Measures of Local Segregation for Monitoring Health Inequities by Local Health Departments

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Objectives. To assess the use of local measures of segregation for monitoring health inequities by local health departments.

Methods. We analyzed preterm birth and premature mortality (death before the age of 65 years) rates for Boston, Massachusetts, for 2010 to 2012, using the Index of Concentration at the Extremes (ICE) and the poverty rate at both the census tract and neighborhood level.

Results. For premature mortality at the census tract level, the rate ratios comparing the worst-off and best-off terciles were 1.58 (95% confidence interval [CI] = 1.36, 1.83) for the ICE for income, 1.66 (95% CI = 1.43, 1.93) for the ICE for race/ethnicity, and 1.63 (95% CI = 1.40, 1.90) for the ICE combining income and race/ethnicity, as compared with 1.47 (95% CI = 1.27, 1.71) for the poverty measure. Results for the ICE and poverty measures were more similar for preterm births than for premature mortality.

Conclusions. The ICE, a measure of social spatial polarization, may be useful for analyzing health inequities at the local level.

Public Health Implications. Local health departments in US cities can meaningfully use the ICE to monitor health inequities associated with racialized economic segregation. (*Am J Public Health.* 2017;107:903–906. doi:10.2105/AJPH.2017.303713)

To evaluate bringing local residential economic and racial/ethnic segregation into population health monitoring, we analyzed health inequities in preterm birth and premature mortality in Boston, Massachusetts (whose population in 2015 equaled 667 137). Our local segregation measure was the Index of Concentration at the Extremes (ICE), a metric newly being used in public health and recently assessed for health monitoring in New York City,[1,2] whose population (8.6 million) is nearly 13 times larger than that of Boston. Our novel questions were whether the ICE could be meaningfully used in a smaller city and whether it would better predict health outcome rates than the poverty level.

METHODS

We obtained geocoded Boston birth and death data for 2010 to 2012 from the Massachusetts Department of Public Health.[3] We used American Community Survey data (5-year estimates for 2008–2012)[4] to generate area-based ICE and poverty measures for both 15 city neighborhoods (as defined by the Boston Public Health Commission) and 170 census tracts (with population size above 100), given that census tract data may be more sensitive to inequities not captured by neighborhood-level measures.[1,5–7]

The ICE measures the extent to which an area's population is concentrated into extremes of deprivation versus privilege.[1,2,5,6] It is calculated with the following formula[2]:

$$(1)\quad ICE_i = (A_i - P_i)/T_i$$

where, in the case of the ICE for income, for area i, A_i is the number of individuals living in high-income households, P_i is the number of individuals living in low-income households, and T_i is the number of individuals with known household incomes. The ICE thus ranges from −1 (everyone in the least privileged group) to 1 (everyone in the most privileged group), as opposed to measuring solely 1 group (e.g., percentage rich or impoverished or percentage White or Black), and thereby brings group relations into view[1,2,5,6]; whether doing so adds value was a question we sought to address.

We defined the extreme categories of least and most privileged[1,5,6] in relation to well-recognized demarcations.[8–10] Extreme low versus high household incomes were operationalized as the bottom versus top 20% of US household incomes.[8,9] We also compared (1) Non-Hispanic Black versus non-Hispanic White individuals and (2) Black low-income households versus non-Hispanic White high-income households, given evidence that these latter 2 groups "continue to occupy opposite ends of the socioeconomic spectrum in the United States."[10(p324)] We computed the poverty rate as defined by the US census.[4]

Using geocoded health data and census denominator data, we computed the preterm birth rate (percentage of births that were preterm) and the premature mortality rate (age-adjusted deaths per 100 000 deaths among individuals younger than 65 years) for each area (i.e., census tract or neighborhood). We stratified results by terciles of the ICE and poverty measures because we

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TABLE 1—Monitoring Health Inequities at the Neighborhood and Census Tract Levels Using the Index of Concentration at the Extremes (ICE) for Income, Race/Ethnicity, and Income Plus Race/Ethnicity and the Poverty Measure, by Tercile: Preterm Births and Premature Mortality, Boston, MA, 2010–2012

Area and Tercile[a]	No. of Areas	ICE for Income			ICE for Race/Ethnicity			ICE for Income + Race/Ethnicity			Poverty Rate		
		Range	Rate, % (95% CI)	RR (95% CI)	Range	Rate, % (95% CI)	RR (95% CI)	Range	Rate, % (95% CI)	RR (95% CI)	Range, %	Rate, % (95% CI)	RR (95% CI)
Preterm births													
Neighborhood[b] (n = 15)													
1	5	−0.363, −0.138	9.7 (9.1, 10.4)	1.09 (0.98, 1.20)	−0.698, −0.059	10.7 (10.1, 11.3)	1.26 (1.14, 1.39)	−0.225, 0.034	10.7 (10.1, 11.3)	1.19 (1.08, 1.31)	25.1, 38.7	9.5 (8.8, 10.1)	1.07 (0.97, 1.18)
2	5	−0.090, 0.084	9.7 (9.1, 10.3)	1.08 (0.98, 1.19)	0.263, 0.608	8.8 (8.1, 9.4)	1.04 (0.93, 1.16)	0.082, 0.168	8.3 (7.7, 9.0)	0.93 (0.84, 1.04)	18.1, 20.4	10.1 (9.4, 10.7)	1.14 (1.04, 1.26)
3	5	0.125, 0.261	8.9 (8.2, 9.6)	1.00 (Ref)	0.626, 0.760	8.5 (7.8, 9.1)	1.00 (Ref)	0.207, 0.386	8.9 (8.2, 9.6)	1.00 (Ref)	4.8, 15.3	8.8 (8.2, 9.5)	1.00 (Ref)
Census tract[c] (n = 169)													
1	57	−0.784, −0.172	10.1 (9.4, 10.8)	1.14 (1.03, 1.26)	−0.884, 0.148	10.2 (9.6, 10.8)	1.20 (1.09, 1.33)	−0.784, −0.006	10.3 (9.7, 11.0)	1.17 (1.06, 1.29)	27.8, 83.0	10.1 (9.4, 10.9)	1.10 (0.99, 1.22)
2	56	−0.168, 0.088	9.4 (8.8, 10.1)	1.07 (0.97, 1.18)	0.160, 0.629	9.3 (8.6, 9.9)	1.09 (0.98, 1.22)	0.004, 0.206	9.1 (8.4, 9.7)	1.03 (0.93, 1.14)	14.6, 26.6	9.2 (8.6, 9.8)	1.00 (0.91, 1.10)
3	56	0.094, 0.663	8.9 (8.2, 9.5)	1.00 (Ref)	0.635, 0.972	8.5 (7.8, 9.2)	1.00 (Ref)	0.208, 0.610	8.8 (8.2, 9.5)	1.00 (Ref)	0.0, 14.4	9.2 (8.6, 9.9)	1.00 (Ref)
Premature mortality													
Neighborhood[b] (n = 15)													
1	5	−0.363, −0.138	230.1 (211.2, 250.7)	1.46 (1.03, 2.09)	−0.698, −0.059	253.7 (232.7, 276.6)	1.42 (1.23, 1.63)	−0.225, 0.034	253.7 (232.7, 276.6)	1.39 (1.19, 1.61)	25.1, 38.7	234.8 (216.0, 255.2)	1.33 (1.15, 1.54)
2	5	−0.090, 0.084	221.4 (200.9, 244.0)	1.38 (0.97, 1.95)	0.263, 0.608	195.1 (175.5, 216.7)	1.09 (0.93, 1.27)	0.082, 0.168	192.0 (174.1, 211.9)	1.05 (0.90, 1.23)	18.1, 20.4	226.5 (204.5, 250.7)	1.29 (1.10, 1.50)
3	5	0.125, 0.261	183.1 (162.2, 206.8)	1.00 (Ref)	0.626, 0.760	179.1 (160.2, 200.3)	1.00 (Ref)	0.207, 0.386	183.1 (162.2, 206.8)	1.00 (Ref)	4.8, 15.3	175.9 (156.2, 198.3)	1.00 (Ref)
Census tract[c] (n = 170)													
1	57	−0.784, −0.172	256.6 (235.3, 279.8)	1.58 (1.36, 1.83)	−0.884, 0.106	253.5 (231.6, 277.4)	1.66 (1.43, 1.93)	−0.784, −0.006	257.3 (235.4, 281.4)	1.63 (1.40, 1.90)	27.9, 86.6	257.8 (235.6, 282.0)	1.47 (1.27, 1.71)
2	57	−0.168, 0.088	211.6 (192.0, 233.1)	1.30 (1.11, 1.52)	0.148, 0.629	207.0 (187.9, 228.0)	1.35 (1.16, 1.58)	0.000, 0.206	203.4 (184.9, 223.8)	1.30 (1.10, 1.51)	14.6, 27.8	206.5 (187.8, 227.0)	1.18 (1.02, 1.37)
3	56	0.094, 0.663	162.8 (144.3, 183.6)	1.00 (Ref)	0.635, 0.972	152.9 (135.4, 172.6)	1.00 (Ref)	0.208, 0.610	157.6 (139.3, 178.3)	1.00 (Ref)	0.0, 14.4	174.8 (155.7, 196.3)	1.00 (Ref)

Note. CI = confidence interval; RR = rate ratio. Preterm birth values are percentages of total births; premature mortality values are deaths among individuals younger than 65 years (age-adjusted rates per 100 000). Birth and death data are from the Massachusetts Department of Public Health[3]; census data are from the American Community Survey (5-year estimates; 2008–2012).[4] The tercile ranges are identical for the neighborhood-level analyses for preterm births and premature mortality but differ slightly at the census tract level because among the 170 census tracts included in the premature mortality analyses, one could not be included for the preterm birth analyses because it had 0 births. All global tests for comparisons of rates across the terciles for all geographic areas had $P < .01$ for premature mortality and $P < .05$ for preterm births with the exception of the poverty measure at the neighborhood level for preterm births ($P > .05$; exact P values are not shown but are available upon request).

[a]Terciles are from 1 (least privilege) to 3 (most privilege).

[b]Neighborhood analysis population size and rates: total births, 23 687 (preterm, 2247; full term, 21 440; Boston average rate for 2010–2012, 9.5%; 95% CI = 9.1%, 9.9%), and premature deaths, 3271 (Boston 2010 population younger than 65 years, 550 465; Boston average age-adjusted rate for 2010–2012 per 100 000, 211.5; 95% CI = 199.7, 224.0).

[c]Census tract analysis population size and rates: total births, 23 568 (preterm, 2229; full term, 21 339; Boston average rate for 2010–2012, 9.5%; 95% CI = 9.1%, 9.8%), and premature deaths, 3202 (Boston 2010 population younger than 65 years, 554 549; Boston average age-adjusted rate for 2010–2012 per 100 000, 206.3; 95% CI = 194.7, 218.6).

found that quintiles (as employed in New York City[1]) yielded unstable estimates given the far smaller population size. We then used Poisson regression to generate rate ratios, setting the most privileged tercile as the referent group, and conducted global tests of significance for rate differences across terciles.[7] We also conducted a novel test of whether each area's rate was better predicted by the ICE measure than by the poverty measure.

RESULTS

Table 1 shows our key findings. First, regardless of the area-based measure used, health inequities (comparing the worst and best terciles) were observed for both preterm birth and premature mortality but were steeper for the latter. Second, for both outcomes, steeper gradients occurred for the 3 ICE measures than for the poverty measure, and these gradients were steeper at the census tract level than at the neighborhood level (with the exception of preterm births for the neighborhood ICE measures that included race/ethnicity). Illustrating these points, for premature mortality at the census tract level, the rate ratios comparing the worst-off with the best-off tercile were 1.58 (95% confidence interval [CI] = 1.36, 1.83) for the ICE for income, 1.66 (95% CI = 1.43, 1.93) for the ICE for race/ethnicity, and 1.63 (95% CI = 1.40, 1.90) for the ICE combining income and race/ethnicity, as compared with 1.47 (95% CI = 1.27, 1.71) for the poverty measure.

In addition, for both preterm birth and premature mortality, the regression model–predicted rates (for the ICE for income and poverty measures) were more similar to the observed rates at the census tract level than at the neighborhood level. Moreover, the predicted versus observed rates for premature mortality were more similar for the ICE for income than for the poverty measure at the census tract level (for the 169 tracts with a premature death and the 166 with a preterm birth). Thus, for premature mortality, the 95% confidence interval for the predicted and observed rates overlapped for only 8 of 15 neighborhoods (53.3%) in the case of both the ICE for income and the poverty measure; however, these 95% CIs overlapped for 142 census tracts (84.0%) for the ICE for income and for only 132 census tracts (78.1%) for the poverty measure. For preterm birth, the overlap of these 95% CIs was the same for both the ICE for income and the poverty measure at the neighborhood level: 13 of 15 neighborhoods (86.7%). At the census tract level, 156 census tracts (94.0%) overlapped for the 95% CIs for the predicted versus observed rates for the ICE for income measure and 155 census tracts (93.4%) had this overlap for the poverty measure.

DISCUSSION

Our study adds to the small but growing body of evidence that the ICE, a measure of social spatial polarization,[1,2,5,6] is a meaningful metric for analyzing health inequities at the local level, including in cities the size of Boston. The ICE has several advantages over more commonly used measures. First, unlike the poverty measure, its computation requires data at both extremes of the distribution at issue (e.g., for income or racial privilege),[1,2,5,6] which likely contributes to why larger gradients were observed for the ICE than for the poverty measure, especially at the census tract level.

Second, unlike solely economic or solely racial/ethnic measures, the ICE combining income and race/ethnicity can efficiently analyze, in a single metric, the impact of racialized economic segregation,[1,5,6] and the ability of the ICE combining income and race/ethnicity to predict more accurately an area's health rates than does the poverty measure points to why monitoring of health inequities requires addressing racial as well as economic segregation. Finally, unlike the most widely used measures of income inequality (the Gini index[8,9]) and racial segregation (the Index of Dissimilarity[11]), the ICE can be meaningfully employed at the census tract level.[1,2,5,6]

At a time of growing social and spatial polarization,[9,10] the ICE thus represents a salient metric for monitoring health inequities by local health departments, one that can potentially contribute to designing place-based interventions to reduce these inequities.[12]

A limitation of our study is that, consistent with how local health departments monitor population health,[1] we did not use multilevel analyses incorporating data at both the neighborhood and census tract levels. Issues for future research include use of the ICE computed in relation to additional racial/ethnic groups and how the ICE can be effectively communicated so that its meaning is clear to both health professionals and the public at large.

PUBLIC HEALTH IMPLICATIONS

In conjunction with our previous ICE analyses,[1,5,6] the results of this study indicate that local health departments in US cities can effectively use the ICE, especially at the census tract level, to monitor health inequities, including in relation to local racialized economic segregation. AJPH

CONTRIBUTORS

N. Krieger originated the study, designed the analyses, and wrote the first draft of the article. P. D. Waterman constructed the Index of Concentration at the Extremes variables and contributed to the analyses. N. Batra, J. S. Murphy, D. P. Dooley, and S. N. Shah obtained the Boston health data and conducted the statistical analyses. All of the authors were involved in interpreting the data and preparing the article.

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HUMAN PARTICIPANT PROTECTION

No protocol approval was needed for this study because nonidentifiable data sets were used.

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