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Maternal cohort measures of child mortality
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Demographers have long noted that fertility patterns look different from period and cohort perspectives (e.g. Ryder 1964, and most recently, Lam 2008). However, despite the fact that child mortality is often considered to play an important role in determining fertility (see e.g. Preston, 1978; UN Secretariat, 1988; Montgomery and Cohen, 1998), little work has been done to distinguish cohort from period patterns in childhood mortality. If one only considers child cohorts, the distinction is not very important – because the concept of childhood mortality is defined for relatively small age groups of at most five years, children dying in any given five year period are necessarily born in the same period or the immediately previous one.

If however we consider the experience of the children of a given birth cohort of mothers, far more variation is possible, and even likely, when fertility and mortality patterns are changing rapidly. In this paper I contrast time patterns of child mortality generated from a more traditional child cohort perspective with those generated from a maternal cohort perspective for a wide variety of developing countries using retrospective survey data.

Data

Data are drawn from 139 Demographic and Health Surveys (DHS) carried out in 65 countries between 1986 and 2005. The surveys were carried out over the course of 5 distinct survey rounds (roughly 1984-1989, 1988-1993, 1992-1997, 1997-2003, and

2003-2005). Since fertility and child mortality are among the most easily defined questions and central to the mandate of the DHS, comparability over time is not of primary concern, though some additional assessments are warranted. Pullum (2006) provides some comparisons for age and date data. Each survey contains a full birth history, including age at death for those children who have died, for all women aged 15-49 in surveyed households[1] Altogether, the surveys contain information about over 3.5 million births.

Methods

For each survey, several infant (1q0) and under-five (5q0) mortality rates were calculated. Maternal cohort rates were calculated for three five-year cohorts, women 35-39, 40-44, and 45-49 at the time of the survey. I limit to these cohorts in most cases because members of younger cohorts are less likely to have completed their childbearing. For consistency across the three cohorts, only births from before the mother turned 35 are counted (i.e. children who will be born to a 42-year-old cannot be accounted for if this future mother is 38 at the time of the survey). The most recent five years of births are excluded because censoring cannot properly be accounted for without assuming an age distribution of mortality. Deaths before age 1 and 5 among these three birth categories are also counted, and by dividing, six maternal cohort mortality rates are calculated for each survey.

[1] In some South Asian, Middle Eastern and North African countries, only ever married women are interviewed. In Brazil and Guatemala, the first survey excluded women 45-49, while the Vietnam survey excluded 15-year-olds.

(True) child cohort rates were calculated as deaths before age x divided by births, for each five-year cohort of children, and ages x=1 and 5. Once again, births to women over the age of 35 are excluded for comparability, and births in the past five years are excluded because of censoring. Note that while these are conceptually closer than maternal cohort rates to the synthetic (child) cohort measures reported for periods in Demographic and Health Survey reports, they are not the same. However, for simplicity of style, below I will typically refer to maternal cohort rates as cohort rates and true child cohort rates as period rates.

Figure 1 shows the categories for each perspective in a pair of Lexis diagrams. By construction, areas m1-m6 and c1-c6 contain the same births. However, most comparisons below will be carried out between m1-m3 and c4-c6, because their distribution of ages and years is more comparable across methods than the full set. Using all twelve period and cohort measures, the last cohort and first period would only include mothers who gave birth in their teens. Since this is a high risk age group, selecting on it would likely bias the slope of mortality over time upward for cohorts and downward for periods. Limiting to m1-m3 and c4-c6, only groups m3 and c4 are truncated, and only slightly so – in each case, approximately half of the births from one cohort's experience in one period (the triangles partially defined by the thin dashed lines in Figure 1) is missing.

Figure 1 also raises the question of where to place these rates in time. For child cohorts, I use the mean birth date. For maternal cohorts, I use the mean maternal birth date plus the mean maternal age at birth. In both cases, means are calculated over all births in the relevant group.[2]

For a crude first comparison of trends, I regress 1q0 (and 5q0) on time independently for each survey and method. I limit myself to 110 surveys because of difficulty distinguishing between multiple surveys in the same DHS round for 12 countries and sample size problems in 4 others[3]. Each regression only contains three points, so slopes are very noisily measured.

Results

One might expect that slopes for the cohorts will be steeper, because in each case (i.e. comparing m1 to c4, m2 to c5, and m3 to c6), they contain more time (and more high fertility time) before the period of comparison than after. For example, the portion of m1 that is in the same period as c4 is ages 25 to 35, between the bold dashed lines. The cohort likely had more children before this period, and therefore in a worse health environment given improving overall health, than after. Since the period mortality rates in these countries are typically decreasing at a decreasing rate, this implies that cohort trends will be flatter.

In fact, for 1q0, the cohort trend is fact steeper on average, by 0.26 deaths/1000 live births/year. For 5q0, the cohort trend is flatter, but by only 0.02 deaths/1000 live

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[2] Cohorts are defined by age with respect to the survey date, which varies slightly across households within a given survey. Other than the two India surveys (1992-93 and 1998-99) which took almost two years each, the largest span is 10 calendar months; the overall mean is 5.6.
[3] Following the practice of DHS final reports, I only calculate mortality rates for populations having at least 500 births.

births/year. Both of these numbers are qualitatively small with respect to the average rates of change as calculated by either method: 2.7 deaths/1000 live births/year for 5q0 and 1.3-1.6 for 1q0. To the extent that they differ from the prediction above, it's possible that the assumption of improving health environments is at fault – it is certainly not universally true.

As expected, the mean year of birth for each cohort is earlier, by approximately 4 years, than the mean year of birth for its paired period. An alternative comparison, between m2 and c4 and between m3 and c5, would reduce the difference between methods in mean birth year to within 0.5 years on average. This would not entirely remove composition effects though, because m3 and c4 are still missing the experience of 30 to 35-year-olds falling in the small triangles partially bounded by the thin dashed lines in Figure 1. In this alternate setup, there are only two data points per method per survey, so the slope is perfectly identified, but since I am not yet able to use the variance of calculated slopes in a meaningful way anyway, this is not a big problem.

Using this alternative comparison, when comparing virtually the same years, cohort rates decline more steeply than period rates, by 2.2 deaths per thousand live births per year (5q0), and 0.9 deaths per thousand live births per year (1q0), on average. These are now substantial average differences between methods. However, there is a lot of variation across surveys, even within regions. Table 1 classifies surveys by DHS region and whether cohort or period rates display a flatter trend. In each region, there are countries in both categories.

Examples

A few examples demonstrate the variety of the differences between these estimates across countries. Each of the following graphs combines estimates from all surveys for a given country, based on both methods. Cohort measures' labels begin with "1", while period measures' labels begin with "0". All estimates from a given individual survey-method combination are attached with lines of the same color.

Figure 2 shows under-five mortality rates for Madagascar based on two surveys, conducted in 1992 and 1997. The period 1980 to 1985 offers the most striking contrast. The period rate from the 1997 survey is almost flat, however, the analogous cohort rate rises by 40 deaths/1000 live births.

Figure 3 shows the analogous picture for 1q0 in Ecuador. While the period measure is consistently declining, the cohort measure stabilizes, even increasing slightly. This suggests that changing (later) age patterns of fertility may have been driving the continued observed decreases in period mortality. A similar pattern is apparent in Mexico and Nepal (not shown) though in Nepal, even the cohort rates decline somewhat.

In both surveys in Haiti (Figure 4), cohort 1q0 rates first decline and then stabilize, while period rates continue to decline. In this case the availability of two surveys is critical to seeing this pattern, because each individual survey does not overlap fully.

By contrast, the trend demonstrated by India's 5q0 is virtually identical, despite significant change over time, regardless of whether it is calculated for periods or cohorts. India does have by far the largest sample size, but it seems unlikely that all of the patterns described above are artifacts of small sample sizes, because in almost all cases sample sizes are in the thousands. More specifically, every point in Figures 2-5 is based on at least 1300 births.

Conclusion

A preliminary comparison of maternal and child cohort rates of infant and child mortality across 65 developing countries reveals some similarities and some differences, but little overarching structure. Cohort rates in general tend to smooth out period shocks (famines, wars, etc.), but with such short time periods covered, and significant potential for sampling and recall error, it is not clear to what extent these three-point time trends really contain different information. Still the given the importance of period-cohort translation in other areas of demography, future work may be warranted.

Potential future directions

Thus far, I am comparing ad hoc measures. A more formal development of the theory may allow for more appropriate comparisons. For example, child mortality is less directly (or at least differently) affected by parental planning in many contexts than fertility. This implies than the interpretation of any period-cohort differences will differ from those for fertility.

Similarly, the magnitudes of any differences in trends are difficult to interpret without better measures of variance that could be constructed from the underlying survey data. Combining data more carefully across surveys within a country may allow for comparison of more robust and long term trends. I have ignored common data quality issues like age heaping and imputed ages at death that may be playing an important role. The maternal cohort measures in particular contain information about births up to 35 years before the interview, and as such are more prone to recall bias than traditional measures, which go back at most 20 years.

More substantively, if these differences survive more rigorous methods, the implications for fertility trends are an obvious application. Related analyses could be done at the individual, cluster and national level to see whether the child mortality experience of neighbors and others is affecting individual women's fertility, net of their own child mortality experience.

References

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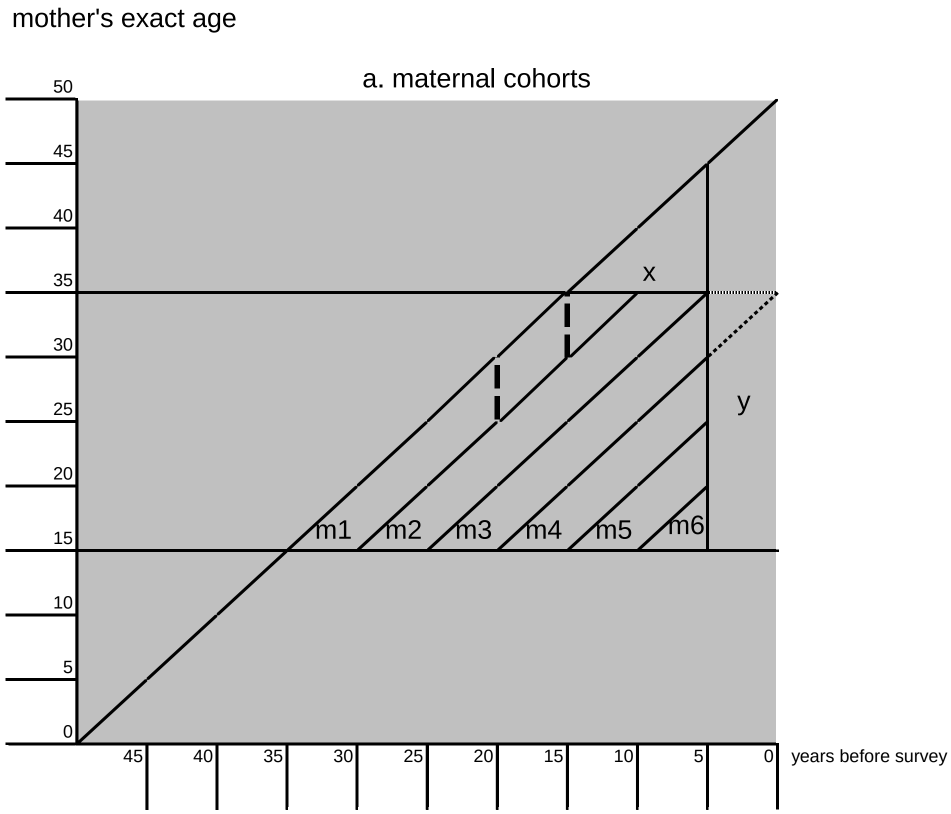
Table 1. Tabulation of surveys by the difference in time trend between period and cohort rates of child mortality, by region and mortality measure

	1q0		5q0	
survey region	period steeper	cohort steeper	period steeper	cohort steeper
Central Asia	1	1	1	1
Latin America & the Caribbean	6	16	3	19
North Africa/West Asia/Europe	3	7	2	8
South & Southeast Asia	7	8	7	8
Sub-Saharan Africa	28	33	19	42
Surveys	110		110	

Figure 1. Births in a retrospective survey of mothers, classified by maternal and child cohorts



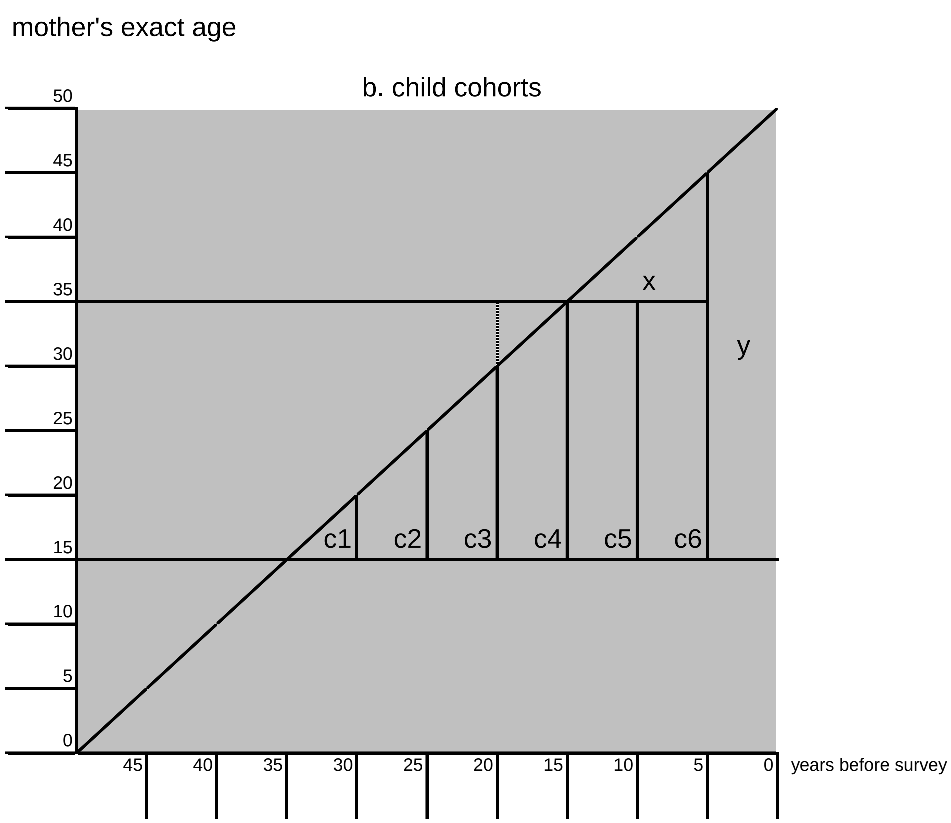


Figure 2. Madagascar under-five mortality rates

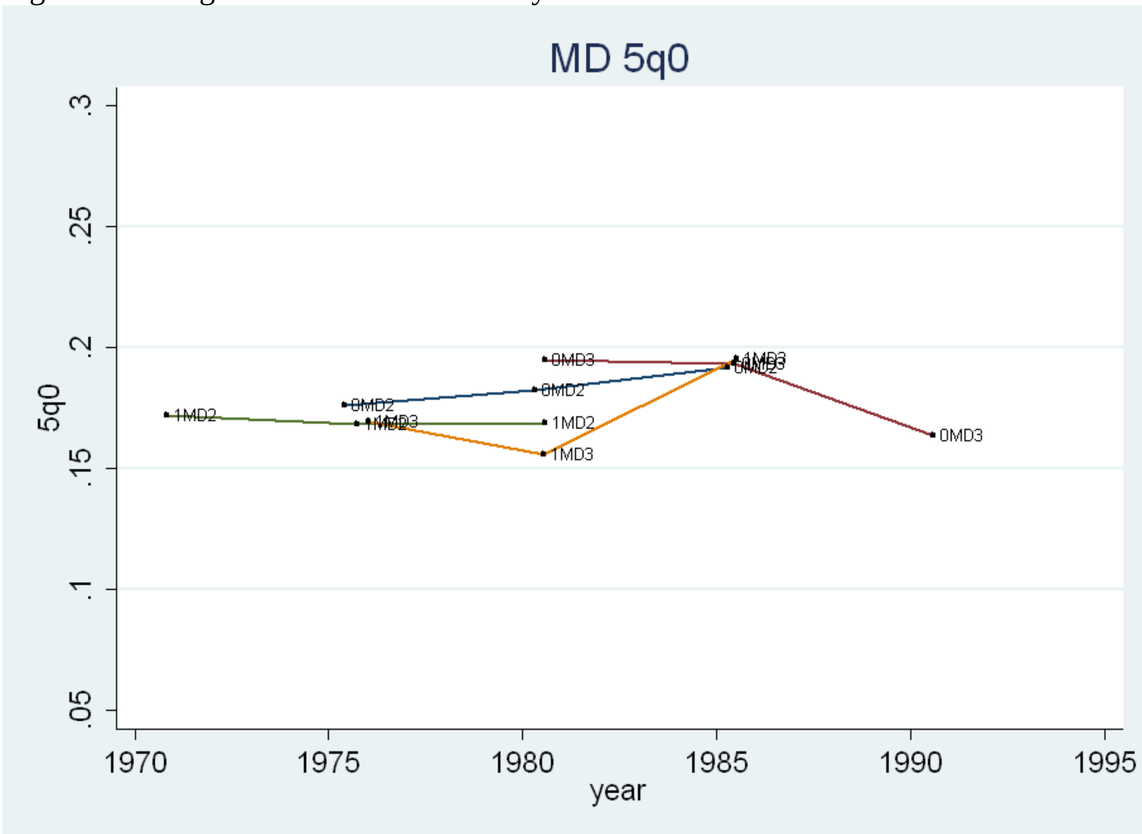


Figure 3. Ecuador infant mortality rates

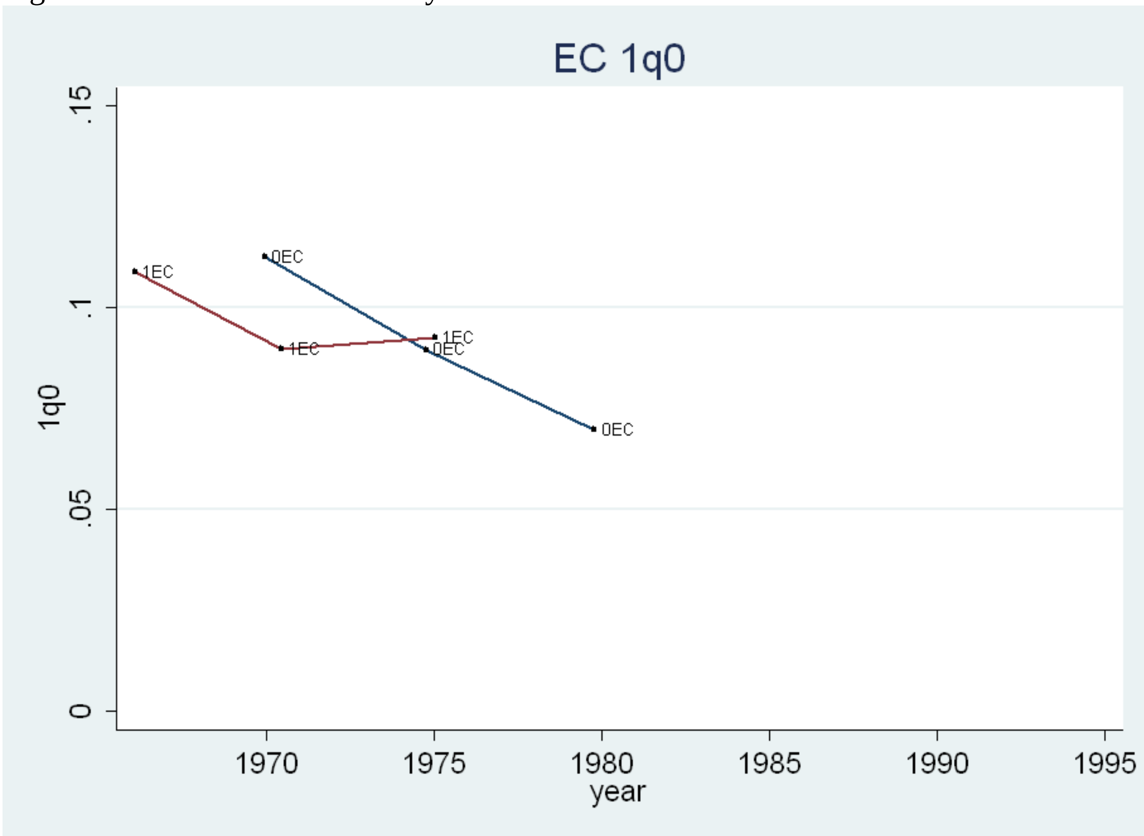


Figure 4. Haiti infant mortality rates

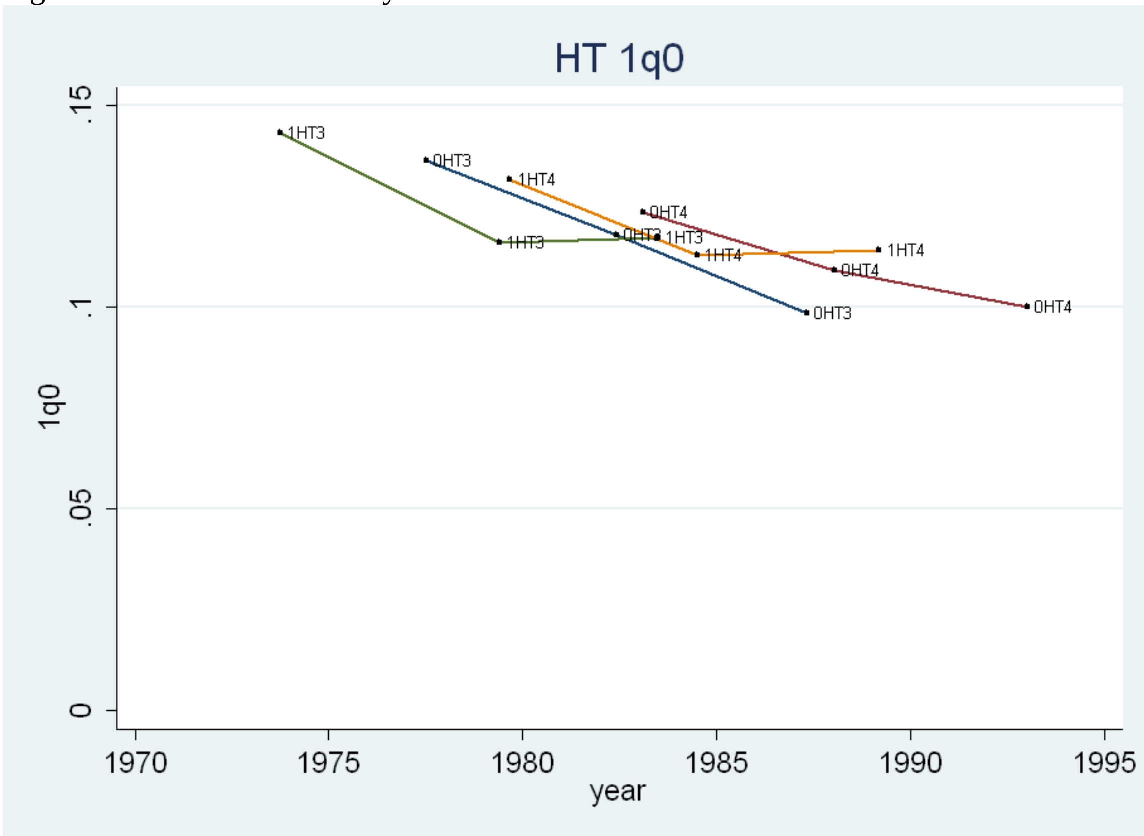


Figure 5. India under-five mortality rates