



Water scarcity and birth outcomes in the Brazilian semiarid[☆]

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ABSTRACT

Roughly one-third of the rural population in developing countries lives in arid and semiarid regions, facing recurrent water scarcity. This is likely to become an even more common situation with climate change. This paper analyzes the impact of rainfall fluctuations during the gestational period on health at birth in the Brazilian semiarid, highlighting the role of water scarcity as a determinant of early life health. We find that negative rainfall shocks are robustly correlated with higher infant mortality, lower birth weight, and shorter gestation periods. Mortality effects are concentrated on intestinal infections and malnutrition, and are greatly minimized when the local public health infrastructure is sufficiently developed (municipality coverage of piped water and sanitation). We also find that effects are stronger during the fetal period (2nd trimester of gestation), for children born during the dry season, and for mortality immediately after birth. Our estimates suggest that expansions in public health infrastructure would be a cost-effective way of reducing the response of infant mortality to rainfall scarcity.

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1. Introduction

Arid and semiarid regions encompass 54% of the developing world's agricultural area and one-third of its rural population. Close to 1 billion people, among the poorest in the planet, live today in regions characterized by recurrent moisture stress. A large fraction of this population has inadequate access to water supplies and improved sanitation facilities (UNDP, 2006; World Bank, 2008).¹ For them, collecting water for consumption, hygiene, and agricultural production is a daily task that demands energy and resources. Lack of adequate access to water also increases the susceptibility to climatic shocks associated with fluctuations in rainfall. In a context of poverty and lack of access to insurance mechanisms, these shocks can have serious welfare consequences

both in the short and in the long run. Notoriously, water scarcity can reduce agricultural production and nutrient intake, impacting health outcomes. In addition, it can directly lead to increased incidence of infectious diseases, such as diarrhea, particularly affecting young children and pregnant women (WHO, 2010, 2012).

This paper analyzes the impact of rainfall fluctuations during the gestational period on health at birth. We concentrate on the semiarid region of Northeastern Brazil – the driest region in the country – to highlight the role of water scarcity as a determinant of early life health. This region has long been subject to harsh climatic conditions, with recurrent events of drought, water scarcity and food insecurity (see, for example, Ab'Sáber, 1999; Áridas, 1995; SUDENE, 1981). We examine whether and how idiosyncratic shocks to rainfall during the time in utero affect a range of health outcomes at birth, including birth weight, number of weeks of gestation, and infant mortality (by cause of death, gender, season of birth, and time since birth). We also explore the specific channels linking variation in rainfall to health outcomes at birth. In our setting, there are two main potential connections in this relationship: (i) lower agricultural production and lower nutrient intake; and (ii) lack of safe drinkable water and higher incidence of infectious diseases.

This research has considerable data requirements. We make use of high frequency gridded information on precipitation and temperature to construct a municipality-by-month weather dataset. This dataset is then combined with birth and mortality registration records to create a municipality-by-month panel on weather conditions and birth outcomes covering the period from 1996 to 2010. Our identification

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¹ An estimated 900 million people in the world live with inadequate access to water supplies and 2.7 billion live without improved sanitation facilities (WHO, 2010).

strategy relies on the hypothesis that temporary rainfall deviations from historical averages, conditional on municipality-by-month fixed-effects, are uncorrelated with other latent determinants of health during gestation. Under this assumption, we are able to identify the causal impact of rainfall variation on outcomes at birth.

Our results indicate that negative rainfall shocks are robustly correlated with higher infant mortality, lower birth weight, and shorter gestation periods. Mortality effects are concentrated on intestinal infections and malnutrition, and are greatly minimized when the local public health infrastructure is sufficiently developed. Conditional on income, the estimated impact of rainfall fluctuation decreases monotonically with municipality coverage of piped water and sanitation, losing statistical significance when coverage of public health infrastructure is high enough. In addition, we present some tentative evidence indicating that results are not associated with agricultural production. We also find that effects are stronger during the fetal period (2nd trimester of gestation) and for children born during the dry season. Overall, our results seem to be capturing the effects of scarcity of drinkable water on birth outcomes. Apart from its own relevance, this evidence is important in light of the long-term effects of early life conditions on cognitive development and human capital accumulation noticed elsewhere (Almond and Currie, 2010; Currie, 2009; Glewwe and Miguel, 2008; Linnet et al., 2006; Mara, 2003; Shenkin et al., 2004).

A series of recent papers have addressed the relationship between environmental shocks and health and socioeconomic outcomes. Deschenes and Moretti (2009) and Deschenes et al. (2009), for example, analyze the impact of temperature fluctuations on mortality and birth weight in the US, while Burgess et al. (2011) conduct a similar exercise for India. Regarding rainfall, there has been a growing body of research exploring different settings and potential channels. Maccini and Yang (2009) look at rural Indonesia and find long-term beneficial effects of rainfall incidence during the first year of life for women (on health, education and labor market outcomes), with no effect for men. Burgess et al. (2011), despite focusing on temperature, present some negative correlations between rainfall incidence and overall mortality. In both cases, authors interpret the correlation between rainfall and health outcomes as working through higher agricultural production and lower food prices. Kim (2010), Kudamatsu et al. (2010), Skoufias et al. (2011), and Aguilar and Vicarelli (2011) on the other hand, document detrimental effects of positive rainfall shocks on child health. Kim (2010) uses DHS data for West Africa and finds a puzzling positive relationship between rainfall and mortality during the growing season, while Kudamatsu et al. (2010), using as well DHS data for Africa, document that both increased rainfall and droughts in the growing season are associated with higher infant mortality. Kudamatsu et al. (2010) also reports a positive effect of increased rainfall on mortality in malaria epidemic areas. Skoufias et al. (2011) and Aguilar and Vicarelli (2011) look at rural Mexico and, similarly to the papers mentioned before, find that positive rainfall shocks have a negative impact on child health (anthropometric measures and cognitive development). These various papers interpret the negative correlation between rainfall and child health as being associated with the increased labor supply of mothers as a response to better agricultural conditions, the disease environment, or the direct effect of excessive rain on agricultural production.

Overall, the evidence on the effect of rainfall on health is mixed, with positive, negative, and non-significant impacts estimated in different settings. This should come as no surprise, since it is not clear a priori whether positive rainfall shocks should be seen as beneficial or harmful events. As recognized by many authors, there are various potential channels linking variations in rainfall to health and socioeconomic outcomes. Within a usual range of variation, increases in rainfall may increase agricultural production and lower food prices, improving nutrition and health. But rainfall may increase the incidence of infectious diseases for which the vector's reproduction cycle or the transmission mechanism trusts on the availability of water. Rainfall may also directly increase the availability of safe drinkable water, reducing the incidence

of infectious diseases and improving the absorption of nutrients. Finally, either too much or too little water may disrupt agricultural production and impact rural households' income and access to food.

The simultaneous operation of these channels is likely to be responsible for the heterogeneous results obtained across the studies mentioned before. Our focus on the Brazilian semiarid turns positive rainfall shocks into unequivocally beneficial events, isolating two potential channels: access to safe drinkable water and agricultural production.² We construct rainfall for specific months before and after birth, with a high geographic resolution (56 km × 56 km), and use municipality-by-month fixed effects in order to guarantee that outcomes associated with particular times of the year in given municipalities are accounted for. So systematic differences across seasons and locations – and combinations of both – do not contaminate the results. Finally, the wealth of information available in our data allows us to look at a broader set of birth outcomes.

We look at a context of water scarcity and document the relationship between rainfall and health at birth with an unprecedented level of detail. Our paper is the first to identify a clear-cut effect of rainfall during pregnancy on multiple birth outcomes: mortality by cause of death, birth weight, and length of gestation. We are also able to go one step further and present suggestive evidence linking the results specifically to the availability of safe drinkable water. Despite not being explicitly considered in previous studies, scarcity of safe drinkable water is a first order concern to rural populations in semiarid regions of the developing world. And it is likely to become an even more prevalent phenomenon with climate change (UNDP, 2006; World Bank, 2008).

The public health literature has long understood the mechanisms linking water scarcity to health outcomes. There are even estimates available of the likely impact of expansions in access to water and sanitation on the incidence of diarrheal diseases and child mortality. But these are based on the distribution of diseases across the globe and on theoretical relationships between water and sanitation and health conditions (see, for example, WHO, 2010). There is no causal estimate available on the observed outcomes that can be unequivocally attributed to water scarcity. Similarly, there is no direct evidence on the quantitative role of water and sanitation infrastructure in minimizing the effects of climatic shocks in a real setting.

The main result from our benchmark specification indicates that a one standard deviation increase in rainfall – corresponding to a 28% increase from the average – leads to a reduction of 1.53 point in the infant mortality rate (or 5% of the sample average of 30 deaths per 1000 births). The concrete meaning of this number can be grasped by considering a period subject to particularly negative shocks, such as the second half of 1998 when rainfall was roughly 50% below the historical average. The estimated coefficient implies that the infant mortality rate during this period was 2.7 points above the level observed in the semiarid in a typical year. Overall, susceptibility to rainfall conditions in the region would have historically led to an average infant mortality rate 2.7 points above what it would otherwise have been.

Our results also suggest that increased coverage of piped water and sanitation greatly reduces the response of infant mortality to rainfall fluctuations. For example, a one standard deviation reduction in rainfall would lead to an increase in infant mortality of 4.55 points in municipalities with 20% coverage of piped water and sanitation. In municipalities with 80% coverage of these public goods, the response of infant mortality to a similar shock would be only 0.43 points (and not statistically significant). Improved access to water and sanitation would therefore lead to a reduction in the impact of this rainfall shock of 4 deaths per 1000 births.

Using cost estimates from the Brazilian Ministry of Cities, we conduct a preliminary cost-effectiveness analysis of the expansion of

² The semiarid area of the Brazilian Northeast faces extremely dry conditions and an almost constant moisture deficit. In addition, it has no occurrence of malaria, which is concentrated in the Northern part of the country (Amazon).

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