The Differential Mortality of Undesired Infants in Sub-Saharan Africa

By Martin Flatø*†

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*Department of Economics, University of Oslo; International Institute for Applied Systems Analysis (IIASA); and Nordic Institute for Studies in Innovation, Research and Education (NIFU). ✉ martin@nifu.no

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Abstract

With high rates of infant mortality in sub-Saharan Africa, investments in infant health are subject to tough prioritizations within the household, in which maternal preferences may play a part. How these preferences will affect infant mortality as African women have ever-lower fertility is still uncertain, as increased female empowerment and increased difficulty in achieving a desired gender composition within a smaller family pull in potentially different directions. I study how being born at a parity or of a gender which is undesired by the mother relates to infant mortality in sub-Saharan Africa and how such differential mortality varies between women at different stages of the demographic transition. Using data from 79 Demographic and Health Surveys, I find that a child being undesired according to the mother is associated with a differential mortality that is not due to constant maternal factors, family composition, or factors that are correlated with maternal preferences and vary continuously across siblings. As a share of overall infant mortality, the excess mortality of undesired children amounts to 3.3 % of male and 4 % of female infant mortality. Undesiredness can explain a larger share of infant mortality among mothers with lower fertility desires and a larger share of female than male infant mortality for children of women who desire 1–3 children. Undesired gender composition is more important for infant mortality than undesired childbearing and may also lead couples to increase family size beyond the maternal desire, in which case infants of the surplus gender are particularly vulnerable.
Keywords: fertility desires, gender preference, infant mortality, unwanted childbearing, sub-Saharan Africa

JEL: I15, J13, J16, O55

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Introduction

With high rates of infant mortality in sub-Saharan Africa, investments in infant and child health are subject to tough prioritizations of time and resources within the household, in which maternal preferences for a desired number and gender composition of children may play a part (Jones 2014; Mosley & Chen 1984; Sartorius & Sartorius 2014). Partly for that reason, reducing unwanted childbearing has been regarded as important for improving child health and survival (Günther & Harttgen 2016; Joshi & Schultz 2013; Lloyd & Montgomery 1996). On the other hand, preferences for the gender[1] of offspring has been given less attention because of a strong, biologically determined female advantage in infant mortality in Africa, suggesting that discrimination of girls in infancy is not widespread (Garenne 2003). This lack of evidence for female excess infant mortality in aggregated numbers stands in contrast to a number of Asian countries, where strong son preferences have led to sex-selective abortions and high infant mortality rates among girls (Anderson & Ray 2010), especially for girls of high parity with many sisters (das Gupta 1987; Guilmoto 2009; Jayachandran & Pande 2017). Given the comparatively high fertility rate in sub-Saharan Africa at 5.1 children per woman in 2010–2015 (United Nations Population Division 2015), one theory suggests that the implementation of gender preferences rises with lower fertility intentions, with potential implications for future sex ratios at birth and differences in infant mortality in Africa (Bongaarts 2013).

I study whether being born at a parity or of a gender that is undesired by the mother matters for infant survival in sub-Saharan Africa. I assess undesiredness by relating the number of brothers and sisters that each infant has at birth to statements the mother made about the ideal family size and gender composition. To do so, I use data from 79 Demographic and Health Surveys (DHS) conducted in 33 countries in the period 1992–2012.

Whereas African mothers are reluctant to label any particular child as unwanted, and more so if the child has died (Smith-Greenaway & Sennott 2016), I show that the measure of undesiredness used in this study is not subject to widespread *rationalization* (Lightbourne 1985)—that is, manipulation of responses to disguise the undesiredness of living or deceased children. I first identify the differential mortality of undesired children by controlling for mother fixed effects, as mothers with, for example, high fertility desires often have higher mortality for all their children. Furthermore, mortality is higher among the firstborns and very late-borns (Lloyd & Montgomery 1996) and there may be resource competition or benefits of scale in larger families, which may also depend on gender (Kravdal et al. 2013). Hence, this study controls for the number of older brothers and sisters at birth and the mother's age at birth. Further confounders that vary between

[1] I use the term "gender" in this article to refer to socially constructed aspects of male–female differences, and expectations of such differences, rather than biologically determined aspects (Haig 2004). Specifically, maternal preferences concern the gender of children whereas the sex of each child is registered in DHS surveys.

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siblings and are correlated with maternal preferences remain uncontrolled for in the fixed-effects framework, which would for instance be present if mothers update their preferences for the number and gender composition of children in response to life events. A second strategy therefore uses a regression discontinuity design, wherein trends in mortality by distance from the ideal are controlled for separately for wanted and unwanted children, effectively comparing siblings who are just below versus just above the ideal family size and composition as stated by the mother. Thus, the estimated relationship between undesiredness and infant mortality in this study does not rely on preferences being revealed only through behavior by deviation from a demographic model (as criticized by Johnson-Hanks (2007)), nor does it rely on an a priori assumption about the accuracy of the stated ideal family size. Vastly inaccurate or unimportant preferences would lead to a zero result using this method because mortality differences would be captured by the continuous trends.

A few previous studies have considered the relationship between undesired or unintended fertility and infant and child mortality in developing countries (for a review, see Gipson et al. (2008)). A study by Montgomery et al. (1997) found that the mother having exceeded her ideal family size at the time of survey was associated with infant and child mortality in three of the five countries studied. Child-specific measures of undesiredness were not found to be associated with higher mortality, bearing in mind that the authors did not include mother-fixed effects in the regressions. Chalasani et al. (2008) used longitudinal data from two districts in Bangladesh to obtain prospective preferences and found elevated mortality for unwanted infants, using mother-fixed effects. Using prospective preferences at an individual level gives high validity to their finding, yet the need for longitudinal data makes their method unavailable for sub-Saharan Africa. Singh et al. (2012) found increased risks of infant mortality for unwanted and mistimed births using retrospective preferences from a national Indian survey, a study that included mother-fixed effects. A similar literature has focused on child health and survival differences across parities with different gender compositions, finding small differences in Africa compared with the relatively large differences found in India (Chamarbagwala 2011; das Gupta & Bhat 1997; Jayachandran & Pande 2017; Mishra et al. 2004). These findings may be due to the lesser importance of maternal gender preferences in Africa, because of, for instance, high levels of female work participation (Sen 1990) or pronatalist cultures in which women perceive their fertility desires as less binding (Bongaarts & Casterline 2013; Caldwell & Caldwell 1987). However, these findings could also be due to the more diverse—and in some places, more balanced—preferences for the number and gender composition of children in Africa. The differential mortality experienced by, for example, unwanted girls with two older sisters will not be apparent in aggregate mortality ratios if boys with older brothers are also subjected to excess mortality or if many mothers also want three daughters. The understanding of the scale of differential mortality that is caused by undesired gender compositions is therefore still very limited.

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In this study, I thus aim to separate differential mortality related to being undesired in gender composition from the differential ascribed to being undesired in parity as well as the interaction between these two. Making this distinction is important because addressing these inequalities may require different policy responses. A policy response to reduce mortality for children born in excess of the ideal family size would require an understanding of the reasons for having children beyond stated ideals. One such reason may be to secure a minimum desired number of live children in a context of high mortality, in which case addressing overall mortality could lead to fewer excess births. Family planning programs may be scaled up to address disproportionate mortality at undesired parities if there is an unmet need for contraceptives (Casterline & Sinding 2000). To target excess mortality among children of undesired gender, policies that can affect gender values in society may be considered, such as changing inheritance rights or strengthening female education (Caldwell 1986). Such policies could also increase female decision-making power in fertility decisions. It is much more difficult to respond to an interaction between these two types of discrimination, for example, if gender preferences become more difficult to achieve with reduced fertility desires. As Jayachandran (2017) noted in a study on India, factors such as female education that lead to more progressive gender attitudes could counterintuitively cause a more male-skewed sex ratio because such policies also reduce the desired family size. Whether such a paradox exists depends on whether gender preferences and the implementation of these preferences are weakened fast enough compared with the pace of reduction in desired family size.

Sub-Saharan Africa is still at the beginning of the fertility transition, and how inequalities in infant mortality between parities and sexes will develop is still uncertain and potentially changeable. The clash between a low demand for children and a high demand for sons—often referred to as the *fertility squeeze*—has been argued to be a key determinant of pre- and post-natal discrimination against daughters (Belanger 2002; Bhat & Zavier 2003; Croll 2000; das Gupta & Bhat 1997; Li et al. 2011). In South Asia, East Asia, and the Caucasus, such discrimination has altered sex ratios through sex selective abortions where ultrasound technology is available and elsewhere through infanticides and neglect of girls during infancy and early childhood (Guilmoto 2009; Jayachandran (2017)). Bongaarts (2013) argued that sex ratios at birth are likely to be altered by the fertility transition in parts of sub-Saharan Africa with strong son preferences. Without access to sex-selective technology, the concern is that discrimination against female infants in Africa will increase if a larger share of girls is born to mothers who desire only more sons. African male-female infant mortality ratios could thus approach the much lower Asian levels and follow a similar trend toward more skewed sex ratios in infant mortality as fertility declines, as has been observed for instance in China (Li et al. 2011; United Nations Population Division 2011). In this article, I will not attempt to overcome the inherent difficulties in making predictions about future mortality ratios, yet I seek to contribute to our understanding of the fertility transition as a mechanism by studying the

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preference-mortality relationship for mothers at various demographic stages in Africa, identified through fertility desires, urban-rural residency, and educational attainment.

Measuring Undesiredness

The measure of undesiredness that I use in this article is derived from a question in DHS where all women aged 15–49 are asked to go back to the time before they had any children and choose exactly the number of children to have in their whole life if they could start over again. They are then asked whether they would like the children to be male, female, or of either gender. I later discuss a number of possible shortcomings of basing a measure of undesiredness on stated desired family size. Nevertheless, this study argues for the usefulness of three concepts of undesiredness to assess individual mortality outcomes: (1) being excess in parity, (2) being excess in gender composition, and (3) being in dual excess. I furthermore describe how the prevalence of these three types of undesired children varies for mothers with different fertility desires as well as the diversity of gender preferences found across the subcontinent.

The measures of undesired children follow a conventional approach (Bongaarts 1990; Lightbourne 1985) and are derived as follows. Let C_i be the number of live children at birth of child i (including i) with the same mother. They may be boys (B_i) or girls (G_i). This gives the identity:

$$C_i = B_i + G_i \tag{1}$$

Furthermore, let mother m's preference for ideal family size be represented by $\hat{C}_m$. She also has preferences for the gender of these children, which are a given number of boys $(\hat{B}_m)$, girls $(\hat{G}_m)$, and children who may be of either gender $(\hat{N}_m)$. The preferences sum in the following way:

$$\hat{C}_m = \hat{B}_m + \hat{G}_m + \hat{N}_m \tag{2}$$

I then define being excess in parity as follows:

$$\tilde{E_i^p} = 1 \, if \, E_i^p = C_i - \hat{C}_m > 0 \tag{3}$$

Let the sex of child i be s, which is either male (b) or female (g). The number of children of the same sex as child i can then be denoted S_i (which is either B_i or G_i), and the preference for children of that gender is $\hat{S}_m$. Excess in composition is thus defined as follows:

$$\tilde{E_i^s} = 1 \, if \, E_i^s = S_i - (\hat{S}_m + \hat{N}_m) > 0 \tag{4}$$

If the total number of children or the number of same-sex children exceeds the preferred

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amount, they are in excess.

As an illustration, suppose a mother has given birth to six children but desires four. Her ideal family composition consists of one girl, two boys, and one of either gender. She first gives birth to four boys. The three first boys are not excess in any manner. The fourth son is excess in composition but not in parity. Her third son then passes away. She then has a daughter, who is not excess in any manner. In contrast, the last son she then delivers is born in dual excess.

Issues of Validity

At least four threats to the validity of this measure of undesired childbearing have been identified in the literature (Bongaarts 1990; Casterline & El-Zeini 2007). These are (1) a high number of nonnumerical responses; (2) a tendency to state the number of children at interview as the ideal number of children (rationalization); (3) changes in preferences between the time of conception and the time of interview; and (4) changes in preferences due to life events, such as the birth, death, or gender composition of children. Previous research has primarily focused on how these issues may cause an inaccuracy in the estimated number of undesired children in the population, leading mostly to too low estimates of the number of undesired children. Here, I discuss whether the validity issues may lead to an error in the estimation of differential mortality from undesiredness.

The first of these concerns is one of sample selection. Many women give nonnumerical responses to the question of ideal family size, and they are generally regarded as wanting a high number of children and thus by definition do not have undesired children. The reasoning behind this is that fertility transitions are characterized by changes in preferences for childbearing in which beliefs that the number of children should be "up to God"—or close to natural fertility rates—are replaced by a fertility desire "within the calculus of conscious choice" (Coale (1973) cited in van de Walle 1992:489). However, these women may be unable or unwilling to state their preference for other reasons. For this analysis, I focus on children of women whose stated ideal family size is between 1 and 9. Women with ideal family size of 0 or who give a nonnumerical answer have no stated gender preference for their children and can therefore not be included. It is also reasonable to exclude women who report an ideal family size around natural fertility levels because such an answer is similar to giving a nonnumerical response, and my interest lies in variation at lower fertility desires.[2]

Second, several authors have pointed to possible rationalization in responses (Bongaarts 2013; das Gupta & Bhat 1997). Rationalization in this setting means that some respondents who have previously exactly achieved their preferred family size will "*ex post facto* revise their stated desired family size upwards in response to the birth of an additional child" (Lightbourne 1985:182).

[2] A model with all women is included in Online Resource 1, section F.

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Mothers feel uneasy about preferring a lower number of children than they already have and thus disguise undesiredness for themselves and/or for others. Rationalization is a cause for concern in the estimation of the differential mortality of undesired children if we observe a heaping of children whose mothers have stated the exact number of children they have given birth to as their ideal, and correspondingly a suspiciously low prevalence of children born right above the ideal. Figure 1 thus plots the number of children by distance to the ideal number of children (E_i^p) and by distance to the sum of wanted children who may be of the same gender as the child or of either gender (E_i^s). There seems to be a fairly smooth distribution across both thresholds and for boys and girls, suggesting that these responses are not heavily manipulated.[3]

[3] Section B of Online Resource 1 shows that similar patterns can be obtained when mothers who have experienced the death of a child are studied separately.

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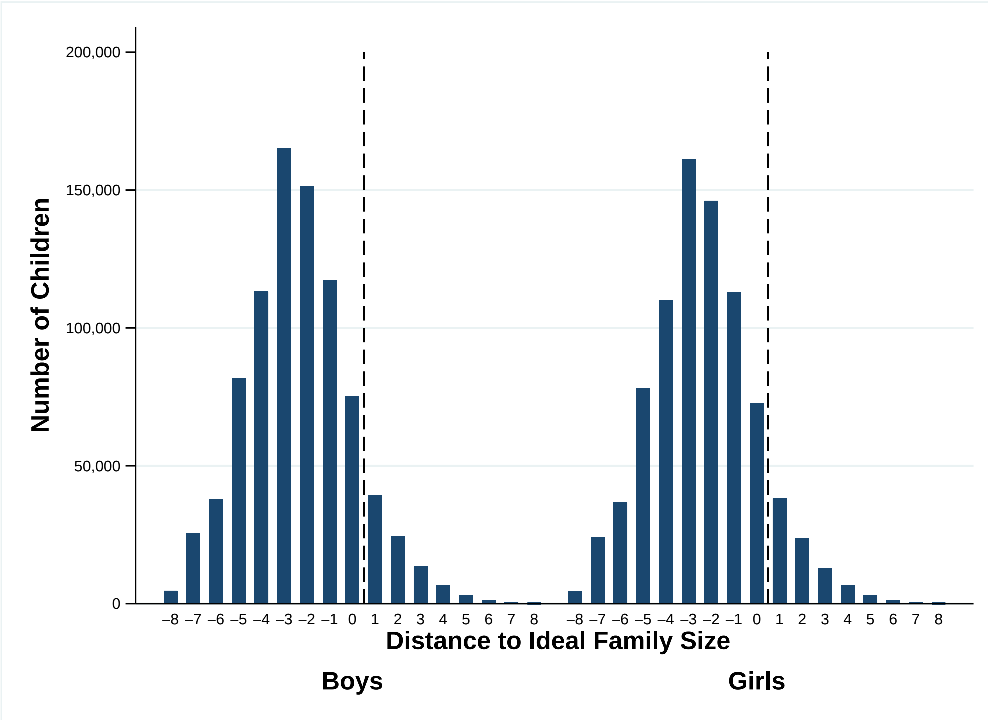

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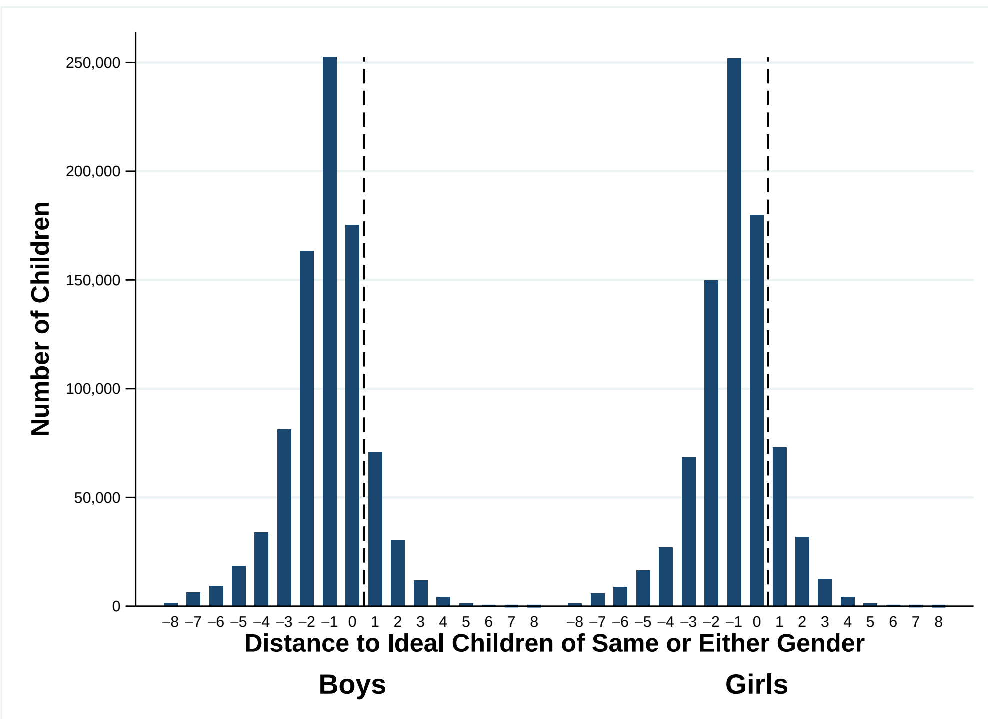

Figure 1: Number of children by distance to ideal family size (panel a) and composition (panel b). Dashed lines indicate cutoff value between wanted and unwanted children

The last two issues both relate to an updating of preferences over women's life courses. In the

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question about fertility desires, women are instructed to go back to the time before childbearing when stating their preferences. If they truly manage to conduct this thought experiment, then the measure of undesiredness is one prior to childbearing, whereas one would want a measure of undesiredness at conception or when the child is in infancy. On the other hand, if they fail to go back to the time before childbearing, such a measure would perhaps capture their ideal family size at interview, which may be several years after the birth of each child. With a general declining trend in fertility desires over time, the women will have lower desires at the time of interview than they had when giving birth.

Furthermore, the preferences may be adjusted according to events that women experience over the life course—most notably, the number or sex composition of the children they already have, and the health and survival of previous children (Smith-Greenaway & Sennott 2016). Flatø (2017) found that ideal family size and the desire for children of a given gender are adjusted upward in response to the birth of an additional child and an additional son or daughter, respectively. In relation to mortality outcomes, one reason why the scaling up of preferences over the life course is an issue of concern is that it causes larger underestimation of undesiredness for early-born children than for later-born children. These issues will need to be taken into account when designing appropriate empirical strategies to identify the differential mortality from undesiredness.

In the first empirical strategy, I assume that controls for mother-specific characteristics, the number of older sisters and brothers, and the mother's age adequately capture these differences in the accuracy of the undesiredness measure to account for possible mortality differences that this may cause. In the second empirical strategy, I instead consider the children who are right at the margin of the mother's ideal family size and family composition, who are subjected to a similar error in the degree to which the stated preferences reflect the true preferences during infancy. If that error is large, this will inflate standard errors and make identifying a differential mortality difficult. This strategy will also make it possible to explore a second reason for concern about up-scaling of preferences: the possibility that the number of undesired children is universally underestimated for all parities, in which case differential mortality should be observed when undesired childbearing is assessed using a smaller ideal family size.

Basing the measure of undesiredness on desired family size offers a few advantages and drawbacks compared with other measures. One such alternative measure is based on mothers being asked retrospectively whether they wanted no more children or wanted to postpone childbearing when they got pregnant with each child, a measure that is a robust indicator of future fertility (Bongaarts 1992). An advantage of that measure is that it refers to each specific birth. The measure is, however, subject to rationalization such that women are reluctant to label any one of their children as unwanted, especially if the child died (Smith-Greenaway & Sennott 2016). A third option is using prospective preferences, in which the share of undesired children is calculated by comparing

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the number of women who state that they want more children at the time of interview with fertility levels in a later survey. This may be the best measure of undesiredness at the population level, but it may not be derived for individual births (Casterline & El-Zeini 2007).

Identifying undesiredness at the level of the individual child and mother has the advantage of allowing estimation of the differential mortality from undesiredness without making any assumptions about these preferences being similar across women. Another advantage of using the stated desires is having gender preferences based on the same ideal family size. Again, there is a value in using a measure at the individual level rather than alternatives such as desired sex ratio at birth, which can be measured at the population level (for a discussion of desired sex ratios, see Bongaarts (2013)). For example, take the commonly found preference among parents across a variety of societies and fertility levels for at least one child of each gender (Andersson et al. 2006; Arnold 1992; Rossi & Rouanet 2015). If such a preference remains unchanged through the fertility transition, the desired sex ratio will not change, but the number of children who can be of either gender ($\hat{N}_m$) will diminish, and the target will be increasingly difficult to meet within the desired family size. With the measures used in this study, preferences for daughters are not contingent on not wanting sons; the family may practice gender-based discrimination of both daughters and sons, depending on abundance of either. Studies from both India (Mishra et al. 2004) and China (United Nations Population Division 2011) have indicated gender-based discrimination also of excess boys, which may disguise discrimination of girls unless taken explicitly into account.

Patterns of Undesiredness in Sub-Saharan Africa

I use data from all 79 available DHS data sets for which I have unrestricted access. These were collected in 33 countries in sub-Saharan Africa in the period 1992–2012 and contain information on 568,385 women who were successfully interviewed and their 2,278,857 children. Among these, I restrict the sample to the 458,202 mothers with a fertility desire of 1–9 children and their 1,693,495 children; 1,597,922 children remain in the sample when fixed effects are included.

Figure 2 shows that most children are born to mothers who wish to have 4–6 children, and even-numbered fertility desires are more common than odd-numbered desires. In percentages of total, the fraction of children who are of a desired gender and parity decreases with lower fertility desires. Most of the undesired children are excess in both parity and composition, which is particularly evident at lower fertility levels. There is a slight tendency for a larger fraction of girls than boys to be of undesired gender for mothers with ideal family size of 3 and more.

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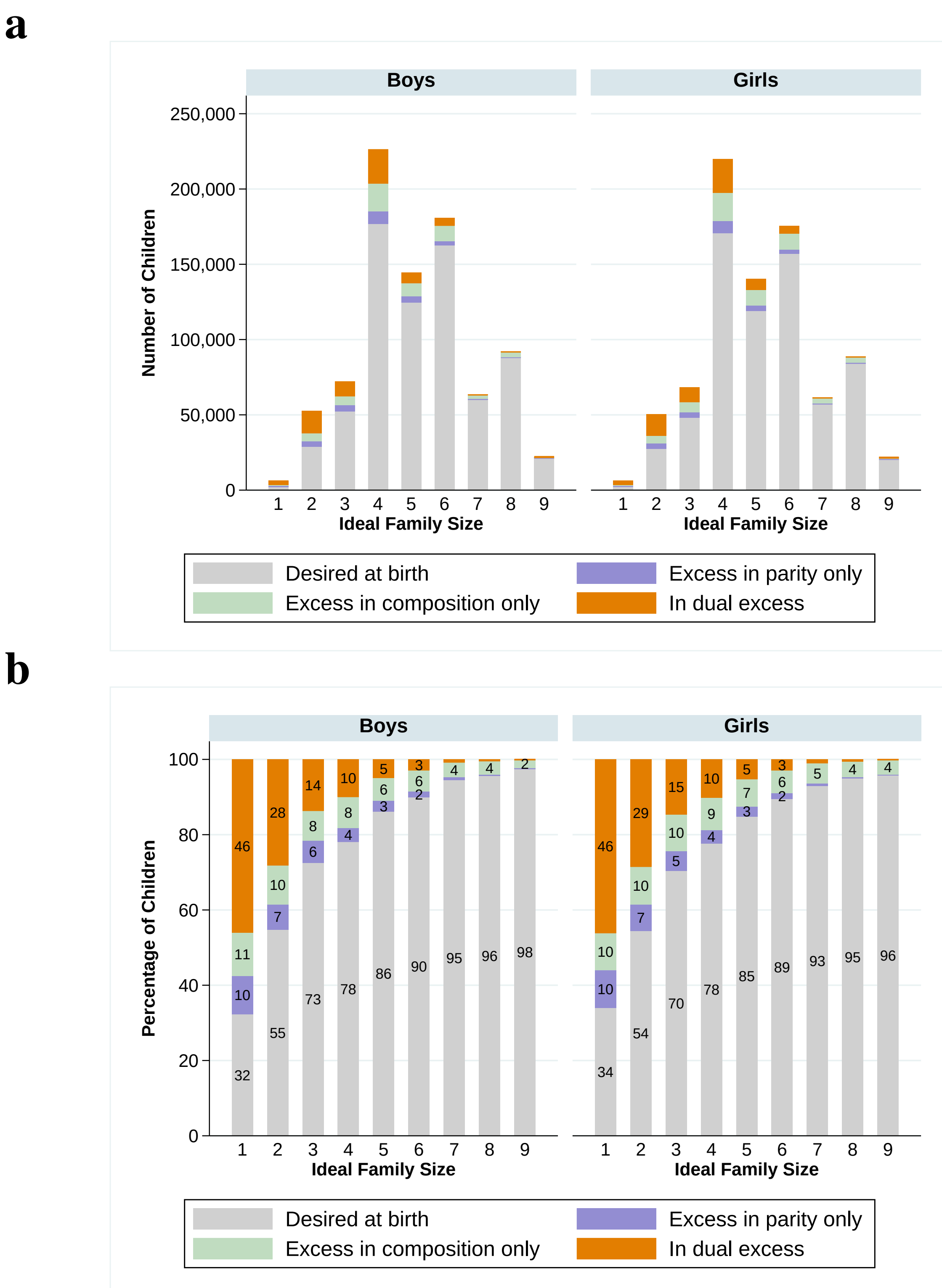

Figure 2: Number (panel a) and percentage (panel b) of live-born children who are desired and undesired at birth, by sex and ideal family size

In terms of gender preferences, Fig. 3 maps the percentage of children born to mothers with

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a dominant son preference, meaning that they desire more boys than girls. Others may be born to mothers who have a balanced gender preference or a dominant preference for daughters. Notice that even in Senegal, where the share of children born to mothers with a dominant son preference is the largest at 47 %, the majority of children do not have a mother with such preference. Rather, balanced gender preferences are widespread in Africa: 61 % of children in the sample are born to mothers with such preference, with only 23 % born to mothers with a dominant son preference and 16 % born to mothers with a dominant daughter preference. Dominant son preferences are most common in northern and western parts of sub-Saharan Africa, and are the least common in southern Africa.

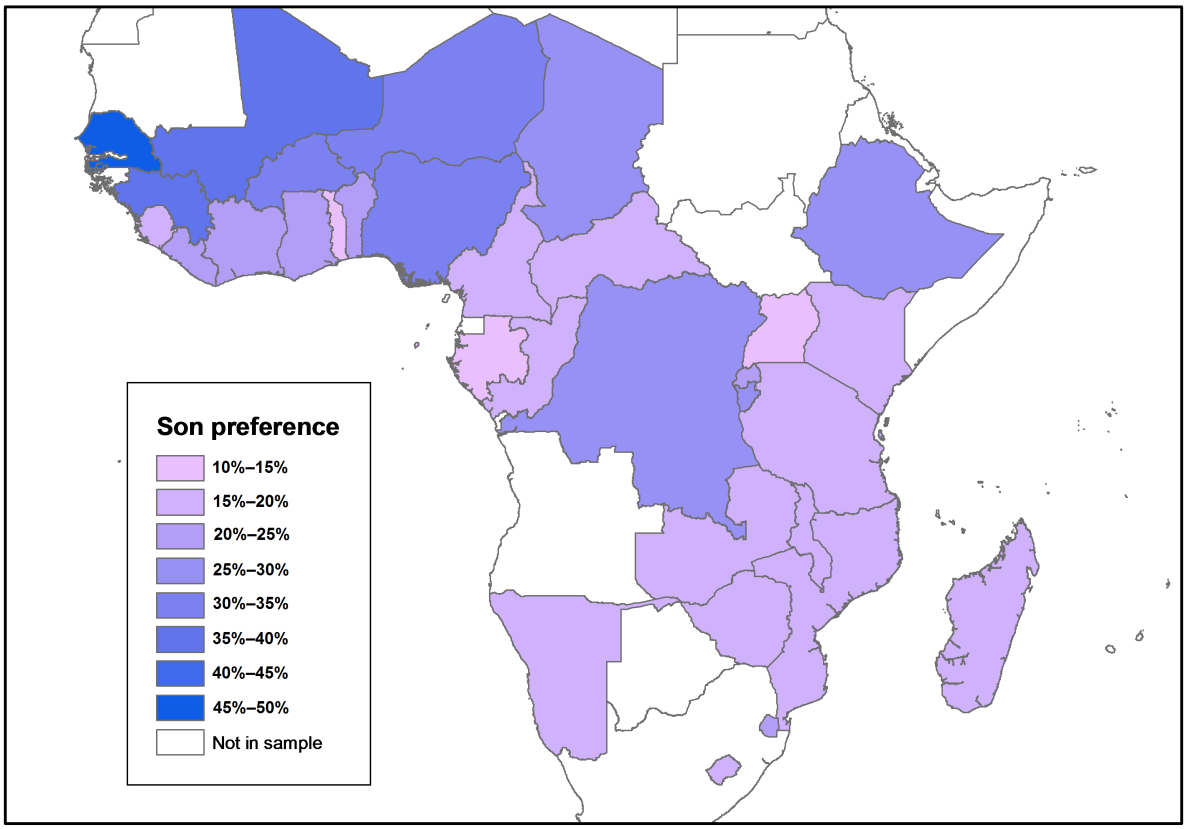

Figure 3: Percentage of children in sample whose mothers have a dominant son preference

Relating Undesiredness to Infant Mortality

Infant mortality rates are higher in sub-Saharan Africa than in any other region, at 68.7 deaths per 1,000 live births for males and 58.9 deaths per 1,000 live births for females in 2010–2015 (United Nations Population Division 2015). The extent of mortality makes it easy to allude to socioeco-

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nomic determinants, given that economic development in sub-Saharan Africa lags behind the rest of the world. Mosley & Chen (1984) provided a commonly used framework for studying determinants of child survival, emphasizing that socioeconomic determinants may influence child survival only through one of the proximate determinants: maternal factors, environmental contamination, nutrient deficiency, injury, or personal illness control.

Undesiredness may not be a concern unless parents act on these preferences in terms of early-life investments in children. Constrained resources may lead mothers and their households to make tough prioritizations regarding the investments in their infants (Baird et al. 2010; Flatø & Kotsadam 2014), which is thought to influence infant mortality mainly through nutrient deficiencies and personal illness control. The length of breast-feeding is thought to be a particularly important determinant of infant mortality (Black et al., 2008), and less time may be allocated to this and other care-taking functions of the mother (Kim 2010; Miller & Urdinola 2010) if the child is undesired. Later in infancy, the nutritional value of complementary food is more important than at any other period in the life cycle: infants' rapid development implies very high nutritional requirements (Dewey 2003; Lartey 2008). Evidence also suggests that the time until next childbearing is shortened by early termination of breast-feeding as a method to increase overall fertility in order to achieve desired family compositions in Africa (Rossi & Rouanet 2015). In India, Khanna et al. (2003) found that differences in health-seeking behavior following diarrhea is the main cause of excess female infant mortality in three socioeconomically deprived areas of Delhi. Because seeking health care when an infant becomes ill may require high costs in terms of travel time and transportation, it may be the case that households make an extra effort to care for children who are of the desired parity and gender.

In this analysis, I aim to separate differential mortality from unwantedness as clearly as possible from mortality differences that may have other causes. Additionally, I aim to separate how infant survival depends on whether the child is excess in composition, excess in parity, or excess in both ways, as well as by the sex of the infant. To study these differences, I propose two empirical strategies, each with its advantages and drawbacks.

The two methods allow me to identify differential infant mortality according to whether the child was desired by the mother, yet the results should not be interpreted as causal effects of undesiredness on mortality. Because the variation in fertility preferences and gender preferences of women is not random, factors in the preconception environment (e.g., maternal testosterone as argued by Pongou (2013; 2015)), the conception environment (e.g., sexual violence), and during pregnancy (e.g., maternal malnutrition (Milazzo 2014)) may have affected mortality outcomes of children born at an undesired parity differentially, and preconception factors may also affect the sex of the offspring. The latter two confounding factors are less likely to be a cause for concern when studying undesiredness by sex composition as few women have access to ultrasound technology

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for sex detection.

Fixed Effects

A first approach to this estimation is fixed-effects analysis. Mothers with different fertility and gender preferences are likely to differ along a number of dimensions, such as women's autonomy and standard of living, that affect infant mortality. Hence, I introduce mother fixed effects and conduct a study of survival differences between siblings. Furthermore, undesired children are generally born later, have more older siblings, and are born to older mothers than desired children. Children born at different parities may fare differently for reasons other than undesiredness, which may also depend on the gender of older siblings and the gender of the child.

Finally, women who want many children often start their fertility career early, in juvenile ages. Infants born to very young mothers face higher mortality risks, for example, due to complications of giving birth (Lloyd & Montgomery 1996).[4] The differential mortality can be studied by the following linear regression model using ordinary least squares (OLS):

$$D_{ims} = \beta_{1s}\tilde{E_i^p} + \beta_{2s}\tilde{E_i^s} + \beta_{3s}\tilde{E_i^p} \times \tilde{E_i^s} + \alpha_s(B_i, G_i) + \alpha_s a_i + \alpha_m + \varepsilon_{ims} \quad (5)$$

where D_{ims} is a binary variable indicating whether child i born to mother m of sex s died in infancy;[5] $\beta_{1s} - \beta_{3s}$ are the six coefficients of interest; $\alpha_s(B_i, G_i)$ include all combinations of the number of older brothers and sisters separately by sex; $\alpha_s a_i$ consists of dummy variables for maternal age at birth in single years, and the effect is allowed to vary by sex; and α_m are mother fixed effects. Reported coefficients will be on mutually exclusive groups of undesired children to ease interpretation.

The identifying assumption for the fixed-effects analysis is that mortality effects that are correlated with undesiredness are either shared among siblings or depend on the composition of older brothers and sisters or the mother's age at birth.

Regression Discontinuity

The fixed-effects analysis controls for most factors that are correlated with undesiredness and that are likely to cause differential mortality. By controlling for differences between mothers and sex-specific differences by the number and sex of older siblings, remaining confounders are limited to those causing differences between siblings that vary systematically between mothers with different preferences. Maternal age is one potential sibling-varying confounder. Yet, there may also be

[4] Section C of Online Resource 1 also includes interactions between maternal age and sibling composition.

[5] Infant mortality is here defined as deaths occurring to live born children until and including the 12th month of life, to include the many children who are reported to die at exactly 12 months due to heaping.

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other factors that make children at some parities born to mothers with higher fertility desires more vulnerable and that are not due to undesiredness.

One additional confounding factor may be present if mothers continuously increase their fertility desires when having more children, which would create a systematic underestimation of undesiredness of children at low parities compared with children at higher parities. This again may cause the mortality difference from undesiredness to be underestimated because children who would have been undesired if their mothers were asked at the time they were born are instead regarded as desired. Furthermore, if the degree of updating of preferences is also correlated with other factors, such as the death or survival of the infant or maternal education, the bias in the estimate may go in any direction. The ages of the older siblings represent another example. Mothers with high fertility desires space their children more closely, perhaps creating more resource competition (e.g., time spent caring for a toddler affects the survival of the infant) or a higher probability of spreading of diseases between children (Kravdal & Kodzi 2011). These confounding factors may cause a larger survival disadvantage for later-born children of mothers with a large ideal family size than for the children of equal parity born to mothers with a lower desired family size, of whom a larger share is undesired. Although some of these confounders could be addressed by controlling for observable variables (as I did with mother's age at birth), the list of potential sibling-varying confounders is long and may also include factors for which an appropriate control variable cannot be found.

The applied strategy is therefore a regression discontinuity design that aims to identify differences between children who are as equal as possible, except that one is just within the ideal family size of the mother, whereas the other is just in excess of the stated preference. I hence assume that mortality differences between children in the absence of an effect of undesiredness would follow continuous trends across parities and control for trends in infant mortality by distance to the ideal number of children and the ideal number of children of the same or either gender, separately for unwanted and wanted children. Identification of the differential mortality associated with maternal preferences is found by observing whether the trends intersect at the stated preference cutoff.

The presence of discontinuities at the cutoff along the two dimensions can be inspected graphically. In Fig. 4, infant mortality rates are plotted by sex and distance to ideal family size and distance to ideal number of children of either or the same gender, respectively. The figure reveals a penalty for being far away from the ideal and a discontinuity at each cutoff.

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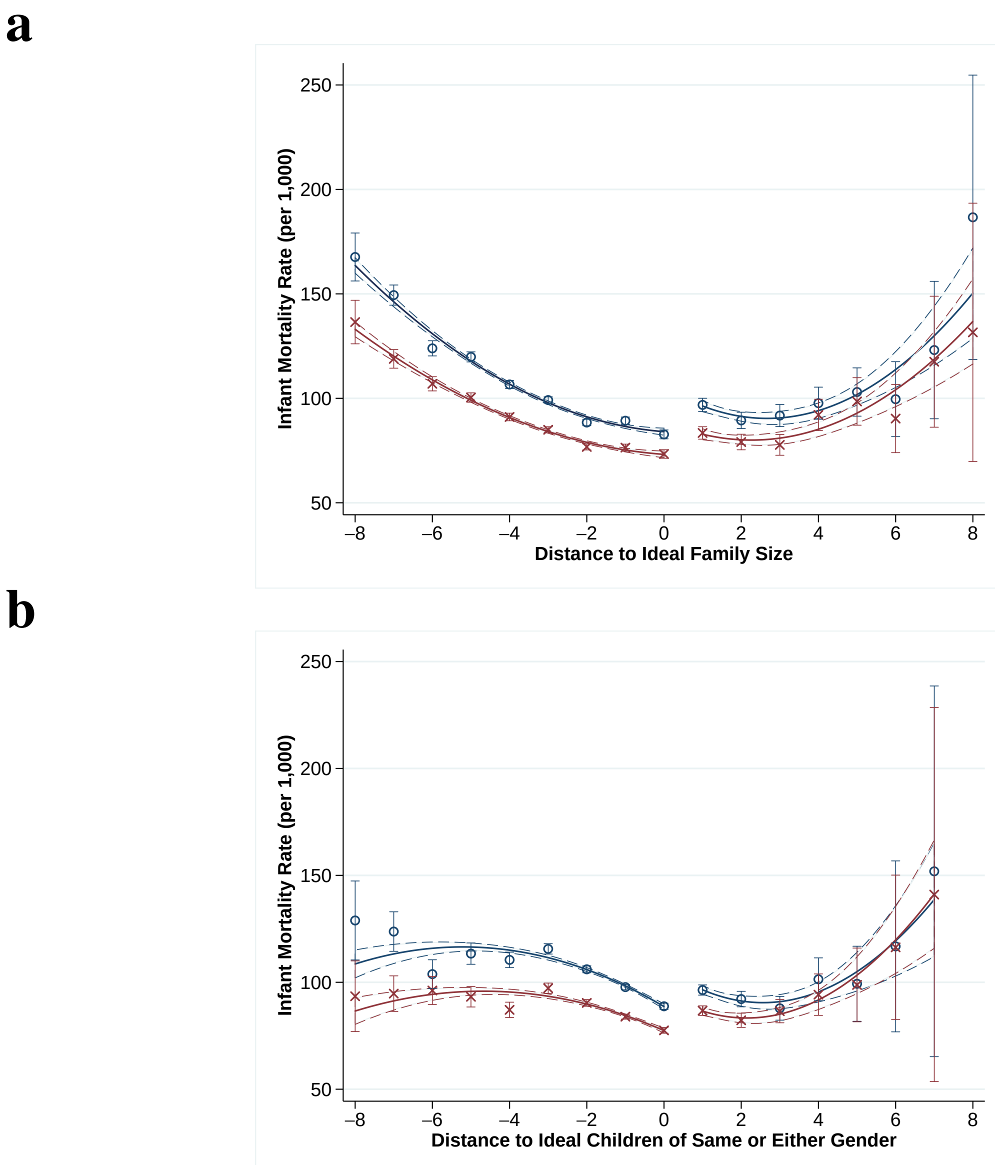

Figure 4: Infant mortality by distance to ideal family size (panel a) and ideal composition of children (panel b). The (blue) circles represent male infant mortality and the (red) crosses female infant mortality. Whiskers are 95 % confidence intervals on the means. The solid curves (in blue and red) are fitted quadratic terms, and the dashed curves are 95 % confidence intervals on these. Distance to ideal number of children refers to the number of children alive at the birth of each child minus the mother's preference for children. Distance to ideal children of same or either gender is the number of boys or girls alive at the birth of a boy or girl, minus the sum of the mother's preference for children of that gender and her preference for children of either gender

This regression discontinuity model is one with multiple assignments (Papay et al. 2011; Reardon & Robinson 2012) and is based on the following equation:

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$$
\begin{aligned}
D_{ims} = \beta_{1s}\tilde{E}_i^p + \beta_{2s}\tilde{E}_i^s + \beta_{3s}\tilde{E}_i^p \times \tilde{E}_i^s \\
+ \beta_{4s} \times \left(E_i^p + E_i^{p^2}\right) + \beta_{5s} \times \left(E_i^p + E_i^{p^2}\right)\tilde{E}_i^p \\
+ \beta_{6s} \times \left(E_i^s + E_i^{s^2}\right) + \beta_{7s} \times \left(E_i^s + E_i^{s^2}\right)\tilde{E}_i^s \\
+ \alpha_s\left(B_i, G_i\right) + \alpha_s a_i + \alpha_m + \varepsilon_{ims} \quad (6)
\end{aligned}
$$

The terms $\beta_{4s} \times \left(E_i^p + E_i^{p^2}\right) + \beta_{5s} \times \left(E_i^p + E_i^{p^2}\right)\tilde{E}_i^p$ fit squared trends in the distance from the ideal number of children, separately by sex, for desired and undesired children. Analogously, the terms $\beta_{6s} \times \left(E_i^s + E_i^{s^2}\right) + \beta_{7s} \times \left(E_i^s + E_i^{s^2}\right)\tilde{E}_i^s$ fit squared trends in the distance from the ideal maximum number of children of the same gender, separately by sex, for desired and undesired children. A key feature of regression discontinuity models in which the assignment to treatment is essentially random at the margin (e.g., where children who are *just* wanted are similar to children who are *just* unwanted) is that the coefficient is not affected by adding more variables, but doing so may improve precision (Imbens & Lemieux 2008). Hence, I can use the same controls as in Eq. (5).

Each method has its advantages and drawbacks. The fixed-effects model is troubled by the issue of omitted sibling-variant confounders, and the extent and direction of this bias is unknown. This is not an issue in the regression discontinuity model because continuous trends in the distances to the ideals are controlled for. As shown earlier, the preferences do not appear to be manipulated, and hence one can safely assume that remaining confounders are captured by continuous trends. The children that are compared at the cutoffs were thus born at a similar parity. Hence, their mothers updated their preferences by an equal amount between their birth and the time of interview; the mortality on each side is equally affected by the timing of previous births; and more generally, any observable or unobservable sibling-variant confounder that influences mortality is accounted for. However, the regression discontinuity design estimates the effect of being undesired at the margin, and hence may not be generalizable to a wider sample (Imbens & Lemieux 2008). For instance, a plausible theory is that the impact of unwantedness becomes more severe when moving further from the threshold; that is, that being the sixth daughter to a mother who wants two daughters is worse than being the third daughter. Hence, these two measures should be viewed in combination, and generalization based on the regression discontinuity results should be done with caution, particularly if the fixed-effects estimate is much larger than the regression discontinuity estimate.

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Findings

In this section, I present the findings of the two models along with a discussion of the validity of each method.[6]

Results of the fixed-effects model in Eq. (5) is shown in column 1 of Table 1. In this model, being undesired is related to additional infant mortality of 6.5–14.3 children per 1,000 births. Children who are excess in composition, excess in parity, or in dual excess seem to have quite similar mortality outcomes. Those excess in composition have only slightly higher mortality, and the differential is slightly larger for boys. With mean infant mortality rates in the sample being 100 per 1,000 live births for boys and 86 for girls, this amounts to differential mortality of 10 % to 14 % for boys and 7 % to 14 % for girls. The sex or the manner in which a child is undesired appears to be secondary; what matters is whether the child fulfills the mother's ideal family size and gender composition or is instead born in excess of her wishes. There thus appears to be some consistency in the implementation of preferences. Where preferences for sons prevail over preferences for daughters, such consistency will lead to higher mortality for girls than boys.

In Table 1, the second column shows the results from the regression discontinuity regression without other controls. The estimates are smaller in column 2 than in columns 3 and 4, where mother fixed effects and all control variables are included, respectively. This suggests that mothers who exceed their desire indeed differ from mothers who stay within the ideal. The assumption that the infants are similar on either side of the margin in respects other than being unwanted seems to perform better when the comparison is made between siblings, which is the case in columns 3 and 4. After mother fixed effects are included, adding more covariates (controls for the number and sex of older children and maternal age) does not change the coefficients of interest, although it improves model fit. The coefficients by and large confirm the findings of the fixed-effects regression and show that if anything, the differential mortality is larger when the trends by distances to the ideals are controlled for. In particular, differential mortality appears to be larger for infants who are born in excess of both types of maternal preferences. The mortality rate for infants born under such circumstances when all controls are included (column 4) exceeds that of those born within the mother's ideal by 25.2 per 1,000 live births for boys, and 26.6 per 1,000 live births for girls. This amounts to an excess mortality of 25 % for boys and 31 % for affected girls.

[6] Alternative models are shown in Online Resource 1, section C.

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Table 1: Results

	(1)	(2)	(3)	(4)
Infant Mortality				
Excess in parity, boys	10.6***	25.9***	18.1***	15.1***
	(2.31)	(3.99)	(3.82)	(3.93)
Excess in parity, girls	6.50**	20.7***	9.27*	7.56*
	(2.21)	(3.84)	(3.70)	(3.76)
Excess in composition, boys	14.3***	17.7***	15.3***	15.3***
	(1.62)	(3.80)	(3.49)	(3.79)
Excess in composition, girls	12.5***	19.2***	14.5***	16.3***
	(1.51)	(3.63)	(3.33)	(3.64)
In dual excess, boys	10.8***	29.4***	21.2***	25.2***
	(1.79)	(5.23)	(4.93)	(5.25)
In dual excess, girls	11.2***	26.2***	23.2***	26.6***
	(1.72)	(5.17)	(4.91)	(5.16)
Continuous trend controls	no	squared	squared	squared
		16	*16*	*16*
Gender-composition controls	$\alpha_s(B_i, G_i)$	no	no	$\alpha_s(B_i, G_i)$
	180			*180*
Maternal age controls	yes	no	no	yes
	85			*85*
Fixed Effects	Mother	no	Mother	Mother
	362,653		*362,653*	*362,653*
Number of observations	1,597,922	1,693,495	1,597,946	1,597,922
Adjusted R^2	0.117	0.003	0.064	0.117

Notes: Results are per 1,000 live births. Coefficients are reported for mutually exclusive groups. Robust standard errors, clustered at the mother level, are shown in parentheses.
*p < .05; **p < .01; ***p < .001

The results seem robust to two types of threats to validity that may be an issue when a regression discontinuity design is used (Imbens & Lemieux 2008): the misspecification of the functional form of the regression and systematic misplacement of children around the cutoff. In the main specification, all children are included in the regression, and squared polynomials are used in both dimensions. Figure 4 presented earlier shows that the squared polynomials fit the observed levels quite well, especially in the vicinity of the cutoffs, which is the most important for identification. Nevertheless, the robustness to using linear instead of squared trends is checked, and the analysis is conducted using all bandwidth pairs. As shown in Online Resource 1, section D, this yields similar results.

The descriptive statistics presented earlier shows a smooth distribution of children around the cutoffs, and hence it does not appear to be common to manipulate the preferences. One remaining

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worry might be that the extent of updating of preferences is so large that the cutoff is a poor reflection of mothers' true preferences and that the true preferences are for a smaller number of children and same-sex children than what mothers stated. Therefore, I conduct a placebo analysis in which the last-born wanted child is regarded as unwanted; results in section D of Online Resource 1 show that this analysis reveals little excess mortality, especially when the bandwidths are narrowed.

Choosing a best estimate between the two methods would require weighing the extent to which sibling-variant confounders are likely to bias the fixed-effects estimate against the possible bias from generalizing the regression-discontinuity estimate beyond the marginal child for whom it was estimated. Because it is reasonable to believe that the differential mortality from undesiredness is increasing rather than declining when moving further away from the ideal, it is surprising that the fixed-effect estimates are not larger than the regression discontinuity estimates. This could be because the impact of undesiredness is not much worse when having more undesired children, or because sibling-variant confounders cause a downward bias in the fixed-effect estimate. In both cases, generalizing based on the regression discontinuity estimate would be as good as, or better than, the fixed-effect estimate, which would be especially problematic if the latter explanation holds true.

Undesiredness and the Demographic Transition

Whether undesiredness will become a major determinant of infant mortality as African populations continue their paths toward lower rates of fertility and mortality is what will ultimately determine the need for policies specifically addressing mortality of undesired children as opposed to broader policies. Preference-based differences in mortality should be assessed as a share of overall infant mortality to reflect opportunities for mortality reduction through targeting of this vulnerable group versus other measures. To construct such a relative measure, the specification used in column 4 of Table 1 gives the differential mortality estimates, which are then multiplied by the shares of each type of undesired children and divided by the overall infant mortality rate. When heterogeneous impacts are considered, the differential mortality is reestimated for each subpopulation of women, multiplied by the corresponding share of infants affected by each type of undesiredness, and divided by the relevant infant mortality rate in the subpopulation.

Figure 5 shows that differential mortality according to preferences can explain 3.3 % of overall male infant mortality and 4 % of overall female infant mortality in the data, mainly due to children who are excess in composition or in excess of both preferences. In this section, I further break down the differential mortality by processes that are important for the demographic transition toward lower fertility. Urbanization is one such factor (Bryant 2007). Preferences explain a larger share of infant mortality in urban than in rural settings, and a larger gender difference is found in urban

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areas, where preferences are more important for female than for male infant mortality.

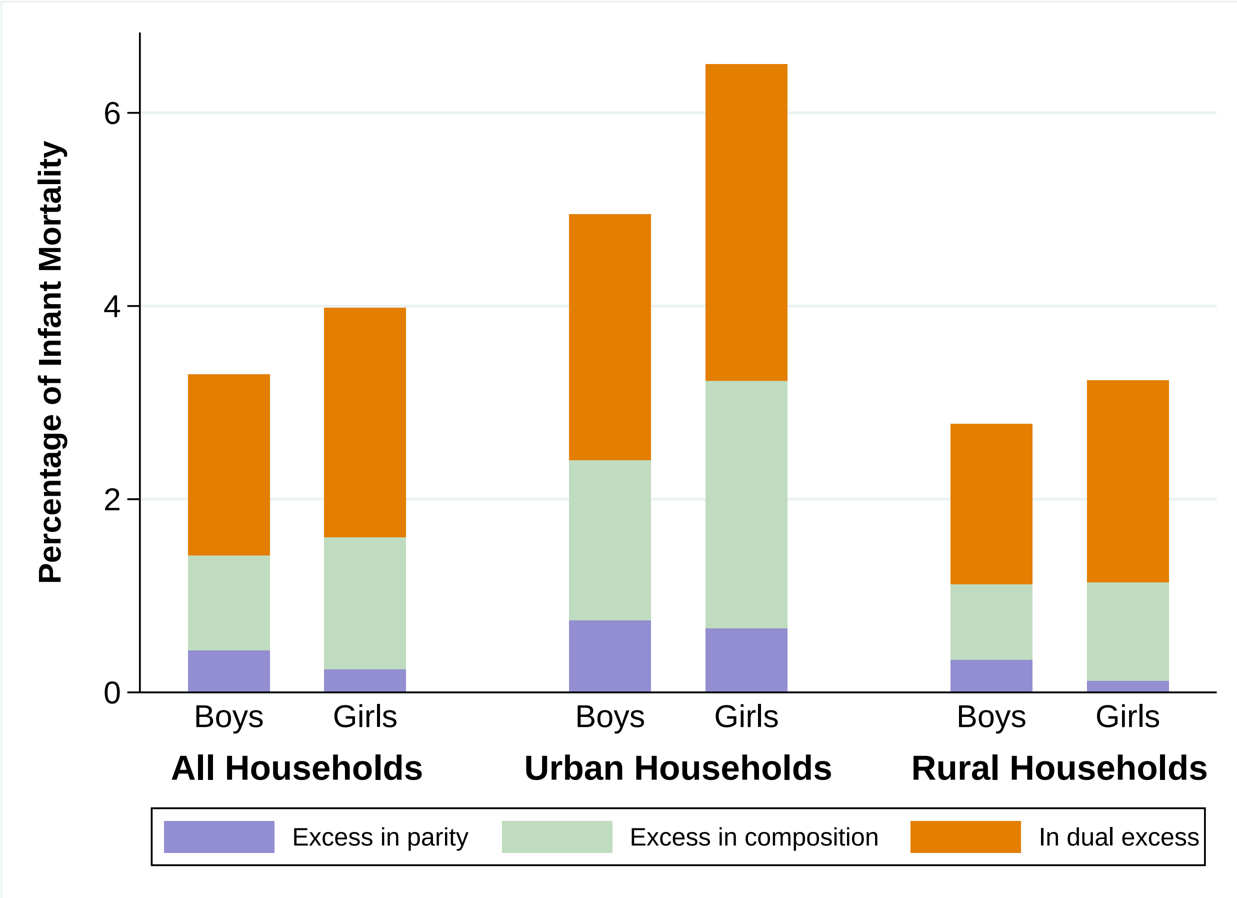

Figure 5: Share of infant mortality rate attributable to undesiredness, by sex and urban versus rural residence

An interesting and more direct way of studying the importance of preferences for mortality across the fertility transition is to consider women with different fertility preferences, as shown in Fig. 6. For women who desire 4 children, differential mortality due to preferences can explain 4 % of male infant mortality and 3.7 % of female infant mortality. Even lower levels are found at higher ideal family sizes, and no apparent gender difference is found. This is different for women who desire 3 children. For their infants, undesiredness can explain 5.2 % of male mortality and 8.4 % of female mortality. The greater importance of preferences for mortality for women with 3 ideal children compared with 4 ideal children is mainly due to a larger share of mortality stemming from female infants who are excess in composition only. The importance of preferences further doubles for each subsequent group of women with lower ideal family size, and the gender difference remains substantial. The increase in importance is mainly driven by larger proportions of children who are undesired along both dimensions and smaller overall mortality rates, as the

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estimated absolute mortality differentials are not significantly different from each other across mothers with different fertility desires.

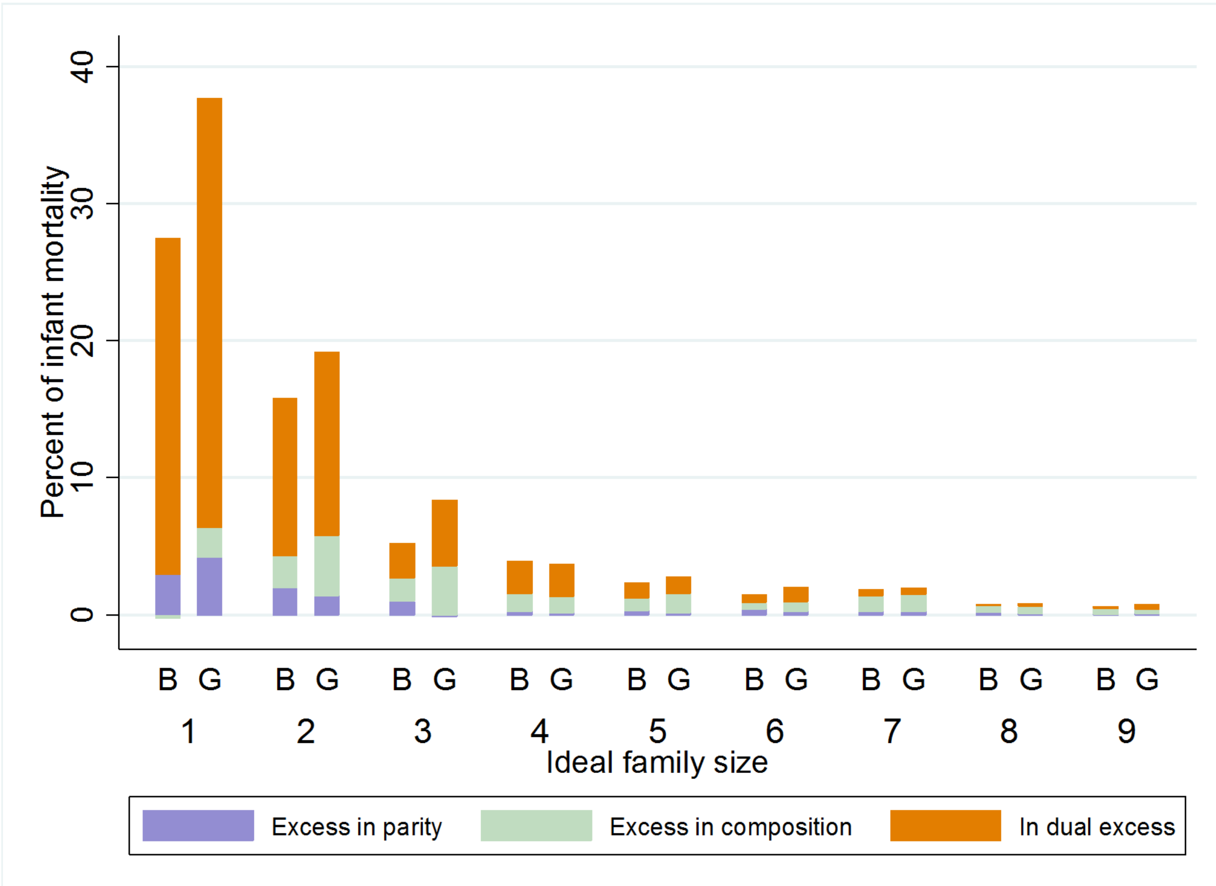

Figure 6: Share of infant mortality rate attributable to undesiredness, by sex and ideal family size. Bars marked B represent shares of male infant mortality, and bars marked G represent shares of female infant mortality

Female education is thought to be a very important driver of fertility decline in sub-Saharan Africa (Kravdal 2002) and has also been connected to large improvements in child survival and women's autonomy (Grepin & Bharadwaj 2015) as well as reduced son preference (Jayachandran 2017). Figure 7 shows relatively small differences by educational attainment compared with what was seen by fertility desire. Nevertheless, the relative contribution of undesiredness to mortality is larger for girls than for boys among mothers who have completed primary education or more. Undesiredness is slightly more important for infant mortality among mothers with some or completed secondary education or higher education than for less-educated women. There is no impact on overall mortality of survival differences associated with being excess only in parity for women with complete secondary education or more, plausibly because of better access to family planning

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for this group.

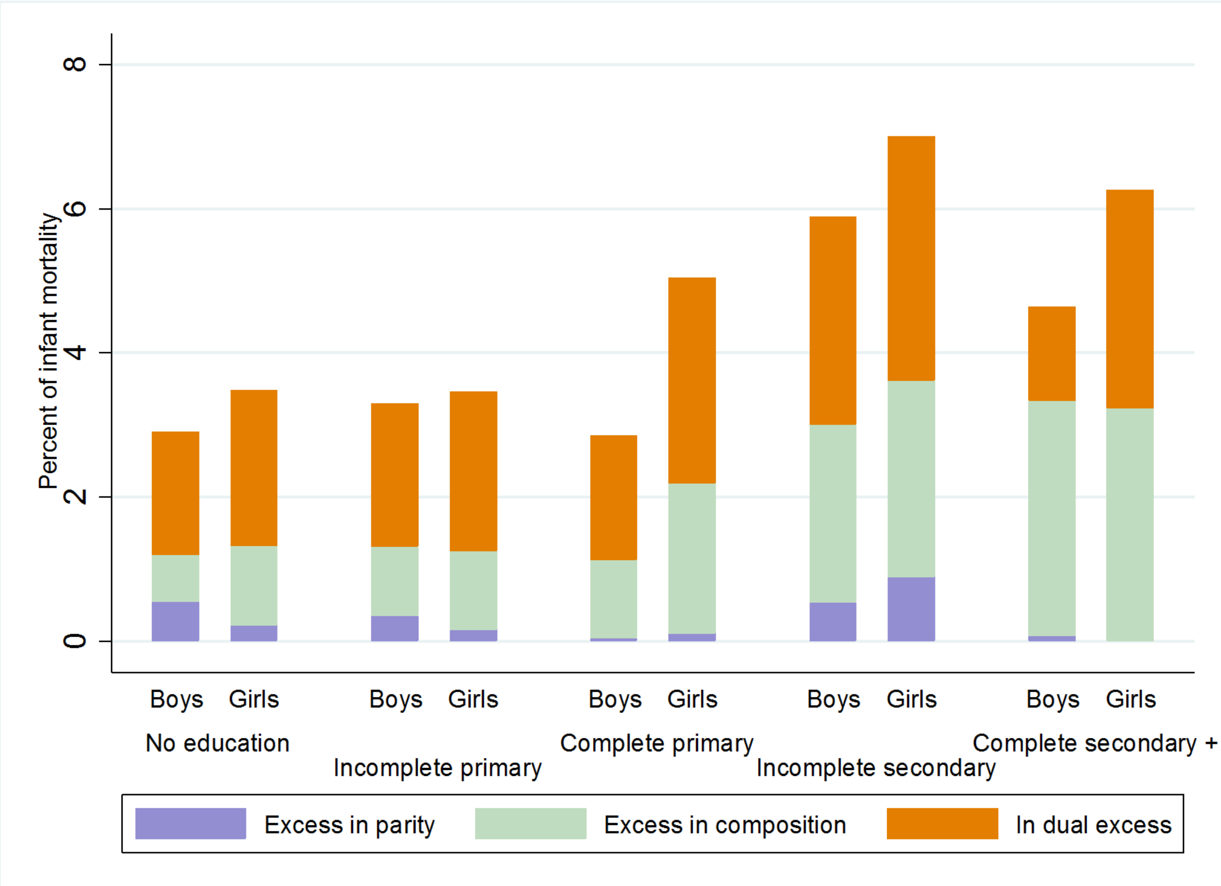

Figure 7: Share of infant mortality rate attributable to undesiredness, by sex and educational attainment

As a final remark, it has been suggested that the implementation of son preferences (in terms of sex selection and postnatal discrimination) is mainly an issue in populations with a high desire for sons compared with daughters (Bongaarts 2013). It may be the case that mothers with a daughter preference or balanced preference implement their preferences to lesser extent than mothers with a dominant son preference, or that parents implement the preference only for the gender they most favor. Indeed, egalitarian gender values in parts of Africa are thought to be a main explanation for few "missing girls" at childhood ages (Sen 1990). On the other hand, it may be the case that also mothers with balanced gender preferences or even a dominant daughter preference treat undesired girls unfavorably if they also want a son, and vice versa.

Figure 8 shows the percentage of infant mortality attributable to undesiredness for women who desire more sons than daughters, more daughters than sons, and an equal number of sons and daughters. The figure shows very small differences in the overall levels explained by undesiredness

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across these three groups, meaning that the implications of balanced preferences are a problem of equal relative importance for infant survival as the problem posed by dominant preferences for sons or daughters. However, preferences explain twice as much of the infant mortality for girls compared with boys among those born to mothers with a dominant son preference, and slightly more of the infant mortality for boys than for girls among mothers with a dominant daughter preference. These gender differences are mostly due to differential mortality among children who are undesired in composition only–that is, whose mothers have more children of the child's gender than they desire but have not exceeded their ideal family size.

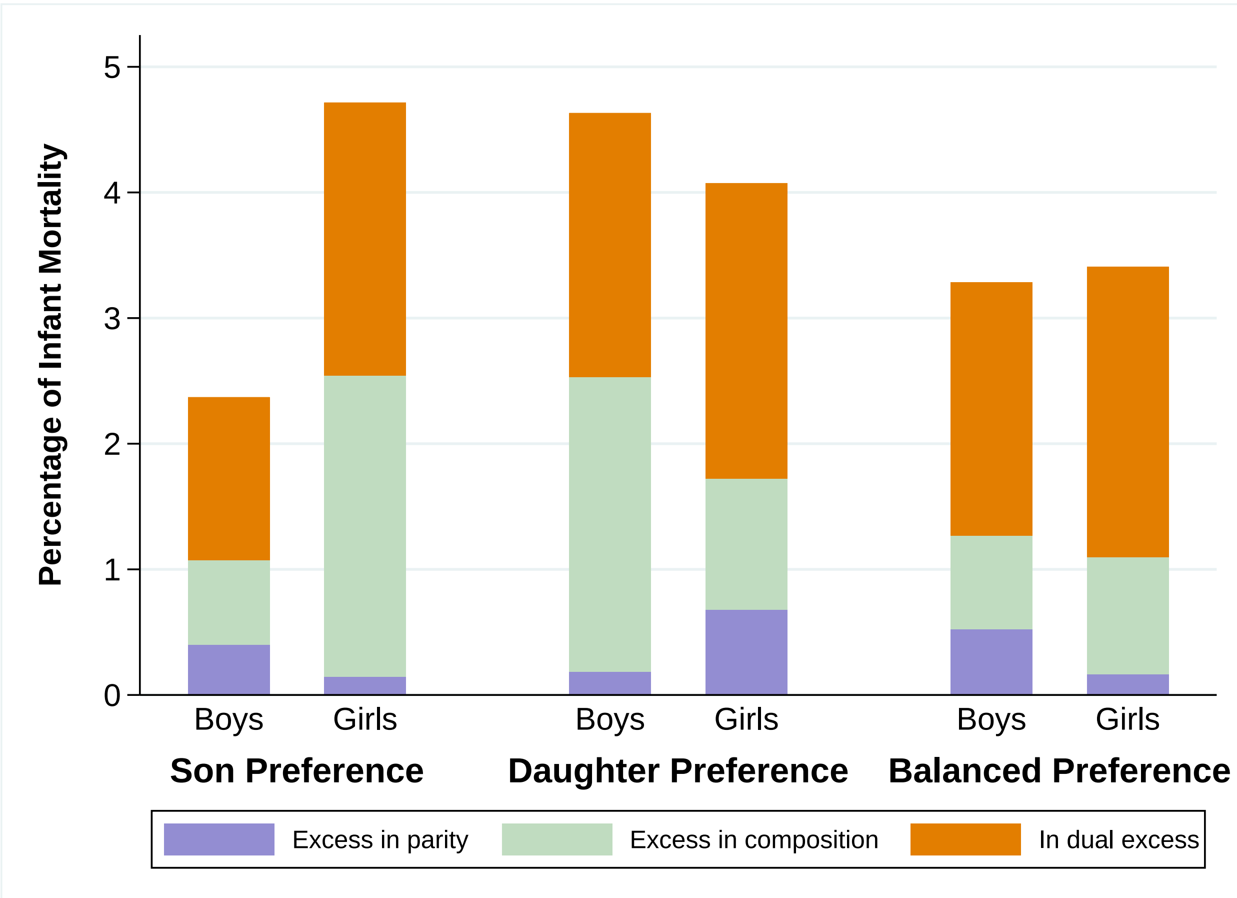

Figure 8: Share of infant mortality rate attributable to undesiredness, by sex and dominant gender preference

Conclusion

In this study, I find that children who are undesired according to their mothers' stated preferences experience a higher risk of mortality than other infants in sub-Saharan Africa. This differential mortality is not due to maternal factors or the number and sex of older siblings, which one might

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think would confound the result.

The analysis distinguishes between infants who are born in excess of the mother's preferences for family size and gender composition as well as those born in excess of both these preferences, and allows the differentials to vary by sex. There is significant excess mortality for all groups of undesired children, and the sex of the child or the type of preference that the infant is born in excess of seems unimportant for the size of the individual disadvantage.

To overcome potential bias from sibling-variant confounders that might be correlated with maternal preferences, this study uses a regression discontinuity design that accounts for variation in mortality between siblings that is continuous in relation to the mother's preference set. The strategy thus compares children who are as similar as possible in aspects other than whether their mothers desired them. Results suggest even stronger associations than what was found in the fixed-effects approach, especially for children born in excess of both their mother's fertility desire and her preferred number of children of a given gender.

I suggest that differential treatment is an important determinant of this difference, yet caution against a causal interpretation of the results given that I am not able to take account of prenatal factors that may influence the mortality and perhaps even the sex of offspring. A further limitation of this study is the inability to capture adverse effects of being born with shorter spacing or sooner than what the mother wanted (Timaeus & Moultrie 2008), nor does it describe the potentially substantial effect of high fertility preferences and specific gender preferences on wanted children.

Despite the clearly unfavorable survival prospects of undesired children, their excess mortality seems to be a fairly minor contributor to overall infant mortality in sub-Saharan Africa during the last decades. However, if future cohorts of African women were to follow the forerunners in African fertility decline, preferences would become much more important for infant mortality over time as ideal family sizes of 2–3 children become more common. This differential mortality is likely to affect both girls and boys given that gender preferences in Africa are diverse and often balanced. Sex ratios in mortality, which is a much used indicator of gender-based mortality differences, is thus not a very suitable indicator in Africa, as excess female mortality is disguised by excess male mortality for infants with many older brothers.

Regarding policies to address infant mortality in sub-Saharan Africa, the findings in this article highlight the relevance of maternal agency and the mothers' concepts of the ideal family for infant mortality. My findings suggest that limiting unwanted childbearing may reduce some of the differential mortality of undesired children and that achieving the Sustainable Development Goal of universal secondary education could contribute to reducing excess mortality coming solely from this channel. However, exclusive focus on unwanted childbearing would miss a dimension of undesiredness that is much more important for aggregate mortality differences: namely, gender composition. Undesired gender compositions both seem more directly relevant for infant mortality

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differences, and represent a major cause of rapid further childbearing (Rossi & Rouanet 2015). When undesired gender compositions lead couples to increase family size beyond the mother's ideal size, children of the surplus gender are particularly vulnerable, and the differential mortality experienced by children in excess of both preference types is the most important determinant of infant mortality found in this study. Because undesiredness is a more important issue for infant mortality for women who have advanced further in the fertility transition in sub-Saharan Africa, additional research is needed to study how the prevalence and implementation of maternal preferences for gender composition may be altered. Here it is important to consider gender-based discrimination not as an issue affecting only girls and also address the problematic aspects of balanced gender preferences in the African context.

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