Democracy, Genes, and the Male Survival Disadvantage

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Abstract

Boys have a survival disadvantage in most societies. This paper examines whether and how improvement in the quality of democratic institutions affects sex differences in infant mortality. Using data on more than 3 million births from sub-Saharan African countries, our identification strategy exploits within-mother variation in the quality of institutions. The main finding demonstrates that the male survival disadvantage in infant mortality falls by 0.31 percentage points, 20% of the sample mean, when we move from autocracy to democracy. Analyzing the channels through which this effect operates, we find that better democratic institutions expand the likelihood of tetanus immunization, access to prenatal care services, breastfeeding practices, and normal birth weight, all of which are associated with stronger health benefits for boys than for girls. Moreover, using twins, we find that better democratic institutions significantly constrain genetic influences on male mortality in early ages. We empirically reject the hypothesis that hormonal (testosterone) transfer could be driving our findings.

Keywords: Infant mortality, Democratic institutions, Male survival disadvantage, Genes, Preconception environment, Hormonal transfer.

JEL: I12, I14, I15, I18, J13, J16, J18, O15.

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1 Introduction

Around the world, among children who died before their fifth birthday between 2000 and 2015, boys outnumbered girls by over 34 million (UN IGME (2018), World Bank (2019)). Beyond posing a major health-equity problem, excess male mortality at early ages leads to a scarcity of male adults in many societies and in turn to grave social consequences including lower marriage prospects for women, decreased wife bargaining power, higher divorce rates, more out-of-wedlock births, and an increased risk of sexually transmitted diseases for women due to greater male infidelity. The seriousness of these effects raises the question of whether appropriate policy interventions can mitigate boysâ survival disadvantage.

This research is conducted in a region that has experienced unprecedented institutional change over the last several decades. Indicators like political participation, competition in the recruitment of the executive, and constraints on executive power have improved substantially in recent years in many African countries. Consistent with economic theory, these developments have led to an improvement in the supply of public goods, especially those that benefit the poor. As a result, several health indicators have improved. In particular, the probability of dying within the first year of life has fallen from 107.8 out of every 1,000 births in 1990 to 54.9 out of every 1,000 births in 2015 (World Bank (2019)). This decline in infant-mortality rates has been more important for boys than for girls. The concurrent improvement in several features of the political context and the excess male mortality suggests the role of the political system in explaining the male-female gap in mortality. Yet, there has been so far no attempt to empirically explore the link between each type of political system and the sex gap in mortality. In this paper, we fill this gap by analyzing the impact of democracy on the male disadvantage in infant mortality. We also examine the main channels through which democracy shapes the male survival disadvantage.

Using micro-panel data from 141 Demographic and Health Surveys, we examine the fertility history of $978,223$ mothers residing in 40 sub-Saharan African countries and extract records of more than 3 million births over the period 1960-2015. Each live birth is matched with information on the quality of democratic institutions in the country and year of birth to get the final dataset. Based on this dataset, we exploit variation within opposite-sex siblings to identify the effect of better quality of democratic institutions on the sex difference in infant mortality. Our identification strategy allows us to control the effect of unobserved time-invariant characteristics at the household (mother) and country-level as potential confounders.

Consistent with previous research, our analysis finds that being a male is associated with a significant increase in the probability of death within the first year of life and this finding is robust to comparing opposite-sex children born to the same mother. However, improvement in the quality of democratic institutions leads to an important decrease in the male survival disadvantage. Indeed, our findings show that moving from autocracy to full democracy reduces the male survival disadvantage in infant mortality by 0.31 percentage points, equivalent to approximately 20% of the average male-female difference in infant mortality estimated from the sample. These findings are robust to controlling for correlates of the quality of democratic institutions that could potentially drive our results. We also show that the main results are highly robust to alternatives definitions and measures of the quality of democratic institutions.

Analyzing the mechanism, we find that better democratic institutions expand the likelihood of tetanus immunization, access to prenatal care services, breastfeeding practices, and normal birth weight, all of which are associated with a stronger effect on the survival of boys within the first year of life.

Furthermore, taking advantage of the natural experiment that occurs among twins pregnancies to further understand the channel, we analyze the effect of better democratic institutions on the distinct contributions of genetic and preconception influences on excess male infant mortality. We find that improved institutions significantly constrain genetic expression, driving down the contribution of biology to the male survival disadvantage. Improved institutions also affect the contribution of preconception factors to excess male mortality, but not as strongly as it affects biology. Genes are constrained when the inputs that they use to produce diseases are minimized. In the context of the sex gap in infant mortality, such inputs could include a lack of immunity against certain diseases, a lack of proper prenatal care, the absence of breastfeeding, and poor maternal conditions resulting, for instance, in low birthweight. Interestingly, we also reject the hormonal (testosterone) transfer theory (Cronqvist et al. (2016)), which holds that the reduced sex gap in infant mortality among twins, as a response to improved institutions, is explained by an increase in the likelihood of death among girls due to in utero exposure to testosterone. Indeed, we do not find that infant mortality differs among girls who have a female twin and girls who have a male twin.

This paper contributes to several strands of the literature. First, we add to the nascent literature that relates political institutions to sex differences in mortality by assessing whether and how democratic institutions affect the male disadvantage in infant mortality. Second, this paper also contributes to the growing literature examining how public health interventions affect genetic influences on several health outcomes (Boardman et al. (2012)). Finally, results from our study have practical policy implications in that it informs policymakers on the extent to which gender-neutral investment in certain health inputs can help to attenuate the sex gap in survival.

Despite increasing evidence of cross-country variations in the male survival disadvantage, studies examining whether country-specific characteristics could partly account for the male disadvantage in infant mortality are very scarce. Perhaps the only attempt is a recent study by Pongou et al. (2017) where the quality of institutions in a country is viewed as another factor shaping the male disadvantage in infant mortality. In a cross-regional analysis, Pongou et al. (2017) divide sub-Saharan Africa into four institutional regions based on the historical development of institutions in Africa and they estimate the distinct contribution of biology and preconception factors in each institutional settings. The comparison of these estimates reveals a gradient in the contribution of biology and preconception environment by institutional settings. Indeed, they show that the estimated effect of child biology and preconception factors on the male survival disadvantage is negatively correlated with the institutional quality in the country. They conclude that improvement in the quality of institutions is associated with a fall in the male survival disadvantage. This finding supports the hypothesis that child biology and preconception environment should perhaps be viewed as factors that prime children to die in the early ages under certain circumstances. In this paper, we contribute to this literature by examining democratic institutions as such circumstances.

Our paper builds on the earlier contribution of Pongou et al. (2017) but with important differences. We quantify the impact of the institutional environment on the male survival disadvantage in early ages by focusing on the quality of democratic institutions. Moreover, we examine the possible channels explaining the link between the quality of democratic institutions and the male disadvantage in infant mortality.

The rest of this paper is laid out as follows. In section 2, we review the related literature and discuss the conceptual framework for our study. Section 3 lays out the datasets and provides descriptive statistics. Section 4 presents the methodology and the empirical strategy. The empirical findings are presented in section 5. Section 6 discusses the mechanisms through which democratic institutions affect the male survival disadvantage. Section 7 concludes.

2 Conceptual Framework

In order to lay out the relationship between democratic institutions and the male-female gap in infant mortality, one needs to understand the basic or proximate causes of excess male mortality. For this reason, we will start by reviewing the literature on the main drivers of the sex difference in child mortality. Then we will describe how democratic institutions shape these determinants to affect the survival disadvantage of boys.

2.1 Literature on the Drivers of Excess Male Mortality in Early Childhood

Two major hypothesis emerge from the literature analyzing the determinants of sex mortality differences in early childhood, when behavioral differences should be minimal. The first hypothesis attributes the male-female difference in infant mortality to biological differences between the sexes (Naeye et al. (1971), Waldron (1983)). According to the proponents of this hypothesis, males have a weaker immune system and are more susceptible to X-linked recessive disorders. As a consequence, they have an inherently greater vulnerability to most leading causes of child morbidity and mortality such as perinatal conditions (including prematurity and respiratory distress), congenital anomalies and infectious diseases (Waldron (1985, 1998), Sawyer (2012)). This greater vulnerability translates into excess male mortality, especially in societies where there is little gender bias in the allocation of foods and health resources. Crediting the biological explanation of the sex gap in infant mortality, many empirical studies have examined the impact of male gender on infant mortality in both developed and developing countries (see Drevenstedt et al. (2008), **?**, Boco (2014) for instance). Consistent with the theory, they have consistently reported a higher risk of death among male infants.

However, the biological hypothesis has some limitations that have been acknowledged in the literature. Studies have pointed out several diseases to which females are more vulnerable than males. Analyzing the sex difference in mortality by causes of deaths, Garenne and Lafon (1998) shows that the female advantage in mortality is reversed for some infectious and autoimmune diseases, especially in late childhood and early adulthood. In the same vein, in a study that focuses on United States, Goldin and Lleras-Muney (2018) attributed the American female advantage in life expectancy to a greater female susceptibility to certain infectious diseases during the 19th century. These studies seems to suggest that the biological explanation of the excess male mortality in early years is not conclusive.

As one might expect that innate biological differences would result in a constant level of excess nale mortality, other studies have stressed the fact that biological differences are less likely to account for the unexpected cross-country and over time variations in the magnituge of the male disadvantage in mortality as documented for example in Drevenstedt et al. (2008), Boco (2014) or UNIGME (2015). Analyzing the surprising rise and fall in the excess male mortality experienced by many industrialized countires over the 20th century, Drevenstedt et al. (2008) suggests that the male survival disadvantage in early-age is the outcome of a complex interplay between biology and both the medical-technical and epidemiological context, rather than the result of solely biological susceptibility to diseases. Indeed he shows that as cause of infant death shifted from infectious diseases to perinatal conditions due to improvement in living conditions in the 1970s, the male disadvantage in mortality worsened because males have a greater vulnerability to mortality for perinatal conditions. The subsequent medical-technical advancements which minimized health complications from perinatal conditions has disproportionately benefited males, reducing, therefore, their disadvantage in mortality.

An additional limitation of the biological hypothesis can be traced into studies that provided evidence of environmental causes common to both sex ratio and reproductive impairment (Pongou (2013) provides a review of these sudies). For instance Pongou (2015) explained the concurrent increase in American female births and their relative mortality after the second world war by the exposure of females to environmental hazards that are likely to increase the probability of female conception and decrease the female survival advantage. Despite these suggestive evidence the biological hypothesis and most of the empirical works that have tested this hypothesis implicitly assumed that the sex of the child is randomly determined. Indeed, failure to consider the endogeneity of the sex of the child contribute to a partial understanding of the determinants of the male survival disadvantage.

In order to address these limitations of the biological hypothesis, Pongou (2013) formulates the preconception origins hypothesis to explain the mortality sex gap. This hypothesis holds that parental circumstances around the time of conception such as diet, health conditions, or exposure to environmental hazards, which have been shown to determine both the sex of a child and the health of a child in utero and after birth, also affect the sex gap in mortality. This hypothesis, which generalizes the biological hypothesis, provides a broader framework for understanding temporal and spatial variation in the sex gap in mortality, and how this variation is related to variation in the sex ratio at birth. These two hypotheses are tested in a unified framework in Pongou (2013). This study proposes a decomposition methodology based on twins to estimate the distinct contributions of child biology and preconception environment to the male disadvantage in infant mortality. [1] Applying this methodology to a large sample of data on twins from sub-Saharan Africa, Pongou (2013) finds that both child biology and preconception factors significantly contribute to excess male infant mortality.

It follows that the male disadvantage in infant mortality is determine by the interaction between both biology and preconception factors and social factors that are likely to disproportionately affect the survival chances of boy. These social factors include health conditions in-utero and after birth, parental conditions (education, health, environmental hazards), and the distribution of diseases. Indeed, improvement in these social factors is likely to affect the male disadvantage in infant mortality through three pathways. First, they can constrain biological or genetic expression by minimizing the input factors utilized by the human biological system to produce diseases. Second, change in these social factors can modify the preconception environment, implying a variation in the sex ratio at birth across countries. Third, change in the social factors can constrain the effect

[1] In order to understand the channels through which improved democratic institutions could affect the infant mortality sex gap, the distinction between child biology and the preconception environment is particularly important because, unlike biology, the preconception environment can be modified if we identify the specific components in this environment that are likely to affect the survival chances of babies. In this sense, the preconception hypothesis lays the groundwork for health policies aiming to reduce this early life health inequality between boys and girls.

of the preconception environment on infant mortality. This is the case even if they don't modify this environment.

2.2 Why Does Democracy Matter for Sex Differences in Infant Mortality?

Why democratic institutions can affect the male disadvantage in infant mortality is not obvious. The previous section revealed the role of social outcomes in shaping the male-female gap in mortality. These factors are themselves highly sensitive to the institutional environment. Indeed, there are good evidence that, compared to nondemocracies democracies produce more public goods and more income redistribution which translate into better social outcomes (Sen (1981), Meltzer and Richard (1981), Przeworski et al. (2000), Lake and Baum (2001), Bueno et al. (2003b), Acemoglu and Robinson (2005), Deacon (2009)). Figures 3 and 4 corroborates this argument. These figures show a positive correlation between the level of democracy, proxied by polity IV index[2] and the prevalence of selected public health inputs.

Prominent political economy models that suggest two major mechanisms explaining why democratic governement outperformed non democratic governement in the provision of public goods. The first mechanism emphasizes the role of accountability structures. It is argued that democracies are constrained by the electoral process with contested elections and universal suffrage to prioritize the provision of public goods rather than private goods, while nondemocracies or less democratic societies face no such constraint. In fact, democratic leaders who are competing for vote are more likely to provide higher level of public good since they are likely to be evaluated on their ability to provide basic benefits to their constituents (Lake and Baum (2001)). Moreover, the median voter theorem implies that a representative democracy governs by the preferences of the majority should have more incentives to provide public goods as long as these policies are the most favoured by the majority. Therefore, in settings where the poor face the greatest health challenges and constitute the majority of the population, the provision of public good become more cost effective than proivate transfer to win support (Bueno et al. (2003b)). Another strand of the literature focuses on the power of citizen coordination. They contend that the coordination problem that hinder public good provision is minimized when citizens share the same preferences or when social norms significantly constraint defectors and free-riders. Since such coordination is more likely in democratic systems possibly because of the existence of civil society groups (Boix and Posner (1998)), local provision of public good is likely to be higher.

However, the empirical research provides conflicting evidence that democracies provide more public goods than autocracies. Focusing on public education (literacy rates, en-

[2] See section 3 for a detailed description of this index

rollement rates) and public health (immunization, access to clean water), Lake and Baum (2001) and Bueno et al. (2003b) found evidence supporting the prediction. Whereas, Gil et al. (2004) found no association between public spending for education and the level of democracy. Focusing on infant mortality[3], cross-country analysis such as **?**, Lake and Baum (2001) and Besley and Kudamatsu (2006) found generally negative effects of democracy on infant mortality, though Ross (2006) has estimated insignificant effects using within-country variations. In a recent work, however, Kudamatsu (2012) produces more consistent estimates by using micro panel data and taking into account several flaws from previous empirical studies. He finds that democracy significantly reduces infant mortality. He also provides evidence, though not conclusive, that sanitation, clean water, immunization and global health spending, are higher following democratization.

2.3 Summary of the Conceptual Framework

Based on the arguments presented in the preceding section, we hypothesize that improvement in the quality of democratic institutions will reduce the male disadvantage in infant mortality to the extent that better democratic institutions foster the provision of public health services and generate health conditions that are effective in reducing either the exposure to causes of child death for which boys have the highest vulnerability or the likelihood that these causes lead to death. This argument is summarized in figure 1. It says that democratic institutions may reduce the male survival disadvantage through three distinct channels. By improving the supply of health inputs likely to generate stronger health benefits for boys compared to girls (arrow A), democratic institutions will constrain genetic[4] (arrow B) and preconception (arrow C) influences on excess male mortality. As an illustration, assume that improved democratic institutions result in an expansion of tetanus immunization coverage among pregnant women. Then this will have a stronger effect on the survival of boys because boys suffer a higher incidence of neonatal tetanus (Garenne and Lafon (1998), Sawyer (2012)). The third channel is that democratic institutions might directly affect some preconception factors known to determine both child sex and mortality.[5] Better institutions could either improve such factors or worsen them (arrow D). For example, better institutions could improve parental living conditions, which is likely to result in more boys being born (Almond and Currie (2011),

[3]The existing literature related to democracy and infant mortality has generally focused on average infant mortality neglecting, male-female differences in infant mortality.

[4]Democratic institutions cannot modify biology; they cannot change the genetic differences between boys and girls. This is why it is generally assumed in the literature that biological or genetic differences between the sexes do not vary across countries. In fact, this is the assumption on which several studies are based, even if they do not state it explicitly (add reference Drevenstedt et al. (2008)).

[5]Within Africa, we do not expect institutions to modify the preconception environment. However, at the global level, institutions can modify the preconception environment, due, for instance, to institutional variation in environmental regulations. One could also view the gender bias explaining sex-selective abortion as part of the preconception environment.

Pongou (2013)) and in a higher survival rate of these boys. But if better institutions accelerate economic growth and if growth leads to more pollution, that could increase the relative number of girls at birth (Mocarelli et al. (2000), Davis et al. (1998)) and their mortality rate (Pongou (2015)).

3 Data and Descriptive Statistics

To estimate the causal effect of democratic institutions on the male disadvantage in infant mortality, this study links country-level data on democracy with micro-data on the survival of babies. In this section, we first describe Demographic and Health Surveys (DHS) from which we obtain individual-level data on mortality. Second, we present how we measure democracy in this project. Then, we briefly present some descriptive statistics.

3.1 Data on Infant Mortality

Our outcome of interest is infant mortality, defined as the risk of death within the first year of life after birth. Primary data on this variable is obtained from the Demographic and Health Surveys (DHS). DHS is a non-profit group funded by the U.S. Agency for International Development (USAID) and dedicated to compiling internationally comparable survey data. In each DHS, a standardized individual questionnaire was administrated to a representative sample of women of reproductive age (between 15 and 49 years old). To construct the dataset, we merge 136 DHS Birth Recode files[6]. To avoid measurement error in our measure of infant mortality, we dropped babies born within one year before interview or before the country's year of the independence.

Selected women in each DHS were asked to provide information about their fertility history including the date of birth of each child, whether the child is still alive, and, if the child has died, the age at death. We use this information to define our dependent variable as a dummy that equals one if the child dies before the age of one and zero otherwise. DHS also gather detailed information on a host of demographic and socio-economic characteristics of mothers and their children. Based on this information, we define the following indicators used in the empirical analysis below: a dummy for whether the child is a boy, a set of birth order dummies, an indicator for whether the child is a twin, an indicator for the age of the mother at delivery, an indicator for the number of children at the time of delivery, an indicator for the mother's level of education, marital status and place of residence. In addition, DHS collect information on many health inputs including prenatal, antenatal, and postnatal health care services. The latter information

[6] The DHS Birth Recode File contains all of the live births reported by interviewed mothers collected between the years 1986 and 2017 in 40 sub-Saharan African countries (see Appendix table A4)

is used in section 6 to investigate the mechanism underlying our results.

3.2 Measure of Democracy

There are myriad measures of democracy in the literature. In the main results of this paper, we rely on a measure of the level of democracy drawn from the Polity IV dataset. Polity IV is the latest version of the polity data series, which assesses the state's level of democracy based on (1) an evaluation of the state's elections for competitiveness and openness, (2) the nature of political participation in general, and (3) the extent of checks on executive authority (Gurr et al. (2010)). These three features of the representative government are differences between democracies and autocracies that one might expect to constrain democracies to be more redistributive and produce more public goods than non-democracies.

The Polity IV dataset contains coded annual information on the level of democracy of over 100 countries around the world including the 40 sub-Saharan African countries for which DHS are available, and it covers the period spanning from 1800 to 2015. In each year and country, a "Polity Score" is constructed from six components categorical variables: XRREG (Regulation of Chief Executive Recruitment), XRCOMP (Competitiveness of Executive Recruitment), XROPEN (Openness of Executive Recruitment), XCONST (Constraint on Chief Executive), PARCOMP (Competitiveness of Political Participation), and PARREG (Regulation of Participation). In practice, the polity score ranges from -10 to +10, with -10 to -6 corresponding to autocracies, -5 to 5 corresponding to anocracies, and 6 to 10 to democracies (Gurr et al. (2010)).

In our empirical analysis, we explore different measures of democracy based on Polity IV. We first use the 21-scale polity index in its continuous form. Then we define two dummies for the level of democracy such that a country is democratic if polity score is strictly greater than the median value of Polity IV or if it is strictly greater than +4. We also construct a trichotomous index of the level of democracy based on three regime categories cited above: full autocracy ($-10 <= \mathsf{Polity} <= -6$), anocracy ($-5 <= \mathsf{Polity} <= 5$) and full democracy ($+6 <= \mathsf{Polity} <= +10$).

Yet, in order to test the sensitivity of our main results, we use alternative measures of democracy collected from other sources including Political Risk Services, Freedom House, a democracy measure define by Boix Miller and Rosato (BMR hereafter), and the dataset on political regimes and transition constructed by Papaioannou and Siourounis (2008) (PS hereafter). In each of these datasets, a score is assigned to the democracy index for each country-year based on the aggregation of different dimensions of democracy.

3.3 Descriptive Statistics

Using the information on the country and year of birth of the child, we merged the two datasets described above and we obtained a final dataset containing information on a sample of $3,792,650$ children born between 1960 and 2015 from 978,223 mothers residing in 40 sub-Saharan African countries.

Table 1 reports summary statistics for the main variables used in the empirical analysis below. The table reveals that the modal child is a boy born in 1995 from a mother aged 25 years old at the time of delivery. This boy is on average 1.18 times more likely to die within the first year of life compared with a girl.

Using the three-part regimes categorization suggested by the authors of Polity IV, we compare the probability of infant death across gender and by the level of democratic institutions. The comparative analysis appears in table 2. Two interesting results emerge from this table. First, as expected, in each democratic settings, the likelihood of death within the first year of life is higher for boys than girls. Second, the excess male mortality within the first year of life decreases from 15.53 deaths per thousand live births to 11.62 deaths per thousand live births, as we move from full autocracy to full democracy. These last figures are suggestive of the role of democratic institutions in shaping the male-female gap in infant mortality. In the next section, we provide further evidence on this relationship.

4 Identification Strategy

Our objective is to explore how the relationship between the male sex and the probability of death within the first year of life is affected by the quality of democratic institutions in a country and to quantify this effect. To do so, we estimate the following linear probability model:

$$M_{icmt} = \lambda_0 + \lambda_1 Male_i + \lambda_2 Demo_{ct} + \lambda_3 Male_i \times Demo_{ct} + X'_{imct}\pi + \alpha_m + \delta_t + \varepsilon_{icmt} \quad (1)$$

where M_{icmt} is the outcome of interest which corresponds to a dummy that equals one if a baby i born at time t from mother m in country c dies within the first year of life. The variable $Male_i$ is a dummy that takes value one if child i is a boy. $Demo_{ct}$ refers to the level of democracy in each country-year. As described in section (3), we measure democracy using Polity IV index. The next regressor $Male_i \times Demo_{ct}$ is an interaction term between the sex of the child dummy and the level of democracy. α_m and δ_t refer to mother fixed effects and time fixed effects, respectively. Finally, X'_{icmt} is a vector of exogenous covariates including an indicator for multiple birth, a set of birth order dummies and a set of a year of survey fixed effects. While these variables are less likely to affect the propensity to democratize or the quality of democratic institutions, they have been shown to have significant impacts on the survival chances of babies. Thus, by controlling for these covariates, we expect to increase the precision of our estimates.

The identification assumption underlying this empirical specification requires that the sex of the child dummy and its interaction with the quality of democratic institutions are as good as randomly assigned conditional on the controls. Globally, infant mortality rates are decreasing on a yearly basis but the pace of reduction varies across countries [7]. Controlling for year fixed effects is thus helpful since they will capture any yearly global trends in infant mortality. Furthermore, we exploit within-mother variations in the quality of democratic institutions by comparing the survival chances across siblings. Using mother fixed effects is particularly helpful since it rules out time-invariant unobserved characteristics of mothers as potential confounders. By adding mother fixed effects, we are also able to indirectly control for time-invariant potential confounders at the country level.

The specification in equation (1) is therefore equivalent to a differences-in-differences strategy where we first compare the probability of death within the first year of life between opposite-sex children born to the same mother. Then, we examine the extent to which this male-female difference in the likelihood of death within the first year of life is reduced following an improvement in the quality of democratic institutions.

In equation (1), λ_1 describes the sex-specific likelihood of death within the first year of life while the parameter of interest λ_3 describes how this sex-based disparity in the likelihood of death changes with the level of democracy. We expect to obtain estimates such that $\lambda 1 > 0$ and $\lambda 3 < 0$ so that $\lambda 1$ will be interpreted as the average male disadvantage in infant mortality and $\lambda 3$, will reflect the extent to which boys born in countries with a high level of democracy should experience a lower survival disadvantage within the first year of life.

Despite the use of individual panel data regression with mother fixed effects, there are many threats to our identification assumption. As pointed by Lipset (1959), democracy is hardly exogenous. Many correlates of democracy such as country-level income or education have been shown to have also an impact on child survival. By not taking into account these endogeneity issues, any finding that improvement in the quality of democratic institutions reduces the male disadvantage in infant mortality by changing health policies might be confounded by the presence of omitted time-varying country-specific factors that correlate with the quality of democratic institutions and affect the survival chances of children. To address this issue, we follow the recommendations from the literature (see for example Kudamatsu (2012)) by adding in our specification controls for a set of correlates of democracy. We also allow each country to have its own trend in

[7] See for example figure A.5 in Kudamatsu (2012) showing heterogeneity in the decreasing trends in infant mortality rates between democratic and non-democratic countries in sub-Saharan Africa.

mortality in order to make sure that our results do not capture more subtle trends in the probability of death in early ages.

5 Empirical Findings

The theoretical prediction is that improvements in the quality of democratic institutions mitigate the survival disadvantage of boys in the early ages. A quick analysis of the means in table 2 reveals a negative correlation between the level of democracy in the country and the size of the male-female difference in infant mortality, providing a suggestive evidence supporting our theoretical prediction. We now turn to a more systematic test of this prediction by using a regression framework (equation (1)) to estimate the causal effect of level of democracy on the relationship between the male gender and the propensity to die within the first year of life.

5.1 Effect of Democracy on the Male Disadvantage in Infant Mortality

Table 3 reports estimated coefficients of the effect of the child's sex on the probability of infant death and how this effect changes with the quality of democracy. To assess the importance of controlling for mother fixed effects, column (2) controls for country fixed effects instead of mother fixed effects in addition of year fixed effects and exogenous covariates [8] Consistent with past research, we find that being a boy significantly increases the probability of dying within the first year of life. The point estimate on the sex of the child dummy reveals that boys are about 13 per thousand points more likely to die within the first year of life than girls. Moreover, the coefficient on the interaction term between the sex of the child dummy and the level of democracy is negative and statistically significant. The point estimate shows that a one unit increase in the level of democracy decreases the excess male infant mortality by 0.24 per thousand points. Which is equivalent to approximately 2% of the average male-female differences in infant mortality. Column (3) controls for mother fixed effects instead of country fixed effects. The effect of democracy on the male disadvantage in infant mortality decreases slightly in absolute terms but remains negative and significant at the 1% level. The gap in the size of the point estimates between the specification in column (2) and (3) might indicate some differences in the composition of mothers after the improvement in the quality of democratic institutions.

Column (4) estimates equation (1) by controlling for an indicator the the number of children at the time of delivery as well as the age of mother at birth and its quadratic

[8] Exogenous covariates include an indicator for multiple birth, a set of birth order dummies and a set of year of survey fixed effects.

term. Results from this specification are roughly the same as in our benchmark specification (column 3). Column (5) additionally controls for country-specific linear trends. To account for more complex heterogeneity in infant mortality trends, we allow each country to have its own linear trend in infant mortality. The effect of the level of democracy on the male disadvantage in infant mortality remains almost the same.

5.2 Robustness Checks

In this section, we explore whether the results presented in Table 3 are robust to different sets of controls and alternatives measures of the quality of democratic institutions.

As briefly stated in the empirical strategy, controlling for mother fixed effects might not be sufficient to ensure that the results described above are totally unbiased. That is, our findings might spuriously attribute the decrease in the male disadvantage in infant mortality to the effect of democracy on the provision of public health inputs. Whereas mother fixed effects implicitly control for time-invariant unobserved mother and country-level characteristics, our empirical specification does not account for several time-varying correlates of democracy that are likely to affect the survival chances of babies in early ages.

One such potential confounder of the effect of democracy on sex differences in infant mortality is the level of income of the mother. As highlighted in the conceptual framework, in order to alleviate the male disadvantage in infant mortality, countries with a high level of democracy might foster the provision of gender-neutral public health goods associated with stronger health benefits for boys than girls. However, a fall in the male excess in infant mortality might still be observed even without true changes in public health policies triggered by better democracies. For instance, it is possible that improvement in the quality of democracy drives political stability in a given country and thus more investment. Consequently, the overall population in this country might become more affluent. As mothers are wealthier, they may become healthier and give birth to more healthy babies even in the absence of public health interventions. Alternatively, more income might increase access to private health care facilities during the prenatal and postnatal period, thus leading to improvement in the survival chances of all babies but especially vulnerable babies such as premature boys.

A related concern consists of the presence of foreign aid to development (ODA). It has been argued that donors generally favour democratized countries. Thus, in order to receive more foreign aid assistance, countries have the incentive to move toward a democratic regime. This implies that if more democratic countries are also countries receiving a larger share of foreign aid assistance, the level of this assistance might be a confounding factor.

We address these concerns in Table 4. For the sake of comparison, the first column replicates the results from our benchmark specification displayed in the fifth column of Table 3. Without a direct measure of the mother's level of income, we indirectly control for income by using information on the logarithm of the country's GDP per capita. We measure the total of Official Development Assistance as a percentage of GDP per capita [9]. In column (2), we estimate equation (1) by controlling for the log of GDP per capita and the level of ODA in addition to the set of controls in column (1). Results are highly robust and indicate that the negative effect of a positive change in the level of democracy on the male disadvantage in infant mortality does not pick up the impact of more income or more development aid.

In columns (3)-(6) we explore whether our results depend on how we define our measure of democracy. Following the literature, we define three democracy indicators based on three different cut-off points. We create two dummies for democracy equals to one if the polity score is strictly greater than -4 (the median value of polity) and 4 respectively. We also define a three-scale measure of democracy based on the three-part regime categories suggested by the authors of the Polity IV project. For each year and country, we define an indicator of democracy equals to 1, 2 or 3 (autocracies, anocracies and democracies respectively) if the polity score is between -10 to -6, -5 to 5, or 6 to 10 respectively. The results suggest that the effect of democracy on the male survival disadvantage becomes economically and statistically large as the cut-off point for the country to be democratic increases. For instance, column (6) shows that moving from autocracy to democracy define based on our trichotomous indicator of the level of democracy, reduces the male disadvantage in infant mortality by 0.31 percentage points. Which is about 20% of the average male-female difference in infant mortality.

Finally, in the appendix table A2 we define indicators of democracy using alternatives measures of democracy that have been widely employed in the literature. Even though some of the point estimates on the interaction term are not significant at the conventional level, the results are almost the same as in our main estimation. Overall, the results suggest that better quality of democratic institutions reduces the male survival disadvantage in infant mortality.

5.3 Which Features of Democracy Matters?

As highlighted in section 3, polity score is an aggregated indicator which captures different institutional features. In this section, we decompose the Polity IV measure into its underlying components to identify the political change likely to contribute the most to the results discussed above. We treat each polity component as a distinct measure for the variable Demo_{ct} in equation (1). Table 5 shows that constraints on chief executive (XCONST), power turn-over through competitive elections (XCONST), and the extent

[9]Our data on GDP and ODA are drawn from the World Bank database (2015)

to which alternative preferences for policy and leadership can be pursued in the political arena (PARCOMP) have negative effects on the male disadvantage in infant mortality.

6 Mechanism

So far, we have shown that improvement in the quality of democratic institutions reduces significantly and economically the male disadvantage in infant mortality. The next question that is worth answering is what could be the pathways through which better democratic institutions mitigate the male disadvantage in infant mortality. In this section, we provide empirical evidence to answer this question. Following our conceptual framework (see figure 1) we will first, examine whether health inputs known to be effective at reducing infant mortality become more accessible in better democracies. Then, we will investigate whether the effectiveness of these health inputs depends on the sex of the child. Specifically, we ask whether the effectiveness of these health inputs is stronger for boys than for girls. Finally, we will investigate whether better democratic institutions mitigate biological and preconception influences on the male disadvantage in infant mortality.

6.1 Democratic Institutions, Health Inputs and the Male Survival Disadvantage

There are many public health interventions that have been shown to be effective in reducing infant mortality. [10] In the analysis below we will focus on 4 health inputs including tetanus toxoid immunization (prevent death from neonatal tetanus); Breastfeeding practices (prevent deaths from diarrhea pneumonia and neonatal sepsis); Prenatal care (prevent death from conditions related to pre-term delivery) and normal birth weight (birth weight >= 2.5kg)[11].

6.1.1 Democracy and Health Inputs

The first step is to analyze how the level of democracy affects the provision of health inputs known to prevent infant death. While information on health inputs cited above is available from the DHS surveys, this information is, however, collected for children born within the last five years before the survey only. This data restriction prevents us from analyzing the impact of the level of democracy on access to health input using individual-level data. Fortunately, country-level data drawn from the World Bank database allow us to examine the association between the quality of democracy and the access to health inputs effective at reducing infant mortality. Figure 3 displays a scatter plot and a regression line showing

[10] see figure 1 in Jones et al. (2003).

[11] Low birth weight is known to increase the likelihood of infant death

the association between the level of democracy measured by Polity IV and the average level of coverage of each health input within each country and Polity score. Graph (a) and (c) reveal an increase in the percentage of children who received a tetanus injection before one year of age and who was exclusively breastfed within the first six months of life respectively following an increase in the level of democracy. Similarly, graph (b) shows that the percentage of pregnant woman who did at least one prenatal visit increases with the level of democracy. Concerning low birth weight, graph (d) shows a lower percentage of low birth weight as Polity IV increases even though in this case, the association is less clear-cut. Overall, figure 3 provides an evidence of a positive association between the level of democracy and the coverage of each of these health inputs.

6.1.2 Health inputs and infant mortality by sex

The second step to understand whether public health inputs with stronger health benefits for boys mediate the effect of better democratic institutions on the male disadvantage in infant mortality is to identify among the four health inputs listed above, which one is associated with stronger health benefits for boys than girls. To do so we, estimate the following linear probability model:

$$M_{icmt} = \lambda_0 + \lambda_1 Male_i + \lambda_2 H_{icmt} + \lambda_3 Male_i \times H_{icmt} + X'_{imt}\pi + \alpha_c + \theta_t + \varepsilon_{icmt} \quad (2)$$

where M_{icmt}, is a dummy equals to one if the child i born to mother m in country c at time t dies within the first year of life. $Male_i$ is a dummy for the sex of the child. H_{icmt}, is a dummy equals to one if the child i born to mother m in country c at time t receives the health input. X'_{imt} is a vector that control for multiple birth, a set of birth order dummies, a set of year of survey fixed effects, the mothers's number of children at the time of delivery, the age of mother at delivery, the square of the age of mother at delivery, the level of education of the mother, the mother's marital status, and an indicator for urban residence. Finally α_c and θ_t stand for country and year fixed effects.

Table 7 reports results from estimating equation (2) separately for each health input. Two main results emerge. First, each of these health inputs reduces significantly the risk of infant death. Second, the negative effect of these health inputs on the likelihood of death is significantly[12] larger for boys than girls. These results indicate that tetanus immunization, prenatal care services, breastfeeding practices, and normal birth weight are likely to produce more benefits for the survival of boys in the early ages. Combined with figure 3 results from table 7 suggest that the negative relationship between the level of democracy and the size of the excess male infant mortality is driven by the provision of health inputs associated with stronger benefits for the survival of boys.

[12] The coefficient on the interaction term is however not significant at the conventional level when we consider Prenatal care.

A major threat to this path is the extent to which sex discrimination in the allocation of health resources prevails across sub-Saharan African countries. Indeed, an allocation of health goods biased towards male [13] is likely to be an alternative pathway if the bias increases with the level of democracy. We empirically test for this alternative explanation and we find no evidence for a sex bias in the provision of tetanus immunization and prenatal care services (table 6). We also find a positive and significant estimate for the regression on birth weight (table 6), which is consistent with the fact that boys weight significantly more at birth than girls. However, the size of this male-female difference in the likelihood that the child weight at birth more than 2.5kg is very small and highly stable across institutional settings. We, therefore, reject the existence of some sex discrimination that would have started in-utero.

Jointly, results from this section suggest that improvement in the quality of democratic institutions reduces the male disadvantage in infant mortality by fostering the provision of ex-ante gender-neutral health inputs including tetanus immunization, prenatal care services, breastfeeding practices, and normal birth weight, all of which are associated with stronger benefits for the survival of boys.

6.2 Democracy, Biology and Preconception factors

The existing literature on the male disadvantage in infant mortality shows that child biology and preconception environmental factors are the key proximate determinants of the male survival disadvantage. Hence, to understand the mechanism underlying the relationship between the quality democratic institutions and the male survival disadvantage, it is crucial to also assess how the level of democracy affects the contribution of biological and preconception environmental factors to the male disadvantage in infant mortality. To do so, we follow the twin-based decomposition methodology developed by Pongou (2013) to separate the contribution of biological and preconception factors to the male survival disadvantage and we assess whether improvement in the quality of democratic institutions affects these contributions.

The twin decomposition methodology takes advantage of the natural experiment occurring within a pair of twins to isolate the effect of biological factors on the male disadvantage in infant mortality from that of preconception environmental factors. The basic assumption in this approach is that co-twins share almost the same preconception and prenatal environment. Thus, conditional on no gender preferences in the allocation of resources related to child survival, any observed male-female difference in the likelihood of death within the first year of life within an opposite-sex twins pair can solely be attributed to biological differences between the sexes.

Specifically, we estimate the separate contribution of each of these factors to the male

[13] Parents who prefer male to female children would like to devote more health care resources to boys.

survival disadvantage by using the following equations:

$$M_{icmt} = \lambda_0 + \lambda_1 Male_i + X'_{imt}\pi + \sigma_c + \theta_t + \varepsilon_{icmt} \quad (3.1)$$

$$M_{icmt} = \lambda_0 + \lambda_1 Male_i + X'_{it}\pi + \alpha_{twin} + \theta_t + \varepsilon_{icmt} \quad (3.2)$$

In equation (3.1) we estimate the effect of the sex of the child by controlling for country fixed effects in addition to exogenous covariates. As a result, the sex gap in infant mortality given by λ_1 is due to the additive effect of biological and preconception environmental factors. In contrast, by controlling for twin fixed effects (equation (3.2)) instead of country fixed effects, we exploit variation within a pair of opposite-sex twin to estimate the effect of the sex of the child on the risk of infant death. In this latter case, our coefficient of interest λ_1 reflects the unique contribution of biological differences between boys and girls. Finally, by taking the difference between the point estimates from each of these regressions, we uncover an estimation for the unique contribution of preconception factors.

We restrict our sample to twin live births [14] and using the three regime categories suggested by Polity IV, we divided our sample of twin births in three groups: children born in autocratic, anocratic or democratic years. Estimating equations (3.1) and (3.2) in each institutional settings allow us to observe how the contribution of biological and preconception environmental factors changes with the level of democracy. Results are summarized in figure 4 [15] where the solid line represents the estimated contributions of biology or preconception factors by regime category. And the dotted line gives the 95% confidence interval. Figure 4 shows that moving from autocracy to democracy reduces substantially the contribution of biology to the male survival disadvantage. The contribution of preconception environmental factors seems to react positively to a small jump in the quality of democracy while it returns to its initial level when we move to the highest level of democracy.

6.3 Hormonal Transfer

Whether the reduction in the survival disadvantage of boys at early ages is a consequence of a rapid decrease in the probability of death of boys or an increase in the probability of death of girls remains unclear. In the analysis above we provide support to the hypothesis that the fall in the male survival disadvantage happens through a rapid decrease in the probability of death of boys. It is, however, possible that our results capture instead the effect of an increase in the probability of death of girls. For instance, if differential

[14] Summary statistics of this subsample can be found in the appendix table A1

[15] Estimated coefficients presented in this figure are available in the appendix table A3

prenatal exposure to the testosterone hormone could affect the survival chances of babies with a stronger effect on the likelihood of death of girls. According to the hormonal transfer theory, the testosterone hormone synthesized by a male fetus is likely to be transferred to its cotwin within the womb and influence development (Cronqvist et al. (2016)). Therefore, within an opposite-sex twin pair, the increased testosterone exposure of female is hypothesized to induce a partial masculinization of several aspects of the female co-twin, including the likelihood of death [16].

Based on this theory, it might be the case that our results derived from the twin-based decomposition analysis capture the effect of the testosterone transfer. Put in other ways it is likely that the reduction in the male survival disadvantage that we found previously are at least partially driven by an increased risk of death among female with a male co-twin following a higher exposure to testosterone in the womb. To show that our results are not driven by the hormonal transfer theory, we estimate the effect of having a male co-twin by comparing the probability of death between a female who shares the womb with a female co-twin, i.e. the control group, and a female who shares the womb with a male co-twin, i.e. the treated group. Regression results are reported in Table 8. Overall, the estimated coefficients show that having a male co-twin does not significantly increase the probability of death of the female suggesting that differential exposure to the testosterone hormone is less likely to explain sex differences in infant mortality.

7 Conclusion

In this paper, we studied the effect of democratic institutions on male-female differences in infant mortality, using individual-level data from sub-Saharan African countries. Our main result demonstrates that improvement in the quality of democratic institutions reduces the male survival disadvantage in the first year of life by about 20% of the average male-female difference in infant mortality.

Analyzing the mechanism, we found that better democratic institutions constrain biological and genetic influences on the male survival disadvantage. Interestingly, we found that improvement in the quality of democratic institutions increases the provision of ex-ante gender-neutral public health goods such as tetanus immunization, access to prenatal care services, breastfeeding practices, and normal birth weight, all of which are effective in reducing infant mortality but with stronger benefits to the survival of boys. The supply of these public health goods is likely to constrain the negative effect of male biology on survival. Furthermore, using twins, we ruled out the hormonal (testosterone) transfer theory as a possible mechanism through which better democratic institutions

[16] Cronqvist et al. (2016) show that females with a male co-twin take more risk in their financial investment than females with a female co-twin and they conclude that an exogenous increase in exposure to prenatal testosterone is associated with the masculinization of financial behavior

reduce the survival disadvantage of boys.

References

Acemoglu, D., Johnson, S., and Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *The American Economic Review*, 91(5):1369–1401.

Acemoglu, D., Naidu, S., Restrepo, P., and Robinson, J. (2013). Democracy, redistribution and inequality. NBER Working Papers 19746, National Bureau of Economic Research, Inc.

Acemoglu, D., Naidu, S., Restrepo, P., and Robinson, J. A. (2017). Democracy does cause growth. *Journal of Political Economy*.

Acemoglu, D. and Robinson, J. (2005). Economic origins of dictatorship and democracy. *New York: Cambridge University Press*.

Alexander, D. and Currie, J. (2017). Is it who you are or where you live? residential segregation and racial gaps in childhood asthma.

Almond, D. and Currie, J. (2011). Killing me softly: The fetal origins hypothesis. *Journal of Economic Perspectives*, 25(3):153–72.

Bank, W. (2019). World bank group indicators.

Besley, T. and Kudamatsu, M. (2006). Health and democracy. *American Economic Review*, 96(2):313–318.

Black, R., Cousens, S., H, J., and et al. (2010). Global, regional, and national causes of child mortality in 2008: a systematic analysis. *The Lancet*, 375:1969–87.

Boardman, J. D. (2009). State-level moderation of genetic tendencies to smoke. *American Journal of Public Health*, 99(3):480–486.

Boardman, J. D. and Fletcher, J. (2015). The promise of integrating genetics into policy analysis. *Journal of Policy Analysis and Management*, 34(3):493–496.

Boardman, J. D., Roettger, M. E., Domingue, B. W., McQueen, M. B., Haberstick, B. C., and Harris, K. M. (2012). Gene-environment interactions related to body mass: School policies and social context as environmental moderators. *Journal of Theoretical Politics*, 24(3):370–388.

Boco, A. G. (2014). Assessing sex differentials in under-five mortality in sub-saharan africa: A cross-national comparative analysis. *Canadian Studies in Population*, 41(34):4987.

Boix, C., Miller, M. K., and Rosato, S. (2014). Boix-miller-rosato dichotomous coding of democracy, 1800-2010.

Boix, C. and Posner, D. N. (1998). Social capital: Explaining its origins and effects on government performance. *British Journal of Political Science*, 28(04):686–693.

Bueno, d. M. B., Smith, A., Siverson, R., and Morrow, J. (2003a). The logic of political survival. *MA: MIT University Press.*

Bueno, D. M. B., Smith, A., Siverson, R. M., and Morrow, J. D. (2003b). The logic of political survival. *Cambridge, MA: MIT University Press.*

Case, A. and Paxson, C. (2005). Sex differences in morbidity and mortality. *Demography*, 42(2):189–214.

Cronqvist, H., Previtero, A., Siegel, S., and White, R. E. (2016). The fetal origins hypothesis in finance: Prenatal environment, the gender gap, and investor behavior. *Review of Financial Studies*, 29(3):739–786.

Davis, D. L., Gottlieb, M. B., and Stampnitzky, J. R. (1998). Reduced ratio of male to female births in several industrial countries: a sentinel health indicators? *Journal of the American Medical Association*, 279(13):10181023.

Deacon, R. T. (2009). Public good provision under dictatorship and democracy. *Public Choice*, 139(1):241–262.

Dinkelman, T. (2015). Long run health repercussions of drought shocks: Evidence from south african homelands. Working Paper 21440, National Bureau of Economic Research.

Drevenstedt, G. L., Crimmins, E. M., Vasunilashorn, S., and Finch, C. E. (2008). The rise and fall of excess male infant mortality. *Proceedings of the National Academy of Sciences of the United States of America*, 105(13):5016–5021.

for Child Mortality Estimation (UN IGME), U. N.-A. G. (2018). Level and trends in child mortality - report 2018.

Garenne, M. and Lafon, M. (1998). Sexist diseases. *Perspectives in Biology and Medicine*, 41(2):176–190.

Gil, R., Mulligan, C., and X. Sala-i Martin, X. (2004). Do democracies have different public policies? *Journal of Economic Perspectives*, 18:51–74.

Goldin, C. and Lleras-Muney, A. (2018). Xx>xy?: The changing female advantage in life expectancy. Working Paper 24716, National Bureau of Economic Research.

Gurr, T. R., Marshall, M., and Jaggers, K. (2010). Polity iv project: Political regime characteristics and transitions, 1800-2009.

Hill, K. and Upchurch, D. M. (1995). Gender differences in child health: Evidence from the demographic and health surveys. *Population and Development Review*, 21(1):127–151.

Jones, G., Richard, W. S., Black, R. E., Zulfiqar, A. B., Saul, S. M., and the Bellagio Child Survival Study Group (2003). How many child deaths can we prevent this year? *The Lancet*, 362:6571.

Kudamatsu, M. (2012). Has democratization reduced infant mortality in sub-saharan africa? evidence from micro data. *Journal of the European Economic Association*, 10(6):1294–1317.

Lake and Baum (2001). The invisible hand of democracy: Political control and the provision of public services. *Comparative Political Studies*, 34:587–621.

Lipset, S. M. (1959). Some social requisites of democracy: Economic development and political legitimacy. *The American Political Science Review*, 53(1):69–105.

Meltzer, A. H. and Richard, S. F. (1981). A Rational Theory of the Size of Government. *Journal of Political Economy*, 89(5):914–927.

Mocarelli, P., Gerthoux, P., Ferrari, E., Patterson, DG, J., Kieszak, S., and Brambilla, P. (2000). Paternal concentrations of dioxin and sex ratio of offspring. *Lancet*, 355:18581863.

Naeye, R. L., Burt, L. S., Wright, D. L., Blanc, W. A., and Tatter, D. (1971). Neonatal mortality, the male disadvantage. *Pediatrics*, 48:902–906.

Nations, U. (2011). Sex differentials in childhood mortality. *Department of Economic and Social Affairs, Population Division*, ST/ESA/SER.A/314.

Papaioannou, E. and Siourounis, G. (2004). Democratisation and growth. *The Economic Journal*, 118(532):1520–1551.

Papaioannou, E. and Siourounis, G. (2008). Economic and social factors driving the third wave of democratization. *Journal of Comparative Economics*, 36(3):365–387.

Pongou, R. (2013). Why is infant mortality higher in boys than in girls? a new hypothesis based on preconception environment and evidence from a large sample of twins. *Demography*, 50(2):421–444.

Pongou, R. (2015). Sex differences in early-age mortality: The preconception origins hypothesis. Working Papers 1512E, University of Ottawa, Department of Economics.

Pongou, R., Kuate Defo, B., and Tsala Dimbuene, Z. (2017). Excess male infant mortality: The gene-institution interactions. *American Economic Review*, 107(5):541–45.

Pozuelo, J. R., Slipowitz, A., and Vuletin, G. (2016). Democracy Does Not Cause Growth: The Importance of Endogeneity Arguments. IDB Publications (Working Papers) 95018, Inter-American Development Bank.

PRSGroup, T. International country risk guide methodology. *https://www.prsgroup.com/about-us/our-two-methodologies/icrg*.

Przeworski, A., Alvarez, M. E., Cheibub, J. A., and Limongi, F. (1996). Classifying political regimes. *Studies in Comparative International Development*, 31((2)):137.

Przeworski, A., Alvarez, M. E., Cheibub, J. A., and Limongi, F. (2000). *Democracy and Development: Political Institutions and Well-Being in the World, 19501990*. Cambridge Studies in the Theory of Democracy. Cambridge University Press.

Ross, M. (2006). Is democracy good for the poor? *American Journal of Political Science*, 50(4):860–874.

Sawyer, C. (2012). Child mortality estimation: Estimating sex differences in childhood mortality since the 1970s. *PLoS Medicine*, 9(8):e1001287.

Sen, A. (1981). *Poverty and Famines: An Essay on Entitlement and Deprivation*. New YoNew Oxford University Press.

UNIGME (2015). Levels trends in child mortality: Report 2015. Technical report, UN Inter-agency Group for Child Mortality Estimation, United Nations Childrens Fund, UNICEF.

Waldron, I. (1983). Sex differences in human mortality: The role of genetic factors. *Social Science & Medicine*, 17(6):321–333.

Waldron, I. (1985). What do we know about causes of sex differences in mortality? a review of the literature. *Population Bulletin of the United Nations*, 18:59–76.

Waldron, I. (1998). Sex differences in infant and early childhood mortality: Major causes of death and possible biological causes. *in Too young to die: Genes or gender?, New York: United Nations*, pages 64–83.

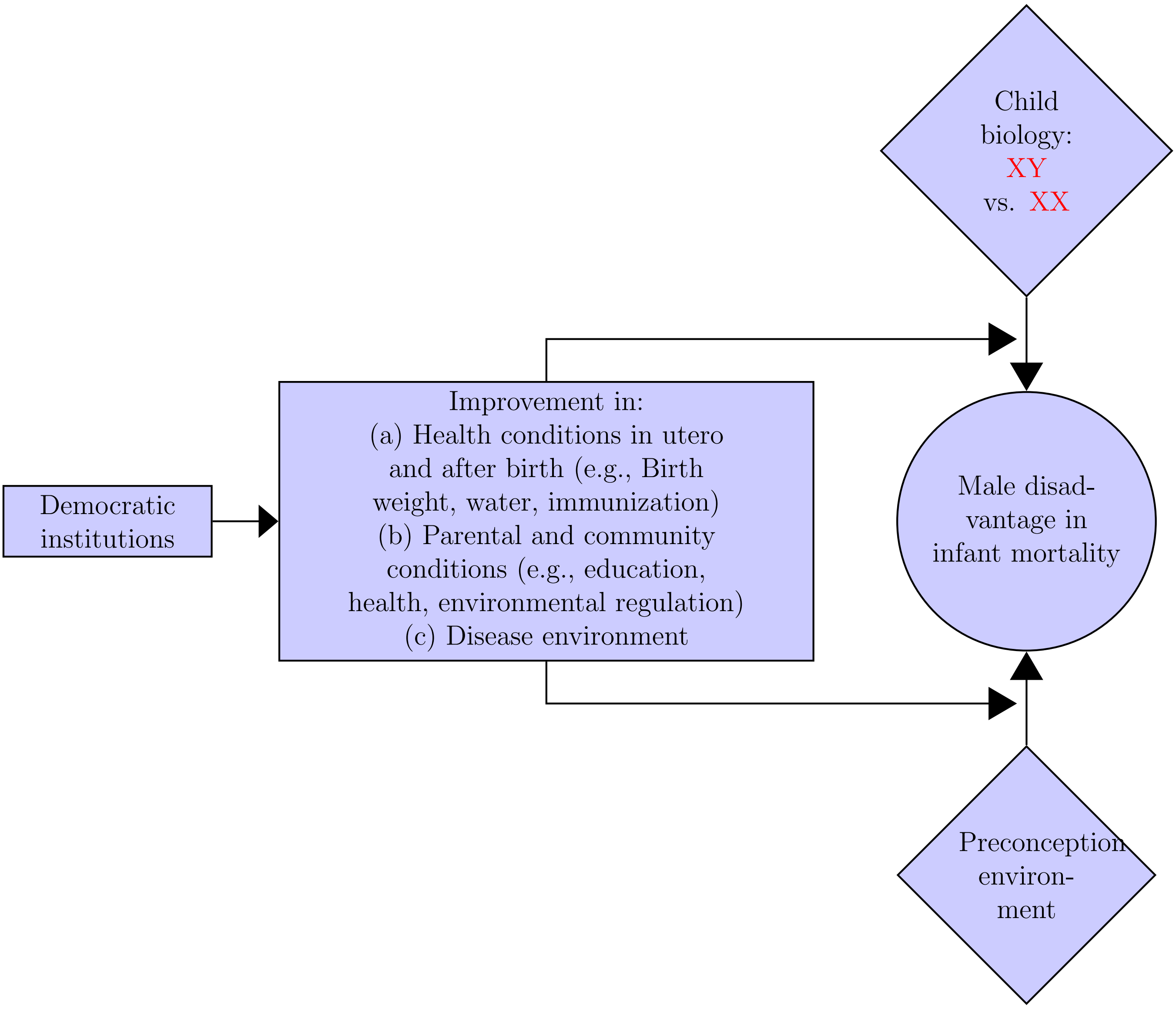

Figure 1: Conceptual Framework

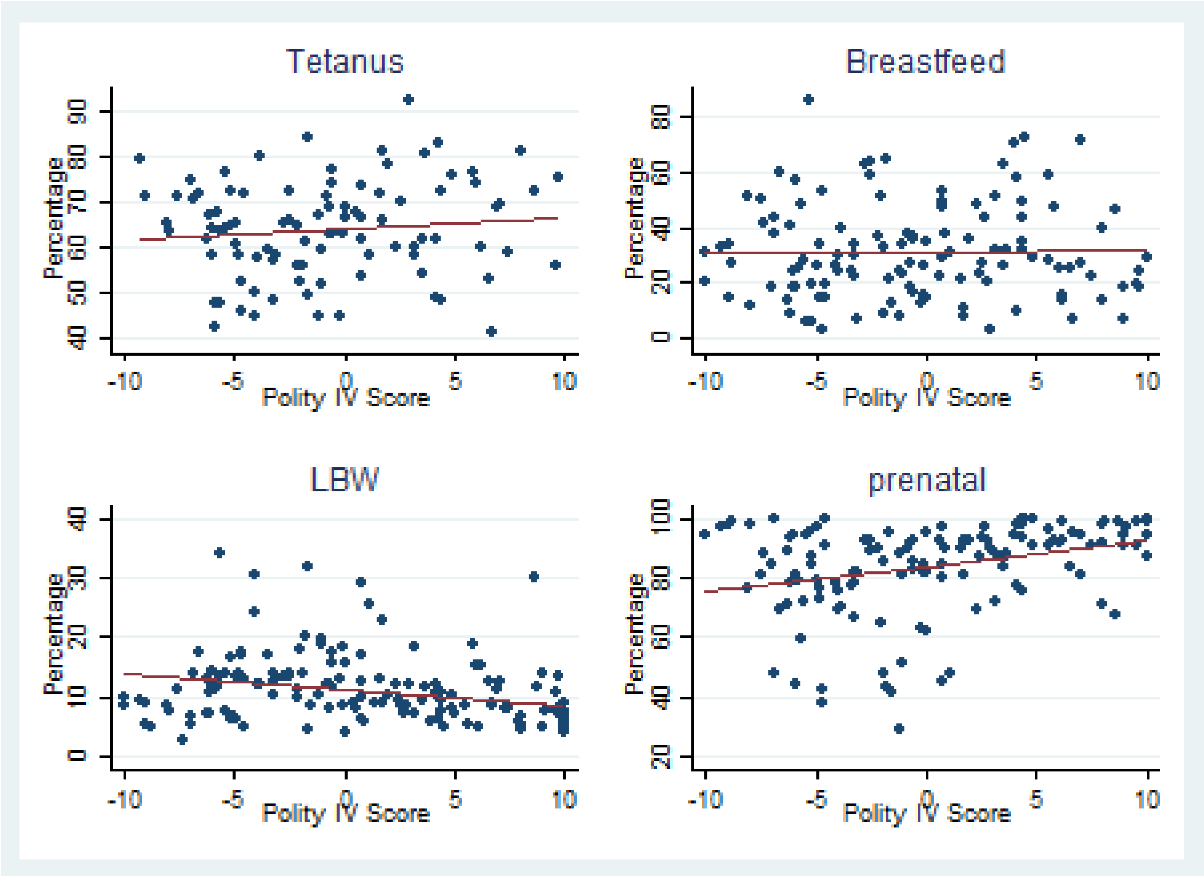

Figure 2: Level of democracy and health inputs access (World)

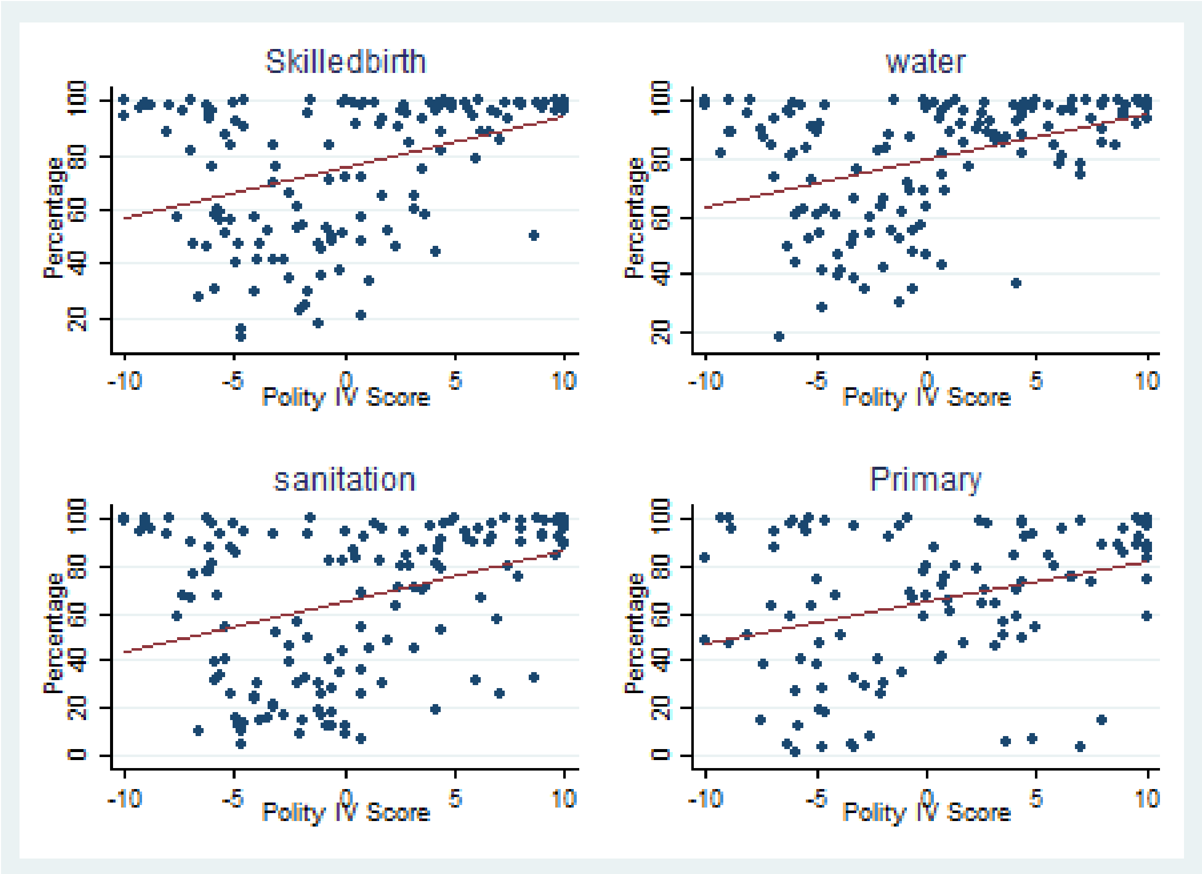

Figure 3: Level of democracy and health inputs access (World)

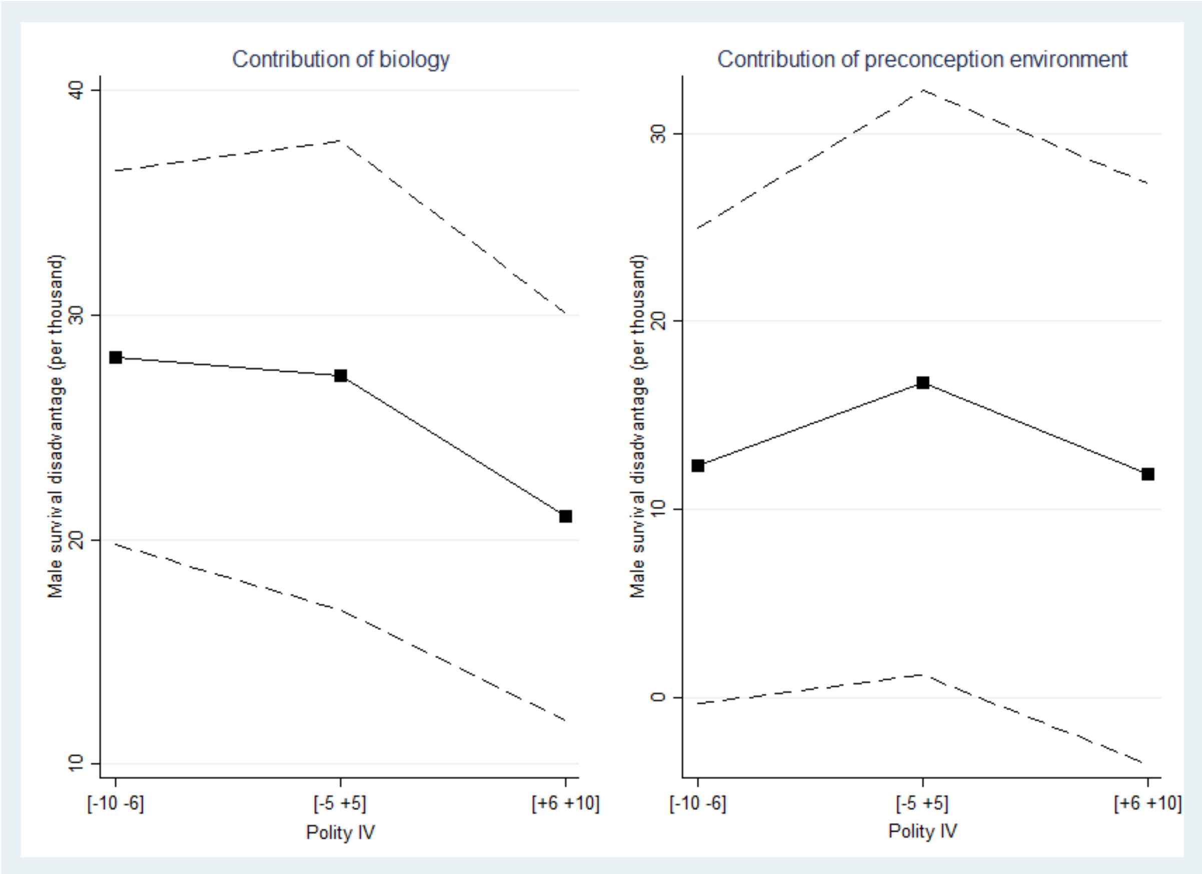

Figure 4: Level of democracy and the contribution of biology and preconception environment.

Note: Plotted are estimated coefficients reported in appendix table A3. Dotted lines represent 95 percent level confidence intervals of the estimated coefficients

Table 1: Descriptive Statistics

	N	Mean	Std. de.	Min.	Max.
Child-level characteristics					
Infant Mortality (IM per thousand)					
IM Male	1,927,074	90.17	286.43	0	1000
IM Female	1,865,576	76.67	266.07	0	1000
IM All children	3,792,650	83.53	276.68	0	1000
Child is a boy	3,792,650	0.51	0.50	0	1
Child is a twin	3,792,650	0.03	0.17	0	1
Birth order number	3,792,650	3.38	2.28	1	21
Year of birth of child	3,792,650	1995	10.63	1960	2015
Age mother at delivery	3,792,650	25	6.25	15	49
Mother-level characteristics					
Year of birth of the mother	978,223	1973	11.33	1936	2000
Number of children	978,223	4.15	2.60	1	20
Mother is married	948,855	0.72	0.45	0	1
Mother has no education	978,159	0.55	0.50	0	1
Household wealth index					
Poor	703,667	0.42	0.49	0	1
Rich	703,667	0.38	0.49	0	1
Urban residence	978,223	0.32	0.47	0	1
Country-level characteristics					
Number of children per country	39	97,247	74,165	9,407	327,261
Polity IV	1,768	-2.68	5.60	-10	9
GDP per capita (2010 US)	1,657	1,280	1,927	116	19,493
ODA† as a percentage of GDP	1,646	0.10	0.11	-0	1.47

Note: †*Official Development Assistance*

Table 2: Democracy and sex differences in infant mortality

	Autocracy (1)	Anocracy (2)	Democracy (3)
Infant Mortality (per thousand)			
Male	109.50	84.29	72.27
Female	93.98	71.54	60.65
Male-Female difference	15.53***	12.75***	11.62***

*Note: A country's regime type is Autocracy, Anocracy or Democracy when its Polity index is strictly less than -5, between -5 and 5 or strictly greater than 5, respectively. ***p<0.01, **p<0.05, *p<0.1*

Table 3: Democracy and the male disadvantage in indant mortality

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Risk of infant death (per thousand)						
Male	13.13***	13.05***	13.48***	13.44***	13.44***	13.46***
	(0.643)	(0.635)	(0.633)	(0.633)	(0.636)	(0.608)
Democracy	-0.57*	-0.53**	-0.39**	-0.37**	-0.13	-0.17
	(0.304)	(0.222)	(0.181)	(0.157)	(0.132)	(0.109)
Male × Democracy	-0.26***	-0.24***	-0.19***	-0.19***	-0.19***	-0.19***
	(0.059)	(0.060)	(0.064)	(0.064)	(0.064)	(0.060)
Year of birth FE	✓	✓	✓	✓	✓	✓
Country FE		✓				
Mother FE			✓	✓	✓	✓
Child Characteristics	✓	✓	✓	✓	✓	✓
Mother Characteristics				✓	✓	✓
Country Characteristics					✓	✓
Country-specific trend						✓
N	3,792,650	3,792,650	3,792,650	3,792,650	3,792,650	3,652,710

*Note: Each entry is from a separate regression. We measure the level of democracy by using Polity IV score. Robust standard errors are in parenthesis, adjusted for clustering by country. Each specification controls for a set of year of survey fixed effects. Child characteristics include an indicator for multiple birth, and a set of birth order dummies. Mother characteristics include the number of children at the time of delivery, the age of mother at delivery, and the square of the age of mother at delivery. Country characteristics include the log of GDP per capita in 2010 US and the level of Official Development Assistance as a percentage of GDP. ***p<0.01, **p<0.05, *p<0.1 .*

Table 4: Robustness checks

	(1)	(2)	(3)	(4)
Dependent variable: Risk of infant death (per thousand)				
Male	13.44***	14.61***	14.38***	15.11***
	(0.636)	(0.896)	(0.778)	(1.057)
Democracy	-0.13			
	(0.132)			
Male × Democracy	-0.19***			
	(0.064)			
Polity>median		-1.33		
		(1.954)		
Male × Polity>median		-1.67**		
		(0.676)		
Polity>4			-3.83**	
			(1.424)	
Male × Polity>4			-2.74***	
			(0.893)	
-5<=Polity<=5				-0.16
				(2.738)
Polity>=6				-3.06
				(2.502)
Male × -5<=Polity<=5				-1.78*
				(0.985)
Male × Polity>=6				-3.09***
				(1.086)
Year of birth FE	✓	✓	✓	✓
Country FE				
Mother FE	✓	✓	✓	✓
Child Characteristics	✓	✓	✓	✓
Mother Characteristics	✓	✓	✓	✓
Country Characteristics	✓	✓	✓	✓
Country-specific trend	✓	✓	✓	✓
N	3,792,650	3,792,650	3,792,650	3,792,650

Note: Robust standard errors are in parenthesis, adjusted for clustering by country. In column (1) we define democracy using the continuous value of Polity IV. In column (2) we use an indicator of democracy equals to 1 if Polity IV is strictly greater than -4 (the median value of Polity IV). In column (3) we use an indicator of democracy equals to 1 if Polity IV is strictly greater than 4. In column (4) displays estimates from a regression where we define a country as "autocratic", "anocratic" or democratic if Polity IV is strictly less than -5, between -5 and 5 or strictly greater than 5, respectively. Child characteristics include an indicator for multiple birth, and a set of birth order dummies. Mother characteristics include the number of children

Table 5: What type of political change matters

	Executive Recruitment			Executive authority	Political Participation	
	Regulation (1)	Competitiveness (2)	Openness (3)	Constraints (4)	Regulation (5)	Competitiveness (6)
Dependent variable: Probability of infant death (per thousand)						
Male	15.33***	14.43***	14.37***	15.74***	9.89***	16.33***
	(1.421)	(0.732)	(0.956)	(1.030)	(1.513)	(1.188)
Components of Polity IV	-0.05	-0.02	0.46	0.09	0.61	-0.81
	(1.290)	(0.675)	(0.474)	(0.377)	(1.188)	(1.022)
Male × Components of Polity IV	-0.91	-0.77***	-0.32	-0.70***	1.15**	-1.21***
	(0.615)	(0.257)	(0.262)	(0.190)	(0.487)	(0.324)
Year FE	✓	✓	✓	✓	✓	✓
Country FE						
Mother FE	✓	✓	✓	✓	✓	✓
Exogenous Covariates	✓	✓	✓	✓	✓	✓
Country-specific trend	✓	✓	✓	✓	✓	✓
N	3,571,491	3,571,491	3,571,491	3,571,491	3,571,491	3,571,491

*Note: Each entry is from a separate OLS regression. Robust standard errors are in parenthesis, adjusted for clustering by country. Each specification controls for an indicator for multiple birth, a set of birth order dummies, a set of year of survey fixed effects, the mothers's number of children at the time of delivery, the age of mother at delivery and the square of the age of mother at delivery. ***p<0.01, **p<0.05, *p<0.1 .*

Table 6: Gender-neutral health inputs

Dependent Variable:	Tetanus		Prenatal Care		Normal Birth Weight		Excl. Breastfeeding	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Male	0.00	-0.00	0.00	0.00	0.02***	0.03***	-0.01***	-
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	-
Democracy by Polity IV	-0.00	-0.00	-0.00***	-0.00	-0.00	0.00*	0.01	-
	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.005)	-
Male × Democracy by Polity IV	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	-
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	-
Year FE	✓	✓	✓	✓	✓	✓	-	
Country FE	✓		✓		✓		✓	-
Mother FE		✓		✓		✓		-
Exogenous Covariates	✓	✓	✓	✓	✓	✓	✓	-
N	754,260	754,338	711,954	712,023	441,246	441,294	107,578	-
Sample mean	0.722	0.722	0.840	0.840	0.891	0.891	0.704	-
Sd	0.45	0.45	0.37	0.37	0.31	0.31	0.46	-

*Note: Each entry is from a separate OLS regression. Robust standard errors are in parenthesis, adjusted for clustering by country. In panel B, each regression controls for an indicator for multiple birth, a set of birth order dummies, a set of year of survey fixed effects, the mothers's number of children at the time of delivery, the age of mother at delivery and the square of the age of mother at delivery. Panel A adds to the set of controls the mother's marital status, mother's level of education and an indicator for urban residence. ***p<0.01, **p<0.05, *p<0.1 .*

Table 7: Effectiveness of health inputs by sex

	Type of health input			
	Tetanus (1)	Prenatal Care (2)	Birth Weight >= 2.5kg (3)	Exclusive Breastfeeding (4)
Dependent variable: Probability of infant death (per thousand)				
Male	11.02***	9.48***	25.39***	28.37***
	(1.038)	(1.798)	(2.575)	(3.474)
health input	-13.77***	-19.80***	-30.74***	-233.65***
	(1.479)	(3.054)	(2.970)	(21.862)
Male × health input	-3.72***	-1.65	-19.17***	-28.15***
	(1.088)	(1.783)	(2.346)	(3.494)
Year FE	✓	✓	✓	✓
Country FE	✓	✓	✓	✓
Exogenous Covariates	✓	✓	✓	✓
N	755,629	713,309	442,798	107,776
Sample mean	0.722	0.840	0.891	0.704
Sd	0.45	0.37	0.31	0.46

Note: *Each entry is from a separate OLS regression. Robust standard errors are in parenthesis, adjusted for clustering by country. Each regression controls for an indicator for multiple birth, a set of birth order dummies, a set of year of survey fixed effects, the mothers's number of children at the time of delivery, the age of mother at delivery, the square of the age of mother at delivery, the level of education of the mother and the mother's marital status. ***p<0.01, **p<0.05, *p<0.1 .*

Table 8: Hormonal Transfer

Dependent Variable:	Infant Mortality	
	(1)	(2)
Panel A: All children		
Male co-twin	4.65	10.64
	(3.459)	(10.489)
N	57,813	57,813
Panel B: Autocracy		
Male co-twin	3.03	36.16
	(10.258)	(36.757)
N	12,904	12,904
Panel C: Anocracy		
Male co-twin	5.84	29.12
	(6.472)	(37.018)
N	16,141	16,141
Panel D: Democracy		
Male co-twin	6.66	-19.01
	(4.931)	(38.567)
N	12,707	12,707
Year fixed effects	✓	✓
Country fixed effects	✓	
Mother fixed effects		✓

Note: *Each entry is from a separate OLS regression. Robust standard errors are in parenthesis, adjusted for clustering by country. Each regression controls for year of survey fixed effects, the age of mother at delivery, the square of the age of mother at delivery, the mothers's number of children at the time of delivery, the level of education of the mother, the mother's marital status, and a set of birth order dummies. The quality of democracy is low, medium or high if Polity IV is respectively strictly less than -5, between -5 and 5 or strictly greater than 5 ***p<0.01, **p<0.05, *p<0.1*

Appendix

Table A1: Descriptive Statistics (Twin sample)

	N	Mean	Std. de.	Min.	Max.
Child-level characteristics					
Infant Mortality (IM per thousand)					
IM Male	60,430	289.48	453.52	0	1000
IM Female	59,348	248.08	431.90	0	1000
IM All children	119,778	268.96	443.42	0	1000
Child is a boy	119,778	0.50	0.50	0	1
Birth order number	119,778	4.55	2.45	1	18
Year of birth of child	119,778	1996	10.25	1960	2015
Mother-level characteristics					
Age mother at delivery	119,778	27	6.22	15	48
Year of birth of the mother	54,363	1969	10.69	1936	1998
Number of children	54,363	6.88	2.68	2	18
Mother is married	52,764	0.76	0.43	0	1
Mother has no education	54,355	0.49	0.50	0	1
Household wealth index					
Poor	39,311	0.45	0.50	0	1
Rich	39,311	0.35	0.48	0	1
Urban residence	54,363	0.29	0.45	0	1

Table A2: Robustness to alternative measures of democracy

	PRS (1)	FH (2)	PS (3)	BMR (4)	ANRR (5)
Dependent variable: Probability of infant death (per thousand)					
Male	14.67***	14.21***	14.55***	14.28***	14.24***
	(1.230)	(0.777)	(0.753)	(0.784)	(0.840)
Democracy measure	-0.73*	-0.22	-3.13*	-2.53	-2.42
	(0.416)	(1.439)	(1.638)	(1.845)	(1.508)
Male × Democracy measure	-0.52	-1.23	-2.06*	-2.00**	-1.21
	(0.319)	(0.829)	(1.029)	(0.968)	(0.924)
Year FE	✓	✓	✓	✓	✓
Country FE					
Mother FE	✓	✓	✓	✓	✓
Exogenous Covariates	✓	✓	✓	✓	✓
Country-specific trend	✓	✓	✓	✓	✓
N	2,669,871	3,719,303	2,892,174	3,636,890	3,636,897

Note: *Each entry is from a separate OLS regression. Robust standard errors are in parenthesis, adjusted for clustering by country. Each specification controls for an indicator for multiple birth, a set of birth order dummies, a set of year of survey fixed effects, the mothers's number of children at the time of delivery, the age of mother at delivery and the square of the age of mother at delivery. In columns (1)-(5) the democracy measure is based on 5 indexes: the democratic accountability index defined by Political Risk Services, the Freedom House index, a measure of democracy derived from Papaionnou and Siourounis's classification, a dichotomous index from Boix Miller and Rosato, and a measure of democracy defined by Acemoglu et al. respectively. ***p<0.01, **p<0.05, *p<0.1 .*

Table A3: Democracy and the contribution of biology and preconception factors to the male disdvantage in mortality

	(1)	(2)	(3)=(1)-(2)
Panel A: Autocracy			
Male	44.05***	27.30***	16.48 ***
	(5.891)	(5.326)	(7.941)
N	36,713	36,713	
Panel B: Anocracy			
Male	40.40***	28.10***	12.30 **
	(4.867)	(4.245)	(6.458)
N	54,446	54,446	
Panel C: Democracy			
Male	32.90***	21.01***	11.89
	(6.393)	(4.620)	(7.887)
N	28,614	28,614	
Year FE	✓	✓	
Country FE	✓		
Twin FE		✓	
Birth Order	✓	✓	

*Note: Each entry is from a separate OLS regression. We restrict the sample to twin birth only. Robust standard errors are in parenthesis, adjusted for clustering by country. Each specification controls for a set of birth order dummies and a set of year of survey fixed effects. ***p<0.01, **p<0.05, *p<0.1 .*

Table A4: List of countries and DHS

Countries	DHS year of surveys
Angola	2011, 2015-16
Benin	1996, 2001, 2006, 2011-12
Botswana	1988
Burkina Faso	1992-93, 1998-99, 2003, 2010
Burundi	1987, 2010-11, 2016-17
Cameroon	1991, 1998, 2004, 2011
Central African Republic	1994-95
Chad	1996-97, 2004, 2014-15
Comoros	1996, 2012
Congo	2005, 2011, 2012
Cote d'Ivoire	1994, 1998-99, 2005, 2011-12
Ethiopia	2000, 2005, 2011, 2016
Gabon	2000-01, 2012
Gambia	2013
Ghana	1988, 1993-94, 1998-99, 2003, 2008, 2014
Guinea	1999, 2005, 2012
Kenya	1988-89, 1993, 1998, 2003, 2008-09, 2014
Lesotho	2004-05, 2009-10, 2014
Liberia	1986, 2006-09, 2013
Madagascar	1992, 1997, 2003-04, 2008-09
Malawi	1992, 2000, 2004-05, 2010, 2015-16
Mali	1987, 1995-96, 2001, 2006, 2012-13
Mauritania	2000-01
Mozambique	1997, 2003-04, 2011, 2015
Namibia	1992, 2000, 2006-07, 2013
Niger	1992, 1998, 2006, 2012
Nigeria	1986-87, 1990, 2003, 2008, 2010, 2013
Rwanda	1992, 2000, 2005, 2007-08, 2010-11, 2014-15
Sao Tome and Principe	2008-09
Senegal	1986, 1992-93, 1997, 2005, 2008-16
Sierra Leone	2008, 2013
South Africa	1998
Sudan	1989, 1990
Swaziland	2006-07
Tanzania	1991-92, 1996, 1999, 2004-05, 2007-12, 2015-16
Togo	1988, 1998, 2013, 2014
Uganda	1988-89, 1995, 2000-01, 2006, 2009-11 2016
Zaire	2007, 2013, 2014
Zambia	1992, 1996-97, 2001-02, 2007, 2013-14
Zimbabwe	1988-89, 1994, 1999, 2005, 2006, 2010-11, 2015