Political Decentralization and the Spatial Distribution of Infant Mortality in Less Developed Nations

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Abstract

This paper focuses on political decentralization as an institutional determinant of the level and spatial distribution of infant mortality rates (IMR). At the national level, we show that political decentralization is linked to lower IMR, but these benefits are concentrated in high-income decentralized nations. In developing nations, decentralization is associated with significantly higher spatial variation in IMR. We explore the mechanisms driving these patterns by leveraging floods as plausibly exogenous events in our global sample and a detailed analysis of Brazil. In Brazil, floods increase municipal variation in IMR, with impacts disproportionately accruing in low-income municipalities with limited government services.

JEL Codes: H77 Intergovernmental Relations, Federalism; I14 Health and Inequality; I15 Health and Economic Development; Q54 Natural Disasters; R12 Size and Spatial Distributions of Regional Economic Activity

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1 Introduction

The decline in infant mortality rates (IMR) is widely held as a success story in comparative development. Indeed, the field of public health has documented a dramatic decline in infant mortality rates across the world in recent decades, especially in developing nations (Rajaratnam et al., 2010). IMR is a crucial indicator of population health and is closely associated with economic development and governance, including provision of essential public goods and services (Fay et al., 2005, Reidpath and Allotey, 2003).

Our analysis focuses on a different aspect of IMR. Declining absolute averages of IMR, while certainly encouraging, mask significant and persistent subnational variation and inequality in its incidence (Sartorius and Sartorius, 2014, Storeygard et al., 2008, Pullan et al., 2014). For example, a recent analysis by Macharia et al. (2019) shows there is large over-time inequality in IMR between Kenya’s provinces despite the trend of declining rates. From a spatial perspective, development is hardly neutral. It is typically spatially clustered and the disparities go beyond well-understood urban-rural lines (Pullan et al., 2014). Therefore, making sense of cross-national variation in the scope of spatial differences of development outcomes is crucial, particularly in the developing world. We examine political decentralization as one of the potential contributors to spatial inequalities in IMR. The role of decentralization in overall health outcomes and their spatial variation is especially important to understand given that international organizations have proposed political decentralization to improve service delivery in the developing world (Ahmad et al., 2005, Faguet, 2001). It is also an essential element to understand how nations respond to major crises, a point we return to below.

We focus our analysis on political decentralization, the election of local officials with policy-making authority. Political decentralization is a broad institutional setup that affects provision of policy in many domains, which may include healthcare but in most cases extends beyond healthcare to infrastructure, economic policies, and a wide range of service provision. Our exploration suggests that, within any given developing nation, some geographic areas contribute more to the downward trend in IMR than others and some nations are better at keeping those trends consistent across regions. We show that there is nontrivial cross-national variation in the scope of cross-regional differences. We ask whether political decentralization may contribute to both overall levels of IMR and their spatial differences.
We expect, consistent with existing literature, that political decentralization is linked to lower overall levels of IMR (Robalino et al., 2001, Channa and Faguet, 2016). We find this result in our global sample of national IMR. However, research on the positive impact of decentralization on health outcomes (including IMR) has mostly focused on globally rich nations. The evidence regarding overall impacts of decentralization on health outcomes in middle and low income countries is mixed but include positive accounts for countries such as Brazil (Guanais and Macinko, 2009), India (Asfaw et al., 2007), and Nigeria (Akpan, 2011). In contrast, some argue that decentralization has led to worse outcomes in developing nations, such as Ahmad et al. (2005) regarding Uganda and Tanzania. We expect that the potential benefits of political decentralization may not be realized in developing world contexts characterized by high spatial inequalities.

A straightforward expectation for politically decentralized nations is that they may experience higher spatial variation in health (and other) outcomes, whether because local demands and local political accountability differ, or because of different policy-making capacities. Indeed these accounts are common in public health research. In country case studies, decentralization of health policy to locally elected officials is associated with higher spatial variation in IMR, with gains concentrated in the most affluent, high capacity areas in Spain (Jiménez-Rubio and García-Gómez, 2017) and Italy (Cavalieri and Ferrante, 2020). Consistent with country case studies, we find that decentralization is associated with higher spatial variation in IMR in our subsample of developing nations.

Importantly, the reasons for this variation may be part of a more complex process. Decentralized government is often chosen as an institutional structure because of heterogeneity of needs and preferences within nations (Beramendi, 2012). Accordingly, if we observe that politically decentralized nations have higher spatial inequalities in health outcomes, it may be that decentralized institutions were adopted precisely because of the underlying economic or social differences that lead to this spatial variation in health outcomes. Within such a process, decentralization may both generate effects at particular times (exogenous), e.g., when nations respond to exogenous shocks, and may become the object of political conflicts itself (endogenous).

We use flood events to manage concerns with endogenous institutions, and to draw out the potential causal mechanisms that may produce divergent outcomes in politically decen-
tralized countries (Lago and Blais, 2023, Sampedro et al., 2023, Ayala García et al., 2023). We show that when politically decentralized nations experience floods, they fall back in their progress in reducing IMR relative to more politically centralized nations. We demonstrate how these dynamics evolve in a detailed empirical analysis of municipalities in Brazil from 2000-2021. When floods impact less affluent and less resourced areas, those areas are less resilient, resulting in setbacks in healthcare provision that limit gains in IMR. We find that flood events result in significant increases in IMR in Brazilian municipalities, especially poorer municipalities and ones with fewer doctors from the public health system. Decentralization may hinder outreach as local health systems struggle to respond and fewer centralized resources, those directly related to health but also infrastructure and food provision, are available to areas in crisis and the central government has weaker tools to address crises when political authority is devolved.

We distinguish our analysis from other contributions in several ways. First, research focused on decentralization and health outcomes, primarily in public policy and economics, typically does not focus on spatial variation in IMR but on national levels, or is restricted to a single country case. We study levels and spatial variation in a cross-national analysis, as well as in a subnational analysis using the case of Brazil to understand how subnational IMR is impacted by external shocks.

Moreover, we contribute to research on decentralization in comparative politics by focusing on health outcomes in the developing world. The majority of research on decentralization has focused on Western nations, with additional studies primarily of Latin America and India. In our cross-national analysis, we include data from as many countries as possible for our national IMR analysis, while our subnational IMR dataset is limited to developing nations, including those with the globally highest levels of IMR. We also add a focus on extreme health outcomes to this literature, emphasizing the impact of political decentralization on major indicators of population outcomes.

Our research is organized as follows. In Section 2, we provide a conceptual framework for how decentralization may influence national IMR and subnational variation in IMR, with a focus on the developing world. Then, we suggest empirical predictions of that conceptual framework. In Sections 3 and 4, we provide empirical specifications and operationalization for the analysis and provide the results in Section 5. In Sections 6 we examine the case of
Brazil. Finally, we offer a discussion of our results and a conclusion.

2 Development, Decentralization, and IMR

Public health research shows that reduction in infant mortality is in large part a function of rising economic development, which provides resources for the provision of health services, whether by governments with greater means, or by individuals with more disposable income to pay for health services in the private market. Access to health care allows for the medical prevention of infant mortality via prenatal care, good nutrition for the expectant mother and child, neonatal care, and pediatric care. In most nations, the vast majority of individuals’ medical care is provided by government-funded health care providers. This is particularly true for low income individuals and those living in poverty who only have access to medical care when it is government provided or government subsidized. Thus, the state plays a central role in reducing IMR around the world, and government institutional structures such as decentralization are expected to influence the provision and quality of health care.

Research on decentralization of policy provision by locally elected officials offers a full range of predictions on its potential impact (positive, negative, neutral) on outcomes. As Bossert (1998) emphasizes, the decentralization of healthcare specifically may be very far from a “Tiebout Model” ideal, because in some cases the decentralization is in policy provision but not in policy-making. Countries also vary considerably in which features of health-care provision they choose to decentralize to local politicians. Classic contributions on the benefits of decentralization would point to the possibility of much greater accountability for services provided at the local level because citizens can better observe the results of policy and hold elected officials accountable those responsible (Oates, 2003). Decentralization may also allow for better tailoring of policy supply to local policy demand (Tiebout, 1956). In nations with very heterogeneous subnational levels of development, which is the condition in most developing nations, decentralization could be a means of targeting different policies where they are needed most, as local politicians provide what is needed most by their constituents. In the public health context, this could be particularly useful, in theory, as programs aimed at people in poverty, such as nutrition for mother and baby, can be disproportionately provided in high-need areas (Bossert and Beauvais, 2002).
A significant literature in public health and health economics has found that decentralization in general, and of healthcare specifically, may lead to positive health outcomes, including IMR (Robalino et al., 2001, Channa and Faguet, 2016). Importantly, much of this research has focused on decentralized health systems in advanced industrial countries, and particularly on the cases of Canada, Italy, and Spain. For example, Rubio (2011) shows significant improvements in Canada’s health care system with greater levels of decentralization. Cantarero and Pascual (2008) find that Spain’s healthcare system improved (in terms of both IMR and life expectancy) with decentralization of services. One potential reason for these differences, at least in the affluent country cases in the OECD, is that decentralized systems spend more on healthcare, on average, due to greater supply of health spending by local elected officials providing desired services to constituents (Mosca, 2007). We expect, consistent with existing literature, that political decentralization is linked to lower overall levels of IMR, and investments in water and sanitation that reduce IMR (Fay et al., 2005, Reidpath and Allotey, 2003). However, we cannot be certain that these findings extend to lower income nations, which have both higher regional inequalities and well-known inefficiencies in federal system designs.

Potential key differences lie in the interaction between late development, the territorial reach of state capacity, and the spatial spread of public goods shaping IMR. A number of aspects of the combination between late development and political decentralization bear direct implications on IMR. First, late industrializers are known to have highly skewed economic geographies (Beramendi and Rogers, 2022). Assets and people tend to agglomerate around very few and very large urban centers, conditioning both investments in infrastructure and the politics of decentralization itself.

In late industrializing contexts, investments in transportation and infrastructure, and related provision of public goods, evolve radially out of one or two core geographic centers. This leads to a tight link between regional disparities in economic prosperity and variation across jurisdictions in institutional capacities. These differences, we argue, are essential to understand health outcomes in general and the dynamics of IMR in particular. While political decentralization may be a more efficient structure in high income countries with similar economic development across regions, when confronted with enormous differences in regional development, decentralization may be an institutional setup that benefits the well-endowed regions and leaves the rest behind.
The process leading to significant capacity differentials have deep political roots. In late developing nations, institutional investments hardly reflect a concern to secure a balanced pattern of development over the long run. Elites in core areas concentrate investments in their own areas, thus perpetuating regional divergence, and use interregional transfers to co-opt locally elected elites in remote areas (Beramendi et al., 2017). The latter, in turn, have incentives to over-spend, under-tax, and blame higher levels of government for poor performance in politically decentralized contexts (Rodden, 2002, Wibbels, 2006). In turn, clientelism facilitates both coordination among elites, and lower levels of democratic accountability. Accountability may also be undermined by differential access to political information in decentralized nations. Scholars of the developing world (and some scholars of the United States) point out that the information for citizens to hold politicians accountable may not be better in local areas. Local elections can be uncompetitive, failing to offer choices for citizens. There may be limited citizen resources to investigate malfeasance, or the elections themselves may not provide good information for voters in federations (Gibson, 2005, Giraudy, 2015).

Jointly, these economic and political channels exacerbate concerns about the impact of political decentralization on the spatial evenness of key health policy mechanisms. A cumulative body of case studies back up a widely-shared concern about the concentration of services in rich areas, even in nations with relatively comparable regional economies. For the reasons outlined above, the concern with subnational inequalities is heightened in lower income nations. Where peripheral areas are poor, political decentralization with policymaking authority in health and infrastructure domains may lead core urban areas to pull ahead and peripheral areas to fall behind (Tang and Bloom, 2000). Scholars have argued in the Latin American context (especially Chile and Colombia) that decentralization can stymie health care improvements in poor areas of the nation (Arredondo and Parada, 2003, Bossert et al., 2003). Some scholars have pointed out this occurs because poorer areas in low income countries do not have access to local revenue or community funding to provide robust local health care (Collins and Green, 1993, Abel-Smith and Dua, 1988). Higher levels of decentralization may exacerbate the skew in the distribution of access to infrastructure and services in developing nations, and weaken the mechanisms whereby citizens in less privileged localities can demand equalization of resources from the central government.

Overall, late development brings about both high levels of urban concentration (Frick
and Rodríguez-Pose, 2018, Rogers and Hammam, 2023), which facilitates proximate health care and access to drinking water to a large segment of the population, and a larger gap in service provision between core areas and the rest of the nation (Fotso, 2006). Accordingly, the positive benefits associated with decentralization are limited to the richest and most populated regions, which tend to have both greater democratic accountability mechanisms and greater access to resources for successful policy provision. With people and resources concentrated in richer localities, decentralization is associated with overall levels of IMR but may lead to divergence within nations. Under these conditions, political decentralization will be associated with both lower overall levels of IMR and higher spatial inequalities in IMR rates. This distinction is particularly important in the context of major crises, situations that make competition for scarce institutional resources even stronger.

2.1 Crises Events and IMR

Crises also provide analytical leverage to unpack the connection between political decentralization and health outcomes, in this case IMR. A strong counterargument to claims that decentralization causes regional inequalities in outcomes is that decentralization may be endogenous to those inequalities in the first place. That is, regionally unequal nations may adopt decentralization so that affluent areas may keep their resources and make policy as they prefer according to local demands, thus limiting the possibility of regional convergence in health (and other) outcomes (Beramendi, 2012). Seen from this angle, political decentralization is not a cause of regional disparities, but a response to regional differences. Examining the impacts of political decentralization on health outcomes thus poses a challenge given its potential endogeneity to subnational inequalities. Major crises are an ideal context to detect whether decentralization lowers IMR through its policy efficiency, as local politicians are responsive to local voters, or exacerbates inequalities in resources. If the former, crises provide opportunities for well-designed systems to respond effectively (Beramendi and Rogers, 2020). If the latter, crises will expose the deficiencies of decentralized policy provision and lead to: (1) worsening in the levels of IMR and (2) concentration of negative effects in low-income areas.

We use floods as major, plausibly exogenous, events to see the impacts of decentralization on health care outcomes. Floods are plausibly exogenous due to their unanticipated nature in occurrence and magnitude. Thus floods may provide us with some leverage on
whether political decentralization matters for IMR. Floods are the most common natural dis-
aster (Mallett and Etzel, 2018) with severe impacts on maternal and child health, including
increases in IMR (Richman, 1993). Research in public health shows that flooding may lead
to malnutrition, infection, and psychological trauma, all of which may lead to adverse birth
outcomes. Flooding may also impact the feeding practices for young children as they are
exposed to contaminated water, they may lack access to formula supplies or refrigeration,
and have unhygienic preparation facilities (Gribble et al., 2011, Gribble, 2013). We expect
decentralized nations under flood conditions to have relatively higher rates of IMR after
flood events than more centralized nations. We should see the negative impacts of flood
events most starkly in poorer areas, which are less resourced and may have less accountable
locally-elected officials.

2.2 Empirical Expectations

To summarize, the following empirical expectations guide our analysis:

H1 Politically decentralized nations have lower IMR, on average. This relationship is
driven by richer decentralized countries.

H2 Politically decentralized developing nations have more subnational variation in IMR.

H3a Following floods, politically decentralized nations fall behind centralized nations in
terms of declines in IMR.

H3b The negative impacts of flood events should accrue in poorer areas of decentralized
nations.

3 Empirical Approach: Cross-National Analysis

We show our cross-national approach in the following subsections. We first describe our
basic models of the association between decentralization and IMR and subnational variation
in IMR. Next, we show how we model the conditional relationship of decentralization and
IMR in cases of flood events. We then discuss how we operationalize the variables featured
in these models.
3.1 National level of IMR

First, we examine the impact of decentralization on national levels of IMR. We specify the following equation:

\[ \ln(IMR_{i,t}) = \beta_0 + \beta_1 DECENT_{i,t-1} + X_{i,t-1} + \mu_i + \gamma_t + \epsilon_{i,t}. \]  \hspace{1cm} (1)

in which the left-side variable is the (logged) national infant mortality rate \((IMR_{i,t})\) of country \(i\) at time \(t\) and the right-hand side contains a measure of decentralization \((DECENT_{i,t-1})\), plus a matrix of control variables \((X_{i,t-1})\), country fixed effects \((\mu_i)\), and year fixed effects \((\gamma_t)\). \(^9\) These controls are described below in Section 4.4. In models to investigate the underlying mechanisms whereby political decentralization is associated with lower national IMR, we employ improved water access and sanitation access as alternative dependent variables.

We employ 5-year averaged value data for all of our cross-national analyses. We do so for several reasons, most importantly because the subnational IMR data are only available in five year increments. More generally, we are unsure of the time horizon of the impacts of political institutions and other covariates on IMR outcomes. In our Online Appendix Section 5, we show that the results are very similar if we use averaged data with alternative time periods.

3.2 Subnational Variation in IMR

Second, we examine the impact of decentralization on subnational variation in IMR. We specify the following equation:

\[ IMR_{COV,i,t} = \beta_0 + \beta_1 DECENT_{i,t-1} + X_{i,t-1} + \mu_i + \gamma_t + \epsilon_{i,t}. \]  \hspace{1cm} (2)

in which the left-side variable is the subnational coefficient of variation in infant mortality rate \((IMR_{COV,i,t})\) of country \(i\) at time \(t\) and the right-hand side contains a measure of decentralization \((DECENT_{i,t-1})\), a matrix of control variables \((X_{i,t-1})\), country fixed effects \((\mu_i)\), and year fixed effects \((\gamma_t)\).
3.3 Conditional Effect of Flood Events

We extend our basic analysis to include an interaction term between decentralization and flood events.

\[
\ln(IMR_{i,t}) = \beta_0 + \beta_1 \text{DECENT}_{i,t-1} + \beta_2 \text{FLOOD}_{i,t-1} + \beta_3 \text{DECENT}_{i,t-1} \times \text{FLOOD}_{i,t-1} + X_{i,t-1} + \mu_i + \gamma_t + \epsilon_{i,t}.
\]

in which the left-side variable is the infant mortality rate (IMR$_{i,t}$) of country $i$ at time $t$ and the right-hand side contains a measure of decentralization (DECENT$_{i,t}$), an interaction term between decentralization and flood events (DECENT$_{i,t-1}$ * FLOOD$_{i,t-1}$), a matrix of control variables (X$_{i,t-1}$), country fixed effects ($\mu_i$), and year fixed effects ($\gamma_t$). We also use flood events in our analysis of the Brazilian case, below, showing how they may impact IMR across municipalities.

4 Operationalization

4.1 Dependent Variable

4.1.1 National and subnational IMR

The first dependent variable, infant mortality rate, is measured as the number of children who die before their first birthday for every 1,000 live births. The data for national IMR come from the World Development Indicators and are available for 2000-2017. These data cover nearly all countries of the world.

The subnational data are calculated at the first administrative level (i.e., province or state) and are obtained from two sources, the Global Subnational Infant Mortality Rates v1 and v2, published by NASA Socioeconomic Data and Applications Center (SEDAC) and from the HDX Humanitarian Data Exchange. Subnational infant mortality rate data from the HDX dataset are available for the years 1990, 1995, 2000, 2005, 2015 and 2020, with uneven coverage across years.

4.1.2 Coefficient of Variation in IMR

The second dependent variable is the coefficient of subnational variation (COV) in IMR. COV in IMR is a measure of dispersion of subnational IMR, calculated at the national level.
COV in IMR is calculated as $\frac{\sigma_{IMR_{i,t}}}{\mu_{IMR_{i,t}}}$, where $\sigma_{IMR_{i,t}}$ is the standard deviation of IMR of a country and $\mu_{IMR_{i,t}}$ is the mean of IMR of the country. Coefficients of variance are commonly employed in economics to calculate regional inequalities (Lessmann, 2011, Lee and Rogers, 2019). Figure A3 in our Online Appendix shows our full sample of countries and their median value for COV IMR in 2015.

4.1.3 Access to Water and Sanitation Services

To measure access to water and sanitation, we use data from the Joint Monitoring Program (JMP) on the percentage of households with access to: (a) improved water sources and (b) improved sanitation. Improved water source is defined as having “basic” or “safely managed” drinking water, where “basic” is defined as “drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip including queuing” and “safely managed” is defined as “drinking water from an improved water source which is located in premises, available when needed and free from fecal and priority chemical contamination” (Unicef et al. 2017, 8).

Improved sanitation is defined as having “basic” or “safely managed” sanitation, where “basic” is defined as the “use of improved facilities which are not shared with other households” and “safely managed” is defined as “use of improved facilities which are not shared with other household and where excreta are safely disposed in situ or transported and treated off-site” (ibid).

4.2 Decentralization Measures

We use the Varieties of Democracy (VDEM) Program’s Division of Power index (v2x_feduni) to capture political decentralization in our primary models (VDEM, 2019). The VDEM project surveys country experts on a yearly basis on topics related to governance in all countries around the world. VDEM asks country experts, “Are there elected local and regional governments, and — if so — to what extent can they operate without interference from unelected bodies at the local level?” The resulting indicator is an interval variable, from low to high levels of decentralization, with a range of 0-1. This measure captures our focus on local elections as a potentially important institutional determinant of comparative health outcomes.

The VDEM dataset has a number of appealing features for our project. First, it is a widely
used indicator and validated approach to measuring decentralization. Second, it has very wide country coverage, including all countries with IMR data for the entire time period under study. We explored using other decentralization measures such as the regional authority index (Hooghe et al., 2021), but many developing nations in Sub-Saharan Africa, South and Southeast Asia, among other areas, have not been coded by the regional authority project. In OA Section 4 we employ alternative measures of decentralization, including the dispersive powersharing index from Graham et al. (2017) and the local elections variable from VDEM (2019).

Importantly, our empirical focus is on political decentralization, especially the role of local elections, not just health decentralization, which could happen with or without political decentralization. We wish to examine the impacts of political decentralization, and related devolved policy implementation, on spatial inequalities in health outcomes. We acknowledge that health decentralization varies widely across country contexts and does not perfectly map onto other dimensions of decentralization. Ideally, we would also have high-quality cross-national indicators of the type and degree of health decentralization, and its quality, alongside our measure of political decentralization, but these indicators are not available cross-nationally. In our Brazil case analysis, we are able to employ more nuanced, informative indicators of healthcare inequalities, such as per capita healthcare providers at the subnational level.

4.3 Floods

To measure floods, we use the EM-DAT dataset by the Centre for Research on the Epidemiology of Disasters. The EM-DAT database “contains worldwide data on the occurrence and impact of over 20,000 natural and technological disasters from 1900 to the present day.”11 These data are geocoded to fine-grained geography, allowing us to match them to country, province/state, and municipal levels. Our flood indicators include, first a binary measure for whether a flood occurred or did not occur in a given location and year, and second, the estimated number of people impacted by the flood event.

4.4 Control Variables

We add traditional controls to account for development-driven differences in infant mortality. We include the logged values of GDP per capita from the World Development Indica-
tors. We expect IMR and the COV of IMR to be lower as economic development rises in terms of per capita GDP. We also include an indicator of the level of democracy from VDEM (2019), given that many have argued that democracy is related to health provision (Baum and Lake, 2003, Salazar et al., 2023) (for a review, see Mejia 2022). We add a measure of public health expenditure from VDEM (2019) to control for basic health service provision. We include time fixed effects to account for year to year changes in IMR, including the global trend of reduced IMR. We also include country fixed effects to account for time invariant features of nations that may be associated with government reach, such as land size. In our most constrained models we include the lagged dependent variable. In our OA Section 7 we show results with additional control variables, including agricultural land, government consumption, and gender equity.

5 Cross-national Results

In this section, we present the results for our empirical analysis. We begin with a visualization of the cross-national associations between the decentralization measure and IMR and the subnational coefficient of variation in IMR for the year 2000 in Figure 1. This figure shows the broad associations we find in our analysis, that political decentralization is associated in general with lower IMR, but higher spatial variation in IMR.
Figure 1: Decentralization and National IMR and COV IMR

AltText: Scatter plot of infant mortality rates and decentralization. In the left side plot, the y axis is the infant mortality rate and the x axis is the decentralization index. In the right side plot, the y axis is the coefficient of variation in the subnational infant mortality rate and the x axis is the decentralization index.
5.1 National level of infant mortality rates (H1)

Our first result in Table 1 shows what is visualized on the left side of Figure 1 and has been found is existing research in public policy and economics. Decentralization is associated with significantly lower levels of IMR. This result is robust to standard controls, including the level of GDP per capita, the degree of democracy in that country, the level of public health expenditure, as well as country and year fixed effects and inclusion of the lagged dependent variable.

In general, our control variables are associated with IMR in the expected direction. More developed nations have lower IMR, and those that spend more on public health also have lower IMR, at least in our less restricted models.

It is critical to note that our cross-national analysis demonstrates an association between political decentralization and IMR, not a causal effect. Our models with lagged dependent variables absorb a significant amount of variance on top of country and year fixed effects. When controlling for the lags of IMR, GDP or Public Health Expenditure and adding fixed effects, they are able to explain the 99.6% of the variance in IMR. However, there is still room for a statistically significant coefficient of the degree of political decentralization, even when the fixed effects and lags are already capturing part of the effect of decentralization.

Importantly, most research on the relationship between political decentralization and IMR has focused on relatively high-income countries, whether those in Europe, North America, or upper middle-income countries in Latin America. These studies may not show a complete picture of the impact of decentralization across different levels of development. As research on federalism and decentralization outside the advanced industrial democracies has shown, local elections may not perform accountability and representation functions if the underlying conditions (fiscal credibility, state capacity, regional inequalities, level of development) do not hold. We show in Figure 2 that the relationship between decentralization and IMR varies by the level of development (logged GDP per capita). While decentralization is associated with lower IMR in most cases, at low levels of GDP per capita, we do not see statistical differences between politically decentralized and more centralized nations. This finding may link directly with our findings for higher subnational variation in
IMR in developing decentralized states in Section 5.3.

Figure 2: Relationship between Decentralization and IMR Across Levels of Development

![Graph](image.png)

AltText: Graph of the predicted relationship between the infant mortality rate and decentralization, according to the level of GDP per capita of the country.

5.2 National Improved Water Access and Sanitation Quality

We examine possible underlying processes driving national differences in IMR in Table 2. Extensive research on the causes and prevention of infant mortality has revealed that water and sanitation are key. Alemu (2017) shows that a one percent increase in improved sanitation reduces infant mortality at a rate of about two infant deaths per 1,000 live births, and safe sanitation and water are proven and cost-effective interventions (World Health Organisation and UNICEF 2010).¹²

There are good reasons to believe that local elections would be linked to human capital-improving service provision such as improved water and sanitation (Lake and Baum, 2001). We show that decentralization is associated with higher quality water and sanitation in Table 2. Both results are robust to standard controls from our base models, as well as country and year fixed effects.
5.3 Coefficient of Variation in Subnational IMR (H2)

Decentralized nations may have lower IMR while also having greater spatial variation in IMR. We test this proposition in Table 3, using our subset of middle and low income nations with data on subnational IMR. As expected, we find that political decentralization is associated with higher variation in subnational IMR in developing nations. This result is robust to inclusion of standard controls as well as year and country fixed effects, and the lagged dependent variable. We include the same controls as for overall IMR, as well as the national IMR to control for overall levels of IMR. The sample is smaller than in the IMR level models, because data are not available yearly on a subnational basis and the country sample is restricted to developing nations.

5.4 Decentralization and Flood Events (H3)

We also show the link between political decentralization and IMR after “exogenous” flood events. Decentralized countries see higher values of national IMR following flood events, as is apparent in the sign and significance of the interactions terms between decentralization and the binary indicator of flood incidence and the number of individuals impacted by the flood (logged) in Table 4. This value should be interpreted relative to the baseline, lower levels, of national IMR shown in the coefficient estimates for political decentralization. In other words, decentralized nations overall have lower IMR, but flood events stall their progress in lowering IMR relative to more centralized nations. This relationship is also plotted in Figure 3. As the level of decentralization increases, flood events are more likely to be associated with higher infant mortality rates.
Figure 3: Flood Impacts Across Levels of Decentralization

AltText: Graph of the predicted changes in the infant mortality rate according to the level of decentralization. On the left side graph, the predicted values are shown for country year observations that experienced flood events. On the right side graph, the predicted values are shown according to the mean value of the logged number of individuals affected by the flood.
6 Subnational Analysis using the Case of Brazil

We have argued and shown through cross-national evidence that natural disasters such as floods may stall declining IMR rates in decentralized nations. In theory, we expect increases in IMR associated with these flood events in decentralized nations to reflect disproportionate deaths from low income, low capacity areas. In the contexts of high spatial inequality, decentralization is associated with more variation in policy outcomes such as IMR (as tested in H2). The spatial variation in IMR that we observe reflects, most likely, worse outcomes in IMR in places with lower economic resources, more remote locations, and lower local administrative capacity. We examine this argument subnationally using the case of Brazil. We see whether flood events impact IMR at the municipal level in Brazil, driving overall variation in IMR between municipalities that experienced floods and those that did not. We also find these impacts were particularly acute in poorer locations. This provides possible evidence of the mechanisms whereby decentralized nations see more spatial variation in IMR due to greater regional inequalities in health conditions and worse outcomes in less-endowed localities.

Brazil is an ideal case to understand the impact of extreme events on development outcomes in a decentralized setting. Brazil is one of the most decentralized countries in the world in terms of the distribution of political power and political power. Brazil has undergone a process of decentralization with the new Federal Constitution in 1988. They have elected state governors and municipal mayors. As part of this decentralization process, a nationally unified health system was also established and the responsibility for health and other public services was delegated to its municipal governments (Touchton et al., 2017). Further devolution of responsibility occurred in 1996 with the establishment of two decentralized primary care programs—the Family Health Strategy and the Community Health Agents Program—and the transfer of responsibilities for existing primary care clinics, health centers, and health posts (Guanais and Macinko 2009). At the same time, the federal government has also made large investments expanding access to healthcare services in rural and underserved regions, with government spending increasing from 7.0 percent of GDP in 2000 to 8.3 percent in 2010 and 9.2 percent in 2018 (Roman 2023), and per capita healthcare spending increasing from $263 in 2000 to $947 in 2014.

Despite significant achievements such as the expansion of the Unified Health System
(Sistema Único de Saúde; SUS) aimed at universal health coverage, there are still regional disparities that make Brazil an interesting case to explore with respect to health outcomes. For instance, while Brazil has achieved near universal immunization, there is variation in the necessary services such as the assistance of a doctor in child delivery, which ranges from 54 percent in Norte to 98.7 percent in Rio de Janeiro. In a similar vein, Massuda et al. (2018) show that the inequalities have left the poor, especially in the northern regions, with unmet healthcare needs - including but not limited to shortage of doctors in rural areas, especially at primary healthcare centers. Data from the Brazilian Public Healthcare Data Repository (DATASUS) shows that in 2018, there were 0.36 “clinical” doctors (médico clínico; the largest group of doctors in Brazil) per 1,000 people with an average coefficient of variation of 73.85 across the provinces, illustrating the large gap between regions in terms of access to medical doctors. We plot the variation in doctors across subnational areas in Figure 4.

Figure 4: Clinical doctors per 1,000 (2018)

AltText: Map of Brazil’s states shaded according to the number of doctors per 1000 citizens.

Brazil features a robust system of local elections in their decentralized political system. Scholars have written extensively about variation across Brazil’s municipalities in account-
ability to citizens for policy outcomes (Ferraz and Finan, 2011, Aranha, 2017, Martell, 2007). These scholars show that there are good reasons to believe that public health outcomes may differ across municipalities in Brazil as politicians vary in responsiveness and in their access to resources to deliver services.

Second, Brazil has large subnational variation in development outcomes, including infant mortality rates, as shown in Figure 5, with data from 2014. The subnational infant mortality rates in Brazil averages at 24.79 deaths per 1,000 with a standard deviation of 56 deaths per 1,000. This high variation in IMR, a basic measure of development, coupled with variation in the quality and access to healthcare in Brazilian municipalities makes it an interesting case to explore the impact of external shocks on IMR.

Figure 5: Subnational Infant Mortality in Brazil (2014)
6.1 Research Design

Incidence of the flood should correspond to an increase in IMR - and more so in resource-deprived municipalities than resource-rich areas. We estimate this relationship at municipality level, analyzing data from 5,564 municipalities in Brazil, measured annually from 2000 to 2021. To test our hypothesis, we use panel data analysis using the following specification:

\[ IMR_{i,t} = \alpha_i + \alpha_t + \beta_1 \text{Flood}_{i,t-1} + \beta_2 \text{GDP}_{i,t-1} + \beta_3 \text{Flood}_{i,t-1} \times \text{GDP}_{i,t-1} + \gamma X_{i,t-1} + \epsilon_{i,t} \] (4)

where \( i \) is the municipality, \( t \) is the time period (year), \( IMR_i \) is the logged rate of infant mortality in municipality \( i \) in year \( t \). The full effects of external shocks of disasters do not emerge immediately, and may persist over time - in this case through channels such as waterborne diseases and lack of refrigeration and access to care. As with our cross-national analysis, we use lags of covariates to capture the delayed impact of flood incidence on IMR. \( \text{Flood}_{i,t-1} \) captures the incidence of flood in year \( t-1 \) in municipality \( i \). We are interested in the heterogeneous effect of external shocks across space that vary by levels of economic resources. Hence we use the log of GDP per capita at municipal level. \( \text{Flood}_{i,t-1} \times \text{GDP}_{i,t-1} \) is the main variable of interest and \( \beta_3 \) the main coefficient of interest.

The model includes a set of covariates \( X \) that vary by municipality and year and account for alternative explanations for the changes in IMR and potential confounders. These include the number of doctors (médicos clínicos) per 1,000 at municipal level, fraction of the population with access to improved water and sanitation, and population density. We also include nightlight luminosity to provide a more granular measure of economic development. We cluster standard errors at municipality level to account for serial correlation in the error term. We include year and municipality fixed effects to account for time- and municipality-specific factors such as outbreaks of epidemics that could affect IMR beyond the impact of floods.

6.2 Operationalization

The dependent variable in the municipal-level analysis is the infant mortality rate, parallel to the cross-national analysis. The annual data on live births and infant deaths from 2000 to 2021 used to calculate (logged) IMR are from DATASUS. Figure 5 shows the wide sub-
national variation in infant mortality in Brazil at the municipal level for year 2014. We also employ the (logged) child mortality rate (CMR), the mortality rate for children below the age of five, as an alternative measure to IMR with data from DATASUS.

To measure the incidence of flood, we again use the EM-DAT dataset, this time at the municipal level. We dichotomize flood events such that municipalities that experience at least one flood are coded as 1 and 0 otherwise. We also use alternative measures of flood, measured as the total number of people affected in the municipality to capture the magnitude of the flood. The data are obtained from Geocoded Disasters (Rosvold and Buhaug 2021).

We include several controls to account for alternative explanations for the differences in IMR across Brazilian municipalities. A key covariate we include is the number of doctors per 1,000 people at municipal level to illustrate the effect of spatial variation in access to healthcare. Data on the number of doctors (both clinical doctors as well as pediatrics) come from DATASUS. Other covariates include the log of nightlight luminosity (Li et al. 2020). Population density is calculated using the population in municipality in a particular year divided by the land coverage of the municipality, data for which come from DATASUS and Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística; IBGE), respectively.\textsuperscript{16} Data on access to water come from National Sanitation Information System (Sistema Nacional de Informações sobre Saneamento; SNIS). The variable is calculated as a fraction of the population with access to treated water by dividing the number of population in municipality with access to treated water by the population.

As for time-invariant covariates, distance to the state capital is calculated as the distance from center of the municipality (determined by ‘polygon centroid’ function in QGIS) to the state capital using ‘distance to nearest hub’ function in QGIS. Distance to the nearest river is also calculated from the center of the municipality to the nearest river. The shapefile data on rivers in Brazil is obtained from International Steering Committee for Global Mapping (ISCGM).\textsuperscript{17} Descriptive statistics are shown in Online Appendix Section 9 (Table 13).

\textbf{6.3 Results}

The main results of the analysis are presented in Table 5. The table reports six different model specifications - models (1)-(3) for IMR and (4)-(6) for CMR as an alternative measure
to IMR. The specifications are parallel for the two outcomes. The first model of the respective outcome variables reports the outcome using only the main explanatory variable of interest - the interaction between the incidence of flood and GDP per capita, along with year fixed effects. The second model of the respective outcome variables (models (2) and (5)) includes controls, and one of the main covariates of interest - Doctors per 1,000 - is displayed. The third model of the respective outcome variables (models (3) and (6)) uses controls and both year and municipality fixed effects.

The results all the models show strong support for our hypothesis that incidences of flood are associated with increases in IMR, and this impact is disproportionate in less economically endowed municipalities. The direct impact of flood on mortality rate is positive and significant; based on models (3) and (6), incidence of flood is associated with a 107 percent increase in the mortality of infants and a 96 percent increase in the mortality of children in the following year. We show in Figure 6 that the relationship between flood and IMR varies by levels of economic development. In municipalities with lower levels of economic development, incidence of flood is more likely to be associated with higher mortality rates compared to those with mean or high levels of development. The results are consistent for child mortality, illustrated in Figure 7, where lower economic development is associated with an increase in CMR compared to mean and high levels of development. What this illustrates is that in the developing decentralized country setting of Brazil, the effects of external shocks impacts municipalities disproportionately across levels of economic endowment, worsening the subnational inequality within the country.

TABLE 5 HERE
Figure 6: Predicted change in Infant Mortality Rate after Flood Incidence

AltText: Graph of the predicted change in the infant mortality rate after the incidence of a flood, depending on the level of income of the municipality.
It is worth noting that the results do not show a direct effect of doctors per 1000 on IMR. Recall that the variable doctors per capita was added to understand the health capacity of the municipality. Perhaps due to federal initiatives to provide more doctors to underserved areas through the program Programa Mais Médicos (PMM)/More Doctors Program, the absolute number of doctors may have increased but has not necessarily shown a direct impact on relative infant mortality across municipalities. Research on the efficacy of PMM on infant mortality suggests that PMM has not had a significant effect on infant mortality but was associated with reductions in IMR in municipalities with initially high levels of IMR and with better quality of healthcare writ large (Bexson et al. 2021; Mattos and Mazetto 2019). We suspect the effect of the number of doctors on IMR is conditional on the region’s pre-existing levels of development (which is not always correlated with the distance from state capital) which could be correlated with the baseline quality of hospital facilities, capacity of hospital staff including nurses, and the population behavior of visiting hospitals (both expecting mothers and infants) (Mattos and Mazetto 2019). Figure 8 illustrates that relationship - only in areas in which GDP per capita is above the mean do we see the number of
doctors significantly related to differences in IMR after flood events (see OA Table A17 for full results). \(^\text{18}\)

Figure 8: Conditional effect of number of doctors on IMR after Flood Incidence

**Predictive margins of treat with 95% CIs**

<table>
<thead>
<tr>
<th>GDPpc below mean</th>
<th>GDPpc above mean</th>
</tr>
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<td>Predicted effect on ln(IMR) (_{1,1})</td>
</tr>
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<td><img src="image" alt="Graph of the results of the triple interaction term between GDP per capita, numbers of doctors per 1000 residents, and the incidence of a flood. The left side of the figure shows results for municipalities with GDP per capita below the mean national value. The right side of the figure show results for municipalities with GDP per capita above the mean national value." /></td>
<td></td>
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**AltText:** Graph of the results of the triple interaction term between GDP per capita, numbers of doctors per 1000 residents, and the incidence of a flood. The left side of the figure shows results for municipalities with GDP per capita below the mean national value. The right side of the figure show results for municipalities with GDP per capita above the mean national value.

We implement a number of robustness checks to ascertain the strength of our findings. Like with our cross-national analysis, we employ the number of individuals affected by the incidence of flood in the municipality to be sure our flood results are robust to this alternative specification. We find very similar results—see OA Table A16 for details. We also use alternative measure of health care coverage, pediatrics per 100,000 children in OA Table A17. The results with this indicator are highly similar to those found in our main results. Our empirical analysis and robustness checks have documented a clear association between the incidence of flood and IMR and the conditional effect of regional economic development, in line with our theoretical argument.
7 Discussion

Our findings have direct implications for the study of the consequences of decentralization for social and developmental outcomes. Our analysis of the link between decentralization and IMR suggests that the effect of decentralization is context dependent. In decentralized countries that developed relatively early and managed to develop a balanced provision of public service capacity across space, decentralization may reduce poor health outcomes such as infant mortality. In late developing contexts, driven by massive urban agglomeration, the impact of decentralization is more complex. Lower overall levels of IMR hide large spatial inequalities that become particularly harmful in times of crisis. This nuance, directly linked to heterogeneous spatial patterns, suggests that the link between regional inequalities and governance operates as a critical moderator of the social and economic consequences of decentralization (Tselios, 2022).

Advancing our understanding of these processes in developing contexts seems critical for a number of pressing issues. Chief among them is the spatial gradient of growth. Provision of basic services is central to the calculus of investors, both households and firms. Extreme spatial inequalities in health become part of the reason why spatial inequalities in growth persist.

In addition, diverging spatial fortunes reinforce the vulnerabilities of local populations and their dependence on elites’ clientelistic strategies. The gap in health provision thus translates into, and reinforces, unequal patterns of political influence. Unequal democracies may then become worse democracies through the channel outlined in this paper.

They are also potentially less stable. The spatial spread of dissatisfaction with the level and quality of public goods provision may impact support for parties willing to engage in active democratic backsliding. This is specially the case if the less favored areas are also the ones demanding more fiscal resources, particularly in times of crises (Goodspeed, 2023). Feeling further left-behind is a well known channel for the spreading of populist messages around the globe.

Our analysis suggests that political decentralization may improve health outcomes, conditional on strong local accountability mechanisms and well-distributed resources to overcome regional inequalities. Given that many regionally unequal nations have instituted political decentralization, it will be important that these inequalities are acknowledged and
addressed by central governments to ensure good health outcomes throughout the nation. We point to several efforts like this in Brazil, such as the PMM program, meant to infuse needed resources to under-served areas. Our analysis also implies that high-quality political accountability mechanisms should also go a long way to ensuring that politicians deliver services to citizens. Brazil’s system of random audits is one such mechanism that may improve outcomes related to political decentralization in that nation (Ferraz and Finan, 2011).

8 Conclusion

This paper examines the relationship between decentralization, crises, and infant mortality rates, focusing especially on developing nations. We find that decentralized nations have lower levels of IMR, on average. Decentralized countries provide higher levels of water and sanitation that drive lower IMR. However, these benefits are concentrated in higher income countries, but also exist in middle income countries. Yet decentralized countries also have higher spatial variation in IMR. Consistent with this logic, we show that flood events lead to relative increases in IMR in decentralized nations, exposing the weakness of states that do not provide uniform levels of services across the nation. We also use the case of Brazil to examine sub-nationally the impact of crises on IMR. We show floods lead to an increase in the levels of IMR in Brazil’s municipalities, especially in those places that are under-resourced in decentralized states—poorer localities.

Our research contributes to scholarship in public health, public policy, economics, and comparative politics on the effects of political institutional structure on health outcomes. Most research on this topic employs country case studies, and often focuses on advanced industrial democracies. While concerns with IMR are critical at every stage of economic development, the challenges are most acute for developing and less developed nations. Our research examines the impact of decentralization in a sample of nations with the highest rates of IMR.

The spatial distribution of health outcomes, including IMR, are crucial to examine as the world is improving on major indicators such as IMR. The regions that fall behind in these gains, which tend to be low income and rural, are ones that will require special attention and policy effort to converge with the national rates. We show that this may be particular challenge in decentralized nations.
Our analyses are admittedly a preliminary approximation to a very complex problem. Ensuring maximum survival rates among children is among the most basic tasks for rulers. Refusing to do so is a political choice. Theoretically, we have not delved deep into the incentives by politicians at different levels of government to provide the necessary goods and services to combat IMR. The lack of attention to IMR is sometimes a matter of capacity and sometimes a matter of choice. Delineating a clear distinction between the two and understanding better the conditions under which forbearance towards death is an acceptable political calculus in decentralized contexts is a pressing line of future inquiry. Empirically, we have complemented high coverage-low nuance measures of decentralization with a more in-depth analysis of the mechanisms using the case of Brazil but there is much left to do. A promising avenue is the exploitation of local natural experiments to identify the impact of quasi-random changes in decentralized designs on the micro-behavior of both elites and households.
Notes

1. The infant mortality rate (IMR) is defined as the number of deaths in children under 1 year per 1000 live births.

2. A rich literature shows that decentralization in health takes many forms, and may not map perfectly onto generalized measures of decentralization. Health system decentralization varies considerably, including devolution or delegation of systems of finance, service organization, human resources, access rules, and governance rules (Bossert and Mitchell, 2011, Bossert, 1998).

3. A major exception is Thomas Bossert and co-authors, who study health decentralization in many countries in the developing world in comparative perspective, c.f., (Bossert, 1998, Bossert et al., 2003, Mitchell and Bossert, 2010).

4. For example, in OECD countries in the 1990s, 70 percent of health care spending was from public funds. Around 50 percent of health care spending in non-OECD countries came from public sources in the 1990s. This number has likely grown over time (Schieber and Maeda, 1999).

5. For summaries of debates on the trade-offs for decentralization in healthcare, see Peckham et al. (2005) and Saltman et al. (2007).

6. Moreover, a complementary literature shows that, given high regional inequalities and concentrated economic development in the developing world, federalism cannot provide either laboratories of experimentation or jurisdictional competition that leads to efficient provision of public goods (Rodden and Rose-Ackerman, 1997, Rogers, 2020).

7. For example, in the health context, Di Novi et al. (2019) find that decentralization reduced regional health inequalities within rich regions in Italy but did not improve health inequalities across regions. Similarly, Jiménez-Rubio and García-Gómez (2017) show with evidence from Spain on IMR and neonatal mortality that the benefits of decentralization were only realized in rich places with full fiscal autonomy (i.e., Basque Country and Navarre). And Capano and Lippi (2021) find that decentralization led to inequalities in subnational COVID-19 responses and outcomes in Italy.

8. Research in public health has found some evidence consistent with this idea. Examining Italy, Costa-Font and Turati (2018) find that policy decentralization to locally elected officials did not change the underlying level of regional inequalities in health, which preexisted the decentralization scheme.

9. To manage potential Nickell bias that may result from having more N than T, and using fixed effects, we took two steps. First in each regression, we show results with and without country fixed effects to show stability in our results. Second, we ran our models with dynamic generalized method of movement (GMM) structures to confirm basic results (direction, significance, size of effect). These results are shown in OA Table A12.
results using both strategies are very similar to what we find in our main analysis.

10. The data are drawn from national offices, Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), amongst other sources.

11. EM-DAT’s disaster criteria is as follows: “For a disaster to be entered into the database at least one of the following criteria must be fulfilled: Ten (10) or more people reported killed; Hundred (100) or more people reported affected; or Declaration of a state of emergency; Call for international assistance.

12. See Gunther et al. (2010) for a review of research on the link between water and sanitation services and health outcomes.

13. In VDEM’s measure of decentralization, Brazil ranks in the top 20 percent in 2021 (0.959; average in 2021 is 0.50).


15. Authors’ calculation from DATASUS (http://tabnet.datasus.gov.br). Numbers of doctors per 1000 at municipal level for the analysis; the map shows provincial level data for the purposes of illustrating the variation across municipalities. Accessed 28 October 2023.


18. We also use alternative measure of healthcare access - log of pediatrics per 100,000 children - on both IMR and CMR. Results are presented in OA Table A18 and Figures 4 and 5.
# Manuscript Tables

## Table 1: National Infant Mortality Rates, by Decentralization

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<td>(0.015)</td>
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*Notes: Data are 5 year averaged values. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*
Table 2: National Water and Sanitation Access, by Decentralization

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Notes: Data are 5 year averaged values. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Table 3: Subnational Coefficient of Variation in IMR, by Decentralization

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<tr>
<td></td>
<td>(1.026)</td>
<td>(4.717)</td>
<td>(8.176)</td>
<td></td>
</tr>
<tr>
<td>Democracy(t_{-1})</td>
<td>-2.170</td>
<td>-11.086</td>
<td>-9.857</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4.646)</td>
<td>(7.993)</td>
<td>(10.885)</td>
<td></td>
</tr>
<tr>
<td>Public Health Expenditure(t_{-1})</td>
<td>1.173*</td>
<td>-1.884</td>
<td>-2.262</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.710)</td>
<td>(1.431)</td>
<td>(2.385)</td>
<td></td>
</tr>
<tr>
<td>ln(National IMR)(t_{-1})</td>
<td>-4.592**</td>
<td>-3.550</td>
<td>-3.495</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.869)</td>
<td>(4.885)</td>
<td>(7.477)</td>
<td></td>
</tr>
<tr>
<td>Coefficient of Variation in IMR(t_{-1})</td>
<td>-0.055</td>
<td></td>
<td></td>
<td>-0.055</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.115)</td>
</tr>
</tbody>
</table>

| Observations | 237 | 237 | 237 | 146 |
| Adjusted R\(^2\) | 0.105 | 0.206 | 0.659 | 0.636 |
| Controls | No | Yes | Yes | Yes |
| Country FE | No | No | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Lagged DV | No | No | No | Yes |

Notes: Data are 5 year averaged values. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Table 4: Change in National IMR after Flood Events, by Decentralization

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Infant Mortality Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decentralization&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>-0.270***</td>
<td>-0.258***</td>
<td>-0.111***</td>
<td>-0.274***</td>
<td>-0.263***</td>
<td>-0.109***</td>
</tr>
<tr>
<td></td>
<td>(0.049)</td>
<td>(0.053)</td>
<td>(0.026)</td>
<td>(0.052)</td>
<td>(0.056)</td>
<td>(0.028)</td>
</tr>
<tr>
<td>Flood Incidence&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>-0.062</td>
<td>-0.136***</td>
<td>-0.100***</td>
<td>-0.042</td>
<td>-0.034*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.042)</td>
<td>(0.048)</td>
<td>(0.024)</td>
<td>(0.034)</td>
<td>(0.017)</td>
<td></td>
</tr>
<tr>
<td>Decentralization&lt;sub&gt;t−1&lt;/sub&gt;*Flood Incidence&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>0.185***</td>
<td>0.198***</td>
<td>0.138***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.065)</td>
<td>(0.062)</td>
<td>(0.031)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln(Total Affected Flood)&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>0.002</td>
<td>0.001</td>
<td>-0.003</td>
<td>-0.003</td>
<td>-0.003*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.002)</td>
<td>(0.001)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>Decentralization&lt;sub&gt;t−1&lt;/sub&gt;*ln(Total Affected Flood)&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td>0.011**</td>
<td>0.012***</td>
<td>0.009***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.002)</td>
</tr>
<tr>
<td>ln(GDP PC)&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>-0.277***</td>
<td>-0.016</td>
<td>-0.279***</td>
<td>-0.017</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.014)</td>
<td>(0.026)</td>
<td>(0.014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Democracy&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>0.247***</td>
<td>0.060*</td>
<td>0.236***</td>
<td>0.052</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.036)</td>
<td>(0.072)</td>
<td>(0.036)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Health Expenditure&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td>0.000</td>
<td>0.011</td>
<td>0.001</td>
<td>0.011</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.007)</td>
<td>(0.014)</td>
<td>(0.007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ln(National IMR)&lt;sub&gt;t−1&lt;/sub&gt;</td>
<td></td>
<td></td>
<td></td>
<td>0.852***</td>
<td>0.853***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.017)</td>
<td>(0.017)</td>
<td></td>
</tr>
</tbody>
</table>

| Observations          | 1,035     | 976       | 976       | 1,131     | 976       | 976       |
| Adjusted R<sup>2</sup> | 0.980     | 0.984     | 0.996     | 0.979     | 0.984     | 0.996     |
| Controls              | No        | Yes       | Yes       | No        | Yes       | Yes       |
| Country FE            | Yes       | Yes       | Yes       | Yes       | Yes       | Yes       |
| Year FE               | Yes       | Yes       | Yes       | Yes       | Yes       | Yes       |
| Lagged DV             | No        | No        | Yes       | No        | No        | Yes       |

Notes: Data are 5 year averaged values. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
Table 5: Change in Municipal Infant Mortality Rate (IMR) and Child Mortality Rate (CMR) after Flood Events

<table>
<thead>
<tr>
<th></th>
<th>ln(IMR)</th>
<th>ln(IMR)</th>
<th>ln(IMR)</th>
<th>ln(IMR)</th>
<th>ln(IMR)</th>
<th>ln(IMR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood$_{t-1}$</td>
<td>0.635***</td>
<td>0.643***</td>
<td>0.728***</td>
<td>0.369***</td>
<td>0.649***</td>
<td>0.673***</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.125)</td>
<td>(0.129)</td>
<td>(0.079)</td>
<td>(0.130)</td>
<td>(0.132)</td>
</tr>
<tr>
<td>ln(GDP per capita)$_{t-1}$</td>
<td>-0.013**</td>
<td>-0.008</td>
<td>-0.003</td>
<td>-0.005</td>
<td>-0.005</td>
<td>-0.003</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.008)</td>
<td>(0.010)</td>
<td>(0.005)</td>
<td>(0.008)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>Flood $\times$ ln(GDP per capita)$_{t-1}$</td>
<td>-0.047***</td>
<td>-0.050***</td>
<td>-0.057***</td>
<td>-0.026***</td>
<td>-0.050***</td>
<td>-0.052***</td>
</tr>
<tr>
<td></td>
<td>(0.006)</td>
<td>(0.009)</td>
<td>(0.009)</td>
<td>(0.006)</td>
<td>(0.010)</td>
<td>(0.010)</td>
</tr>
<tr>
<td>ln(Doctors per 1,000)$_{t-1}$</td>
<td>0.004</td>
<td>-0.001</td>
<td>0.002</td>
<td>-0.004</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.006)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>99005</td>
<td>44133</td>
<td>44133</td>
<td>116695</td>
<td>52396</td>
<td>52396</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.055</td>
<td>0.030</td>
<td>0.031</td>
<td>0.030</td>
<td>0.024</td>
<td>0.018</td>
</tr>
<tr>
<td>Controls</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Munic FE</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Year FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Notes: Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Regression diagnostics and results with all control variables displayed are shown in OA Section 10.
Statements

Disclosure statement: The authors have no known conflicts of interest.

Data Availability Statement: The data that support the findings of this study are openly available in the Harvard Dataverse at https://doi.org/10.7910/DVN/QNCPKD.

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