Long-term effect of in-utero conditions on maternal survival later in life: Evidence from sub-Saharan Africa

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Background

Countries in sub-Saharan Africa (SSA) continue to have some of the highest rates of maternal mortality in the world. Most research on the causes of maternal mortality focuses on conditions during pregnancy and at the time of delivery. However, consistent with the fetal programming hypothesis, a woman's maternal survival may also be related to conditions she experienced while in-utero.

There is growing evidence from both the economics and medical literature that fetal conditions can have long-term and permanent effects on educational attainment, income, and adult health outcomes. There exist various plausible pathways through which in-utero conditions could affect risk factors for maternal mortality later in a woman's life and no study has yet investigated the potential causal impact of fetal conditions on maternal survival.

Data

The data for this study come from 14 countries in SSA where Demographic and Health Surveys (DHS) were conducted from 1994 to 2007 and which include both sibling-reported maternal survival data and GPS data on the households' current residential location. I link each individual observation (n= 365,214), including both the respondents and the sisters they report on, to the nearest weather station using the GPS location of her household. Based on each observation's month and year of birth, I identify the level of rainfall as recorded at the nearest weather station during the period when each woman was in-utero, using rainfall data from the Global Historical Climatology Network (GHCN) Precipitation Data. Since the DHS do not include information on the individuals' residence at birth and because migration from birthplace may bias the results, I conduct robustness checks, using available variables, to account for migration. In the main specification, I assess whether women who experienced a positive rainfall shock during the in-utero period (defined as rainfall that is at least three standard deviations greater than mean rainfall in the local area) have a different likelihood of surviving pregnancy and delivery later in life compared to those who did not experience a positive rainfall shock while in-utero. Similarly, I assess whether women who experienced a negative rainfall shock during the in-utero period, compared to those who did not, have a different likelihood of surviving pregnancy and delivery later in life.

Methods

Consistent with other studies assessing the impact of in-utero conditions, I use the level of rainfall during the in-utero period as a source of exogenous variation for in-utero conditions. The level of rainfall during the in-utero period is predicted to independently affect in-utero conditions (particularly nutrition for the fetus) which subsequently may affect future maternal survival (when the female fetus is an adult woman).

I use multi-variate regression analysis to identify the impact of rainfall shocks during the in-utero period on the probability of maternal death later in life. Assuming *i* denotes the individual woman, *j* represents her closest weather station, *k* represents her month of birth, and *t* represents her year of birth, I estimate the following specification:

$$(1)\quad m_{ijkt} = \alpha + R_{1ijkt}\beta + R_{2ijkt}\pi + \delta_t + \lambda_j + \eta x_{ij} + \mathrm{Y}_i\theta + \varepsilon_{ijkt}$$

where the outcome, *m*, is a dummy variable that takes on a value of one if the woman died during pregnancy, delivery, or the post-partum period (see Appendix Table A2 for variable definitions). Vector R_1 is composed of three variables. The first variable measures the level of rainfall during the in-utero period, defined as the twelve-month period preceding the woman's month and year of birth. This variable is measured as a z-score, whereby the level of rainfall during the in-utero period is normalized using the mean and standard deviation for rainfall in the woman's closest weather station. The two other variables are dummy variables which measure whether the level of rainfall represents a positive or negative rainfall shock, respectively.

Since rainfall may be serially correlated across years, vector R_2 is included to control for the level of rainfall during other early-life years; these years include the woman's first three years of life and the year prior to when she was conceived. The pre-conception period is defined as the twelve-month period preceding the in-utero period (before the woman's mother was pregnant with her). The first year of life is measured as the twelve-month period starting with the woman's month and year of birth. The second and third years of life (up to the woman's 3rd birthday) are defined similarly. δ is a year of birth fixed effect to control for time-invariant differences by year of birth, such as better average health for a cohort of women due to an early-life health intervention in a certain year. λ is a weather station fixed effect to control for time-invariant characteristics by geographic location. *x* represents household religion and is the only household-level characteristic in the regression. Finally, *Y* is a vector of two variables to control for the potential effect of imputing missing rainfall data. I use a linear probability model, with robust standard errors clustered at the weather station level. The model includes DHS individual sampling weights which are adjusted to account for differences in sample size and population size by country, consistent with methodologies to analyze cross-country DHS data (Balk 2003).

Results

The main results demonstrate that women who experienced a positive rainfall shock while in-utero are significantly less likely to die during pregnancy or delivery later in life. A positive rainfall shock in-utero decreases the probability of maternal death by 1.6 percentage points, representing an 82% decrease from a mean of 1.9% in the sample. In addition, women who experienced a negative rainfall shock while in-utero also have a lower probability of maternal death, with a negative rainfall shock in-utero decreasing the probability of maternal death by 1.8 percentage points, representing a 92% decrease. The specification controls for rainfall during other early-life years, which suggests that the main result is identifying the effect from rainfall during the in-utero period, independent from rainfall during other early years of life. The specification also controls for year of birth fixed effects and weather station fixed effects. Robustness checks are conducted to: account for migration from birthplace, adjust for potential maternal mortality bias in sampling, control for birth season, and control for conditions at the time of delivery. None of the specification checks invalidate the study's main findings.

I further explore the possible pathways which may explain the relationship between rainfall shocks during the in-utero period and subsequent maternal survival by assessing the effect of rainfall shocks during the in-utero period on various health, socio-economic, and fertility-related outcomes, as well as outcomes related to access to care at delivery. These analyses demonstrate that a positive rainfall shock while in-utero reduces body-mass index (BMI) in adulthood. Adult BMI influences cardiovascular risk factors, such as hypertension, which could affect the probability of developing pregnancy-induced hypertension, a risk factor for one of the leading causes of maternal deaths.

While priors predicted that a negative rainfall shock while in-utero would increase the probability of maternal death, the main findings demonstrate that a negative rainfall shock while in-utero has a protective effect on maternal survival. Exploring the causal pathway for this, I find that a negative rainfall shock while in-utero increases the probability of a facility-based delivery, which represents a critical intervention for improving maternal survival. The higher probability of facility-based deliveries may be the result of higher risk pregnancies and deliveries which are either identified during the prenatal period and/or at the time of labor and referred for facility-based deliveries.

Conclusion

This study draws on the growing medical literature related to the long-term effects of in-utero conditions on health outcomes and extends the scope of the fetal origins hypothesis in a novel direction by investigating whether and how potential risk factors for maternal death relate to in-utero conditions. These findings suggest that, in addition to conditions during pregnancy and at the time of delivery, conditions experienced by women when they were themselves in-utero also seem to play a significant role in affecting maternal mortality in SSA.