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Why history matters for quantitative target setting: long-term trends in socioeconomic and racial/ethnic inequities in US infant death rates (1960–2010)

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Abstract

Policy-oriented population health targets, such as the Millennium Development Goals and national targets to address health inequities, typically are based on trends of a decade or less. To test whether expanded timeframes might be more apt, we analyzed 50-year trends in US infant death rates (1960–2010) jointly by income and race/ethnicity. The largest annual percent changes in the infant death rate (between –4% and –10%) occurred, for all racial/ethnic groups, in the lowest income quintile between the mid-1960s and early 1980s, and in the second lowest income quintile between the mid-1960s and 1973; since the 1990s, they have hovered, in all groups, between –1% and –3%. Hence, to look back only 15 years, in 2014, to 1999, would ignore gains achieved prior

to the post-1980 onset of neoliberal policies. Target setting should be informed by a deeper and more long-term appraisal of what is possible to achieve.

Keywords

infant mortality; race/ethnicity; social determinants of health; socioeconomic; targets; trends

To the extent quantitative health data can contribute to guiding policy decisions for future targets, in conjunction with relevant qualitative, economic, and policy data,^{1–6} a long-term perspective may be desirable. Yet, quantitative targets are typically based only on recent trends, e.g., a decade or less, as per the case of the Millennium Development Goals (MGDs),¹ in part because current data may seem most immediately relevant and are also most readily available. Such reliance on short-term data may, however, be problematic: looking back only 10 years in, say, 2014, to 2004, would ignore gains achieved, in relation to both improving population health and reducing health inequities, prior to the post-1980 onset of neoliberal policies, whose prioritization of private wealth over public investment and benefits has been associated with set-backs to reductions in health inequities.^{7–10}

Accordingly, to explore the salience of history to policy-relevant quantitative target setting^{11,12} for both on-average rates and health inequities, we present a novel analysis of long-term trends in US infant death rates (1960–2010), overall and jointly in relation to socioeconomic position and race/ethnicity. Infant mortality has long served as a key indicator of a population's well-being,^{1–4,13} and socioeconomic and racial/ethnic inequalities in this outcome^{4,13,14} warrant being conceptualized as health inequities, i.e., unfair and avoidable differences in health outcomes across social groups who would otherwise have similar rates except for the embodied health consequences of injustice.^{15–17}

Methods

Infant death data

We analyzed: (1) 1960–1967 US national mortality data from the National Center for Health Statistics (NCHS),¹⁸ the earliest publicly available computerized US national mortality data (with death registration estimated to be >99% complete), for which we manually located and identified the correct county code for each of the 3073 counties⁸ (the primary legal division of most states, most of which are functioning governmental units¹⁹), and (2) 1968–2010 data from the publicly available NCHS US compressed mortality file (CMF).²⁰ Together, these files encompass a longer span of time than the NCHS linked birth cohort and period files, which respectively go back only to 1983 and 1995.²

Records were thus comprised of individual-level mortality records and census denominator data, stratified by age, gender, and race/ethnicity, and aggregated to the county level. Using these data, we computed the infant death rate ($[\text{deaths} < \text{age } 1]/[\text{population} < \text{age } 1]$, in the same calendar year), an outcome which is highly correlated with the infant mortality rate (deaths per liveborn infants).²⁰ Data limitations required that, for 1960–1967 only, we employ the NCHS algorithm for the infant death denominator (i.e., multiplying “the population in the 1–4 age category by 0.25”²⁰).

County income data

To overcome the absence of socioeconomic data in the mortality records, we linked the mortality data to county median family income obtained from US census decennial 1960–2010 data (missingness <1%), which we adjusted for inflation and regional cost of living.^{8,22} We used linear interpolation for intercensal years and then assigned counties to income quintiles, weighted by county population size, given its enormous variation.⁸ For 1960–1988, the lack of county data for one US state with a small population (Alaska) required the state’s data to be analyzed as one county.⁸

Racial/ethnic classification

Reflecting changing US race relations and conceptualizations of race/ethnicity,^{8,17,21,23} available racial/ethnic categories were, as well-documented,^{8,20,21} for: 1960–1967, “white” and “non-white”; 1968–2010: “white,” “black,” and “other”; and since 1999: “non-Hispanic”: “white,” “black,” “American Indian and Alaska Native,” “Asian or Pacific Islander,” and “Hispanic or Latino.”^{20,23} For the 1960–1967 data, we followed standard practice by reclassifying “non-white” persons as “black.”²⁴ Suggesting this approach is reasonable, in 1960 92% of US “non-white” persons were black, and mortality rates of these two groups were almost identical.²⁴ One state (New Jersey) did not identify race/ethnicity in 1962 and 1963, precluding use of these two years’ data (< 3% of the US population).¹⁸

Statistical analysis

We first computed and plotted 3-year moving averages of infant death rates by county income quintile, for the total population and within each racial/ethnic group. We then computed the corresponding cross-sectional rate differences and rate ratios, and their 95% confidence interval, for: (1) income quintile, for the total population and within racial/ethnic groups, setting as referent the highest income quintile (Q5), and (2) race/ethnicity, within income quintiles, setting as referent, for 1960–2010, the white population, and for 1999–2010, the white non-Hispanic population.

To analyze time trends, we then employed joinpoint regression,^{8,25,26} by specifying a Poisson model for the time series of annual infant death rates in each income and racial/ethnic stratum. To account for heteroscedasticity, each year’s data is weighted by the inverse of the standard error of the rate for that year. To carry out these analyses, we used the National Cancer Institute’s Joinpoint software,^{25,26} which employs a grid search algorithm to identify statistically significant inflection points ($p < 0.05$) in a series of data. The slope from the resulting regression function fit yields estimates of the annual percent change (APC) in rates.^{25,26}

Findings

Between 1960 and 2010, in the US there were ~2.5 million infant deaths and 189 million person-years at risk for persons < age 1 (Appendix Table A1). The only racial/ethnic groups for whom the percentage of infant deaths exceeded their percent share of the population, in each and every income quintile, were the US black and American Indian and Alaska Native populations. For example, for 1960–2010, black infants comprised 15.4% of all US infants

and 27.8% of all US infant deaths, and in the lowest income quintile, equaled 20.7% of total infants and 35.4% the infant deaths.

Figure 1 displays the 1960–2010 infant death rates (3-year moving average) by income quintile for the total US population, white population, black population, and populations of color, along with the rate difference and rate ratio, by income quintile, for each group. Also shown is the annual percent change in infant death rates by income quintile. In the Appendix, Figure A1 in turn presents, within each income quintile, the rate difference and rate ratio by race/ethnicity. Analogous data are shown, respectively, in Appendix Figures A2 and A3 for 1999–2010, using the more refined racial/ethnic categories.

Four primary findings stand out. First, the largest beneficial changes, in both rates and health inequities for the total population, by income quintile, primarily occurred between the mid-1960s and 1980 (Figure 1 and Appendix Figure A1). Second, although rate differences by race/ethnicity within all income quintiles shrank over time, the largest declines occurred in the two lowest income quintiles between 1960 and the early 1970s. Third, the largest annual percent changes in the infant death rate (between –4% and –10%) occurred, for all racial/ethnic groups, in the two lowest income quintiles between the mid-1960s and early 1980s; since the 1990s, they have hovered between –1% and –3%, considered across all income quintiles (Figure 1). Fourth, analyses using the more refined racial/ethnic groups, available for 1999–2010, revealed smaller absolute and relative inequities and smaller changes in their magnitudes as compared to the longer-term analyses (Table 1; Appendix Figures A2 and A3).

Exemplifying these trends, among the US total and white population, infant death rates in the lower 4 income quintiles, which in 1960 ranged between 25 to 30 per 1000, dropped, by the mid-1980s, to ~9.5 to 11/1000, leading to convergence of their excess absolute and relative risks of infant death compared to highest income quintile; thereafter, their rates diverged, leading to re-emergence of differential risk by county income quintile (Figure 1). Among the US black population and populations of color, by contrast, socioeconomic gradients among the 3 lower compared to highest income quintile that were evident in 1960 (when rates ranged between ~46 to 51/1000) more quickly converged by the early 1970s, after which they re-emerged, then re-converged in the early 1980s, and re-emerged again in the mid-2000s. (Figure 1).

Concomitantly, the magnitude of the absolute gap in the infant death rate between the lowest and highest income quintile, in the total population and each racial/ethnic group, shrank by ~5/1000 (over 25% of the total infant death rate), comparing 1970–1972 vs. 1980–1982, whereas the size of the absolute gap remained unchanged comparing 1999–2001 vs. 2008–2010 (Table 1). Yet, whereas the significantly elevated rate ratios comparing the lowest to highest income quintile increased, between 1960 and 2010, for the total and white population (respectively from 1.3 to 1.5 and from 1.2 to 1.4), they declined among the black population between 1960 and 1990 (from 1.2 to 2.0), then rose again to 1.2 in 2010 (Table 1). Additionally none of the reductions in rates and inequities, using the more refined racial/ethnic categories available for 1999–2010, were as large as those observed between the mid-1960s and 1980 (Table 2; Appendix Figures A2 and A3).

Finally, the Healthy People 2020 target of 6 infant deaths per 1000 livebirths³ (as proxied by the infant death rate) was already met, a decade in advance, by the US white non-Hispanic population in the top income quintiles and also overall and by Hispanics and Asian and Pacific Islanders in all income quintiles and overall (Table 1; Appendix Figure A2). This target was not met, however, by black non-Hispanics or American Indian and Alaska Natives in any income quintile (Table 1; Appendix Figure A2).

Interpretation

The case example of long-term 50-year trends, spanning from 1960 to 2010, in US infant death rates and their economic and racial/ethnic inequities, reveals that the current comparative stagnation in or worsening of infant death rates and their socioeconomic and racial/ethnic inequities contrast sharply to prior patterns, primarily before 1980, of pronounced beneficial change, especially for infants in the lower income quintiles. A key implication is that the population health data that contribute to setting quantitative targets should extend beyond the recent past, especially when there are good grounds to believe that temporal dynamics reflect not only changing technology but also political priorities, whose implications for health cut across both the lifecourse and generations.^{5–14}

Our findings are unlikely to be compromised by well-known potential biases. Death registration was 99% complete by 1960,¹⁸ and the US census undercount (disproportionately affecting poor persons and/or persons of color) has also declined substantially over time,²⁷ thereby shrinking any inflation of recent estimates of social inequalities in mortality. Moreover, data indicate that racial/ethnic misclassification of “black” and “white” in the mortality data is <1%,³¹ and that the higher levels of misclassification for other racial/ethnic groups,²⁸ especially American Indians and Alaska Natives,²⁹ primarily results in underestimation, not inflation, of the magnitude of racial/ethnic inequities.^{28,29} Furthermore, cross-sectional analysis of county income quintile data and infant death data is unlikely to be affected by issues of lag time and migration, because even if the mother/parents migrated prior to the infant’s death, conditions at the time of death remain highly salient, as reflected by higher racial/ethnic and socioeconomic inequities for post-neonatal (>28 days) compared to neonatal (<28 days) mortality.^{2,4,13,24}

Assuming our results are valid, the reported findings raise important substantive questions regarding the specific changes in political, legal, and social conditions and health systems that over time likely contributed to the observed results.^{8,14,24} Ascertaining both how – and the extent to which -- these diverse phenomena have shaped US trends in infant mortality rates and inequities in these rates will require not only rich multi-level and longitudinal data on the etiologic drivers implicated by prior research,^{4,8,13,14,17} but also quantitative and qualitative research attuned to investigating the impacts of actual interventions – in context.^{11,12,30}

Beyond this, our results raise provocative questions about reliance on short-term data to set quantitative targets, whether for on-average rates or for health inequities. For example, the original MDG targets for 2015, including for infant mortality, were announced in 2000 and set in relation to 1990 baseline data, with calls for disaggregation of data framed solely in

relation to “sex” and “urban/rural” location; only in the 2012 documentation is there reference to disaggregation by socioeconomic level and race/ethnicity,¹ and the kinds of data that will contribute to target setting in the post-2015 era remain under active discussion.^{1,2} The SACIM report, in turn, relied on the average trend for 2007–2010 (4 years; –3.1% decline) to formulate its proposed target of reducing the US infant mortality rate to 5.0 deaths/1000 livebirths by 2015 and to 4.5 by 2020 (i.e., lower than the Healthy People 2020 target of 6)^{4,p.18}; the setting of additional targets for reducing the excess rates among African American and American Indian/Alaska Native compared to white infants is a task recommended for a future panel, with no mention of socioeconomic inequities.^{4, p. 43}

The past 15 years, or past decade, or even past few years, as a span of time, however, is a human invention. It is based on a solar calendar and has no intrinsic social or biological meaning, even as it may feel like and function as a political eternity; its relevance to population health and health targets is instead historically contingent, depending on societal conditions – and also the biological processes involved.^{31,32} Although experiences of a decade or two may shape expectations, understanding possibilities for change requires a far deeper grasp of causal processes – both social and biological – that contribute to shaping long-term trends for not only on-average health but also health inequities.^{7–13,17,31,32} For example, introduction of a fast-acting new vaccine or new policy mandating vaccination,³³ may dramatically shift on-average rates of the infectious disease at issue and thus appear to render the need for knowledge of past (i.e., pre-vaccine) trends moot. However, as suggested by the case of childhood compulsory vaccination in the US and in other countries,^{33,34} long-term data on trends in inequities in the disease distribution nevertheless remain salient to guiding contemporary interventions, by demonstrating which social groups have faced enduring obstacles to achieving rates of the outcome on par with the most privileged groups. The goal, after all, must be to do more than align with trends underway (including improvements in technology) that would happen even without any concerted public health action.⁵

Hence, although reliance on recent population health data may appear both pragmatic and cutting-edge, as our findings reveal, it can – depending on historical circumstances – potentially undercut the progressive objective of target setting. Data on long-term trends in on-average health and health inequities are thus a necessity, not a luxury. Consequently, initiatives to improve the availability of accurate and publicly accessible historical population health data -- in which health records (and their denominators) can be used to monitor trends in both on-average health and health inequities -- warrant support.^{31,35–37} Support likewise is needed for efforts to obtain the pertinent long-term social, economic, legal, and policy data relevant to shaping the public’s health,^{6,11,12,30,31,35} and also to improve statistical methods to analyze large complex spatiotemporal data sets.^{8,31,35–37} The goal should be to formulate quantitative targets, informed by principles that prioritize advancing both overall health and health equity,³⁸ that push beyond recent trends.⁵

In summary, adequately planning for the people’s health requires reckoning with history. Focus only on the recent past, and changes seen and envisioned will reflect only the scope of possibilities under current societal arrangements, as experienced by the relevant birth

cohorts who embody their respective cumulative exposures.^{8,31} Expanding the timeframe allows for new insights into comprehending and advancing what can be achieved.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
US infant death rates (3-year moving average), and rate difference and rate ratio by income quintile, for the total, black, and white population, 1960–2010.

Table 1

US infant death rate: rate difference (RD) and rate ratio (RR), with 95% confidence interval, for infant deaths per 1000 persons <age 1, comparing lowest county income quintile (Q1) to highest county income quintile (Q5, referent rate), by race/ethnicity and time period: (a) 1960–2010 (total, black, white), and (b) 1999–2010 (more refined racial/ethnic groups).

Race/ethnicity	Rate comparisons	Time period							
		1960–1962	1970–1972	1980–1982	1990–1992	2000–2002	2008–2010		
Total population	a) 1960–2010								
	Rate difference (95% CI): Q1 vs. Q5	6.99 (6.72, 7.27)	8.74 (8.47, 9.02)	3.09 (2.87, 3.30)	3.06 (2.89, 3.23)	2.77 (2.62, 2.91)	2.59 (2.45, 2.74)		
	Rate ratio (95% CI): Q1 vs. Q5	1.33 (1.31, 1.34)	1.59 (1.57, 1.61)	1.28 (1.26, 1.30)	1.43 (1.40, 1.45)	1.52 (1.48, 1.55)	1.51 (1.47, 1.54)		
	Referent rate (Q5)	21.5	14.8	11.0	7.2	5.4	5.1		
Black	Rate difference (95% CI): Q1 vs. Q5	8.67 (7.75, 9.60)	6.79 (5.68, 7.9)	1.72 (0.91, 2.54)	0.36 (−0.29, 1.00)	1.89 (1.36, 2.42)	2.20 (1.73, 2.67)		
	Rate ratio (95% CI): Q1 vs. Q5	1.22 (1.19, 1.25)	1.22 (1.18, 1.27)	1.08 (1.04, 1.12)	1.02 (0.98, 1.06)	1.16 (1.11, 1.22)	1.22 (1.17, 1.27)		
	Referent rate (Q5)	39.2	30.4	21.5	17.2	11.5	10.1		
	Rate difference (95% CI): Q1 vs. Q5	3.53 (3.25, 3.81)	6.52 (6.24, 6.80)	1.66 (1.43, 1.88)	2.22 (2.05, 2.39)	2.07 (1.92, 2.23)	1.94 (1.78, 2.09)		
White	Rate ratio (95% CI): Q1 vs. Q5	1.19 (1.17, 1.20)	1.48 (1.45, 1.50)	1.17 (1.14, 1.19)	1.36 (1.33, 1.39)	1.44 (1.40, 1.48)	1.43 (1.39, 1.47)		
	Referent rate (Q5)	19.0	13.6	10.0	6.2	4.7	4.5		
American Indian + Alaska Native	b) 1999–2010								
	Rate difference (95% CI): Q1 vs. Q5	1.06 (−0.89, 3.01)		−0.75 (−2.91, 1.41)		2.70 (0.92, 4.48)			
	Rate ratio (95% CI): Q1 vs. Q5	1.14 (0.89, 1.48)		0.92 (0.73, 1.17)		1.42 (1.09, 1.89)			
	Referent rate (Q5)	7.8		9.6		6.4			
Asian and Pacific Islander	Rate difference (95% CI): Q1 vs. Q5	0.35 (−0.38, 1.08)		0.84 (0.14, 1.53)		0.75 (0.06, 1.43)			
	Rate ratio (95% CI): Q1 vs. Q5	1.09 (0.91, 1.29)		1.22 (1.04, 1.43)		1.20 (1.02, 1.40)			
	Referent rate (Q5)	4.0		3.8		3.8			
	Rate difference (95% CI): Q1 vs. Q5	1.48 (0.90, 2.06)		2.80 (2.23, 3.37)		1.99 (1.47, 2.51)			
Black non-Hispanic	Rate ratio (95% CI): Q1 vs. Q5	1.12 (1.07, 1.17)		1.23 (1.18, 1.29)		1.18 (1.13, 1.24)			
	Referent rate (Q5)	12.8		12.1		11.0			
Hispanic	Rate difference (95% CI): Q1 vs. Q5	0.21 (−0.09, 0.51)		0.38 (0.10, 0.65)		0.44 (0.17, 0.71)			
	Rate ratio (95% CI): Q1 vs. Q5	1.04 (0.98, 1.1)		1.07 (1.02, 1.13)		1.09 (1.03, 1.15)			
	Referent rate (Q5)	5.3		5.2		5.0			
	Rate difference (95% CI): Q1 vs. Q5	2.49 (2.31, 2.68)		2.60 (2.42, 2.79)		2.50 (2.31, 2.68)			
White non-Hispanic	Rate ratio (95% CI): Q1 vs. Q5	1.55 (1.50, 1.60)		1.58 (1.53, 1.63)		1.60 (1.54, 1.66)			

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