Distribution of Education and Population Health: An Ecological Analysis of New York City Neighborhoods

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Objectives. We assessed the relationship between distribution of education and health indicators in a large urban area to determine if distribution of education may be a determinant of population health.

Methods. We studied the association between distribution of education, measured with the education Gini coefficient, and rates of 8 health indicators in 59 neighborhoods in New York City.

Results. In separate adjusted ecological models, neighborhoods with more poorly distributed education had *better* population health indicators that might plausibly be associated with short-term changes in the social environment (e.g., homicide and infant mortality rate); there was no association between education distribution and health indicators more likely to be associated with long-term accumulation of social and behavioral stressors (e.g., cardiovascular disease and chronic lung disease mortality rates). These findings were robust to measures of income and to adjustment for several potential confounders (e.g., gender and race/ethnicity).

Conclusions. The presence in a neighborhood of highly educated people may be salutary for all residents, independent of the potentially deleterious consequences of income maldistribution. (*Am J Public Health.* 2005;95:2198–2205. doi:10.2105/AJPH.2004.050617)

Income and education are often considered "fundamental" determinants of health and primary indicators of socioeconomic status.[1–3] The relationships between income and health and between education and health are well established; people who are wealthier and people who are better educated live longer and suffer less morbidity during their lifetimes.[4–6]

In the past 2 decades, a substantial body of work also has assessed the relationship between unequal distribution of income (frequently referred to in the public health literature as "income inequality") and population health.[7–10] The evidence in the field remains controversial, but recent systematic reviews of the literature suggest that while there is little consistent evidence of a cross-national relationship between income distribution and health, there may be a relationship in the United States between income maldistribution and indicators of poor health at the state, city, and neighborhood levels.[9,10]

At the group level, the relation between distribution of education and population health may be different from that between distribution of income and population health.[11,12] The presence in a community of people with a wide range of incomes has been hypothesized to generate interpersonal stress and concentrate resources among those with more wealth; in contrast, the presence of people with a wide range of educational attainment may be accompanied by positive ("spillover") benefits generated by the actions of those of high educational attainment.[13] For example, a health care facility may provide services and information at the level demanded by its most educated patients, which would then benefit all who use the facility. Similarly, more educated people may have access to individuals in power and may, for example, successfully lobby against undesirable projects such as construction of waste disposal facilities.

Such improvements in health determinants, while driven by individuals at higher education levels, will then be available to all other residents of a particular area as long as the improved resources are not prohibitively expensive. Therefore, it is plausible that a small group of more highly educated individuals may contribute to improvements in the shared facilities and resources of a given area. These shared facilities and resources, in turn, barring significant financial barriers, may contribute to improved well-being among all the area's residents. These benefits may be particularly important in the context of health indicators, such as homicide and infant mortality rates, that are likely to be affected by short-term changes in the social environment.

Therefore, distribution of education may be an important determinant of population health, and it may play a role different from that of income distribution. Although all US residents have access to education at the primary and secondary school levels, there are wide ranges in educational attainment.[14] Substantial educational disparities exist between various racial/ethnic and socioeconomic groups in the United States,[15–17] and it has been argued that these disparities may contribute to racial/ethnic inequalities in health.[18] However, we are not aware of previous work in which the role of area-level education distribution has been explicitly assessed as a potential determinant of health.

We examined the relations between education distribution, income distribution, and specific health indicators in New York City neighborhoods. We hypothesized that neighborhoods with wider education distributions would fare better in terms of population health indicators that may be sensitive to short-term changes in the social environment (homicide, infant mortality, low birthweight, late or no prenatal care) after neighborhood educational levels, income levels, and income distribution had been taken into account. We also hypothesized that there would be no association between education distribution and health indicators that are more likely to reflect biological factors or cumulative social stressors over the long term (mortality resulting from cardiovascular disease, chronic lower respiratory disease, chronic liver disease and cirrhosis, and cerebrovascular disease).

METHODS

Data

We created a neighborhood-level ecological data set using data from the 2000 US census and the New York City Department of Health and Mental Hygiene. The city's community districts served as proxies for neighborhoods; these districts are well-defined units with administrative community boards, and their residents view them as politically and socially significant entities. There are 59 community districts in New York City, including, for example, the Upper West Side in Manhattan and Bedford-Stuyvesant in Brooklyn. Community districts roughly correspond to aggregations of census tracts, and they were initially defined by a resident consultative process organized by the Office of City Planning to reflect residents' own descriptions of neighborhoods in the 1970s.

It should be noted that the political and social decisions of community boards could have had an impact on the factors considered here. For example, community boards may make decisions that influence school quality and placement—and, hence, educational attainment—in a given neighborhood. Previous studies have demonstrated that community districts represent neighborhoods whose characteristics may affect residents' behavior and health.[19–21]

Independent Variables

Education and education distribution. We used 2000 US census data on educational attainment among individuals 25 years or older to estimate mean educational levels and distributions of education in the study neighborhoods. Mean educational levels were calculated via the following equation:

$$\mu = \sum_{i=1}^{n} p_i y_i, \tag{1}$$

where p_i is the proportion of individuals at a given level of schooling in the population of interest and y_i is the midpoint of (or the most likely value for) the schooling category (e.g., y_i=5.5 for completion of fifth and sixth grades, y_i=16 for completion of a bachelor's degree).

The education Gini coefficient was used to measure the distribution of education and extent of inequality in each neighborhood.[18,22,23] A Gini coefficient of 0 denotes a perfectly equitable education distribution, whereas a coefficient of 1.0 represents maximal maldistribution. The 2 methods—direct and indirect—used in calculating Gini coefficients have been discussed and explored extensively in the income distribution literature. Briefly, the direct method is "the ratio to the mean of half of the average over all pairs of the absolute deviations between [all possible pairs of people]."[23(p139)] When the indirect method is used, the Gini coefficient is calculated from the Lorenz curve, which is created by plotting proportions of the population from least to most educated on the x-axis and proportions of educational attainment on the y-axis. The Gini coefficient is the area between the diagonal line indicating no inequality and the concave line representing the education distribution in a particular population.

Given the sample size in this analysis, we used the small-sample Gini estimation.[18] This small-sample formula is related, through the factor $N/(N-1)$, to the large-sample Gini calculation. In practical terms, when a sample is large enough, $N/(N-1)$ is approximately equal to 1, and the small-sample approximation is equivalent to the large-sample formula. This definition is mathematically represented as follows:

$$E = \left(\frac{N}{N-1}\right) \times \left[\left(\frac{1}{\mu}\right) \sum_{i=2}^{n} \sum_{j=1}^{i-1} p_i \left| y_i - y_j \right| p_j\right], \tag{2}$$

where E is the education Gini coefficient, N is the number of individuals in the population of interest, μ is the mean number of years of schooling in the population of interest, p_i and p_j are the proportions of the population at certain levels of schooling, y_i and y_j are the years of schooling at different educational attainment levels, and n is the number of levels of educational attainment. We used 16 levels of educational attainment in this study.[24] We also calculated, as a secondary measure of education distribution, the standard deviation of schooling (SDS) (the earlier notation applies here as well):

$$SDS = \sqrt{\sum_{i=1}^{n} p_i (y_i - \mu)^2} \ . \tag{3}$$

Income and income distribution. We used per capita income data from the 2000 US census to calculate the Gini coefficient as a measure of income distribution in each New York City neighborhood.[14,22]

Dependent Variables

In the case of each neighborhood, we assessed 8 health indicators using data for 2000 obtained from the Bureau of Vital Statistics of the New York Department of Health and Mental Hygiene.[25] We selected 4 indicators that might be affected by short-term changes in the social environment ("short-term indicators"): *homicide rate* (number of deaths per 1000 population caused by homicide in each neighborhood), *infant mortality rate* (number of infants younger than 1 year who died per 1000 live births in each neighborhood), *low-birthweight rate* (percentage of live-born infants below 2500 g in each neighborhood), and *late or no prenatal care rate* (percentage of live-born infants delivered by mothers with late or no prenatal care in each neighborhood).

In addition, we selected 4 chronic disease indicators that we expected to be primarily affected by biological factors and the cumulative impact of social factors over the long term ("long-term" indicators). These long-term indicators were *cardiovascular disease mortality rate* (rate per 100 000 population of deaths from diseases of the heart), *chronic lower respiratory disease mortality rate* (rate per 100 000 population of deaths from chronic lower respiratory diseases), *chronic liver disease and cirrhosis mortality rate* (rate per 100 000 population of deaths from chronic liver disease and cirrhosis), and *cerebrovascular disease mortality rate* (rate per 100 000 population of deaths from cerebrovascular diseases).

Data Analysis

We summarized each of the variables of interest using means, medians, standard deviations, and ranges. We assessed bivariate relations between each of the education distribution measures (education Gini coefficient and SDS) and the health indicators. We then assessed the multivariate relationships between education Gini and SDS and the health indicators while adjusting for mean educational level. Next, we assessed the multivariate relations of education Gini and SDS with each of the dependent variables of interest while adjusting for mean educational level, income

Gini, and per capita income. We considered the quadratic form of per capita income in these models.[26,27] Model fit (assessed via likelihood ratio tests) was not improved when the quadratic form of per capita income was considered; we present data on per capita income in linear form only.

In a secondary analysis, we examined the effect of using mean education as the measure of neighborhood educational level by considering models in which the mean education measure was replaced by percentage of residents with a college education or greater and by percentage of residents with a high school education or greater. In addition, we considered the impact on our final models of also adjusting for racial composition, gender composition, and presence of postsecondary educational institutions.

We describe the relationships between neighborhood education distribution and the health outcomes examined using measures assessing deviation from the lines of best fit between mean educational level and education distribution (education Gini and SDS). These measures (residuals) reflect the relative level of education distribution for the corresponding level of mean education; they are equivalent to measures of the effects of education distribution after adjustment for mean educational level. To exemplify areas at differing levels of educational inequality, we provide additional details on 2 neighborhoods—Washington Heights/Inwood in Manhattan and Kingsbridge Heights/Bedford Park in the Bronx—that are otherwise similar demographically.

RESULTS

Because the results were similar when the 2 different measures of educational inequality were used, we present only results for the education Gini coefficient. (Results of the SDS analysis are available from the authors.) A description of the sample is presented in Table 1. The mean education Gini in the 59 neighborhoods studied was 0.16 (SD=0.04, range=0.09–0.26), comparable to values calculated by other authors for the United States as a whole.[18] The mean income Gini was 0.45 (SD=0.03, range=0.37–0.51), again comparable to previously published US values.[28] Education Gini and mean education were significantly correlated (–0.84, $P<.01$), as were education Gini and per capita income (–0.68, $P<.01$). The correlation between education Gini and income Gini was not as strong (–0.34, $P<.01$).

The bivariate and adjusted associations between distribution of education and the 8 health indicators assessed are presented in Table 2. In the bivariate model (model 1), education Gini was significantly associated with 3 of the health indicators: homicide rate ($\beta=59.15$, $P<.01$), late or no prenatal care rate ($\beta=24.66$, $P<.01$), and liver disease mortality rate ($\beta=44.76$, $P<.01$). In all 3 cases, health indicators were worse in neighborhoods with more unequal education distributions. However, after adjustment for mean educational level (model 2), education Gini was inversely associated with homicide rate ($\beta=-84.10$, $P=.01$), infant mortality rate ($\beta=-49.47$, $P<.01$), and low-birthweight rate ($\beta=-40.87$, $P<.01$), and there was a trend for an association with late or no prenatal care rate ($\beta=-21.95$, $P=.06$). Overall, after adjustment for mean education, more unequally distributed education was associated with *better* short-term neighborhood health indicators.

These associations also are illustrated in Figure 1, which presents the relationships between education Gini residuals and the 4 short-term health indicators. Higher rates of health problems were observed in neighborhoods with less educational inequality at the different levels of education (i.e., a negative education Gini residual), and lower rates of health problems were observed in neighborhoods with more educational inequality at the different education levels (i.e., a positive education Gini residual). There were no associations between education Gini and rates of chronic disease.

In multivariate models including education Gini, mean educational level, income Gini, and per capita income, education Gini was significantly associated ($P\leq.01$) with all of the short-term health indicators assessed, and in all instances health indicators were *better* in neighborhoods with more widely distributed education (Table 3). While income Gini was

TABLE 1—Characteristics of the 59 Study Neighborhoods: New York City, 2000

	Mean	SD	Median	Range
Total population (2000 census)	135 681	45 806	128 313	208 532
Education Gini coefficient	0.16	0.04	0.16	0.17
Mean education, y	12.60	1.47	12.42	6.04
College education or more, %	26.20	18.50	20.48	69.22
High school education or more, %	70.86	13.27	71.14	52.66
Income Gini coefficient	0.45	0.03	0.45	0.14
Per capita income, $	22 833.73	16 841.80	16 883.00	73 644.00
Homicide rate (per 1000)	8.8	6.6	7.6	24.8
Infant mortality rate (per 1000)	6.3	2.8	6.1	12.1
Low-birthweight rate, %	8.3	1.8	8.2	6.8
Late or no prenatal care rate, %	6.6	2.4	6.3	10.7
Cardiovascular disease mortality rate (per 100 000)	290.9	121.3	262.9	586.9
Chronic lower respiratory disease mortality rate (per 100 000)	19.3	7.4	17.8	37.5
Chronic liver disease/cirrhosis mortality rate (per 100 000)	7.0	4.3	6.3	23.3
Cerebrovascular disease mortality rate (per 100 000)	23.3	6.7	21.7	29.2
Black, %	24.84	25.28	15.69	88.00
Hispanic, %	28.03	20.88	18.21	70.24
Asian, %	9.08	9.00	5.54	35.63
Male, %	47.40	2.08	47.08	9.39

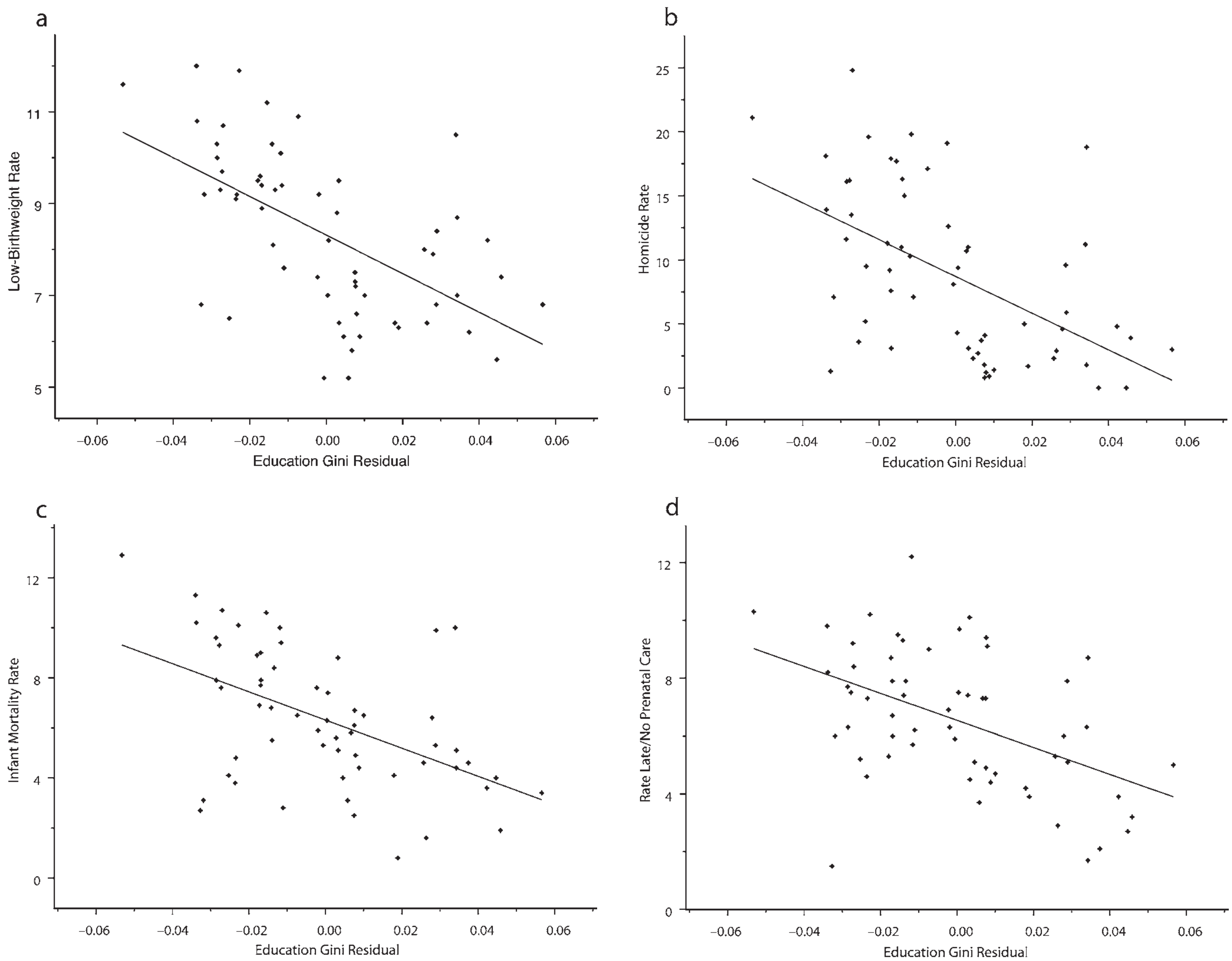
TABLE 2—Adjusted Multivariate Relationships Between Education Distribution (Education Gini Coefficient) and 8 Health Indicators: New York City, 2000

		Model 1			Model 2			Model 3		
Outcome	Parameter	β	SE	*P*	β	SE	*P*	β	SE	*P*
Homicide rate	Intercept	−0.80	3.47	.82	78.83	15.21	<.01	47.80	17.19	.01
	Education Gini coefficient	59.15	20.85	<.01	−84.10	31.86	.01	−156.10	27.08	<.01
	Mean education level	...	...	...	−4.48	0.84	<.01	−5.34	1.13	<.01
	Income Gini coefficient	...	...	...	...	...	...	120.41	17.74	<.01
	Per capita income	...	...	...	...	...	...	−0.04	0.07	.62
Infant mortality rate	Intercept	5.24	1.54	.00	36.52	7.09	<.01	15.41	8.92	.08
	Education Gini coefficient	6.79	9.25	.46	−49.47	14.86	<.01	−70.35	14.06	<.01
	Mean education level	...	...	...	−1.76	0.39	<.01	−1.34	0.59	.02
	Income Gini coefficient	...	...	...	...	...	...	46.16	9.21	<.01
	Per capita income	...	...	...	...	...	...	−0.07	0.04	.06
Low-birthweight rate	Intercept	8.15	1.00	<.01	31.52	4.35	<.01	21.96	5.32	<.01
	Education Gini coefficient	1.18	6.01	.84	−40.87	9.11	<.01	−57.90	8.38	<.01
	Mean education level	...	...	...	−1.31	0.24	<.01	−1.40	0.35	<.01
	Income Gini coefficient	...	...	...	...	...	...	30.53	5.49	<.01
	Per capita income	...	...	...	...	...	...	−0.02	0.02	.38
Late or no prenatal care rate	Intercept	2.57	1.23	.04	28.48	5.60	<.01	9.30	7.34	.21
	Education Gini coefficient	24.66	7.40	<.01	−21.95	11.74	.06	−31.67	11.57	.01
	Mean education level	...	...	...	−1.46	0.31	<.01	−0.75	0.48	.12
	Income Gini coefficient	...	...	...	...	...	...	30.16	7.58	<.01
	Per capita income	...	...	...	...	...	...	−0.08	0.03	.01
Cardiovascular disease mortality rate	Intercept	397.62	66.48	<.01	316.00	354.66	.37	−1077.48	473.59	.02
	Education Gini coefficient	−659.09	399.64	.10	−512.25	743.19	.49	210.91	746.11	.78
	Mean education level	...	...	...	4.59	19.59	.81	107.46	31.11	<.01
	Income Gini coefficient	...	...	...	...	...	...	372.56	488.93	.45
	Per capita income	...	...	...	...	...	...	−8.26	2.03	<.01
Chronic lower respiratory disease mortality rate	Intercept	18.56	4.15	<.01	26.25	22.15	.24	−0.77	33.11	.98
	Education Gini coefficient	4.58	24.97	.85	−9.27	46.41	.84	−11.98	52.16	.82
	Mean education level	...	...	...	−0.43	1.22	.72	0.96	2.18	.66
	Income Gini coefficient	...	...	...	...	...	...	28.52	34.18	.40
	Per capita income	...	...	...	...	...	...	−0.13	0.14	.35
Chronic liver disease/cirrhosis mortality rate	Intercept	−0.27	2.23	.91	17.58	11.65	.13	11.25	16.10	.48
	Education Gini coefficient	44.76	13.39	<.01	12.65	24.41	.60	−25.13	25.37	.32
	Mean education level	...	...	...	−1.00	0.64	.12	−2.01	1.06	.06
	Income Gini coefficient	...	...	...	...	...	...	53.95	16.62	<.01
	Per capita income	...	...	...	...	...	...	0.03	0.07	.65
Cerebrovascular disease mortality rate	Intercept	26.35	3.75	<.01	14.56	19.95	.47	−14.42	26.00	.58
	Education Gini coefficient	−18.61	22.54	.41	2.60	41.81	.95	−70.78	40.97	.08
	Mean education level	...	...	...	0.66	1.10	.55	−0.36	1.71	.83
	Income Gini coefficient	...	...	...	...	...	...	120.26	26.84	<.01
	Per capita income	...	...	...	...	...	...	−0.02	0.11	.83

Note. Stepwise adjustment was made for mean education, income Gini coefficient, and per capita income.

also associated with 6 of the 8 health indicators, health indicators were consistently *worse* in neighborhoods with more unequally distributed incomes.

The results of the secondary analyses are presented in Table 3. The original final model (model 1) is presented for comparison. Replacing our measure of mean educational level with percentage of residents with a college education or more, we found that education Gini was significantly negatively associated with the 4 short-term health indicators,



Note. A positive education Gini residual indicates a wider education distribution per level of mean education, and a negative education Gini residual indicates a narrower education distribution per level of mean education.

FIGURE 1—Scatter plots of the associations between education Gini residuals and 4 associated health indicators: (a) low-birthweight rate, (b) homicide rate, (c) infant mortality rate, and (d) late/no prenatal care rate..

as in the original final model, and was also negatively associated with cardiovascular disease and cerebrovascular disease mortality rates (model 2). Replacing mean educational level with percentage of residents with a high school education or more, we found the same associations as in the original final model (model 3).

After addition of neighborhood racial composition to the final model, some of the educational inequality parameters were reduced in magnitude, but they remained significant for all of the short-term health indicators other than infant mortality rate (model 4). Adjusting for gender composition led to a smaller reduction in the educational inequality parameters, and all remained significant for the short-term health indicators (model 5). Adjusting for presence of postsecondary educational institutions had no appreciable impact on findings associated with educational inequality (model 6).

As mentioned, we examined in further detail 2 areas at differing levels of educational inequality: Washington Heights/Inwood and Kingsbridge Heights/Bedford Park, located just across the Harlem River from each other. Their mean education levels (11.3 years and 11.6 years, respectively), per capita incomes ($13 912 and $12 389, respectively), and ethnic composition (74% and 59% Hispanic, respectively) were similar. However, Washington Heights/Inwood exhibited higher education inequality (education Gini=0.23) than Kingsbridge Heights/Bedford Park (education Gini=0.19), along with lower rates of homicide, infant mortality, and low birthweight.

DISCUSSION

Our ecological analysis of neighborhoods in a large metropolitan area showed that maldistributed educational attainment was associated with indicators of better short-term

TABLE 3—Adjusted Multivariate Relationships Between Education Distribution (Education Gini Coefficient) and 8 Health Indicators: New York City, 2000

Outcome	Parameter	Model 1[a] β	Model 1[a] SE	Model 1[a] P	Model 2[b] β	Model 2[b] SE	Model 2[b] P	Model 3[c] β	Model 3[c] SE	Model 3[c] P	Model 4[d] β	Model 4[d] SE	Model 4[d] P	Model 5[e] β	Model 5[e] SE	Model 5[e] P	Model 6[f] β	Model 6[f] SE	Model 6[f] P
Homicide rate	Intercept	47.80	17.19	.01	–29.73	7.17	<.01	51.06	11.81	<.01	1.92	12.72	.88	80.12	18.32	<.01	51.72	17.34	<.01
	Education Gini coefficient	–156.10	27.08	<.01	–69.19	19.80	<.01	–186.38	22.71	<.01	–79.76	32.45	.01	–100.70	29.56	<.01	–158.15	26.84	<.01
Infant mortality rate	Intercept	15.41	8.92	.08	–4.20	3.66	.25	15.56	7.11	.03	1.09	8.26	.90	22.43	10.26	.03	14.42	9.08	.11
	Education Gini coefficient	–70.35	14.06	<.01	–48.55	10.12	<.01	–76.93	13.67	<.01	–21.36	21.06	.31	–58.32	16.55	<.01	–69.84	14.05	<.01
Low-birthweight rate	Intercept	21.96	5.32	<.01	1.64	2.18	.45	20.21	4.16	<.01	9.31	4.12	.02	30.09	5.86	<.01	24.12	5.24	<.01
	Education Gini coefficient	–57.90	8.38	<.01	–35.18	6.02	<.01	–61.84	7.99	<.01	–25.06	10.51	.02	–43.96	9.46	<.01	–59.02	8.11	<.01
Late or no prenatal care rate	Intercept	9.30	7.34	.21	–1.56	3.06	.61	8.80	5.98	.14	0.61	6.98	.93	8.46	8.57	.32	9.97	7.48	.18
	Education Gini coefficient	–31.67	11.57	.01	–19.54	8.45	.02	–34.44	11.49	<.01	–40.54	17.79	.02	–33.11	13.82	.02	–32.02	11.57	.01
Cardiovascular disease mortality rate	Intercept	–1077.48	473.59	.02	468.06	204.72	.02	–1209.35	349.90	<.01	–276.93	422.89	.51	–825.20	548.93	.13	–1323.81	454.64	<.01
	Education Gini coefficient	210.91	746.11	.78	–1538.23	565.53	.01	920.98	672.61	.17	–1015.82	1078.44	.35	643.34	885.66	.47	339.79	703.84	.63
Chronic lower respiratory disease mortality rate	Intercept	–0.77	33.11	.98	12.28	13.86	.38	–27.20	26.59	.31	22.73	32.61	.49	6.26	38.59	.87	–8.82	33.34	.79
	Education Gini coefficient	–11.98	52.16	.82	–27.70	38.28	.47	32.78	51.11	.52	–34.71	83.15	.68	0.07	62.26	.99	–7.77	51.62	.88
Chronic liver disease/cirrhosis mortality rate	Intercept	11.25	16.10	.48	–17.39	6.85	.01	12.59	12.90	.33	–1.34	16.78	.94	5.87	18.74	.75	12.79	16.39	.44
	Education Gini coefficient	–25.13	25.37	.32	7.56	18.92	.69	–36.68	24.80	.14	–66.40	42.78	.12	–34.36	30.23	.26	–25.94	25.37	.31
Cerebrovascular disease mortality rate	Intercept	–14.42	26.00	.58	–51.42	16.65	<.01	–19.30	21.38	.37	–26.46	28.50	.35	22.48	28.87	.44	–8.54	26.23	.74
	Education Gini coefficient	–70.78	40.97	.08	–102.42	46.01	.03	–65.08	41.10	.11	–72.00	72.68	.32	–7.54	46.59	.87	–73.85	40.61	.07

Note. The primary analyses (Models 1–3) adjusted for mean education, income Gini coefficient, and per capita income; in the secondary analyses (Models 4–6), additional adjustment was made for racial composition, gender composition, and presence of postsecondary educational institutions.
[a]Education Gini coefficient adjusted for education, income Gini coefficient, and income (see Table 2).
[b]Identical to model 1 with replacement of mean educational level with percentage of residents with college or higher education.
[c]Identical to model 1 with replacement of mean educational level with percentage of residents with high school or higher education.
[d]Identical to model 1 with addition of adjustment for racial/ethnic composition (percentage Black, percentage Hispanic, and percentage Asian).
[e]Identical to model 1 with addition of adjustment for gender composition (percentage male).
[f]Identical to model 1 with addition of adjustment for presence or absence of postsecondary educational institutions.

population health (e.g., homicide rate, infant mortality rate) after adjustment for average neighborhood educational attainment. This finding is in contrast to the association observed between maldistributed income and indicators of worse population health after adjustment for average per capita income.

Public health as a discipline has a long tradition of concern with issues of social justice and equity, and as such the results presented here, suggesting a health benefit produced by a form of inequality, might be counterintuitive and unappealing. However, we suggest that our observations are not inconsistent with established theories about the relationships between contextual factors and health but that they reflect a more nuanced appreciation of the role of distribution of fundamental determinants in shaping health.

We have shown that overall mean level of education is associated with better short-term health indicators in a given neighborhood and that educational inequality is associated with better health indicators only *after adjustment* for mean neighborhood educational level. These results suggest that, at any particular level of education, population health is better in urban neighborhoods where there are at least some residents with high educational attainment (i.e., neighborhoods with educational inequality) than in neighborhoods where there are very few such residents (i.e., neighborhoods without educational inequality). Therefore, although we refer here to "educational inequality" to reflect an empirical reality, it may be more accurate to describe what we observed as heterogeneity in educational attainment. Our findings imply that, in a given community, high overall educational achievement is better than low overall educational achievement, and the presence of some individuals with high educational achievement may improve the community's overall health.

That educational inequality was associated with health indicators that may be responsive to short-term changes in the social environment (e.g., homicide and infant mortality rates) but not with other chronic health indicators (e.g., cardiovascular disease and chronic respiratory disease mortality rates) suggests that educational inequality may be associated with health outcomes through relatively short-term mechanisms. For example, in neighborhoods with low overall educational attainment, the presence of a few highly educated individuals may be critical in terms of their introducing social and health resources and collective human capital that may benefit all residents.[29–32] Also, in contrast to accumulation of income and wealth,[13,33] educational attainment may be determined in part by long-established institutions and traditions, such as the existence of publicly subsidized schooling. As a result, individuals with high educational achievement may be more likely to contribute to social welfare and cohesion than are individuals who have accumulated wealth.

We observed that educational inequality was associated with certain health indicators (e.g., infant mortality) but not others (e.g., cerebrovascular mortality). In the case of health indicators that are susceptible to short-term environmental influences, the greater availability of health and social resources in neighborhoods with high rates of educational inequality may explain the relationship between educational inequality and population health. Health indicators that are more dependent on longer term effects of stressors may be better explained by longitudinal assessments in which both the distant and cumulative effects of social context can be considered. Several other mechanisms, including neighborhood differences in social class status and access to power and political resources, may also explain the observed relationships.[32]

The findings documented here with respect to income inequality replicate what has been observed by other researchers.[9] However, we were unable to identify comparable analyses in the public health literature that have assessed the potential role of education distribution. Extant work pertaining to education distribution has focused on its role as an economic determinant of income generation, and countries have been the areas of interest.[13,18] The literature in this regard is inconsistent; however, recent work has suggested that while income inequality may have a negative effect on national growth, education inequality may have a positive effect, for many of the same reasons proposed here at the small-area level.[34–37] Others have shown that distribution of education is associated with income levels and with investment in human capital.[18,38]

Important methodological issues need to be considered in interpreting our findings. Many of the critiques of the income inequality–health hypothesis have centered around methodological concerns, suggesting that the observed effect is a residual one that stems from the well-accepted but nonlinear income–health relationship.[39,40] It is also plausible that the observations documented here are artifacts of the underlying education–health relationship. Reassuring in this regard is that we used 2 different measures of educational distribution, and our results are consistent with those documented in cross-national comparisons.

We recognize that theoretical developments in this area are nascent and that subsequent work would do well to explore the appropriate temporal lags involved in associations between education distribution and health. Although we used 2000 data for both our dependent and independent variables, we also assessed distribution of education in 1990. We found no appreciable changes either in education distribution between 1990 and 2000 or in the results documented here when education distribution in 1990 was used as the independent variable. Subsequent longitudinal assessments would permit further elucidation of the differences documented here in the relationships between education distribution and health indicators that, according to our hypotheses, are or are not susceptible to short-term changes in the social environment.

The present ecological analysis has inherent limitations in terms of inference at the individual level. We do not draw individual-level conclusions here but suggest that educational distribution may be an important determinant of population health. Further work will be needed to determine whether area-level distribution of education is also associated with individual health and well-being. In addition, we considered aggregate neighborhood-level educational attainment. Further work may also fruitfully consider whether quality of educational attainment in specific groups (e.g., immigrants) and specific age cohorts exhibits different associations with health indicators.

We analyzed intraurban differences in the largest city in the United States. This may limit the generalizability of our observations to other, smaller areas. All of our findings involving contextual determinants need to be considered carefully with respect to the contextual levels selected. We argue that neighborhoods are an important unit at which to assess the potential role of distribution of education; the hypothesized mechanisms that may explain an association between education distribution and health involve the sharing of human and social resources that would primarily manifest themselves at the small-area level. This does not preclude the possibility that educational inequality may be an important determinant at the county, state, or national level. Relations demonstrable in an urban environment may not be applicable to suburban or rural contexts, and future analyses would have to consider the role of educational inequality, if any, in different contexts.

This study was not designed to assess potential mechanisms explaining the associations observed. Although adjustment for neighborhood-level proportion of residents with a college or high school education, gender composition, racial/ethnic composition, and presence of postsecondary institutions did not explain the primary associations of interest described here, we cannot rule out that other factors (e.g., racial residential segregation patterns) may in part explain the ecological association between educational inequality and health indicators.

Finally, the associations demonstrated here were robust to multiple key independent variables and health indicators, and modeling of residuals of education distribution suggested that the results observed were not unduly influenced by collinearity between key independent variables. However, further analyses involving different data sets will be needed to confirm these observations.

In summary, our analysis showed that, at the neighborhood level, the relation between education distribution and health is the opposite of, and independent from, the relation between income distribution and health. Educational inequality is associated with better health indicators after adjustment for mean educational level, consistent with a hypothesis that the presence in a neighborhood of individuals with high educational attainment can be salutary for all residents, independent of the potentially deleterious consequences of income maldistribution. Our results suggest that different contextual factors may have very different associations with population health. There should be acknowledgment in comprehensive models of health determinants of the nuanced role of absolute levels and distributions of the fundamental determinants of population health. Further work should assess whether the observations documented here are repeated in other contexts. ■

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Contributors

S. Galea and J. Ahern jointly designed and participated in all aspects of the study. S. Galea had primary responsibility for reporting, and J. Ahern had primary responsibility for the analyses.

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Human Participant Protection

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