# Dynamics of Child Mortality Inequality

By Tom S. Vogl [*]

Improvements in global health since 1960 have coincided with decreases in the dispersion of life expectancy across countries, driven in large part by converging mortality rates among the young (Becker, Philipson, and Soares 2005). But just as in the case of the global income distribution, both within-country and cross-country inequality are relevant for thinking about welfare. Compiling data from 238 household surveys in 79 developing countries, this paper explores how the distribution of child deaths across mothers evolves over the course of aggregate mortality decline.

If every mother had exactly one child, then as death rates fell, child deaths would trivially become more concentrated in a few mothers. But the existence of larger families leads to an ambiguous relationship between the frequency of child deaths and their distribution across mothers. To take an extreme example, consider a population in which all mothers had 10 children each, with a single child dying for 9 out of every 10 mothers and all children dying for every tenth. If the high-risk group experienced a decline of 9 child deaths per mother, then the aggregate mortality rate would fall by nearly half, and the distribution of child deaths would become less unequal.

The 'clustering' of child deaths in large, high-risk families is the subject of a demographic literature dating to Das Gupta (1990). A general conclusion is that clustering is more common than would be expected from a binomial distribution with a constant probability of death per child. Whether this phenomenon strengthens or diminishes with overall mortality decline is an open question, with parallels to the link between economic growth and inequality.

To shed light on this question, the paper estimates Lorenz curves and Gini coef-

ficients for the distribution of child deaths across mothers. The data suggest that declining child mortality has not disproportionately favored mothers with more children, nor higher-risk mothers within a parity (children ever born). Consequently, as child deaths have become rarer, they have also become more unequally distributed.

Relative to the literature on health inequality, the paper innovates in two ways. First, it measures overall health inequality, rather than the more common approach of focusing on differences across socioeconomic groups. As Murray, Gakidou, and Frenk (1999) argue, while the 'social gradient' in health is important, overall health inequality is more comprehensive and less susceptible to concerns about unmeasured health determinants or changing selection patterns. Second, it changes the unit of analysis from the deceased individual to the family members who survive the individual. Most research on overall health inequality deals with variability in age at death (Peltzman 2009), an individual-level phenomenon. By focusing instead on mothers at risk of experiencing multiple child deaths, the paper raises questions about the welfare consequences of death for survivors of the deceased. In this sense, the paper builds on Umberson et al.'s (2017) study of racial differences in exposure to death of family members in the United States. Loss of a child is a traumatic event, and its distribution sheds light on an understudied source of inequality in wellbeing.

## I. Data

The Demographic and Health Surveys (DHS) have interviewed millions of women of childbearing age (15-49) in developing countries since the 1980s, offering comparable data on the distribution of child mortality for many countries. The analysis sample draws on all 238 standard DHS sur-

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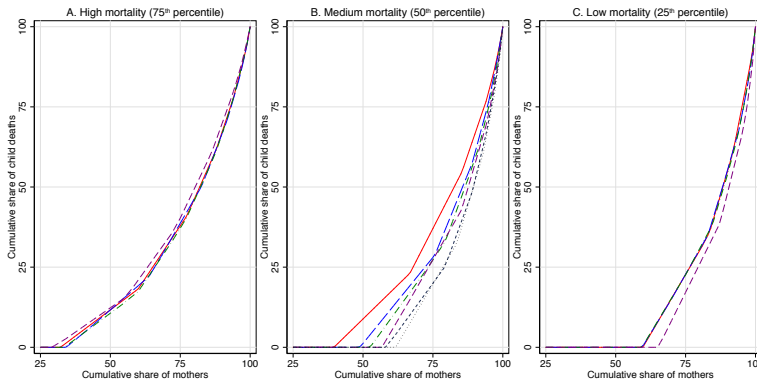

FIGURE 1. MORTALITY LORENZ CURVES ACROSS THE DISTRIBUTION OF AGGREGATE MORTALITY

*Note:* Cumulative share of child deaths accruing to the bottom x percent of mothers, in cohorts with at least 500 observations that are within 0.25 percentage points of each quantile of the fraction of children dead. The $75^{th}$ percentile is 0.21 (4 cohorts); the $50^{th}$ percentile is 0.15 (6 cohorts); the $25^{th}$ percentile is 0.11 (4 cohorts).

veys in the public domain, representing 79 countries in all world regions except Western Europe. It includes all mothers born during 1940-1969 who were 45+ (to ensure that childbearing is complete) with no more than 12 children ever born (99% of all mothers) at the time of the survey. All analyses separate mothers into cells defined by country and decadal birth cohort; some further disaggregate by the number of children ever born, or parity. To reduce noise in the parameter estimates, cells with fewer than 30 observations are dropped. After applying these restrictions, the sample consists of 249,575 mothers, forming 183 country-cohort cells (henceforth, 'cohorts') and 1445 country-cohort-parity cells.

For simplicity, all children who died before the survey date are counted as deceased. Aggregate mortality for a cohort is measured as the fraction of the cohort's children who died. This fraction takes on values from 0.03 to 0.36, with a mean of 0.16 and a median of 0.15.

## II. Applying Standard Inequality Measures to Child Mortality

The Lorenz curve provides a good starting point for studying inequality in child death. It plots the cumulative share of child deaths against the cumulative share of mothers, ordered by the number of deceased children. To illustrate at different levels

of aggregate mortality, Figure 1 plots child mortality Lorenz curves for large cohorts near the $75^{th}$, $50^{th}$, and $25^{th}$ percentiles of the distribution of the fraction dead.

The figure suggests several properties of child mortality Lorenz curves and their evolution during mortality decline. First, in high mortality populations, child deaths are widely dispersed across mothers, albeit not equally. Near the $75^{th}$ percentile, one-third of mothers experienced at least one child death, while one-tenth experienced at least three, and the top 1% of mothers accounted for 4-5% of child deaths. Second, in low mortality populations, Lorenz curves are shifted to the right, indicating greater concentration of child deaths or, equivalently, more inequality. Near the $25^{th}$ percentile, the top 1% of mothers accounted for 7-10% of child deaths. Third, among medium mortality populations, Lorenz curves land between those in high and low mortality populations but take on a wide range of shapes. At one extreme is Sudan 1940-49 (solid red), where the top 1% of mothers accounted for 5% of child deaths; at the other is India 1950-59 (dotted black), where the top 1% accounted for 9%.

These top 1% shares offer an intuitive measure of inequality in child deaths, but the choice of a percentile–rather than, say, a decile–is arbitrary and ignores the distribution of deaths over the bottom 99% or within the top 1%. As in the study of in-
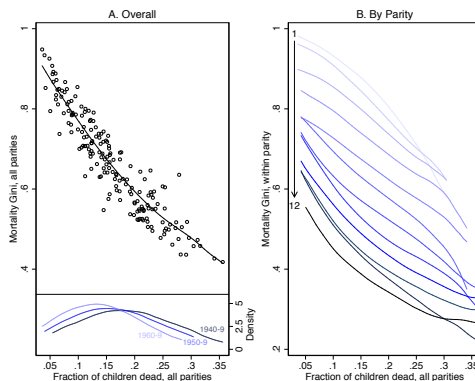
FIGURE 2. AGGREGATE MORTALITY AND MORTALITY INEQUALITY

*Note:* Local linear regressions and kernel densities with bandwidths of 0.05. Sample consists of 181 10-year birth cohorts from 79 countries. In Panel B, parity-cohort cells are included if they contain at least 30 observations.

come or wealth inequality, the Gini coefficient provides a solution that reflects the entire distribituion. Graphically, the Gini coefficient is the area between the Lorenz curve and the line of perfect equality (the 45° line) divided by the area beneath the line of perfect equality ($\frac{1}{2}$). More formally, let $i$ index mothers in increasing order of deceased children, let $y_i$ be mother $i$'s number of deceased children, and let $k$ and $n$ be the overall numbers of deceased children and mothers, respectively. Then the Gini coefficient can be written as:

$$G = \frac{2}{nk} \sum_{i=1}^{n} iy_i - \frac{n+1}{n}$$

Greater concentration of child deaths raises the summation in the first term.

Among mothers with only one child, the Gini coefficient has a trivial relationship with fraction of children dead. To see this point, note that $y_i$ becomes a binary variable in this case, so that $\sum_{i=1}^{n} iy_i = \sum_{i=1}^{k}(n+1-i) = kn + k - \frac{k(k+1)}{2}$. Plugging in leads to $G = 1 - d$, where $d \equiv \frac{k}{n}$ is the number of deceased children per mother in the population, which in the only-child case equals the fraction of children dead. Equivalently using graphical reasoning, the Lorenz curve is flat at 0 until the $x$-axis reaches $1-d$, after which it rises linearly toward 1. The area between the Lorenz curve and the line of perfect equality is $\frac{1-d}{2}$, again

leading to $G = 1 - d$. Because deaths are most equally distributed when mothers differ from each other by at most one death, a corollary is that in any population, the Gini coefficient is bounded below by 1 minus the number of deceased children per mother.[1]

While the one-child case provides a lower bound, the actual Gini coefficient need not be a negative function of the fraction dead in populations with more children per mother. In the example from the Introduction, the decline in child deaths accruing to high-risk mothers reduces the Gini coefficient from 0.43 to 0. More generally, mortality reduction that strongly favors large or high-risk families will reduce inequality in child deaths, while most other forms of mortality reduction will concentrate deaths, increasing inequality.

Thus, the relationship between aggregate mortality decline and mortality inequality fundamentally reflects a race between the progressivity of mortality decline and the growing share of mothers who experience no child deaths. In addition to these forces, the distribution of family size shapes child mortality inequality, as having fewer children per mother reduces the scope for equally distributing child deaths. Family size may explain the greater Lorenz curve heterogeneity in Figure 1 at median aggregate mortality. Because countries at this mortal-

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[1] A tighter bound exists when $d > 1$, but one can show that it never exceeds 0.18.
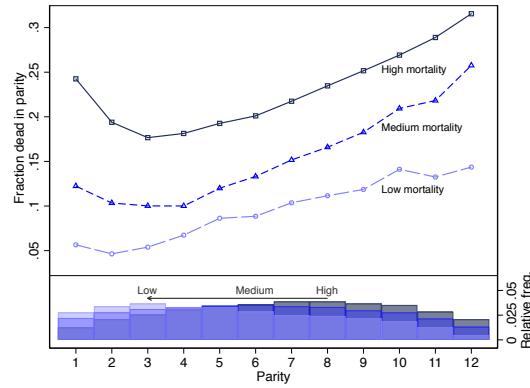
FIGURE 3. PARITY AND FRACTION DEAD

*Note:* Conditional means and histograms. 'High,' 'medium,' and 'low' are, respectively, the top (.19-.36), middle (.12-.19), and bottom (.03-.12) terciles of the fraction dead in all parities. Sample consists of 1445 country-cohort-parity cells from 79 countries.

ity level are undergoing demographic transition, they may exhibit greater variation in fertility. Indeed, the Sudanese and Indian cohorts discussed above have means of 7.6 and 4.4 children ever born, respectively.

## III. Dynamics of Mortality Inequality During Mortality Decline

Across the 181 cohorts, the child mortality Gini takes on values from 0.42 to 0.94, with a mean of 0.66 and a median of 0.67. Figure 2, Panel A, plots it against the fraction of children dead, revealing a tight negative relationship. In settings where more than one in four children die, Ginis hover around 0.5; where fewer than one in ten die, they range from 0.8 to 0.9. At the bottom, kernel densities show that later birth cohorts experienced less child death.

Panel B disaggregates by children ever born, finding that the negative slope in Panel A is not an artifact of the mechanical relationship for lower-parity mothers. Gini coefficients decline with the aggregate mortality rate for all parities from 1-12. That is to say, the forces of concentration dominate even in the example from the Introduction with 10 children per mother, which gave ample opportunity for progressive redistribution of deaths during mortality decline. Mortality decline does not reduce the relative importance of death clustering, even among large families.

Also apparent in Panel B is the greater inequality of child deaths among lower parity mothers. The estimated regression function for each parity lies below that for the next lowest parity. This tendency for less equality at lower parities is in part because, even with a constant risk of death per child, fewer children per mother leave less scope for equally distributing deaths.

However, a child's risk of death is not constant across family sizes, which also contributes to the relationship between parity and child mortality inequality. As Figure 3 makes clear, higher parity mothers experience higher rates of child death, regardless of the aggregate mortality environment. Splitting cohorts into three groups based on terciles of the aggregate fraction dead, the figure finds predominantly positive relationships between parity and the fraction dead within that parity. As aggregate mortality declines, parity-specific death rates all decline, without the bias toward higher parities necessary to reduce overall inequality. In fact, the greatest declines are at the lowest parity, likely because of changes in the socioeconomic composition of that group.

The bottom of Figure 3 draws a parity histogram for the high, medium, and low mortality cohorts, showing lower fertility in lower mortality cohorts. As a result, when aggregate mortality is low, more weight is placed on lower parity mothers, who exhibit more within-parity inequality.

TABLE 1—DEMOGRAPHIC DETERMINANTS OF THE CHILD MORTALITY GINI

|  | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Fraction of children dead | -1.630 | -1.080 | -1.111 | -0.938 |
| ($\mu = 0.16, \sigma = 0.07$) | (0.070) | (0.233) | (0.085) | (0.202) |
| Mean children ever born |  |  | -0.039 | -0.042 |
| ($\mu = 5.86, \sigma = 1.32$) |  |  | (0.003) | (0.007) |
| | | | | |
| Adjusted $R^2$ | 0.86 | 0.96 | 0.95 | 0.97 |
| Country, period of birth FE | No | Yes | No | Yes |

*Note:* OLS regressions with standard errors (clustered by country) in parentheses. Sample consists of 181 10-year birth cohorts from 79 countries. The mean and standard deviation of the Gini coefficient are 0.66 and 0.12, respectively. $\mu$ and $\sigma$ refer to the means and standard deviations of the covariates.

To summarize these patterns quantitatively and assess the importance of cross- and within-country variation, Table 1 reports regressions of the child mortality Gini coefficient on the fraction dead and mean children ever born, with and without country and birth period fixed effects. All four regressions indicate a large, significant negative association, with columns (2)-(4) implying that a 1 standard deviation decline in aggregate mortality raises the mortality Gini by 0.07-0.08. The mortality Gini also rises with falling mean fertility, as expected.

According to the regression results, aggregate fertility and mortality can account for almost all variation in mortality inequality. After conditioning on fertility, the adjusted $R^2$ is at least 0.95, with or without country and birth period fixed effects. In fact, the (unreported) birth period fixed effects are jointly insignificant in the regression in column (4), so changes in aggregate mortality and the mean fertility can entirely explain average cross-cohort changes in the mortality Gini. Between the birth cohorts of the 1940s and 1960s, the Gini grew 0.10 on average, the fraction dead shrank 0.06 on average, and mean fertility shrank 0.93 on average. Using column (4), nearly 60% of the rise in mortality inequality is attributable to mortality decline, while nearly 40% is attributable to fertility decline.

## IV.   Discussion

Survey data from 79 developing countries reveal that as child mortality has declined, it has become more unequally distributed across mothers. The welfare implications of this finding depend on whether grief compounds or abates with multiple losses, an interesting question for future work. Work in progress asks whether inequalities in child mortality persist across generations and how this persistence changes with mortality decline.

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