15	14 508	2189	662	2.25 (2.17, 2.33)	
< 12	3316	586	566	1.92 (1.84, 2.01)	
Census tract-level percentage below poverty					2.81 (2.67, 2.94)
0.0–4.9	7722	1980	390	1.00	
5.0–9.9	6461	1259	513	1.31 (1.27, 1.36)	
10.0–19.9	4300	632	680	1.74 (1.68, 1.81)	
20.0–100	3441	385	894	2.29 (2.20, 2.38)	
Census tract-level percentage of adults 25 and older with less than a high-school education					2.91 (2.77, 3.06)
0.0–14.9	11 354	2745	413	1.00	
15.0–24.9	5497	889	619	1.50 (1.45, 1.54)	
25.0–39.9	3504	451	776	1.88 (1.81, 1.95)	
40.0–100	1569	174	900	2.18 (2.06, 2.29)	
Census tract-level percentage of adults 25 and older with a bachelor's degree					2.68 (2.55, 2.81)
40.0–100	4899	1354	361	1.00	
25.0–39.9	6078	1267	480	1.50 (1.45, 1.54)	
15.0–24.9	5820	998	583	1.88 (1.81, 1.95)	
0.0–14.9	5127	640	801	2.18 (2.06, 2.29)	
	Ages ≥ 65 y				
Individual-level education, y					0.80 (0.78, 0.81)
≥ 16	17 480	457	3829	1.00	
12–15	83 951	1357	6185	1.62 (1.59, 1.64)	
< 12	28 950	765	3784	0.99 (0.97, 1.01)	
Census tract-level percentage below poverty					1.23 (1.21, 1.26)
0.0–4.9	50 779	1072	4736	1.00	
5.0–9.9	40 663	828	4911	1.04 (1.02, 1.05)	
10.0–19.9	24 239	435	5572	1.18 (1.16, 1.20)	
20.0–100	13 252	246	5387	1.14 (1.12, 1.16)	
Census tract-level percentage of adults 25 and older with less than a high-school education					1.29 (1.27, 1.32)
0.0–14.9	74 266	1567	4740	1.00	
15.0–24.9	31 180	592	5268	1.11 (1.10, 1.13)	
25.0–39.9	16 810	298	5632	1.19 (1.17, 1.21)	
40.0–100	6677	123	5418	1.14 (1.11, 1.17)	
Census tract-level percentage of adults 25 and older with a bachelor's degree					1.24 (1.22, 1.27)
40.0–100	35 185	760	4630	1.00	
25.0–39.9	37 150	756	4914	1.11 (1.10, 1.13)	
15.0–24.9	32 964	634	5195	1.19 (1.17, 1.21)	
0.0–14.9	23 634	430	5492	1.14 (1.11, 1.17)	

Note. CI = confidence interval. Person-years for individual-level education are calculated from US 2000 census summary file (SF) 3 (Table PCT025). Person-years for area-based socioeconomic measures are calculated from US 2000 census SF1 (Table P012). Area-based socioeconomic measures are calculated from US 2000 census SF3 (Table P087, % poverty; and Table P037, % with less than high-school education and % with bachelor's degree).  
<sup>a</sup>Person-years are in thousands.

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## ERRATUM

In: Rehkopf DH, Haughton LT, Chen JT, Waterman PD, Subramanian SV, Krieger N. Monitoring socioeconomic disparities in death: comparing individual-level education and area-based socioeconomic measures. *Am J Public Health*. 2006;96:2135–2138. doi:10.2105/AJPH.2005.075408.

Table 2 was printed with incorrect data. Corrected values (in bold) for affected portions of **Table 2—Age-Stratified All-Cause Mortality Rates, by Individual-Level Education and Census Tract Area-Based Socioeconomic Measures: Massachusetts, 1999–2001** are as follows:

	Deaths	Person-Years <sup>a</sup>	Age-Stratified Mortality Rates, per 100 000	Incident Rate Ratio (95% CI)	Relative Index of Inequality (95% CI)
<b>Ages 0–24 y</b>					
Census tract-level % of adults 25 and older with a bachelor's degree					3.03 (2.64, 3.48)
40.0–100	496	1852	27	1.00	
25.0–39.9	662	1656	40	<b>1.49 (1.32, 1.68)</b>	
15.0–24.9	716	1440	50	<b>1.86 (1.66, 2.08)</b>	
0.0–14.9	814	1290	63	<b>2.35 (2.11, 2.63)</b>	
<b>Ages 25–44</b>					
Census tract-level % of adults 25 and older with a bachelor's degree					3.63 (3.32, 3.96)
40.0–100	1231	1794	69	1.00	
25.0–39.9	1735	1721	101	<b>1.47 (1.37, 1.58)</b>	
15.0–24.9	1835	1408	130	<b>1.90 (1.77, 2.04)</b>	
0.0–14.9	1970	1047	188	<b>2.74 (2.56, 2.95)</b>	
<b>Ages 45–64</b>					
Census tract-level % of adults 25 and older with a bachelor's degree					2.68 (2.55, 2.81)
40.0–100	4899	1354	361	1.00	
25.0–39.9	6078	1267	480	<b>1.33 (1.28, 1.38)</b>	
15.0–24.9	5820	998	583	<b>1.61 (1.55, 1.67)</b>	
0.0–14.9	5127	640	801	<b>2.21 (2.13, 2.30)</b>	
<b>Ages ≥ 65</b>					
Census tract-level % of adults 25 and older with a bachelor's degree					1.24 (1.22, 1.27)
40.0–100	35 185	760	4630	1.00	
25.0–39.9	37 150	756	4914	<b>1.06 (1.05, 1.08)</b>	
15.0–24.9	32 964	634	5195	<b>1.12 (1.11, 1.14)</b>	
0.0–14.9	23 634	430	5492	<b>1.19 (1.17, 1.21)</b>	

<sup>a</sup>Person-years are in thousands.

The article's conclusion were not affected by these changes.

doi:10.2105/AJPH.2005.075408e.