# Gender Bias and Gendered Outcomes Some Pitfalls of Inference

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#### Abstract

The ratio of females to males has become a popular proxy for both gender discrimination in treatment and gender bias in preferences. The link between preference bias towards male children and the sex-ratio is however mediated through other factors of a household's environment that affect mortality such as malnutrition, disease and social norms. In this paper we explore the relationship between sex-ratios and the cost of accessing medical care. We construct a simple model in which both male and female children are born with equal probability. If a child falls sick, families have to decide whether or not to access costly treatment. We present three main results. First, sex-ratios are non-monotonic in treatment costs, since for prohibitively high costs families cannot afford treatment of either child and at very low costs they do not care to discriminate among them. At intermediate levels, gender-bias will lead to higher probabilities of treatment and survival of male children. Our second result compares sex-ratios across populations which exhibit different levels of preference bias but face the same treatment costs. We show that the *difference* in the sex-ratio across the two populations depends on the *level* of treatment costs. Our final result compares populations with different treatment cost trajectories and preference bias. We show that the ranking of populations by sex-ratios is not necessarily the same as their gender-bias ranks since high degrees of bias combined with either very high or very low treatment costs will result in sex-ratios that are close to one. Taken together, our results caution against the simplistic use of sex-ratios as a measure of gender-bias.

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## 1 Introduction

It is widely known that millions of women in South-Asia are "missing" in that they may have been alive had they faced non-discriminatory environments. We have also learned that female children are less likely to have access to curative and preventive medical care (Sen, 1992; Coale, 1991; Oster, 2009). The nature of the theoretical relationship between health access, gender-bias and the observed ratio of females to males is however not well understood, and this is the focus of our paper.

We examine the relationship between the ratio of female to male children and treatment costs using a household model in which parents have preferences over the number of boy and girl children and other consumption. Children may face a health shock and the parents have to decide whether or not to take them for treatment, which is costly. If treated, the child survives. The juvenile sex-ratio therefore depends both on treatment costs.

If access to medical care is an important component of excess female mortality, then populations with different trajectories of public health infrastructure would experience different ratios of females to males even if their preferences are identical. When medical care is simply not available, or its cost is prohibitive for poor families, it cannot influence survival rates and when it is nearly universal, households have no need to discriminate among their children. We would therefore expect a "U-shaped" relationship between health access and female to male ratios. This is the first result of our paper.

We present two additional results. We show that, for populations exhibiting different levels of bias, the *gap* in the sex-ratio across the two populations depends on the *level* of treatment costs. It is not therefore appropriate to use changes in sex-ratios to measure changes in bias. Our final result compares populations with different treatment cost trajectories and preference bias. We show that the ranking of populations by sex-ratios is not necessarily the same as their gender-bias ranks. Sex-ratios for the population of households exhibiting greater preference-bias against girl children can lie either above or below that of the population with less preference bias, depending on the trajectories of treatment costs faced by the two populations.

Taken together, our results caution against the simplistic use of sex-ratios as a measure of genderbias.

### 2 The Model

Consider a population of n identical families, each with an income of y, and preferences over girl and boy children that are given by:

$$U(b,g,c) \tag{1}$$

where b and g are the number of girls and boys respectively, and c is the expenditure of a numeraire consumption good. This is simply household income minus expenditure on raising and treating children. We assume that utility is increasing in all arguments.

We begin with a very simple set up in which each family first decides how many children to have and these fertility choices determine the composition of children in the family. A cost p is incurred per child. Next one or more of the children may be hit by a health shock. These shocks occur with a probability  $\pi$  that is independent across the siblings. Any child that falls ill can be treated and brought back to health at a unit cost t. Untreated children do not survive. We denote by T, the total treatment cost. Remaining income, is spent on consumption.

$$c = y - p(b+g) - T \tag{2}$$

Finally utility is realized based on consumption and the number and composition of surviving children according to (1). This sequence of events is illustrated in the Figure below:

Figure 1: Timeline of Decisions



We assume that p is low enough for all families to want at least one child, male or female. For this it is sufficient that  $(1 - \pi)U(0, 1, y - p) > U(0, 0, y)$ .

Our objective is to explore how the public health environment mediates the relationship between preference bias towards male children and outcome bias as measured by the differential rates of treatment and mortality between male and female children. We define each of these biases below:

We use the following definition of gender bias in preferences:

**Definition 1** (Preference Bias). There is no gender bias in preferences iff  $U(n_1, n_2, c) = U(n_2, n_1, c)$  for all non-negative integers,  $n_1$  and  $n_2$ . If  $U(n_1, n_2, c) > U(n_2, n_1, c)$  when  $n_1 > n_2$ , there is preference bias towards male children. There is bias towards female children when the above inequalities are reversed. Defining outcome bias is more complicated, since it depends on rates of morbidity and treatment by gender. At the time that treatment decisions are made, each family is characterized by a four-element state vector which indicates the numbers of boy and girl children born and the numbers of each gender that have fallen sick. There is no outcome bias if switching the boy and girl labels in the state vector, switches the number of girls and boys being treated:

**Definition 2** (Outcome Bias). After fertility is complete and health shocks realized, a family is characterized by a four-element state vector  $(b, g, s^b, s^g)$  where b and g are the number of boys and girls born and  $s^b, s^g$ are the numbers that fall sick. A family exhibits no gender bias in outcomes, if the treatment decisions for boys in the state  $(b, g, s^b, s^g) = (n_1, n_2, m_1, m_2)$  are the same as the treatment decisions for girls in the state  $(b, g, s^b, s^g) = (n_2, n_1, m_2, m_1)$  and vice-versa.

#### **3** Treatment Decisions

We begin by treating fertility as exogenous in that we present results conditional on a chosen fertility rate without deriving this rate from a utility maximization exercise based on the expected number of surviving children. Our main result establishes that for a given set of preferences which exhibit gender bias, outcome bias will occur over a range of treatment costs. For costs outside this range, preference bias will not be reflected in biased outcomes.

This is easy to see for the case where families have a single child. For n = 1, a family with a boy child will take him for treatment if he fall sick as long as costs are below  $t_1^b$ , which is defined implicitly by

$$U(1,0,y-t_1^b) = U(0,0,y)$$

For a single girl child, costs must be below  $t_1^g$  defined by

$$U(0, 1, y - t_1^g) = U(0, 0, y)$$

Since U(1,0,c) > U(0,1,c),  $t_1^b > t_1^g$ . The interval  $(t_1^g, t_1^b]$  defines a set of treatment costs for which families will treat boy children but not treat girls. The expected ratio of girls to boys for this range of costs will simply be  $(1 - \pi)$ . Outside this interval, the bias in preferences is not manifested in treatment behavior so as long as treatment costs are outside the interval above, the child sex-ratio is always one.

Next consider the case of a family with several children, with equal numbers of boys and girls. Let  $t_{ij}^k$  denote the maximum treatment cost below which a child of gender k is treated when there are i children of that gender in the family out of a total of j children. With equal numbers of boys and girls,  $i = \frac{j}{2}$  treatment cost thresholds are defined by the following equalities:

$$U(i, i, y - t_{ij}^b) = U(i - 1, i, y)$$
$$U(i, i, y - t_{ij}^g) = U(i, i - 1, y)$$

With gender bias favoring boys, the right hand side of the second equality is bigger than in the first, so we must have  $t_{ij}^g < t_{ij}^b$ . For treatment costs in the interval  $(t_{ij}^g, t_{ij}^b]$ , families will take a sick boy for treatment but sick girls will be untreated.

**Proposition 1.** Consider a family with j children. If j = 1 or if there are equal numbers of girls and boys, there exists an interval of treatment costs for which a single sick child will be treated if male and not if female. Outside this interval, the child-sex ratio will always be one.

This implies that populations with the same degree of gender bias in preferences, but different trajectories of treatment costs, could experience very different ratios of female to male children.

This result is illustrated in Figure 2 for a CES utility function of the form

$$U(b,g,c) = (\beta b^r + \gamma g^r + (1-\beta-\gamma)c^r)^{\frac{1}{r}}; \qquad \beta \ge 0, \gamma \ge 0, \beta + \gamma < 1, r = 0.5$$
(3)

We plot intervals for two different values of the parameter  $\beta$ , the strength of preference bias towards male children. The figure plots the interval  $t_{ij}^k$  for  $j = \{2, 4, 6, 8, 10\}$  and for  $i = \frac{j}{2}$ . The green band is for the case where  $\beta = .35$ . When  $\beta = .4$ , the additional gold bands show how this interval gets extended.



Figure 2: Treatment Cost Intervals for CES Utility Function

#### 4 Sex-Ratio Dynamics: Simulation Results

In the previous section, we have assumed that a family's fertility is complete before the realization of health shocks and we also restrict ourselves to a single child falling sick. We now ask how sex-ratios evolve in communities over time given a trajectory of falling treatment costs. Each period one child arrives. This child, and all other surviving children may fall sick. This happens with probability  $\pi$  that is independent across all children. Treatment decisions are made to maximize current period utility. Based on these decisions, the family composition at the end of the period is determined and we aggregate across families to obtain the child sex-ratio for the population. Throughout this section, we present simulation results using the CES utility function in (3).

Figure 3 is related to Proposition 1, in that it shows that the ratio of girls to boys is non-monotonic in treatment costs in this setting. For  $\beta = 0.4$ , the ratio is close to 1 for high treatment costs. At some point, as costs fall, boys are relatively more likely to be treated and the ratio falls. It rises again once costs fall further and treatment rates among girl children rise. The figure cautions us from using sex ratio as a measure of gender bias. Two communities, A and B, with the same underlying son preference,  $\beta = 0.40$ , can exhibit different child sex ratios if they are at different points of the treatment cost trajectory. A with a very high treatment cost exhibits a child sex ratio of 1, whereas B with a lower treatment cost will exhibit a lower child sex ratio. Hence, a simplistic use of child sex ratios as a measure of bias may register very different biases for communities with the same underlying bias.



Figure 3: Trend in Sex Ratio with  $\beta = 0.40$ 

We now present two additional results in this framework. Our second result relates to the difference in sexratios for populations with different levels of bias and the same treatment costs. We show that the *difference* in sex-ratios between the populations depends on the *level* of treatment costs. This is seen in Figure 4. At high treatment costs, families in both populations do not treat their children. The sex ratio is close to 1 and provides no information on the extent to which their preferences differ. As treatment costs fall, the community with higher bias has its ratio fall more steeply and the difference between the two populations widens. Eventually, the ratios in both populations rise. The magnitude of the difference between the child sex ratios in two communities is not in itself informative about the prevailing differences in the strength of the bias.



Figure 4: Trend in Sex Ratio For Different Values of Bias

Our final result considers variation in both preference bias and treatment cost trajectories across populations. In this case, the sex-ratio does not even allow us to rank the degree of preference bias in the two populations. This is seen clearly in Figure 5.The treatment costs in the population with a stronger bias falls relatively faster than that in the other population. Consequently, the sex ratios in population with a stronger bias rises and approaches 1 before that in the population with lower bias. In this period, marked by the shaded region in Figure 5, the relative order of sex-ratio belies the ranking of the degree of preference bias across the populations.



Figure 5: Trend in Sex Ratio For Different Preferences and Treatment Trajectories

### 5 Conclusion

Child sex ratio is a popular measure for the degree of gender discrimination and gender bias in preferences. The link between preference bias towards male children and the sex ratio, however, is mediated by factors, particularly the cost of health care. We show that the relation between treatment costs and sex ratios in a population with biased preferences is non-monotonic. The non-monotonicity implies that two populations with the same degree of gender bias may have different sex ratios depending on the level of prevalent treatment costs. Additionally, we show that the *difference* in the sex-ratio across the two populations with varying degrees of gender bias depends on the *level* of treatment costs. Our final result compares populations with different treatment cost trajectories and preference bias. We show that the ranking of populations by sex-ratios is not necessarily the same as their gender-bias ranks since high degrees of bias combined with either very high or very low treatment costs will result in sex-ratios that are close to one. Taken together, our results caution against the simplistic use of sex-ratios as a measure of gender-bias.

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