DEMOGRAPHIC RESEARCH
A peer-reviewed, open-access journal of population sciences

DEMOGRAPHIC RESEARCH

VOLUME 50, ARTICLE 15, PAGES 411‒442
PUBLISHED 5 MARCH 2024
https://www.demographic-research.org/Volumes/Vol50/15/
DOI: 10.4054/DemRes.2024.50.15

Research Article

Losing the female survival advantage: Sex differentials in infant and child mortality in Pakistan

Batool Zaidi

Contents

Demographic Research: Volume 50, Article 15
Research Article

Losing the female survival advantage: Sex differentials in infant and child mortality in Pakistan

Batool Zaidi[1]

Abstract

OBJECTIVE
To understand patterns of gender discrimination by exploring whether the risk of dying during infancy and childhood is correlated with not only the sex and birth order of the child but also the sex composition of previous siblings.

METHODS
Event history analysis (Cox proportional hazards model) is applied to pooled data from the 2006–2007, 2012–2013, and 2017–2018 rounds of the Pakistan Demographic and Health Survey to highlight patterns of mortality risk during infancy (0–11 months) and childhood (1–4 years) by the sex composition of previous siblings, birth order, and the sex of the index child.

RESULTS
Females lose the survival advantage early. Evidence of generalized discrimination against all girls is reflected in higher-than-expected mortality risk during infancy and childhood. Evidence of selective preferential treatment of first sons is reflected in a survival advantage, even as early as the first year of life in large families and in all family sizes during childhood.

CONTRIBUTION
This paper examines sex differentials in infant and child mortality in a context with strong son preference but with a lack of evidence on sex-selective abortions. It gives theoretical and empirical attention to the birth order and sibling composition contexts within which births and discrimination occur. The specific pattern of discrimination provides clues to the rationale for, and mechanisms causing, differential mortality risk among siblings and across genders.

[1] Sociology Department, College of Humanities and Social Sciences, Western Washington University, Bellingham, WA, USA. Email: zaidir@wwu.edu.

1. Introduction

Amartya Sen's (1992) article on the approximately 100 million "missing women" of Asia brought global attention to excess female mortality in the most populous part of the world. Much of this excess female mortality is concentrated during infancy and childhood. As a result, a significant number of researchers have studied age-specific sex ratios and sex differentials in mortality rates across Asia. While the probability of giving birth to a boy is slightly higher than that of giving birth to a girl, newborn girls have a natural biological survival advantage during the early days of life. That is, the sex ratio of male-to-female mortality up to the age of 5 is greater than one in the absence of severe gender discrimination (Alkema et al. 2014). However, if severe, gender discrimination can increase the mortality rate of girls (relative to boys) such that there is either no female mortality advantage or even a female disadvantage.

Indeed, sex differentials in child mortality, skewed in favor of boys, have been shown to persist in several parts of the globe to varying degrees. In both India and China, which account for more than 80% of the global estimates of missing women, there is clear evidence of excess female mortality during childhood (Alkema et al. 2014; Attane 2009; Khera et al. 2014; Bongaarts and Guilmoto 2015; Kashyap and Behrman 2020). Several other countries in Asia (including Pakistan, Afghanistan, Azerbaijan, Jordan, and Nepal), North Africa (including Egypt), and more recently other parts of Africa (including Nigeria, Senegal, and Comoros) also show a survival disadvantage for girls under the age of 5 (Alkema et al. 2014; Bongaarts and Guilmoto 2015; Costa, da Silva, and Victora 2017). In fact, excess female child mortality is now widely used to make cross-national comparisons of female disadvantage and to measure gender inequality within and across countries (United Nations 2011; Brinda, Rajkumar, and Enemark 2015).

As suggested by Croll (2001), it is more appropriate to use "missing girls" or "missing daughters" to refer to this phenomenon since most of the excess female mortality is concentrated during childhood and son preference has been the most widely offered explanation for it. The desire or preference for sons leads to greater investments in the survival of male children and to female neglect. The reasons for this preference for sons include patrilineal kinship systems, dowry practices, inheritance laws, earning potential, old age support, and religious practices that favor males (Croll 2000; Bongaarts and Guilmoto 2015). Of course, excess female child mortality is just one outcome of the desire for sons. Skewed sex ratios at birth highlight the prevalence of sex-selective abortion as another means to realize the desire for sons while limiting family size in countries such as Korea, China. and India (Guilmoto 2009). In other places, differential fertility-stopping behavior has been the tool for ensuring sons (Basu and De Jong 2010;

Jayaraman, Mishra, and Arnold 2009; Bairagi 2001; Zaidi and Morgan 2016; Channon 2015).

Understanding gendered patterns of infant and child mortality rooted in son preference requires that researchers pay attention to not only overall sex disparities but also how they play out by birth order and, within birth orders, by sibling composition. These fertility characteristics are important because they identify the family contexts within which female and male children are born and raised, and because they are themselves correlated with son preference and mortality risk. In Indian Punjab, Das Gupta (1987) showed that parents selectively discriminated against female children if they already had surviving daughters; girls with older sisters had higher mortality rates than those with brothers and higher rates than girls with no older sisters. More recent literature on India, looking at infant mortality between 1992 and 2016, found selective treatment of boys with older sisters such that their chances of survival were higher than those of other children (Raj et al. 2019). Other Indian studies have found that the sex of the child, birth order, and the sex composition of older siblings affect risk of infant and child mortality (Arnold, Choe, and Roy 1998; Chamarbagwala 2011; Mishra et al. 2018).

The effect of family composition on sex differentials in childhood mortality has also been tested in countries other than India. Muhuri and Preston (1991) found that daughters with an older sister had an increased risk of dying in the Matlab research area of Bangladesh. Later, Kabeer, Huq, and Mahmud (2014) found that discrimination against daughters had all but disappeared in Bangladesh over the previous two decades. Altindag’s (2016) analysis of data from Turkey showed strong evidence of differential stopping and found that the biological female survival advantage disappears if the previous sibling is female. In Turkey, having older female siblings shifts the gender gap in infant mortality by two percentage points in favor of males; the improvement is strongest for males with no older brothers (first sons).

Pakistan is glaringly absent in the literature on family contexts that lead to sex differentials in child mortality. In Sen’s article on missing women (1992), Pakistan had the highest ratio of males to females of all countries. In Bongaarts and Guilmoto’s (2015) comprehensive trends analysis of missing women, Pakistan had the highest percentage of missing women in 1970 and the third highest in 2010 (after China and India); by 2050 its male-to-female life expectancy ratio is projected to surpass India’s. Of the 195 countries studied by Alkema et al. (2014), Pakistan has the third-highest excess female under-5 mortality rate, after India and Afghanistan. Yet there is no research on family contexts that lead to sex differentials in childhood mortality in Pakistan, despite it having high excess female mortality and despite it being prominently featured in studies on the missing women of Asia.

Addressing this gap in the literature, this paper analyzes sex differentials in infant and child mortality in Pakistan while giving theoretical and empirical attention to the birth order and sibling composition contexts within which births occur. Using comprehensive birth history data from three rounds of the Pakistan Demographic and Health Surveys (PDHS), I test whether, similar to previous findings in India and Turkey, the family context in which children are born affects life chances. Specifically, do girls have a higher risk of infant and child mortality and is this risk greater for girls with older sisters? I add further nuance to this analysis by exploring whether it is a preferential treatment of the first son, rather than an aversion to daughters, that is driving sex differentials in mortality during young ages. In other words, do girls experience deprivation that results in higher mortality in comparison to boys? Or is there evidence that only the first-born son has a lower mortality risk relative to daughters and higher-order sons? The specific pattern of discrimination provides clues to the rationale for, and mechanisms causing, differential mortality risk among siblings.

In the next section, I discuss previous literature on the different theoretical and conceptual nuances in son preference and its impact on sex differentials in mortality, and how they apply to the Pakistani context. In Section 3, I describe the data and methods used to identify different types of discrimination based on birth order and sibling sex composition. I present the results of the statistical analysis in Section 4, and in Section 5 I consider the implications of these findings for Pakistan, for broader policy interventions, and for the theoretical understanding of son preference and gender discrimination.

2. Conceptual framework and context

2.1 Theoretical distinctions in son preference and gender discrimination

2.1.1 Generalized versus selective discrimination

Das Gupta’s (1987) analysis of the effect of sex composition on child mortality in Indian Punjab sets the stage for the present analysis. Das Gupta offered a distinction between generalized and selective discrimination based on sex as an explanation for gender inequality in mortality. The generalized discrimination explanation is rooted in the assumption that the low value of women in South Asian culture translates to a generalized tendency among parents to give preferential treatment to sons over daughters (Das Gupta 1987). Excess female mortality is then an unintended (unconscious) consequence of parents’ internalization of gender norms that lead them to treat sons more favorably than daughters. Das Gupta made an important contribution to the theoretical understanding of discriminatory behavior by distinguishing between generalized and selective discrimination. She argued that in societies with a strong desire to have sons and evidence of differential-stopping fertility behavior or sex-selective abortions to meet those desires, it is possible that parents heavily discriminate against some daughters to have fewer girls than boys (Das Gupta 1987). Higher female infant and child mortality is in this way a result of conscious selective neglect of individual children and not a "general pattern of cultural practices that treats all girls differently from boys" (Muhuri and Preston 1991: 431).

2.1.2 Son preference versus daughter aversion

On the other hand, the higher status of, or strong desire for, boys does not in itself guarantee less favorable health outcomes for girls; son preference is related to but distinct from "daughter aversion" (Borooah and Iyer 2004). Daughter aversion (the discrimination against girls discussed above) is an extension of son preference; if sons bring benefits to families and daughters impose costs, then along with the desire to have sons is a complementary desire to *not* have daughters. It is possible then to have varying degrees of son preference and daughter aversion. Borooah and Iyer (2004) argue that in India, son preference is common to Hindus and Muslims, but Muslims show a lower degree of daughter aversion than Hindus. In other words, Muslim parents may prefer to have sons, but once they have daughters, they often do their best to care for them. Thus son preference does not always have to translate to active neglect of or discrimination against all girls, or even girls with older sisters. This may be reflected in the smaller sex differentials in infant mortality found among Muslims relative to Hindus in India (Guillot and Allendorf 2009).

2.1.3 Secondariness of daughters versus unsubstitutability of sons

Elisabeth Croll makes a similar distinction in her book *Endangered Daughters* (2000). Her comprehensive review of demographic and ethnographic work on son preference in Asia (Croll 2000) highlights that children are gendered such that girls are secondary and a supplement to, but rarely a substitute for, boys. Croll argues that notions of "secondariness" and "unsubstitutability" underlie son preference and are reflected in a gender system that focuses on complementarity, not equality (Croll 2000: 17 and 71). The presence of generalized discrimination against daughters reflects the secondariness characteristic of son preference, and preferential treatment of sons, particularly the first son, reflects the unsubstitutability factor.

In this way, son preference and its impact on parental decisions and behaviors regarding individual children are dependent on the degree to which sons are not substitutable and daughters are considered secondary (and costly), both of which affect and are affected by the number of children and the sex composition of previous children.

2.2 Pakistani context

Pakistan presents an interesting context for examining the family contexts in which son preference leads to excess mortality for girls. The world's fifth-most-populous country is arguably one of the worst places for women and girls, consistently ranking in the bottom five for various global gender equality indices (UNDP and UN Women 2023). Pakistan has the highest neonatal mortality rate in the world, has high levels of infant and child mortality, and exhibits evidence of severe gender discrimination in survival favoring boys (UN Population Prospects 2022; UNICEF 2018; Alkema et al. 2014; Bongaarts and Guilmoto 2015). Most studies find that Pakistan has excess female mortality among children (1–4 years) and among the under-5 population (0–4 years) but not specifically with regard to infant mortality (0–1 years) (Sathar 1985; Agha 2000; Gangadharan and Maitra 2000; Nisar and Dibley 2014; Alkema et al. 2014). The 2017–2018 PDHS also reflects this: the male-to-female ratio for infant mortality rate was above one, while the male-to-female ratio for child mortality rate was well below one (NIPS/Pakistan and ICF 2019). Interestingly, the absence of excess female mortality during infancy does not imply a lack of discriminatory practice. For one, it may be that daughter neglect starts early but only cumulatively affects mortality risk. Second, sex differentials in mortality risk change over the first year of life. A recent study that used population-based data to look at mortality risk for different age periods during the first year found that while early neonatal (first week of life) mortality showed a female advantage, there was no female advantage in late neonatal or post-neonatal mortality (Aghai et al. 2020). The same pattern is reflected in the PDHS reports. Girls in Pakistan lose their survival advantage as early as the second week of life.

Pakistani couples also exhibit one of the strongest stated desires for sons. Pakistan has one of the highest desired sex ratios at birth (DSRB), a ratio of the ideal number of boys and girls that men and women would like to have, second only to India (Bongaarts 2013). Unlike India, Pakistan does not yet exhibit strong evidence of sex-selective abortion practices (Chao, Wazir, and Ombao 2021; Sathar et al. 2015; Zaidi and Morgan 2016). Instead, Pakistani couples rely heavily on additional childbearing to realize the desire for sons (Channon 2017; Javed and Mughal 2020, 2022; Zaidi and Morgan 2016). At parities 3 and 4, women with no sons are almost two times as likely to progress to a next birth than those with one or more sons (Zaidi and Morgan 2016). Channon (2017) shows that contraceptive use in Pakistan would be 19 percentage points higher without son-preferential stopping behavior. Moreover, differential stopping behavior (through parity progression, intention to have more children, contraceptive use, or birth spacing) has gotten stronger over time (Javed and Mughal 2020). This reliance on differential stopping behavior is reflected in the relatively high, and slow to decline, levels of fertility in Pakistan. Compared to India, Bangladesh, and Nepal, where women have two births on average, women in Pakistan still have around 3.5 births. Relatedly, contraceptive use remains low, with only around a third of women of reproductive age using any form of contraception.

In this context of a strong desire for sons, relatively high fertility, and weak evidence of sex-selective abortions, how does son preference play out in sex-differential childhood mortality? I use comprehensive birth history data from three rounds of the PDHS to explore whether the risk of dying during infancy and childhood is correlated with not only the sex and birth order of the child but also the sex composition of their previous siblings. Specifically, I test three different hypotheses. The first hypothesis concerns generalized discrimination against girls: Are all daughters at greater risk of mortality relative to sons? In a society with a low status of women and a strong desire for sons, discrimination against daughters may likely be unconscious and generalized. The second hypothesis involves selective discrimination against girls: Are daughters that have older sisters especially disadvantaged? In the absence of sex-selective abortions, active neglect of girls may be the only mechanism for parents to achieve their desired family size and composition together. Conversely, does the desire to have at least one daughter, as shown in previous work focused on Pakistan (Zaidi and Morgan 2016; Channon 2017), translate into higher chances of survival for first-born daughters relative to other girls? And, finally, the third hypothesis involves the selective preferential treatment of first (or the first two) sons: Are first (and second) sons at lower mortality risk than daughters (and later-born sons)? Given the relatively larger family sizes (both actual and desired), perhaps daughters are not considered costly and thus actively neglected. Rather, it is the high value placed on having a son or two that leads Pakistani parents to put greater investments toward ensuring their survival and treating all other children, irrespective of sex, the same. And finally, given that son preference is about the relative values of sons and daughters, both generalized and selective discrimination/treatment could be at play.

3. Data and methods

3.1 Sample

I use pooled data from the 2006–2007, 2012–2013, and 2017–2018 PDHS. All three waves of the PDHS are nationally representative samples of women of reproductive age (15–49) and their households. The PDHS sample for 2006–2007 included information on

10,032 ever-married women and 39,049 births. The 2012–2013 sample was larger, including 13,558 ever-married women and 50,238 births. The 2017–2018 sample included 12,364 ever-married women and 40,832 births. Pooling the datasets provides a large enough sample and enough deaths to allow for a detailed analysis of infant and child mortality.

The PDHS adopts a uniform sampling design consisting of a multistage, systematic, stratified sample of households in rural and urban areas. The PDHS asks for information on women's fertility history, sociodemographic characteristics, and the survival of their children, among other topics. It collects complete birth histories for all female respondents, which allows for the construction of a previous-sibling sex composition for each birth that accounts for multiple births and previous deaths.

3.2 Dependent variables

I use two mutually exclusive categories of mortality: infant mortality during the first year of life and child mortality from age 1 to age 5. It is important to conduct a survival analysis of the two categories of mortality separately because at each stage, different factors impact the chances of survival. Unlike most cross-national studies but similar to Das Gupta's article (1987), I further disaggregate infant mortality into neonatal and post-neonatal mortality categories because biological factors play a greater role during the first month than during the post-neonatal period, when health-seeking behavior and environmental/social factors come into greater play.

The dependent variable is risk of death for infants/children, measured as the duration from birth to the age of death (in months) or right-censoring for each given period of risk corresponding to the three categories of mortality. I restrict my analysis to births during the 10 years preceding each survey. I exclude multiple births from my sample because of their significantly higher risk of mortality compared to singleton births. Of the total 62,346 singleton births in the 10 years preceding the survey from the pooled sample of the three rounds, 4,607 (7.4%) ended in death. Among the deaths, 58% occurred during the first month of life (the neonatal period). Another 28% occurred in the post-neonatal period, and 14% of deaths occurred between the ages of 1 and 5.

3.3 Independent variable

To create the independent variable of interest, I first create a variable to capture the sex composition of older siblings in combination with the sex of the index child at each birth order,[2] based on previous studies (Das Gupta 1987; Rajan and Morgan 2018; Zaidi 2022). Specifically, at every birth order (from 1 to 4+), I include distinct combinations of the sex composition of surviving children (or sibling composition) and the sex of the index child. For example, a third-born boy could have two older sisters (ggB), one older sister and one older brother (gbB), or two older brothers (bbB). In describing the categories of sibling composition within each birth order, I record the number and sex of older siblings but not the order in which they were born. For models analyzing the first birth, the primary independent variable is simply the index child's sex. Since the probability of having certain sibling sex compositions, such as all girls or all boys, gets very small as birth order increases, I group birth order 4 and higher together in "birth order 4+." Since this is an open-ended birth order, I base sibling composition there on the number of same-sex siblings before the index child. For example, a boy who has zero brothers can have three sisters, four sisters, or five sisters, depending on whether his birth order is 4, 5, or 6.

Next I use a modified version of Rajan and Morgan's (2018) analytical strategy to capture unique forms of differential treatment based on sex. Table 1 provides the template for the models used to detect differentials in mortality risk and capture different forms of discrimination and preferential treatment. Models 1 through 3 test the three forms of differential treatment. The rows present the sex of the index birth and the sex composition of previous siblings for each birth order (1–4+). Note that it is not possible to measure nuances in differential treatment based on sex when looking at first-order births. At birth order 1, it is only possible to determine whether boys and girls have significantly different risk of death; in other words, not all the hypotheses can be tested for first births.

Generalized discrimination: The low value of women in Pakistani culture translates to a generalized tendency among parents to invest less in girls. Thus, at any given birth order or sibling composition, parents discriminate against daughters. Under such conditions of generalized discrimination, girls may face a higher infant and childhood mortality risk than boys no matter the birth order or sibling composition. A dichotomous variable *GD* captures this generalized discrimination; it constrains the effect of being a girl (*GD* = 1) to be different from the effect of being a boy (*GD* = 0) within each birth order/composition. For example, for third-order births, all girls (bbG, gbG, ggG), irrespective of their sibling composition, face a different (higher) mortality risk compared to all boys (ggB, gbB, bbB). Higher mortality risk is represented by + in the table and would yield a hazard ratio greater than one.

[2] In this paper, the birth order of the index child is based on the number of older siblings alive at the time of birth. This system excludes siblings who did not survive to the index child's birth. So a boy who was born after two daughters, one of whom died before the birth of the boy, will be a second-order birth in the sample rather than a third-order birth.

Table 1: Models operationalizing different mechanisms of gender discrimination on mortality risk

<table>
<tr><th></th><th></th><th>Model 1</th><th>Model 2</th><th>Model 3</th><th>Model 4</th></tr>
<tr><th></th><th></th><th>Generalized discrimination</th><th>Selective discrimination</th><th>Preferential treatment</th><th>Full</th></tr>
<tr><td rowspan="2">Birth order 1</td><td>B</td><td>(ref)</td><td rowspan="2">n/a</td><td rowspan="2">n/a</td><td>(ref)</td></tr>
<tr><td>G</td><td>+</td><td>1</td></tr>
<tr><td rowspan="4">Birth order 2</td><td>gB</td><td rowspan="2">(ref)</td><td rowspan="2">(ref)</td><td>−</td><td>(ref)</td></tr>
<tr><td>bB</td><td>(ref)</td><td>1</td></tr>
<tr><td>bG</td><td rowspan="2">+</td><td>=/+</td><td rowspan="2">+</td><td>2</td></tr>
<tr><td>gG</td><td>+</td><td>3</td></tr>
<tr><td rowspan="6">Birth order 3</td><td>ggB</td><td rowspan="3">(ref)</td><td rowspan="3">(ref)</td><td>−</td><td>(ref)</td></tr>
<tr><td>bgB</td><td rowspan="2">(ref)</td><td>1</td></tr>
<tr><td>bbB</td><td>2</td></tr>
<tr><td>bbG</td><td rowspan="3">+</td><td>=/+</td><td rowspan="3">+</td><td>3</td></tr>
<tr><td>bgG</td><td rowspan="2">+</td><td>4</td></tr>
<tr><td>ggG</td><td>5</td></tr>
<tr><td rowspan="8">Birth order 4+</td><td>0 brothers, B</td><td rowspan="4">(ref)</td><td rowspan="4">(ref)</td><td>−</td><td>(ref)</td></tr>
<tr><td>1 brother, B</td><td rowspan="3">(ref)</td><td>1</td></tr>
<tr><td>2 brothers, B</td><td>2</td></tr>
<tr><td>3+ brothers, B</td><td>3</td></tr>
<tr><td>0 sisters, G</td><td rowspan="4">+</td><td>=/+</td><td rowspan="4">+</td><td>4</td></tr>
<tr><td>1 sister, G</td><td rowspan="3">+</td><td>5</td></tr>
<tr><td>2 sisters, G</td><td>6</td></tr>
<tr><td>3+ sisters, G</td><td>7</td></tr>
</table>

Selective discrimination against a daughter with older sisters: In a society where parents have a strong desire to have sons and often act on this desire (through differential-stopping behavior in Pakistan's case), it is possible that they heavily discriminate against some of their daughters to ensure that they have fewer girls than boys. Thus, at higher birth orders, daughters with older sisters may exhibit higher infant and child mortality rates than daughters with only older brothers. The variable *SD* captures selective discrimination by constraining the effect of being a girl without an older sister (*SD* = 1) or being a girl with an older sister (SD = 2) to be different than the effect of being a boy (*SD* = 0). So, at birth order 3, it is hypothesized that girls with no older sisters (bbG) will have the same or higher risk of mortality than boys and that girls with older sisters (bgG, ggG) will have a higher risk of mortality than boys. Here, equal risk is represented by = and higher risk is represented by **+**.

Preferential treatment of first sons: Given the strong desire for sons, parents pay special attention to their first-born sons. Therefore first-born boys may have a lower risk of dying than either higher-order boys or all girls. Moreover, the secondariness of daughters and unsubstitutability of a son are not mutually exclusive features of son preference, so both might be reflected in sex differentials in infant and child mortality risk. The dichotomous variable *GDPS1* constrains the effect of being a second or higher-order son (GDPS1 = 0) to be different from the effect of being the first son and

(*GDPS1* = 1) from the effect of being a girl (*GDPS1* = 2). So at birth order 3 it is hypothesized that all girls (bbG, bgG, ggG) will have higher risk of mortality and boys that are first sons (ggB) will have lower risk of mortality compared to other boys (gbB, bbB). Here, lower risk is represented by – and higher risk by **+**.

Lastly, I run a full model that treats every combination of sex and sibling sex composition at every birth order as unique (represented by numbers rather than + or – symbols). Note that I tested several combinations of preferential treatment of sons and selective discrimination against daughters, including preferential treatment of the first son relative to all others, preferential treatment of the first two sons, a combination of selective discrimination and preferential treatment together, and so on. The three models included in the paper are the ones that capture the theoretical distinctions and fit the data best.

3.4 Control variables

The PDHS allows me to include several control variables in my analysis. I chose these variables based on the child mortality framework of Mosley and Chen (2003) as well as studies focusing on child mortality in Pakistan (Asif et al. 2022; Patel, Rai, and Rai 2021; Nisar and Dibley 2014; Agha 2000). I include maternal fertility-related factors, socioeconomic factors, and community-level factors.

Maternal fertility-related characteristics such as mother's age at birth, preceding birth interval, birth order, and singleton or multiple birth have been shown to affect birth outcomes in Pakistan (Cleland and Sathar 1984; Agha 2000). My sample selection and modeling account for the effects of multiple versus singleton births and birth order. I include mother's age at birth, the index child's year of birth, and duration of the preceding birth interval in my analysis.

Socioeconomic factors at the individual and household levels also impact survival chances during infancy and childhood. Parental education and income are strongly correlated with health behaviors and family consumption levels, while access to quality housing, water, and sanitation are important determinants of exposure to environmental contaminants that impact infant health (Asif et al. 2022). My analysis includes the following variables to account for socioeconomic variation: mother's education, father's education, household wealth index,[3] and type of toilet facility. Community-level factors such as the availability of medical facilities and health systems influence parents' ability to provide adequate health care and a clean environment for their children. Health care and sanitation systems vary greatly by region in Pakistan and whether individuals reside

[3] A categorical variable that summarizes the relative wealth of the household based on the type of material used to build the house, water and sanitation access, and availability of household amenities.

in a rural or urban area. Therefore I include both these geographic variables in my analysis.

3.5 Methods

Since the outcome variable in this analysis is the likelihood of death during the first five years of life, I use event history analysis, converting individual child data to person-month data using the *stset* command in Stata. I calculate survival separately for four different time periods: neonatal (0 to 1 month), post-neonatal (1 to 11 months), infant (0 to 11 months combined), and child (12 months to 59 months). For the purpose of simplicity, the results for neonatal and post-neonatal mortality categories are included in Table A-1 and Table A-2 and not discussed in the text of the paper. The results of the analysis for these two groups are in line with the broader findings.

I use the Cox proportional hazard model for all four time periods. Since the first time period has survival over only one unit of time, the proportional hazard assumption is not applicable. For the other three time periods, I tested the proportional hazard assumption using the *estat phtest* command in Stata and found that it held for all three time periods. Prior to estimating the final mortality models, I explored whether evidence of gender discrimination varied over time (by survey year). I also tested for period effects in the models below. There was no significant pattern of change in discrimination over the 11-year time period. Therefore all estimates presented in this paper are based on data pooled from the three rounds of the PDHS.

3.6 Identifying “excess” sex differentials in mortality risk

Studying sex differentials in mortality is a challenging task because these differentials are a result of a complex interplay of behavioral and biological factors over different stages of the life course. Studying sex differentials in child mortality is even more challenging because of changing causes of death over the course of the first few years of life that impact boys and girls differently. It’s also challenging because of the lack of universal and complete vital registration data, and the biases and errors in reporting and sampling that affect survey data.

Moreover, due to the natural female advantage, “equity in survival between females and males does not imply equal mortality rates” (Sawyer 2012: 2). Studies undertaken by the United Nations and others (United Nations 2011; Drevenstedt et al. 2008; Sawyer 2012; Alkema et al. 2014) have made efforts to calculate disaggregated mortality rates by sex and map the trends in sex differentials at different ages (infant, child, and under-

5 mortality) over time and by nation and region. Results show that the natural sex ratio of infant mortality (the rate of female infant mortality divided by the rate of male infant mortality, multiplied by 100) is lower than 100 and usually between 77 and 83. In turn, the expected sex ratio of child mortality and under-5 mortality ranges from 83 to 100. According to previous work on the natural survival advantage of female infants (Alkema et al. 2014; United Nations 2011), in the absence of gender discrimination, girls should exhibit higher rates of survival than boys during the first year of life and, to a smaller degree, during the first four years of life. A hazard ratio (HR) of 1.00 for the risk of dying during infancy reflects gender discrimination against girls rather than equity in risk. In other words, "the lack of a sex effect" does not mean we can reject the hypothesis that boys and girls are treated differently. During infancy, equal treatment would be an HR between 0.77 and 0.83 for girls compared to boys and around 1.00 when comparing girls to other girls or boys to other boys. For child mortality, equal treatment would be an HR between 0.83 and 1.00 for girls compared to boys and around 1.00 when comparing girls to other girls or boys to other boys.

3.7 Model fit

Results of the hazard analyses for each model tell us whether there is a significant difference in the mortality risk faced by boys and girls with different birth order and sibling sex composition combinations. However, to identify what kind of differential treatment (discrimination against girls, preferential treatment of the first son, or both) is at play, we need to determine which of these three models best fits the data. I identify the preferred model based on the joint considerations of model fit to the data, parsimony, significant coefficients, and substantive plausibility for each outcome (infant mortality and child mortality) across birth orders 1–4+. Since my models are non-nested, I use the AIC statistic to identify the best-fitting (preferred) model (Fabozzi et al. 2014; Raftery 1995). It should be noted that because the AIC adjusts for degrees of freedom, it captures the tradeoff in fit and parsimony. The best-fitting model, given the degrees of freedom, is thus indicated by the lowest AIC value. I take Raftery's (1995: 139) classification of an AIC difference greater than four to be clear evidence of improvement between models. I take an AIC difference of less than two to be weak evidence of a difference between models.

4. Results

4.1 Descriptive statistics

Table 2 shows the birth order and sibling sex composition of the sample by mortality status. In the sample of 62,346 births, 7.4% end in death by the age of 5. At any given birth order, most deaths take place during the first year of life; 6.4% of deaths occur during infancy versus 1% between ages 1 and 5. Several interesting patterns are visible when looking at sibling sex composition differences within each birth order. The natural female advantage is visible at birth order 1; a lower proportion of first-order girls die during infancy than first-order boys – 6.9% versus 8.4%. For second-order births, girls have lower infant mortality rates than boys, but the difference is smaller compared to first-order births, and sibling sex composition does not affect mortality rates. However, when looking at child mortality, first sons (boys with no brothers) have a much lower proportion dying between the ages of 1 and 5 than girls or than boys with an older brother, all of whom have similar rates. Among third-order births, there is no clear pattern in infant mortality, but boys with no older brother (ggB) or just one older brother (bgB) – that is, the first two sons – have a lower percentage dying during childhood than other children. At higher birth orders (4+), first-order boys (boys with no brothers) have a lower proportion dying during infancy compared to others. There is no clear pattern of discrimination in child mortality among high-order births. Overall, this table shows that mortality varies by both the sex of the child and sibling sex composition.

Table 2: Percentage of children born in the 10 years preceding the survey by mortality status and sibling sex composition

		Infant mortality	Child mortality	Living	Total (N)
Birth order 1	B	8.4	0.9	90.7	7,740
	G	6.9	0.9	92.2	6,993
	All	7.7	0.9	91.4	14,733
Birth order 2	gB	6.1	0.4	93.4	3,142
	bB	6.1	1.1	92.8	3,450
	bG	5.6	1.2	93.2	3,214
	gG	5.5	1.1	93.4	3,036
	All	5.8	0.9	93.2	12,842
Birth order 3	ggB	6.1	0.5	93.3	1,353
	bgB	5.7	0.6	93.7	2,601
	bbB	7.6	1.0	91.4	1,456
	bbG	5.0	1.3	93.7	1,373
	bgG	5.6	1.1	93.3	2,536
	ggG	6.2	1.1	92.8	1,299
	All	6.0	0.9	93.1	10,618
Birth order 4+	0 brothers, B	3.9	1.0	95.1	937
	1 brother, B	6.2	1.2	92.6	3,219
	2 brothers, B	6.6	0.9	92.5	3,885
	3+ brothers, B	6.3	1.2	92.5	4,480
	0 sisters, G	5.8	1.2	93.1	850
	1 sister, G	5.7	0.9	93.4	2,649
	2 sisters, G	6.3	1.6	92.2	3,509
	3+ sisters, G	5.5	1.4	93.1	4,624
	All	6.0	1.2	92.8	24,153
	Total	6.4	1.0	92.6	62,346

The distribution of childhood mortality and survival across relevant demographic, socioeconomic, and community characteristics is presented in Table 3. The table shows that mortality levels have declined over time (year of birth), are higher among birth orders 1 and 4+, and are lower among births with preceding intervals longer than two years. As expected, mortality is higher among children of poorer households, households with unimproved or no-flush toilet systems, rural areas, and parents with no education.

Table 3: Sample of births and deaths by demographic, socioeconomic, and community characteristics (%)

		Deceased	Living	All
Individual-level and fertility-related characteristics				
Sex	Male	7.8	92.2	32,263
	Female	7.3	92.7	30,083
Age	< 6 months	6.1	93.9	3,222
	6–11 months	5.4	94.6	2,861
	12–17 months	6.9	93.1	3,361
	18–23 months	7.2	92.8	2,411
	2 years	6.7	93.3	6,113
	3 years	6.7	93.3	6,402
	4 years	7.2	92.8	6,169
	5+ years	8.4	91.6	31,807
Birth order	1	8.7	91.3	14,733
	2	6.9	93.1	12,842
	3	7.0	93.0	10,618
	4+	7.6	92.4	38,193
Year of birth	1996–2000	9.2	90.8	8,040
	2001–2005	8.5	91.5	15,808
	2006–2010	7.6	92.4	19,820
	2011–2015	6.1	93.9	14,589
	2016–2018	5.5	94.5	4,089
Preceding birth interval	< 2 years	11	89	19,195
	2 years	5.6	94.4	15,178
	3 years	4.8	95.2	7,094
	4+ years	4.4	95.6	7,337
Socioeconomic characteristics				
Household wealth index	Poorest	10.0	90.1	14,883
	Poorer	8.4	91.7	13,291
	Middle	7.3	92.7	12,284
	Richer	6.3	93.8	11,206
	Richest	4.7	95.3	10,682
Flush system	Flush to sewer system	6.4	93.6	38,144
	Flush to other	9.4	90.6	24,202
Mother's education	No education	8.7	91.3	38,843
	Primary	7.4	92.7	8,294
	Secondary	5.3	94.7	9,537
	Higher	3.4	96.6	5,672
Father's education	No education	9.3	90.7	22,259
	Primary	8.4	91.7	9,244
	Secondary	6.8	93.2	19,004
	Higher	4.7	95.3	11,839
Community-level characteristics				
Place of residence	Urban	6.3	93.8	25,599
	Rural	8.4	91.6	36,747
Region	Punjab	8.1	91.9	21,916
	Sindh	8.1	91.9	14,576
	KP	5.9	94.1	12,189
	Balochistan	7.8	92.2	9,552
	Gilgit/Baltistan	6.9	93.1	4,113
Total		7.5	92.5	62,346

4.2 Hazard models

Tables 4 and 5 present the results of Cox proportional hazards analysis specific to the birth order and sibling sex composition for infant and child mortality, respectively. Each row of the tables presents each sibling-sex composition/sex of index child combination for birth orders 1 to 4+ as well as the AIC statistic for each birth order. The columns present the three different models of differential treatment that map onto the three hypotheses discussed above as well as a full model. The numbers in the cells are the hazard ratios for the specific sibling sex composition/sex of index child within each birth order compared to the category or categories of sibling sex composition/sex of index child within that birth order with a – symbol in the cell. All regression models for both infant and child mortality control for province, rural residence, household wealth status, type of toilet facility, mother's education, father's education, preceding birth interval, and birth year. Hazard ratios for the control variables are available upon request.

4.2.1 Infant mortality

Results of the survival analysis support the presence of a female biological advantage during the first year of life in Pakistan for first-order births most clearly. Model 1 of Table 4 shows that first-order daughters have a 17% lower risk of dying during the first year (hazard ratio of 0.830) than first-order sons, even when controlling for sociodemographic differences. This ratio of female-to-male infant mortality is in line with the global average for developing countries (Alkema et al. 2014; United Nations 2011) and would indicate the absence of discrimination against girls.

The female survival advantage halves among second-order births. The results for generalized discrimination show that second-order girls have an 8.9% lower mortality risk (HR: 0.911) than second-order boys, with the upper limit of the confidence interval for the ratio showing no advantage (HR: 1.052). As seen in the hazard ratios for model 2, girls with an older sister and girls without an older sister have similar mortality risks relative to boys. Hazard ratios close to one (with upper limits of confidence intervals higher than one) suggest that there is discrimination against girls in the first year of life, but it is not directed toward or stronger for girls with an older sister. There is also no evidence that boys who are the first sons (gB) have a lower mortality risk than boys with older brothers. The hazard ratios and AIC statistics across all models of discrimination suggest that the model for generalized discrimination best captures the mortality differentials among second-order births.

Table 4: Hazard ratios for infant mortality

<table>
<tr><th></th><th></th><th>Model 1
Generalized discrimination</th><th>Model 2
Selective discrimination</th><th>Model 3
Preferential treatment</th><th>Model 4
Full</th></tr>
<tr><td rowspan="2">Birth order 1</td><td>B</td><td>(ref)</td><td rowspan="2">n/a</td><td rowspan="2">n/a</td><td rowspan="2"></td></tr>
<tr><td>G</td><td>0.8298
(0.7374 – 0.9337)</td></tr>
<tr><td rowspan="5">Birth order 2</td><td>gB</td><td rowspan="2">(ref)</td><td rowspan="2">(ref)</td><td>1.0224
(0.8403 – 1.2441)</td><td>(ref)</td></tr>
<tr><td>bB</td><td>(ref)</td><td>0.9781
(0.8038 – 1.1901)</td></tr>
<tr><td>bG</td><td rowspan="2">0.9110
(0.7891 – 1.0519)</td><td>0.9250
(0.7758 – 1.1029)</td><td rowspan="2">0.9207
(0.7755 – 1.0931)</td><td>0.9143
(0.7459 – 1.1207)</td></tr>
<tr><td>gG</td><td>0.8965
(0.7483 – 1.0740)</td><td>0.8861
(0.7199 – 1.0906)</td></tr>
<tr><td>AIC</td><td>13908</td><td>13910</td><td>13910</td><td>13912</td></tr>
<tr><td rowspan="7">Birth order 3</td><td>ggB</td><td rowspan="3">(ref)</td><td rowspan="3">(ref)</td><td>0.9585
(0.7481 – 1.2281)</td><td>(ref)</td></tr>
<tr><td>bgB</td><td rowspan="2">(ref)</td><td>0.9312
(0.7114 – 1.2190)</td></tr>
<tr><td>bbB</td><td>1.2445
(0.9353 – 1.6560)</td></tr>
<tr><td>bbG</td><td rowspan="3">0.881
(0.7535 – 1.0308)</td><td>0.8015
(0.6174 – 1.0405)</td><td rowspan="3">0.8721
(0.7373 – 1.0315)</td><td>0.8283
(0.6008 – 1.1421)</td></tr>
<tr><td>bgG</td><td rowspan="2">0.9088
(0.7674 – 1.0762)</td><td>0.9071
(0.6915 – 1.1900)</td></tr>
<tr><td>ggG</td><td>0.9984
(0.7341 – 1.3579)</td></tr>
<tr><td>AIC</td><td>11486</td><td>11487</td><td>11488</td><td>11487</td></tr>
<tr><td rowspan="9">Birth order 4+</td><td>0 brothers, B</td><td rowspan="4">(ref)</td><td rowspan="4">(ref)</td><td>0.6314
(0.4536 – 0.8789)</td><td>(ref)</td></tr>
<tr><td>1 brother, B</td><td rowspan="3">(ref)</td><td>1.5412
(1.0849 – 2.1894)</td></tr>
<tr><td>2 brothers, B</td><td>1.6579
(1.1741 – 2.3410)</td></tr>
<tr><td>3+ brothers, B</td><td>1.5477
(1.0977 – 2.1824)</td></tr>
<tr><td>0 sisters, G</td><td rowspan="4">0.9267
(0.8359 – 1.0274)</td><td>0.9746
(0.7299 – 1.3014)</td><td rowspan="4">0.9044
(0.8148 – 1.0039)</td><td>1.5002
(0.9787 – 2.2998)</td></tr>
<tr><td>1 sister, G</td><td rowspan="3">0.9263
(0.8337 – 1.0291)</td><td>1.4724
(1.0277 – 2.1096)</td></tr>
<tr><td>2 sisters, G</td><td>1.5436
(1.0891 – 2.1877)</td></tr>
<tr><td>3+ sisters, G</td><td>1.3153
(0.9310 – 1.8583)</td></tr>
<tr><td>AIC</td><td>28810</td><td>28802</td><td>28794</td><td>28800</td></tr>
</table>

Notes: Controlling for province, rural residence, household wealth status, type of flush system, mother's education, father's education, preceding birth interval, and birth year; 95% confidence intervals in parentheses.

For third-order births there is evidence that sibling sex composition plays a role in chances of survival. The risk of death for all girls is lower (HR: 0.881) than for all boys, as seen in model 1 (*generalized discrimination*). There is some evidence of selective discrimination (model 2) because the risk of dying is higher for girls with older sisters

(HR: 0.91) than for girls with no older sisters (HR: 0.80) compared to boys. Girls who are the first daughter after two sons keep their survival advantage, while those with older sisters see a reduction in theirs. Model 3 shows that first sons of the third birth order have a mortality risk (HR: 0.96) similar to boys with older brothers. The AIC does not offer a best-fitting model. The presence of selective treatment is best illustrated by the full model (model 4), which finds that the risk of death for the second son is similar to that of the first son (HR: 0.93), while the risk of death is higher for a boy who is the third son (HR: 1.25). The full model also shows that the first daughter has a lower risk of death (HR: 0.83) relative to the first son than girls with one or two older sisters (HR: 0.91 and 0.99).

At birth order 4 or higher, the comparison of models capturing generalized discrimination and selective discrimination (models 1 and 2) shows that girls with older sisters are not worse off – the hazard ratio is around 0.93 whether looking at all girls or looking at girls with older sisters separately. According to model 3 (*preferential treatment of first son*), a boy born after three or more daughters has 37% less risk of dying during infancy (HR: 0.63) than boys with older brothers. This suggests that parents go above and beyond to ensure the survival of their first son at high parities, so much so that this preferential treatment not only eliminates the female advantage at the aggregate level but also ensures significantly higher survival of first sons than survival for all other births in order 4+ (also seen in the full model). Model 3 is also the best-fitting model according to the AIC statistic. There is also evidence of generalized discrimination against all girls.

4.2.2 Child mortality

The results for child mortality (age 1 to 5) in Table 5 show that for first-order births there is no effect of sex on survival. Since the natural female advantage in mortality dissipates after early infancy, the almost equal risk of death (HR: 1.06) for girls relative to boys suggests slight discrimination against girls but does not conclusively indicate gender discrimination at this age.

Table 5: Hazard ratios for child mortality

		Model 1	*Model 2*	*Model 3*	*Model 4*
		Generalized discrimination	**Selective discrimination**	**Preferential treatment**	**Full**
Birth order 1	B	(ref)	n/a	n/a	
	G	1.0635 (0.7553 – 1.4973)			
Birth order 2	gB	(ref)	(ref)	0.4127 (0.2233 – 0.7627)	(ref)
	bB			(ref)	2.4326 (1.3114 – 4.4791)
	bG	1.4275 (0.9955 – 2.0469)	1.509 (0.9894 – 2.3029)	1.0316 (0.6935 – 1.5345)	2.6450 (1.4285 – 4.8974)
	gG		1.3432 (0.8642 – 2.0878)		2.3509 (1.2539 – 4.4078)
	AIC	2133	2135	2126	2128
Birth order 3	ggB	(ref)	(ref)	0.6772 (0.2970 – 1.5441)	(ref)
	bgB			(ref)	1.1725 (0.4774 – 2.8799)
	bbB				1.9936 (0.8113 – 4.8991)
	bbG	1.6332 (1.0821 – 2.4651)	1.8434 (1.0485 – 3.2409)	1.4984 (0.9648 – 2.3269)	2.4984 (1.0420 – 5.9902)
	bgG		1.5553 (0.9965 – 2.4275)		2.1244 (0.9235 – 4.8871)
	ggG				2.0747 (0.8360 – 5.1485)
	AIC	1696	1698	1697	1701
Birth order 4+	0 brothers, B	(ref)	(ref)	0.9124 (0.4637 – 1.7952)	(ref)
	1 brother, B			(ref)	1.2803 (0.6200 – 2.6437)
	2 brothers, B				0.9067 (0.4355 – 1.8876)
	3+ brothers, B				1.1324 (0.5582 – 2.2973)
	0 sisters, G	1.2300 (0.9773 – 1.5480)	1.1271 (0.5926 – 2.1435)	1.2223 (0.9670 – 1.5449)	1.2259 (0.4978 – 3.0192)
	1 sister, G		1.2378 (0.9799 – 1.5635)		0.8933 (0.4132 – 1.9315)
	2 sisters, G				1.6259 (0.8030 – 3.2920)
	3+ sisters, G				1.3980 (0.6963 – 2.8066)
	AIC	5645	5647	5647	5649

Notes: Controlling for province, rural residence, household wealth status, type of flush system, mother's education, father's education, preceding birth interval, and birth year; 95% confidence intervals in parentheses.

The analysis of childhood mortality for second-order births finds sex differences in the risk of dying within certain family contexts. In Model 1, which captures general discrimination, the risk of dying for girls of the second order (bG, gG) is 43% more (HR: 1.43) than for second-order boys (gB, bB). Model 2 shows that girls with older sisters are not discriminated against more than girls who are the first daughter in a two-child family. Model 3 shows that the risk of dying during childhood for a boy who is the first son (gB) is less than half (HR: 0.41) compared to boys with older brothers (bB) and that mortality risks of girls are similar to those of boys with older brothers (HR: 1.04). Model 3 is also the best-fitting model according to the AIC statistic for second-order births.

Among third-order births, there is again no evidence of selective discrimination against girls with older sisters (model 2). There is still evidence of the preferential treatment of first sons, as well as evidence suggesting generalized discrimination against all girls. Model 3 shows that compared to boys with older brothers, boys who are first sons (ggB) are 33% less likely to die and girls are 50% more likely to die. There is no best-fitting model of discrimination based on the AIC, and the full model suggests that it may be the first two sons who are advantaged compared to all others.

Finally, for births in the 4+ order, the risk of dying during childhood (after having survived that first year of life) is affected by sibling sex composition and sex of the index child. The comparison of models 1 and 2 does not show strong indication of selective discrimination against girls with older sisters. When looking at model 3, there is some evidence of preferential treatment of first sons and discrimination against all girls. However, due to small sample sizes and numbers of cases in certain sibling sex composition categories, confidence intervals for estimates in all models are wide and make it difficult to reach a strong conclusion about the form of differential treatment among very high-order births.

5. Summary and discussion

In the son-preference literature, generalized discrimination is said to reflect widely held schemas of the different value of, and perceived needs for, girls and boys, or the broader culture of gender, where women have a lower status than men (Das Gupta 1987; Rajan and Morgan 2018). On the other hand, the theoretical focus of the selective discrimination literature is the behavior of individuals (parents), often acting as “utility maximizers,” who have economic incentives to ensure having sons and avoid having daughters (Edlund 1999; Rosenblum 2013: 152). Borrowing from Borooah and Iyer (2004), I argue that within the category of selective treatment, there is a need to make a distinction between active neglect of, or aversion to, daughters with older sisters and preferential treatment given to the first son.

The primary focus of this paper is to distinguish between the different types of differential treatment that best capture the sex differences in infant and child mortality in Pakistan. Specifically, are sex differentials in mortality a result of generalized discrimination against all girls, selective neglect of girls with older sisters, and/or preferential treatment of the first son?

The results of my analysis show that during the first year of life only, first-order girls experience the natural female advantage in mortality. The female advantage declines and even disappears among second- and higher-order births. Regardless of how gender-based differential treatment is operationalized, there is clear evidence of gender discrimination that works against girls. There is also evidence of preferential treatment of first sons in a family of four or more children; first sons in large families have a much lower risk of dying during infancy than other children.

For childhood mortality, in the absence of differential treatment, there should either be a slight female advantage (carrying forward from the first year of life) or no difference in the chance of survival between boys and girls. Unfortunately, I find that to be the case only for first-order births in Pakistan; first-born girls and boys have similar mortality risk. At higher birth orders, gender discrimination against girls is highly visible. For second-order births, there is evidence of preferential treatment given to the first son. For birth order 3, there is evidence of preferential treatment of the first son and generalized discrimination against girls. While hazard ratios for birth order 4+ should be interpreted with caution due to the small sample size, results seem to suggest that there is preferential treatment of the first son and generalized discrimination against all girls.

The clearest overall result from this study is that gender and family context matter for infant and childhood mortality in Pakistan. Whether this equates to preferential treatment of sons or discrimination against daughters, the findings strongly suggest that parents treat their children differently based on sex, sibling composition, and birth order. Moreover, the effect of sex on survival gets stronger over the course of childhood, strongly suggesting that differential treatment experienced in childhood may have a cumulative effect over time. This analysis also confirms the importance of distinguishing between infant and child mortality. The effect of sex, birth order, and sibling sex composition varies for infant and child mortality.

In terms of the forms of gender discrimination, there is very little evidence supporting the “selective discrimination against girls with older sisters” hypothesis. Except for third-order girls during infancy, girls who have older sisters are not worse off than girls who are the first daughter. At no other birth order for infant mortality and at no birth order for child mortality is there evidence of this form of selective discrimination. Furthermore, I argue that rather than signaling active neglect of “redundant” girls to alter the sex composition of children, this selective discrimination in three-children families reflects the secondary desire for having a daughter in addition to sons reported by Pakistani parents.

There is also strong evidence of selective preferential treatment given to the first son in large families during infancy and in families of all sizes during childhood. During infancy, among families of four or more children, first sons have a 37% lower risk of dying than boys with older brothers. During childhood, when the role of behavioral factors becomes stronger than that of biological factors, the preferential treatment of first sons, giving them a survival advantage, is visible among second- and third-order births as well. In smaller families it is harder to distinguish between discrimination against girls and preferential treatment of sons or to determine whether both are present. However, in larger families it is evident that there is preferential treatment of first sons along with generalized discrimination against all daughters (see birth orders 3 and 4+ for infant and child mortality).

The findings of this paper support the theoretical understanding of son preference proposed by Croll (2000). Evidence of the presence of generalized discrimination against daughters and preferential treatment of the first son reflects the secondariness and unsubstitutability features of son preference, respectively. Shifting the focus from selective discrimination against daughters to selective preferential treatment of first sons enables us to incorporate the unsubstitutability aspects of son preference into the analysis. Moreover, conceptualizing and operationalizing son preference in this nuanced way highlights the need to look at it from both individual and structural perspectives and acknowledges the interaction between the two.

Despite its methodological and theoretical contributions, this paper has limitations. Since mortality is a relatively rare occurrence, even in a high-mortality society such as Pakistan, small sample sizes sometimes result in large standard errors, especially when looking at patterns across each sibling sex composition/sex of index child/birth order combination. But I stress that the sample sizes in the PDHS are large and that no other publicly available data allow for the analysis I report here. Second, this analysis also leaves room for further investigation of the patterns of discrimination for the proximate causes of infant and child mortality. However, studies looking at the effect of birth order and sex composition of siblings on Pakistani child health outcomes, such as immunization, breastfeeding, and health care–seeking behavior, confirm the findings of this paper. These studies also find evidence of generalized discrimination against girls and the preferential treatment of boys who are the first son in the family (Chaudhry and Khan 2020; Zaidi 2022). Third, the strong practice of son-preferring fertility-stopping behaviors in Pakistan implies that girls tend to belong to larger families and at earlier parities. Although the use of birth-order-specific models and control for household education and wealth in this analysis mitigates some of this implicit form of discrimination, there are likely some unobserved family-level effects of son preference on mortality.

While further research and data are needed to understand the pathways to excess mortality while controlling for unobserved family differences, the results of this paper clearly show the presence of selective treatment of first sons in Pakistan. They also present evidence of generalized discrimination against girls. Therefore combatting the discrimination that leads to female disadvantages should not simply mean that parents be instructed to change their behavior through awareness campaigns and incentive programs focusing on girl children. The broader social structure comprising institutions of patrilineality, patrilocality, and dowry, which incentivizes parents to go above and beyond to ensure the survival of a son rather than a daughter, needs to be accounted for and addressed. Further research is needed to deepen our understanding of son preference and its motivations and to design more effective policies. To this end, analyzing variations in the strength and type of differential treatment across income, education, and regional groups will be invaluable.

References

Agha, S. (2000). The determinants of infant mortality in Pakistan. *Social Science and Medicine* 51(2): 199–208. doi:10.1016/S0277-9536(99)00460-8.

Aghai, Z.H., Goudar, S.S., Patel, A., Saleem, S., Dhaded, S.M., Kavi, A., and Derman, R.J. (2020). Gender variations in neonatal and early infant mortality in India and Pakistan: A secondary analysis from the Global Network Maternal Newborn Health Registry. *Reproductive Health* 17:1–11. doi:10.1186/s12978-020-01028-0.

Alkema, L., Chao, F., You, D., Pedersen, J., and Sawyer, C.C. (2014). National, regional, and global sex ratios of infant, child, and under-5 mortality and identification of countries with outlying ratios: A systematic assessment. *The Lancet Global Health* 2(9): e521–e530. doi:10.1016/S2214-109X(14)70280-3.

Altindag, O. (2016). Son preference, fertility decline, and the nonmissing girls of Turkey. *Demography* 53(2): 541–566. doi:10.1007/s13524-016-0455-0.

Arnold, F., Choe, K., and Roy, T.K. (1998). Son preference, the family-building process and child mortality in India. *Population Studies* 52(3): 301–315. doi:10.1080/0032472031000150486.

Asif, M.F., Ali, S., Ali, M., Abid, G., and Lassi, Z.S. (2022). The moderating role of maternal education and employment on child health in Pakistan. *Children* 9(10): 1559. doi:10.3390/children9101559.

Attane, I. (2009). The determinants of discrimination against daughters in China: Evidence from a provincial-level analysis. *Population Studies* 63(1): 87–102. doi:10.1080/00324720802535023.

Bairagi, R. (2001). Effects of sex preference on contraceptive use, abortion and fertility in Matlab. *International Family Planning Perspectives* 27(3): 137–143. doi:10.2307/2673835.

Basu, D. and De Jong, R. (2010). Son targeting fertility behavior: Some consequences and determinants son targeting fertility behavior. *Demography* 47(2): 521–536. doi:10.1353/dem.0.0110.

Bongaarts, J. (2013). The implementation of preferences for male offspring. *Population and Development Review* 39(2): 185–208. doi:10.1111/j.1728-4457.2013.00588.x.

Bongaarts, J. and Guilmoto, C.Z. (2015). How many more missing women? Excess female mortality and prenatal sex selection, 1970–2050. *Population and Development Review* 41(2): 241–269. doi:10.1111/j.1728-4457.2015.00046.x.

Borooah, V. and Iyer, S. (2004). Religion and fertility in India: The role of son preference and daughter aversion. (Cambridge Working Papers in Economics).

Brinda, E.M., Rajkumar, A.P., and Enemark, U. (2015). Association between gender inequality index and child mortality rates: A cross-national study of 138 countries. *BMC Public Health* 15(97). doi:10.1186/s12889-015-1449-3.

Chamarbagwala, R. (2011). Sibling composition and selective gender-based survival bias. *Journal of Population Economics* 24(3): 935–955. doi:10.1007/s00148-010-0314-z.

Channon, M.D. (2015). Son preference, parity progression and contraceptive use in South Asia. *Population Horizons* 12(1): 24–36. doi:10.1515/pophzn-2015-0004.

Channon, M.D. (2017). Son preference and family limitation in Pakistan : A parity- and contraceptive method – specific analysis. *International Perspectives on Sexual and Reproductive Health* 43(3): 99–110. doi:10.1363/43e4317.

Chao, F., Wazir, M.A., and Ombao, H. (2021). Levels and trends in sex ratio at birth in provinces of Pakistan from 1980 to 2020 with scenario-based missing female birth projections to 2050: A Bayesian modeling approach. SocArXiv Nov 3. doi:10.31235/osf.io/5n3y8.

Chaudhry, T.T. and Khan, M. (2020). Effects of birth order and son preference on utilization of pre-and post-natal health inputs in Punjab. *Journal of the Pakistan Medical Association* 70(1): 110–115. doi:10.5455/JPMA.300923.

Cleland, J.G. and Sathar, Z.A. (1984). The effect of birth spacing on childhood mortality in Pakistan. *Population Studies* 38(3): 401–418. doi:10.1080/00324728.1984.10410300.

Costa, J.C., da Silva, I.C.M., and Victora, C.G. (2017). Gender bias in under-five mortality in low/middle-income countries. *BMJ Global Health* 2(2): e000350. doi:10.1136/bmjgh-2017-000350.

Croll, E. (2000). *Endangered daughters: Discrimination and development in Asia*. London: Psychology Press.

Croll, E. (2001). Amertya Sen's 100 million missing women. *Oxford Development Studies* 29(3): 225–244. doi:10.1080/13600810120088840.

Das Gupta, M. (1987). Selective discrimination against female children in rural Punjab, India. *Population and Development Review* 13(1): 77–100. doi:10.2307/1972121.

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* 105(13): 5016–5021. doi:10.1073/pnas.0800221105.

Edlund, L. (1999). Son preference, sex ratios, and marriage patterns. *Journal of Political Economy* 107(6): 1275–1304. doi:10.1086/250097.

Fabozzi, F., Focardi, S.M., Rachev, T., and Arshanapalli, B.G. (2014). *Appendix E: Model selection criterion: AIC and BIC*. John Wiley and Sons, Inc. doi:10.1002/9781118856406.app5.

Gangadharan, L. and Maitra, P. (2000). Does child mortality reflect gender bias? Evidence from Pakistan. *Indian Economic Review* 35(2): 113–131.

Guillot, M. and Allendorf, K. (2010). Hindu-Muslim differentials in child mortality in India. *Genus* 66(2).

Guilmoto, C.Z. (2009). The sex ratio transition in Asia. *Population and Development Review* 35(3): 519–549. doi:10.1111/j.1728-4457.2009.00295.x.

Javed, R. and Mughal, M. (2020). Preference for boys and length of birth intervals in Pakistan. *Research in Economics* 74(2): 140–152. doi:10.1016/j.rie.2020.04.001.

Javed, R. and Mughal, M. (2022). Changing patterns of son preference and fertility in Pakistan. *Journal of International Development* 34(6): 1086–1109. doi:10.1002/jid.3618.

Jayaraman, A., Mishra, V., and Arnold, F. (2009). The relationship of family size and composition to fertility desires , contraceptive adoption and method choice in South Asia. *International Perspectives on Sexual and Reproductive Health* 35(1): 29–38. doi:10.1363/3502909.

Kabeer, N., Huq, L., and Mahmud, S. (2014). Diverging stories of ‘missing women’ in South Asia: Is son preference weakening in Bangladesh? *Feminist Economics* 20(4): 138–163. doi:10.1080/13545701.2013.857423.

Kashyap, R. and Behrman, J. (2020). Gender discrimination and excess female under-5 mortality in India: a new perspective using mixed-sex twins. *Demography* 57(6): 2143–2167. doi:10.1007/s13524-020-00909-0.

Khera, R., Jain, S., Lodha, R., and Ramakrishnan, S. (2014). Gender bias in child care and child health: Global patterns. *Archives of Disease in Childhood* 99(4): 369–374. doi:10.1136/archdischild-2013-303889.

Mishra, S.K., Ram, B., Singh, A., and Yadav, A. (2018). Birth order, stage of infancy and infant mortality in India. *Journal of Biosocial Science* 50(5): 604–625. doi:10.1017/S0021932017000487.

Mosley, W.H. and Chen, L.C. (2003). An analytical framework for the study of child survival in developing countries. *Bulletin of the World Health Organization* 81(2): 140.

Muhuri, P.K. and Preston, S.H. (1991). Effects of family composition on mortality differentials by sex among children in Matlab, Bangladesh. *Population and Development Review* 17(3): 415–434. doi:10.2307/1971948.

National Institute of Population Studies – NIPS/Pakistan and ICF (2019). *Pakistan Demographic and Health Survey 2017-18*. Islamabad, Pakistan and Rockville, Maryland: NIPS and ICF.

Nisar, Y.B. and Dibley, M.J. (2014). Determinants of neonatal mortality in Pakistan: Secondary analysis of Pakistan Demographic and Health Survey 2006–07. *BMC Public Health* 14(1): 663. doi:10.1186/1471-2458-14-663.

Patel, K.K., Rai, R., and Rai, A.K. (2021). Determinants of infant mortality in Pakistan: Evidence from Pakistan Demographic and Health Survey 2017–18. *Journal of Public Health* 29: 693–701. doi:10.1007/s10389-019-01175-0.

Raftery, A.E. (1995). Bayesian model selection in social research. *Sociological Methodology* 25(1995): 111–163. doi:10.2307/271063.

Raj, A., Johns, N.E., McDougal, L., Trivedi, A., Bharadwaj, P., Silverman, J.G., Kumar, K., Ladusingh, L., and Singh, A. (2019). Associations between sex composition of older siblings and infant mortality in India from 1992 to 2016. *EClinicalMedicine* 14(2019): 14–22. doi:10.1016/j.eclinm.2019.08.016.

Rajan, S. and Morgan, S.P. (2018). Selective versus generalized gender bias in childhood health and nutrition: Evidence from India. *Population and Development Review* 44(2): 231–255. doi:10.1111/padr.12132.

Rosenblum, D. (2013). The effect of fertility decisions on excess female mortality in India. *Journal of Population Economics* 26(1): 147–180. doi:10.1007/s00148-012-0427-7.

Sathar, Z.A. (1985). Infant and child mortality in Pakistan: Some trends and differentials. *Journal of Biosocial Science* 17(3): 351–360. doi:10.1017/S0021932000015820.

Sathar, Z.A., Rashida, G., Hussain, S., and Hassan, A. (2015). Evidence of son preference and resulting demographic and health outcomes in Pakistan. Islamabad: Population Council. doi:10.31899/pgy9.1085.

Sawyer, C.C. (2012). Child mortality estimation: Estimating sex differences in childhood mortality since the 1970s. *PLoS Medicine* 9(8). doi:10.1371/journal.pmed.1001287.

Sen, A. (1992). Missing women. *BMJ British Medical Journal* 304(6827): 587–588. doi:10.1136/bmj.304.6827.587.

UNICEF (2018). *Every child alive:The urgent need to end newborn deaths*. Geneva: UNICEF.

United Nations Department of Economic and Social Affairs Population Division (2011). Sex differentials in childhood mortality. (United Nations 228).

United Nations Department of Economic and Social Affairs, Population Division (2022). World Population Prospects 2022: Summary of results. (UN DESA/POP/2022/TR/NO. 3). New York City, NY: UNDESA.

United Nations Development Programme (UNDP) and United Nations Entity for Gender Equality and the Empowerment of Women (UN Women) (2023). *The paths to equal: Twin indices on women's empowerment and gender equality*. New York.

Zaidi, B. (2022). Son preference and sex differentials in receipt of key dimensions of children's healthcare: Evidence from Pakistan. *Population Studies* 76(2): 309–328. doi:10.1080/00324728.2022.2032290.

Zaidi, B. and Morgan, S.P. (2016). In the pursuit of sons: Additional births or sex-selective abortion in Pakistan? *Population and Development Review* 42(4): 693–710. doi:10.1111/padr.12002.

Appendix

Table A-1: Hazard ratios for neonatal mortality

	Model 1	*Model 2*	*Model 3*	*Model 4*
	Generalized discrimination	Selective discrimination	Preferential treatment	Full
B	(ref)	n/a	n/a	
G	0.7355 (0.6406 – 0.8445)			
gB	(ref)	(ref)	1.1055 (0.8692 – 1.4060)	(ref)
bB			(ref)	0.9046 (0.7113 – 1.1505)
bG	0.9069 (0.7600 – 1.0822)	0.9073 (0.7268 – 1.1306)	0.9522 (0.7692 – 1.1788)	0.8617 (0.6720 – 1.1050)
gG		0.9065 (0.7268 – 1.1306)		0.8610 (0.6694 – 1.1074)
AIC	9240	9242	9241	9243
ggB	(ref)	(ref)	0.9659 (0.7144 – 1.3061)	(ref)
bgB			(ref)	0.9599 (0.6932 – 1.3290)
bbB				1.1736 (0.8252 – 1.6691)
bbG	0.8459 (0.6971 – 1.0264)	0.7100 (0.5071 – 0.9940)	0.8387 (0.6819 – 1.0315)	0.7294 (0.4858 – 1.0953)
bgG		0.8924 (0.7252 – 1.0981)		0.9385 (0.6757 – 1.3033)
ggG				0.8725 (0.5918 – 1.2864)
AIC	7637	7636	7638	7640
0 brothers, B	(ref)	(ref)	0.6361 (0.4254 – 0.9512)	(ref)
1 brother, B			(ref)	1.4493 (0.9439 – 2.2254)
2 brothers, B				1.6777 (1.1032 – 2.5511)
3+ brothers, B				1.5663 (1.0314 – 2.3786)
0 sisters, G	0.8424 (0.7406 – 0.9583)	1.0615 (0.7568 – 1.4889)	.8201 (0.7199 – 0.9342)	1.6228 (0.9738 – 2.7043)
1 sister, G		0.8262 (0.7238 – 0.9430)		1.3691 (0.8813 – 2.1267)
2 sisters, G				1.2970 (0.8439 – 1.9933)
3+ sisters, G				1.1827 (0.7745 – 1.8062)
AIC	18706	18706	18702	18707

Notes: Controlling for province, rural residence, household wealth status, type of flush system, mother's education, father's education, preceding birth interval, and birth year; 95% confidence intervals in parentheses.

Table A-2: Hazard ratios for post-neonatal mortality

	Model 1 Generalized discrimination	*Model 2* Selective discrimination	*Model 3* Preferential treatment	*Model 4* Full
B	(ref)	n/a	n/a	
G	1.1685 (0.9270 – 1.4730)			
gB	(ref)	(ref)	0.8767 (0.6233 – 1.2331)	(ref)
bB			(ref)	1.1406 (0.8109 – 1.6044)
bG	0.9191 (0.7177 – 1.1769)	0.9587 (0.7106 – 1.2933)	0.8658 (0.6486 – 1.1558)	1.0301 (0.7219 – 1.4699)
gG		0.8775 (0.6411 – 1.2012)		0.9430 (0.6527– 1.3623)
AIC	4692	4693	4693	4695
ggB	(ref)	(ref)	0.9460 (0.6124 – 1.4612)	(ref)
bgB			(ref)	0.8464 (0.5346 – 1.3982)
bbB				1.3953 (0.8552 – 2.2765)
bbG	0.9536 (0.7295 – 1.2466)	0.9803 (0.6469 – 1.4854)	0.9406 (0.7052 – 1.2545)	1.0228 (0.6022 – 1.7371)
bgG		0.9442 (0.7050 – 1.2647)		0.8424 (0.5199 – 1.3649)
ggG				1.2571 (0.7552 – 2.0926)
AIC	3875	3877	3877	3875
0 brothers, B	(ref)	(ref)	0.6234 (0.3488 – 1.1141)	(ref)
1 brother, B			(ref)	1.7350 (0.9408 – 3.1996)
2 brothers, B				1.6047 (0.8737– 2.9471)
3+ brothers, B				1.5083 (0.8243 – 2.7601)
0 sisters, G	1.1109 (.9343 – 1.3210)	0.7937 (0.4542 – 1.3869)	1.0797 (0.9060 – 1.2868)	1.2359 (0.5637 – 2.7098)
1 sister, G		1.1346 (0.9521 – 1.3522)		1.6853 (0.9031 – 3.1451)
2 sisters, G				2.0661 (1.1322 – 3.7703)
3+ sisters, G				1.5928 (0.8741 – 2.9027)
AIC	10097	10097	10096	10100

Notes: Controlling for province, rural residence, household wealth status, type of flush system, mother's education, father's education, preceding birth interval, and birth year; 95% confidence intervals in parentheses.