EQUALIZING CHILD SEX RATIOS IN INDIA:

UNDERSTANDING THE TRENDS, DISTRIBUTION, COMPOSITION, AND

POTENTIAL DRIVERS

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ABSTRACT

Child sex ratios have been falling in recent decades in India, leading to an increasing number of missing girls. Although the country as a whole is becoming more imbalanced, in almost a quarter of districts the child sex ratio began to equalize between 2001 and 2011. This analysis explores the trends, composition, and drivers of the equalizing child sex ratios. **Procedures and Methods:** In the first paper, I test for evidence that the equalization in child sex ratios is associated with how imbalanced the sex ratio had been previously, at a district-level using fixed effects models. In the second paper, I decompose the equalization in child sex ratio into equalization in the sex ratio at birth (relating to pre-birth events) and reductions in excess female child mortality. I decompose districts by rural and urban populations and then explore the decomposition pattern by geographic clusters. In the third paper, I test various drivers of the equalization using individual level data and regression models. Specifically, I look at factors related to the marriage and labor market, changing social norms, and access to sex-selective technology. **Results**: The equalization in child sex ratios is associated with how imbalanced the sex ratio was in previous decades, controlling for other district-level socio-economic factors. Pre-birth events make up the majority of cause of imbalanced sex ratios, and though the magnitudes have gone down over time, the relative contribution from pre-birth events and mortality has remained the same. No substantial differences in the decomposition exist between rural and urban areas and based on geographic clusters. Finally, women's labor force opportunities, both at the individual and community-level, are associated with the probability of a family having a boy and the community-level child sex ratio. **Conclusions**: Equalization in child sex ratios in Indian

districts is related to the imbalance of the sex ratios in the past and female labor force opportunities. Most of the imbalance is due to pre-birth events rather than excess female child mortality, and a reduction in pre-birth events are also responsible for the majority of the magnitude of the equalization.

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DEDICATION

This dissertation is dedicated to the people who have moved with me:

My parents, Joan Diamond and Kirk Smith, for having the tenacity to move to India with

their one year old, drag me through village huts around the world in the succeeding years,

and giving me a drive and purpose to want to work to improve the lives of the least

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I have learned so much from and emulate so much in each of you.

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If I have seen further it is by standing on the shoulders of giants.

-Issac Newton

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CHAPTER 1

INTRODUCTION

"More than 100 Million Women Are Missing"

(Sen, 1990)

Child sex ratios (the number of girls under five divided by the number of boys under five) in India have shown an increased girl deficit in the past few decades. The 2011 census showed the child sex ratios were more imbalanced than ever in recorded history, with 914 girls for every 1000 boys under the age of five nation-wide, down from 927/1000 in 2001 (Jha et al., 2011). India, especially in the north, has a long history of son preference, due to social, economic, and religious reasons (Arnold et al., 1998). Son preference has driven families to not want, and therefore discriminate against, girls, which has taken the forms of neglect and infanticide historically, and sex-selective abortion in more recent years, especially as desired family size has declined (Guilmoto, 2008).

Despite the overall national trend in child sex ratios becoming more imbalanced, child sex ratios in almost 25% of districts in India began to equalize between 2001 and 2011. There has been very little attention paid to these districts, or why or how their child sex ratios are showing equalization. Recent analysis by Diamond-Smith and Bishai (2012) suggested that at a state level, an extremely imbalanced child sex ratio at one time point was associated with an equalized child sex ratio at the later time point (10 years apart using the census data) (Diamond-Smith and Bishai, 2012). Extremely or very imbalanced, in this case, means child sex ratios that are far below the average child sex ratio in India, generally below 800/1000. This suggests that something about an extremely imbalanced sex ratio is leading to self-correction in some states in India. This intriguing finding deserves exploration in more detail at a district-level. India's current population is over 1.2 billion, with 35 states and territories and over 600 districts. Districts range in population from 7,948 (Dibang Valley, Andhra Pradesh) to over 11

million (Thane, Maharashtra), with over 70% of districts having more than a million people (Registrar General of India, 2011). Examining district-level trends in India is essential due to India's large population, geographic size, and socio-cultural diversity.

Imbalanced child sex ratios are made up of two components: pre-birth events (measured by the sex ratio at birth) and excess mortality for girl children. Evidence suggests that the current imbalance is due predominantly to pre-birth events, usually accepted to be sex-selective abortion that has become much more widely available and affordable in recent decades (Jha et al., 2011, Retherford and Roy, 2003). Before the creation and proliferation of sex-selective technology, child sex ratios were imbalanced due to excess female mortality because (among other reasons) girls were fed less, breastfed for a shorter duration, taken to health facilities less frequently when sick, and were less likely to be fully immunized (Arnold et al., 1998, Mishra et al., 2004, Barcellos et al., 2012). The equalization in child sex ratio seen between 2001 and 2011 could be due to either reductions in pre-birth events (sex-selective abortions) or improved girl child mortality relative to boys.

If indeed something happens when child sex ratios become very deficient in girls that changes behavior and makes child sex ratios equalize, it is essential to understand what this might be. There are a number of possible outcomes of very unequal sex ratios that could have social consequences and which would subsequently change people's preferences for girls or boys. Some possible drivers of a reversal are tensions due to lack of females in the marriage market or to fulfill female specific occupations (improved

labor market for women), changing social norms, and reductions in access to sex-selective technology because of effective programs and enforcement of laws.

The first paper in this series (Chapter 2) uses fixed effects models to test whether there is evidence that the child sex ratio at one point in time is associated with the change in child sex ratio at the next point in time, using census data from four censuses (1981, 1991, 2001, and 2011). The aim is to determine whether a very unequal sex ratio at one census is a predictor of equalization in the child sex ratio in the next census. This would provide evidence that equalization could be a reaction to having a very unequal sex ratio.   In this paper, I control for various potentially confounding factors such as the fertility rate, infant mortality rate, female literacy rate, the percent of the population that is of lower caste or tribal population, and the percent of the district that is urban versus rural.

Controlling for these other factors, the level of the child sex ratio in one period is associated with the change in child sex ratio in the next time point, specifically, the more imbalanced a sex ratio was in the earlier time period, the greater the positive change (equalization) in the next time period. Fertility rate, female literacy, total literacy rate, and the percent of the population that are Scheduled Tribe were significantly associated with the change in child sex ratio between two censuses. This suggests that something happens when the child sex ratio falls to a low level that causes people to stop discriminating against girls as much.

The second paper in this series focuses in on the districts that have shown signs of equalization in their child sex ratios between 2001 and 2011, primarily using census data and additional demographic estimation techniques. As mentioned above, the child sex ratio is made up of two components: the sex ratio at birth, which is driven by pre-birth events (fertility related, most likely due to sex-selective abortion), and the sex ratio between birth and age five, which is driven by differentials in mortality rates for boys and girls (mortality related). I decompose the child sex ratio in 2001 and 2011, and the change between the two census years, into fertility and mortality components. Since there are no data on the sex ratio at birth for both the 2001 and 2011 censuses, I reverse-survive the child population of boys and girls using life tables to estimate the sex ratio at birth at a district-level at each time point. I then evaluate if the equalization in child sex ratios is mostly due to events before or after birth. I then decompose the child sex ratio in rural and urban areas of each district to test if there are differences between these populations. I also explore the decomposition by regional clusters of districts where child sex ratios are equalizing.

Pre-birth events make up the majority (93-4%) of missing girls in the imbalanced sex ratio at both time points. The relative contribution of pre-birth events and mortality to the imbalanced sex ratio remained stable between 2001 and 2011. Reductions in pre-birth events are the main contributor (in terms of magnitude) to the equalization in child sex ratio. Pre-birth events make up the majority of the cause of imbalanced sex ratios and reason for equalization in both rural and urban areas. Interestingly, there is evidence that in urban areas child mortality is contributing more to the imbalanced sex ratio in 2011

compared to 2001, suggesting that improvements in girl child mortality compared to boy child mortality may have decreased or stagnated. Four main geographical clusters of equalizing districts emerged when the equalizing districts were mapped: in the north around Delhi, Chandigarh, Punjab. and Haryana; the west around the capital of Gujarat, Ahmedabad; the south stretching in a narrow line from Tamil Nadu up through Karnataka; and many scattered districts in the northeastern region. Child sex ratios were much lower in the north and west clusters than in the south and northeastern clusters. However, the decomposed contribution to the child sex ratio did not differ substantially by cluster.

Various supply and demand side factors could act as motivating forces for the equalization of child sex ratios. On the demand-side, changing desires for girls or boys due to tensions in the marriage market (because of a shortage of girls), improvements in women's labor force opportunities (because a shortage of girls in the labor market leads to as increase in female labor opportunities), or shifting social norms could be changing preferences. From the supply-side, reductions in access to sex-selective technology, perhaps due to better regulation, could be restricting people's access to sex-selective abortions. The third paper moves from the population to the individual-level, using household-level data to explore different potential drivers for equalized child sex ratios. I test the marriage and labor market, as well as social norm-related variables and supply-side variables, on an individual's probability of having a boy, and on the community-level child sex ratio using India's third National Family Health Survey collected in 2005-2006.

Labor supply opportunities for women at an individual and at a community-level (percent of women in the labor force) stand out as predictors for both an individual woman's odds of having a boy, and the community-level child sex ratio. Interestingly, any labor force participation was associated with increased odds of having a boy, whereas labor force participation/opportunities in professional occupations had the opposite effect, equalizing child sex ratios and decreasing the odds of having a boy. There was some evidence that supply variables relating to access to doctors were associated with having a boy, however, marriage and norm variables were not for the most part significantly associated with either outcome.

These three papers build upon each other to paint a fuller picture of the recent phenomenon of equalizing child sex ratios in India. First, I show that there is evidence that larger pro-girl increments in the sex ratio in 2011 occurred in areas where the sex-ratio was least pro-girl in 2001, controlling for other demographic factors. I then delve deeper into the districts that have become more equal to understand the contribution from excess female mortality and pre-birth events to the child sex ratio via decomposition, and explore whether there are geographic patterns, and if the increase is occurring in both rural and urban areas within districts. Finally, I test potential demand and supply-side drivers of the equalization at an individual-level to see if variables relating to the marriage market, labor market, norms, or access to technology are associated with people's probability of having a boy and the community-level child sex ratio. In

summary, I explore if the trend in equalizing child sex ratios is real, dissect the trend into components, and then test potential drivers of the trend.

Taken together, these three papers give insight into the nascent trend of equalizing child sex ratios, which has yet to be explored at all in depth. It provides hope that the increasing imbalance in child sex ratios in recent decades in India will not continue forever, and may begin to slow and reverse in other regions as well. Where occurring, the equalization appears to be deep rooted (both in rural and urban areas), and might spread from the current epicenters to the rest of the country as other social and demographic trends have in the past. People are either making a conscious choice not to abort female fetuses as frequently, or access to sex-selective technology has been restricted effectively, both of which provide promise for future behavior change or the possibility of effective regulation (which to date has been mostly unsuccessful).   More research on the drivers of the equalization is necessary, especially the relationship between more opportunities for women in the labor force, gender preferences, and the child sex ratio.

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CHAPTER 2

PAPER 1:

EVIDENCE OF SELF-CORRECTION OF CHILD SEX RATIOS IN INDIA:

A DISTRICT-LEVEL ANALYSIS

FROM 1981-2011

"500 rupees today to save 50,000 rupees tomorrow"

(Advertisement on ultrasound clinics suggesting that families pay for an ultrasound and

abortion today (if it's a girl) rather than a more expensive dowry in the future)

(MacFarquhar, 1994)

ABSTRACT

Sex ratios in India have become increasingly imbalanced over the past decades. I

hypothesize that when sex ratios become very uneven, the shortage of girls will increase

girls' future value leading sex ratios to self-correct. Using data on children under five

from the last four Indian censuses I examine the relationship between the sex ratio at one

point in time and the change in sex ratio over the next ten years by district. Indian

districts with imbalanced sex ratios became even more unequal between 1991 and 2001.

However, analysis shows that districts with the most imbalanced sex ratios in 2001 had

larger corrections by 2011. Fixed effects models show that, accounting for unobserved

district-level characteristics, sex ratios are now significantly negatively correlated with

the change in sex ratio in the successive ten-year period. This suggests that self-corrective

forces are at work on imbalanced sex ratios in India.

INTRODUCTION:

Uneven sex ratios at birth and throughout childhood have been noted for decades in India, where the ratio is imbalanced in favor of boys (Jha et al., 2011). This is hypothesized to be due to a strong cultural preference for sons, combined with access to sex-selective technologies and a falling fertility rate (Guilmoto, 2009). In India as a whole in 2011 there were 914 girls for every 1000 boys under six years old, compared to 927/1000 in 2001 and 945/1000 in 1991(Jha et al., 2011). Most of the increase in imbalance is thought to be due to increases in sex-selective abortion, rather than excess mortality for girls, although both contribute to the imbalance in children under six (Jha et al., 2011). Desired sex ratios (as reported by individuals) in India are even higher than actual sex ratios in most states, suggesting that with increased access to sex-selective technologies in the future, it is possible sex ratios will become even more imbalanced (Bongaarts, 2013).

Much media and scholarly attention over the past few years has been paid to the increasingly imbalanced sex ratios in India, which may have dire consequences for marriage patterns, social stability, violence, and mental health in the future (Guilmoto, 2012, Hesketh, 2011). Scholars have suggested that there will be 40 million men remaining single between 2020-2080 in India (Guilmoto, 2012). Men spending longer periods outside of unions may increase their exposure to sex with prostitutes posing the threat of an increase of sexually transmitted diseases and HIV/AIDS, as has been seen in China (Tucker et al., 2006). Additionally, evidence from China has suggested that a more

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imbalanced sex ratio (by 0.01) increased violent and property crimes by 5-6% (Edlund et al., 2007). Research in India has found a relationship between sex ratios, violence, and homicide rates (as a whole, not only against women) (Hudson and Den Boer, 2002). These authors also suggested that men who are unmarried are more likely to join military groups, which could lead to increases in domestic or regional violence. Other research has suggested uneven sex ratios could increase sex trafficking (Hesketh and Xing, 2006). These studies do not prove causality, but they do suggest that there may be negative social outcomes related to imbalanced sex ratios.

Increasingly imbalanced sex ratios are not sustainable in the long term at a population level because of biological, social, and economic factors, and we would expect that at some point population-level sex ratios would begin to self-correct, perhaps due to social forces such as the labor or marriage market. Recent research on the 2011 census has noted that the child sex ratio in three states appeared to have equalized slightly, although the country as a whole has become more imbalanced (Navaneetham and Dharmalingam, 2011). But no research to date has looked at this phenomenon in more detail, or at a district-level. This paper explores the changing pattern of Indian sex ratios at a district-level, controlling for other social and demographic factors.

I. Biological Perspective

Some non-human species have the ability to shift their sex ratio in response to ecological factors that favor imbalance. The rationale, as advanced by Trivers and Willard (1973) is

that in many species males born in good ecological conditions will out-reproduce females because strong males in times of plenty can produce offspring at a higher frequency. In poor ecological conditions, the females will out reproduce males (Trivers and Willard, 1973). From the evolutionary perspective of the mother, it is therefore advantageous to have sons in good times, and daughters when times are bad. This theory—the Trivers-Willard Hypothesis—has been shown to hold for population-wide stresses due to environmental conditions, but to be mediated by individual specific factors due to an animal's position in a social hierarchy. For example, the Seychelles warbler has a higher proportion of female offspring during good ecological conditions being born to higher ranking females, while more male offspring are born during bad conditions or to less well established females (Komdeur, 2002 , Komdeur et al., 1997). Higher ranking red deer have been shown to produce more male than female offspring (Clutton-Brock et al., 1984).

In human populations, there is evidence of a biological mechanism through which sex ratios are affected by stresses. The "natural" sex ratio at birth (meaning the sex ratio in a population that is not using sex-selective technologies to alter its sex ratio or is not experiencing environmental stresses) is estimated at around 105 males born for every 100 females (Dyson, 2012).[1] There is evidence that stresses that the mother experiences while the fetus is in utero, such as terrorism, extreme temperatures, and economic instability, can lead to the spontaneous abortion of male fetuses and thus alter the sex ratio at birth

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[1] Note: The literature on sex ratios conventionally uses a ratio of the number of boys over the number of girls, however, the discussion of sex ratios in India uses the reverse (the ratio of number of girls over the number of boys). For the purposes of this paper I use the same standard as is customarily used for India (girls/boys), unless otherwise specified.

(Catalano et al., 2008, Catalano et al., 2006, Catalano, 2003). Conversely, sex ratios after wars have at times been noted to favor males (James, 2009). Research into the life expectancies of males born in Sweden in cold years, when the sex ratio favored females, showed that those males who were born lived longer than males born in normal years, suggesting that pregnant women abort weaker male fetuses in times of stress (Catalano et al., 2008).

As mentioned above, on average, the sex ratio at birth in humans is estimated to be about 105 boys for every 100 girls. However, male neonates and infants have higher mortality than females. For example, diarrheal disease, tuberculosis, measles, diphtheria, pneumonia, syphilis, respiratory distress syndrome, and sudden infant death syndrome all show higher mortality in the post-natal period for males compared to females (Wells, 2000). Overall, male infants show a higher propensity to become malnourished, and are less robust in general (Wells, 2000). Wells (2000) suggests that rather than looking at the Trivers-Willard hypothesis in the narrow constraints of pregnancy, we should think about the whole period of parental investment (which he defines as through the end of breastfeeding) as a time when parents could be adjusting their sex ratio based on environmental conditions and information about the strength of the infant (Wells, 2000). Hence, he argues that the weakness of male infants is a method by which natural selection has allowed parents to be able to prolong the period for deciding whether to invest in a certain infant. If times are bad, and it would be disadvantageous to have a male, the weaker male infants will be more at risk to disease and death, thereby conserving maternal fitness, and allowing the mother to have another pregnancy sooner.

II. Social and Cultural Perspective

In much of Asia, son preference is thought to be a manifestation of patrilineal social structures that favor males and generally create situations in which boys are a better investment than girls (Das Gupta, 2009). As in most agrarian societies, in rural India, sons traditionally have been a better investment because they work on the farms using the male advantage in aggression to protect rural property and other assets from theft. Agrarian sons, thus, can produce more income than daughters and provide security and support in old age (Arnold et al., 1998). Another stated cause of son preference (especially for Hindus in India) is the religious role that sons play in funeral ceremonies (Arnold et al., 1998). Modernization and a reduction in the threat of violence may have reduced the gendered physical advantages underlying income disparities, but culture and tradition can sustain son preference long after the economic rationale has declined.

Social factors are sometimes intertwined with the economic factors that lead to son preference. Where the kinship system is patrilineal, girls drain family resources because they require inputs (food, health care, dowry) and once they marry they no longer contribute (in terms of care or money) to the household, while boys remain with their families and contribute for the remainder of their lives (Chakraborty and Kim, 2012). Therefore, in the Indian context, it is not just that families prefer boys, but there are also disincentives to having girls. Past qualitative research in southern India showed that women are well aware of the economic benefit of boys, and that families are actually averse to having girls, due to the costs of marriage. However, girls do provide other

important benefits in terms of emotional support and care. As one respondent described "Two boys and one girl is enough because two boys will support themselves, and the girl will be more useful to me. When I am old with problems, she will come to help me." p.702 (Diamond-Smith et al., 2008).

Since Amartya Sen first described 100 million missing women in Asia in the 1990s, much attention has focused on understanding the causes, consequences, and magnitude of son preference and daughter discrimination (Sen, 1990). Since Sen's publication other authors have tried to estimate the number of missing women in India at various time periods. Research in the 1990s suggested that over one million girls were "missing" due to sex-selective abortion and female infanticide between 1981 and 1991 (Das Gupta and Bhat, 1997). Recently, Anderson and Ray (2012) estimated that a total of over two million women are missing in India in a given year, with 12% missing at birth, 25% missing in childhood, 18% in reproductive ages and 45% in older ages (Anderson and Ray, 2012). Another way to think about this is that of the women who could be alive today, 25 million are missing (Anderson and Ray, 2012). Other work suggests that virtually all of the gender imbalance in India is due to excess mortality under the age of five, and mostly between ages two to five years (Oster, 2009). Given the lack of conclusive evidence about whether the sex ratio imbalance is due predominantly to sex-selective abortion or to excess mortality, this paper will look at the sex ratio in children five and under to capture information about both of these factors.

III. Excess mortality for girl children

There are many ways that son preference can be expressed. It can be expressed in uneven investment in children by gender, for example, sending boys to school longer than girls, seeking health care for boys sooner than girls, and/or giving boys better nutrition than girls (Arnold et al., 1998, Mishra et al., 2004). These practices can be described as discrimination against girls, some types of which can lead to excess mortality for girls, and subsequent uneven sex ratios post-birth.

Mortality for girls in childhood exceeded mortality for boys in childhood by 43% in India in the 1990s (Arnold et al., 1998). This excess mortality was due to discrimination against girls in terms of food allocation, nutritional level, care-seeking behavior when the child is ill, and preventative services (vaccinations, etc.) (Mishra et al., 2004). Sons have also been shown to be breastfed longer, receive more vitamin supplements, partially due to the fact that girls more often end up in larger families (Barcellos et al., 2012). Oster (2009) looked at the impact of specific types of biases on mortality, and found that uneven vaccination rates explain about 20-30% of the sex imbalance, malnutrition explains 20%, respiratory infections and diarrhea combined explain 5%, and the remaining roughly 50% is unexplained by these factors (Oster, 2009).

As mentioned above, in populations without gender preference, male infants have higher rates of mortality than female infants in general, especially in the neonatal period (Wells, 2000). Hill and Upchurch (1995) used Demographic and Health Survey data from around

the world to look at gender differences in child mortality. With development, mortality in the neonatal period generally declines, most of which is due to infectious diseases initially which disproportionally affects males. Hence, the female advantage in the neonatal/infant period may decline with the changing cause of death structure (Hill and Upchurch, 1995). Therefore, even in the absence of gender preference and uneven care-giving practices, with development, we would expect the relative situation for girls to appear to decline.

Sex ratios at a family level were manipulated (and continue to be today) through "stopping rules." (Jha et al., 2011) "Stopping rules" is the concept that a family continues having children until they have reached some goal (such as having one son), and then they stop childbearing (Andersson et al., 2006). As was put eloquently by a woman in northern India, "I myself would like one son. And I don't want many children. But it isn't a question of what I want. Until I have a son, I won't stop having children" p.96 (Jeffery and Jeffery, 1996). In the absence of sex-selective technologies, stopping rules lead to more girls in a family than boys, which further impoverishes girls, as they are more often in larger households competing for household resources. In India, girls with older sisters have been shown to have the highest risk of mortality (Arnold et al., 1998).

IV. Uneven sex ratios at birth

As people are choosing to have fewer children, they are more pressured (squeezed) to have the gender of children they want in a narrower window (Guilmoto, 2009). Fertility

has been declining rapidly in India, heightening son preference because families are more pressured to have their desired number of sons as soon as possible (Basu, 1999). Sex-selective abortion is technically illegal in India since 1994, although abortion itself has been legal since the 1970s (Naqvi and Kumar, 2012). There has been a proliferation of mobile ultrasound clinics, which offer (and even advertise aggressively) a relatively inexpensive way of finding out the sex of a fetus (Retherford and Roy, 2003). Once the sex has been determined, people have little trouble obtaining an abortion under the pretense of other reasons.

Some authors have argued that access to pre-natal sex determination and abortion should allow those girls that are born to be more "wanted" and therefore excess girl-child mortality would decrease with increasing sex-selective abortion. Evidence of this effect has been found by some authors in India (Sudha and Rajan, 2003). Others have argued that sex-selective abortion and girl-child neglect are additive, or even re-enforce and strengthen each other, and that additivity has lead to further imbalanced sex ratios in parts of Asia in recent years (Goodkind, 1996). More research is needed to understand this relationship.

Recent work by Roy and Chattopadhyay (2012) projected the likely sex ratio at birth in India given historical trends in fertility decline and sex-selective behavior by parity, and future projections about fertility decline. Their median projection of the peak sex ratio at birth for 2021-2026 (which is when fertility is projected to fall to replacement level in India) is 117 boys/100 girls (which is about 85.5 girls/100 boys in the reverse ratio form)

(Roy and Chattopadhyay, 2012). Much of this imbalance is due to son preference and sex selection in a select group of states mostly in northwest India. If son preference and sex selection spreads increasingly to other parts of the country where it is currently lower, such as the southeast, the authors estimate that the peak sex ratio at birth could be closer to 124 boys/100 girls (about 81 girls/100 boys). Perhaps hearteningly, or perhaps dishearteningly, other research looking at the spread of imbalanced sex ratios in India has suggested that areas with highly imbalanced sex ratios act as epicenters, from which imbalance spills outwards over time. However, the opposite is also true: where areas of relative equality affect their surrounding areas to lower imbalanced over time (Kuzhiparambil and Rajani, 2012).

V. Theory of sex ratio self-correction

From a biological perspective, there are limits to the number of generations a Trivers-Willard gender imbalance can be sustained at a population level. Eventually the scarcity of the rarer gender makes offspring of the superfluous gender a less rewarding reproductive strategy. Fisher's principle predicts long-term failure for any mutant attempting reproductive success by consistently producing more male or female progeny (Fischer, 1930). Over the long run most species oscillate around a stable gender balance that is remarkably close to 1:1 (Fischer, 1930). In human populations, cognitive mechanisms and social signaling could potentially recognize that one gender is in shortage and hence more valuable in terms of future wages and reproductive potential. Human populations that achieve surplus boys using stopping rules, sex-selective abortion,

and differential child treatment can make choices to reduce these practices on the margin when they recognize an increased value of girls due to shortage. However, so far, there has been little evidence to suggest that human populations self-correct their sex ratios in response to marked imbalance (Judson, 1994 , Tuljapurkar et al., 1995).

This paper uses census data from 1981 to 2011 to check for self-correction by examining the correlation between sex ratios in Indian districts to the subsequent change in sex ratios over the next ten years. I hypothesize that populations with more imbalanced sex ratios will see proportionately greater corrective change in the subsequent sex ratios, compared to districts with less imbalanced sex ratios.

DATA AND METHODS

I. Data

District-level data from the 1981-2011 censuses are collected from various sources of the Indian Census Bureau (see Table 2.1 in Appendix 1 for data sources). Infant mortality rates are not yet available at a district-level for the 2011 censuses, therefore data from Annual Health Survey 2010 and Sample Registration System of 2010 are used for the major states (available at the district-level), and for non-major states, state level infant mortality rates from the 2011 census are used (Registrar General and Census Commissioner, 2012, Registrar General of India, 2011).

There has been a great deal of change in district boundaries: districts have been split into

smaller districts, and new states have been created over the last 40 years in India.

Districts that were split into new, smaller, districts kept information about the full

districts that they came from for the older years. For example, if a district was split into

smaller districts in 1995, the same data from the original district in 1981 and 1991 was

used in the model (entered twice), and then the individual data for the two new districts

used for 2001 and 2011. In some cases, new districts were created from more than one

former district, and in that case, the new district used information from whichever

original district constituted the largest proportion of the new district. Much of the

information about changing district boundaries came from Kumar and Somanathan

(2009) (Kumar and Somanathan, 2009).   Jammu and Kashmir and Assam are dropped

from the analysis because of civil strife that interfered with census data collection at

various times over the last 40 years.

II. Methods

The dependent variable of this analysis is the change in child sex ratio between two

censuses (for example, between 1981 and 1991). This is calculated by subtracting the

child sex ratio in the prior period from the child sex ratio in the later period. The main

predictor of interest is the child sex ratio in the earlier period (in this case, periods are 10

years between each census). The child sex ratio is the ratio of the count of living girls to

living boys under age six in each district. Control variables (for each census year 1981-

2011) include the total fertility rate (TFR), the infant mortality rate (IMR), the percent of

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adults in each district who were literate, the percent of female adults who were literate, the percent of each district that was Scheduled Caste and Scheduled Tribe, and the percent of each district that is rural. Scheduled Caste (SC) refers to the castes at the bottom of the caste hierarchy in India, and Scheduled Tribes (ST) refer to the tribal populations, which live mostly in the northern Indian states of Bihar, Gujarat, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, and West Bengal, and in North-East Indian as well (Gang et al., 2008). SC and ST populations make up about 25% of the total country's population, but almost 50% of India's poor are in these groups (Gang et al., 2008). Literacy rates are used as a proxy for educational status, as has been done in other studies in this setting (Echavarri and Ezcurra, 2010). Additionally, a time trend variable and an interaction term between time trend and sex ratio lagged 10 years are included. To account for the fact that the population of states and territories differ substantially, all models are weight adjusted by the mean population size of that district over the 30-year period.

I first regress the change in sex ratio over ten years against the sex ratio ten years prior for each group of years (1981 to 1991; 1991 to 2001; 2001 to 2011). I then estimate a series of fixed effects models to account for unobservable district-level factors that I hypothesize do not change over time. Hausman tests are conducted that showed that a fixed effects model is preferable to random effects or ordinary least-squared models (chi squared=1108, probability>chi squared=0.000).

Both the regression analyses and fixed effects models are run multiple times. Models A-F test for robustness by adding and removing different variables. Model A includes only the change in sex ratio over ten years and the lagged sex ratio (10 years prior). Model B adds covariates for time trend and an interaction term for time trend and the sex ratio lagged ten years. Model C includes covariates for the total fertility rate and the infant mortality rate in each time period, without the time trend variables in model B. Model D includes variables about rural/urban percent, literacy, and SC/ST percent, again without the time trend variables. Model E combines both model C and D. Model F extends model E to include the time trend variables

RESULTS

Table 2.1 shows how the main covariates of interest change over time at the district-level. The national child sex ratio fell from 978.86 girls per 1000 boys to 921.58 girls per 1000 boys under age six between 1981 and 2011. The total fertility rate fell from 5.12 to 2.81 and the infant mortality rate from 116/1000 to 47/1000, a remarkable change in 30 years. The percent of literate adults increased more than 2 fold, from about 35% to 74%, and percent of female adults literate rose from 24% to 65% for women. The percent rural decreased over time (from 79% to 75%), and there was little change in the percent of each district that was scheduled caste or scheduled tribe (about 15% and 17% respectively).

Figures 1-3 show the relationship between the change in sex ratio and the sex ratio 10

years prior. As can be seen in Figure 1, there does not seem to be much of a relationship

between the sex ratio in 1981 and the change in sex ratio in the next period. There is

some hint that sex ratios that were higher in 1981 became more negative in 1991, but it is

not clear. In Figure 2 again the relationship is not quite clear, but there is some indication

that sex ratios that were already imbalanced became even more imbalanced. In Figure 3

there seems to be more evidence of a trend where districts that were more imbalanced in

2001 showed positive change (became less imbalanced in 2011), whereas districts that

were less imbalanced in 2001 became more imbalanced in 2011.
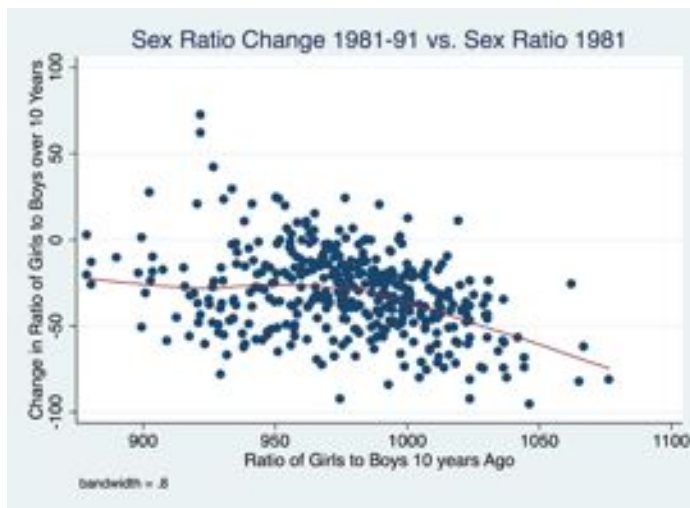
Fig 2.1: Sex ratio change 1981-1991 versus sex ratio in 1981
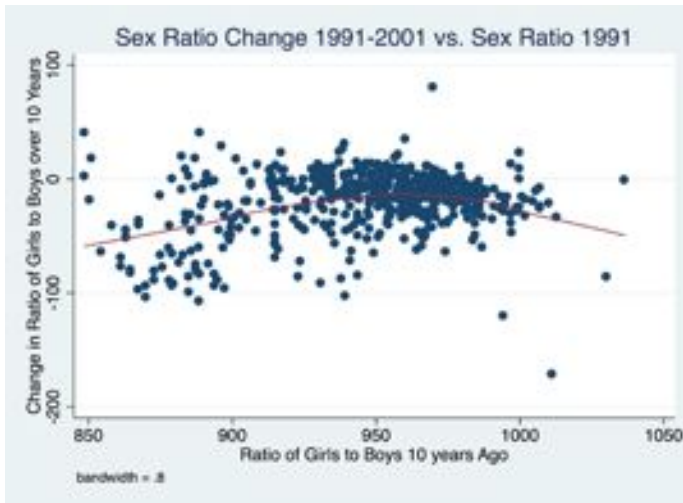
Fig 2.2: Sex ratio change 1991-2001 versus sex ratio in 1991
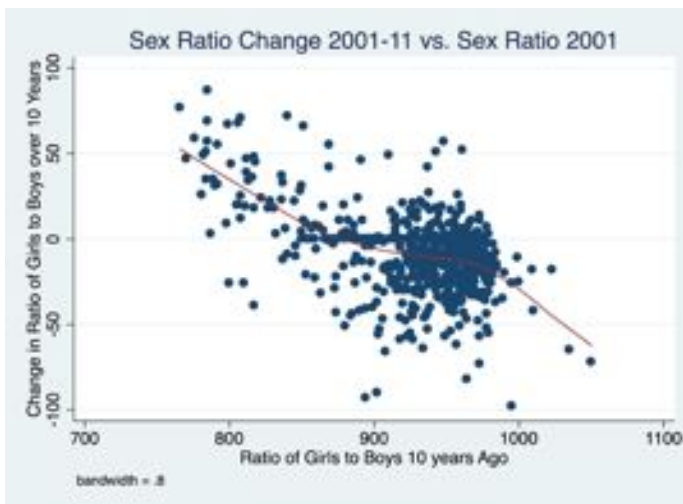
Fig 2.3: Sex ratio change 2001-2011 versus sex ratio in 2001

I. Ordinary Least Squared Regression

In the standard OLS regression (Table 2.2), there is a relationship between the outcome of interest (change in child sex ratio) and main predictor of interest (child sex ratio 10 years prior), controlling for other variables, between each individual set of years. The association was negative between 1981 and 1991, positive between 1991 and 2001, and

again negative between 2001 and 2011—but all were significantly associated with p-values <0.01. This means that the higher the sex ratio in 1981 (or 2001), the greater the negative change in sex ratio in the next period (1991 and 2011, respectively); however, the greater the sex ratio in 1991, the more positive (less imbalanced) the sex ratio became in 2001.

The percent of literate adults was associated with increasingly imbalanced sex ratios in the first and last time periods, and the percent of literate female adults was associated with less imbalanced sex ratios in those two time periods as well (p<0.01). The more rural a district was in 1981 and 2001, the greater the equalization in sex ratio in 1991 and 2011, respectively (p<0.01). The percent of a district that was SC was only associated with the change in sex ratio marginally between 1981 and 1991, and in this case the larger the percent, the less imbalanced the sex ratio became. The percent of the population that was ST was significantly associated with the change in sex ratio in 1981-1991 and 1991-2001, but in different directions. The larger the percent of the population that was ST in 1981, the less imbalanced the sex ratio became in 1991 (p<0.01), but the larger the percent in 1991, the more imbalanced the sex ratio became in 2001 (p<0.05). The greater the Total Fertility Rate (TFR) in 1981, the more imbalanced the sex ratio became in 1991 (p<0.01), however, the greater the TFR in 1991, the less imbalanced the sex ratio became in 2001. Infant Mortality Rate (IMR) was only associated with the change in sex ratio in the last time period (2001-2011), and here the higher the IMR, the less imbalanced the sex ratio became (p<0.01).

II. Fixed Effects Models

As can be seen in Table 2.3, in the basic fixed effects model, the higher the sex ratio in the previous period, the more it declined in the next period (Model A, -0.617, p<0.01). This means that in districts where the sex ratio was lower, the change in sex ratio became less imbalanced than in districts where the sex ratio was higher, suggesting that as sex ratios fall, the pace of their fall lessens. In other words, a higher starting sex ratio (a less imbalanced sex ratio) leads to more imbalance, however, having an already imbalanced sex ratio leads to less imbalance in the following period. This is consistent with a deceleration model.

This effect became stronger after the time trend variables were controlled for (Model B). When only TFR and IMR were controlled for (without the time trend, Model C), the main effect remained significant and larger than in the basic model, and an increase in TFR was associated with an increase in the change in sex ratio (10.115, p<0.01). In Model D, when percent rural, literacy, and caste were taken into account, the main effect remained significant and was larger than in the basic model. An increase in the percent of adults who were literate increased the change in child sex ratio (more imbalance) (p<0.01), but an increase in the percent of female adults who were literate decreased the change in the sex ratio (less imbalance) (p<0.01). The larger the percent of the district that was ST, the higher the sex ratio change (p<0.05). The percent rural and percent SC were not significantly associated. In Model E where all covariates except for the time trend variables were added, all of the above-mentioned factors remained significantly

associated with the sex ratio change to the same significance level and similar magnitude. The final model, Model F, includes all of the above-mentioned covariates, and again, all of the covariates that were significant remain significant in the same direction and similar magnitude, and with the same level of significance. This suggests that the model is robust and provides strong evidence that a more unbalanced sex ratio in an earlier period is associated with more equality in the sex ratio in the next period.

DISCUSSION

Overall, the sex ratio in children has fallen in India over the past 30 years. This has been concurrent with a fall in total fertility rate (TFR) from 5.12 to 2.81 and infant mortality rate (IMR) from 115.7/1000 to 46.55/1000. Literacy for the population as a whole and for women specifically has risen over that time period. A smaller proportion of districts are rural, and about the same percent of the population of districts are ST and SC. All of these changes are in the direction expected for a rapidly developing country, although India does lag behind other countries, especially in female literacy rates (for example, China's female literacy rate in 2007 was 88.5%) (CIA World Factbook).

Our models find that, controlling for other demographic factors, districts in India that have historically had increasingly imbalanced sex ratios are beginning to decelerate their decline, and in some cases even begin to equalize in their sex ratios. This suggests that as sex ratios become increasingly imbalanced, people begin to adjust their behavior to not

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discriminate against their female children as much. In other words, the situation for girls begins to improve as girls become increasingly scarce.

I. Total Fertility Rate and Infant Mortality Rate

Theoretically, a decline in TFR should accompany an increasingly imbalanced sex ratio, as discussed above (Guilmoto, 2009, Basu, 1999). When families have fewer children and son preference still exists, they are more pressured to have the desired number of sons in a smaller number of child "slots." Therefore, the sex ratio in children is expected to become more imbalanced. In the OLS regressions, a higher TFR is associated with a decline in child sex ratio in the 1981-1991 period, an increase in child sex ratio in the 1991-2001 period, and not significantly associated between 2001-2011 (although the direction is negative, in that a higher TFR is associated with more imbalance in child sex ratio). Therefore, it is expected that as TFR falls, the sex ratio should become more imbalanced, as was seen in 1991-2001 period. This might have been the period where access to and use of sex-selective technology increased greatly in the country. As expected, TFR is significantly associated with the change in child sex ratio in the fixed effects model, with a lower TFR being associated with more imbalanced sex ratios.

Much literature has explored the relationship between IMR and TFR, as TFR and IMR often fall in similar time periods. Some literature suggests that a decline in IMR allows families to feel safe having fewer children (they have more assurance that some children will live to adulthood), and therefore precedes a decline in TFR, this is consistent with

the general idea of the Demographic Transition Theory (for a summary see Kirk, 1996 (Kirk, 1996)). Other research is not as conclusive that IMR falls before TFR, and suggests that by having smaller sized families, parents are better able to care for and invest in the children they have, thereby lowering IMR (Bongaarts, 1987, Rosenzweig and Schultz, 1983). There is other evidence that other changes (such as improvements in sanitation) have an impact on both of these factors, but they themselves are not causally related (Newell and Gazeley, 2012).

II. Rural/Urban

Past research has found that child sex ratios were more imbalanced in urban areas than rural areas (Jha et al., 2011). Although ultrasounds and abortions are available in rural areas, they usually start off in urban areas and move to rural areas, and therefore may be less accessible in rural areas (Akbulut-Yuksel and Rosenblum, 2012). Also, fertility tends to be lower in urban areas, thereby heightening the pressure to have sons as soon as possible where son preference exists (Guilmoto and Rajan, 2001). More educated and wealthy families (and therefore those more likely to live in urban areas) are more likely to have imbalanced sex ratios (Subramanian and Selvaraj, 2009). The relationship between rural percent and sex ratio in this study might have been subsumed under the other factors related to rural populations, such as TFR and literacy, which were significantly associated.

III. Scheduled Tribe and Scheduled Caste (ST/SC)

There is a long history of poorer educational attainment, occupational choices and income, and health outcomes for ST/SC populations compared to non-ST/SC populations in India. For example, infants, children and the elderly from ST and SC groups had higher mortality than non-scheduled populations (Subramanian et al., 2006). However, there is recent evidence of a reduction in the gap in education and wages in recent years although states with larger ST populations have showed less convergence in wages and education compared to SC and non-scheduled populations (Hnatkovskay and Lahiri, forthcoming). Other work has found that the causes of poverty for ST and SC populations differ, with the social constrictions created by the caste system being more important for SC population, while "..returns to the occupational structure" are more important factors for ST populations (Gang et al., 2008). These findings suggest that SC and ST populations should not be lumped together indiscriminately.

The percent of the ST population was associated with the change in child sex ratio, however, percent SC was not. This supports other research that scheduled castes and tribes are different, and should not be clumped together necessarily. More research could explore what differentiates ST and SC populations in terms of their preference for sons or use of sex-selective technologies, and why larger ST populations might be associated with more equalization in sex ratios as they become more imbalanced.

IV. Literacy and Education

Extensive literature has explored and argued about the relationship between education and sex ratios in India (Echavarri and Ezcurra, 2010). The debate revolves around whether increased education will lead people to change their values to have lower levels of son preference, and thereby will lead to less sex discrimination, or if more highly educated individuals are better able to act on their desires and utilize sex-selective technology, thereby increasing imbalanced sex ratios (Clark, 2000, Bhat and Zavier, 2003). Recent work has suggested that the relationship between education and sex ratio follows an inverted U-shaped pattern, where initially with increasing education sex ratios become more imbalanced, and then sex ratios begin to fall at higher levels of educational attainment (Echavarri and Ezcurra, 2010). This same work looked at female and male literacy separately, and found that they acted in the same direction, which is not consistent with the findings in this analysis, where female literacy and literacy overall acted in opposite directions.

As districts became more highly educated overall (men and women combined), they increased in their imbalance. However, female literacy rate had the opposite effect (less imbalance with increased female literacy). This could suggest that women being more educated is associated with other changes in preferences for girls compared to boys.

V. Limitations

i. *Creation of New Districts*

The changing district and state boundaries over the past 30 years in India created

challenges for merging the data from the censuses of each year. Newly created districts

were given information about past indicators of the entire districts from which they were

formed. It is possible that when a district divided, the portion of the original district from

which the new district was formed had different levels of the covariates of interest than

the district as a whole. If this is the case, than applying the full district rates of the

original district for the newly formed district is problematic. However, there is limited (or

no) information about the covariates of the sub-portion of the original district from which

the new district was formed.

ii. *Data Quality of the Census*

A vast body of literature has looked at the quality of the data collected in the census and

Sample Registration System. There is evidence of underreporting of births, deaths, and

age-misreporting throughout the country, with heterogeneity in quality between states

(Retherford and Mishra, 2001). Larger states have been found to have better quality data.

Using demographic estimation methods to test the quality of the data, other work has

suggested that the quality was fairly good in the 1970s and 1980s, and deteriorated in the

1990s. For example, Bhat (2002) found that under-enumeration for men was 0.7% worse

in the 1991 compared to 1981 census, and 1.4% worse for females (Bhat, 2002). The most recent 2011 census made a specific effort to improve enumeration of women (Navaneetham and Dharmalingam, 2011). Despite problems in the Indian censuses, it is the only source for district-level estimates of our variables of interest, and therefore our only source for answering these questions at a district-level (Guilmoto and Rajan, 2013).

Most likely the under-enumeration is in more disadvantaged populations (poorer, more rural, more likely to be ST/SC). Since this analysis finds that sex ratios are more imbalanced in urban, wealthier, more educated populations, it is possible that imbalance is actually underrepresented. Assuming that whatever makes the data quality poorer in one state is consistent over time, then the fixed effects model helps control for these state/district-level factors.

Fertility starting in 1981 was estimated at the district-level, and has, for the last four censuses, taken into account potential age misreporting and correct for poor quality data on morality (Guilmoto and Rajan, 2013, Guilmoto and Rajan, 2001). There is evidence that reporting for children 6 and under in the censuses is fairly high quality, therefore the computation of the child sex ratio is straightforward (a ratio of girls/boys taken from the population age structure) (Bhat, 1996). Infant mortality has been estimated from the 1981-2001 censuses at a district-level. Research double-checking the quality of the IMR trends calculated from the census by using the Brass method to calculate IMR (which takes into account problems in age misreporting and misreporting of infant and child mortality) found that the census estimates were fairly strong (Sarma and Choudhury,

2012). This paper does not attempt to correct for possible data quality problems using demographic estimation techniques.

CONCLUSIONS

Despite India as a whole having increasingly imbalanced sex ratios, this analysis provides evidence that the districts and states that have been on the steepest downward slope in imbalance appear to be decelerating their decline and are beginning to see equalization in their child sex ratios. This gives hope that perhaps the states that had the most imbalanced sex ratios hit some type of inflection point from which they have begun to rebound up; the decline in sex ratios does not appear to fall indefinitely. However, the question remains as to whether the remaining (majority) of the districts in India will have to fall to the same level of imbalance before beginning to equalize. If this is the case, there would likely be many more years of increasingly imbalanced sex ratios before the country as a whole begins moving upwards, and even longer before sex ratios become close to normal (even). This would mean many more years of discrimination against girls, both due to sex-selective abortions and excess mortality for girl children. Of course, as of yet, there is no evidence that this deceleration and upward trend will be sustained permanently or even temporarily. Understanding which of the components that makes up the child sex ratio (abortion and excess girl mortality) is responsible for the equalization seen in some districts and states is key to both reducing these practices and knowing how the trend will change in the future.

Evidence from this analysis helps us understand which populations might be at risk in future years of having increasingly imbalanced sex ratios. These findings suggest that as women's literacy rate rises, we are likely to see increasingly imbalanced sex ratios, but as literacy for the population as a whole increases, this slope will decline and perhaps reverse. Declining fertility is unsurprisingly associated with sex ratio imbalance. Interestingly, states with larger ST populations showed more deceleration in their sex ratio imbalance, and this finding deserves more careful exploration.

Further work needs to explore what factors are associated with the self-correction in sex ratios. A shortage of women in the marriage market or the labor market (therefore driving up women's wages) may be mechanisms for this change. It is also possible that laws or program aimed to decrease sex-selective abortion or improve the status of girls have had an effect on this trend. Some evidence has suggested that the Post-natal Diagnostic Technique Act of 1996, which aimed to regulate and eliminate the misuse of sex-selective technologies did not have an impact on the probability of a family having a boy (Subramanian and Selvaraj, 2009). There have been a variety of schemes to improve the welfare of Indian girl children, but there are poor data on the extent and quality of their implementation and impact (Sekher, 2010, Sekher, 2012).

While at first glance, the findings of this analysis are optimistic, in that sex ratio imbalance does not appear to continue downwards forever, if all states had to reach such a imbalanced sex ratio as is seen in the more imbalanced districts of India before beginning to equalize, the situation for girls in India would remain dire. Raising the

threshold at which states decelerate and reverse could potentially save the lives of

millions of girl children, and reduce sex-selective abortions. This analysis helps us

understand the factors associated with this very nascent trend, and the next steps are to

explore its components and potential mechanisms for change.

Table 2.1: Mean and Rage of covariates in 1981, 1991, 2001 and 2011 (N=590 per year)

	Total missing (over all four time periods)	1981	1991	2001	2011
Child Sex Ratio	44	978.86 (878.9, 1076.4)	948.42 (848.6, 1036.3)	929.76 (766, 150)	921.58 (774, 1013)
Total Fertility Rate	30	5.12 (2.5, 9.1)	4.47 (1.85, 7.08)	3.32 (1.3, 5.8)	2.81 (1.2, 5.8)
Infant Mortality Rate	30	115.7 (12, 257)	78.90 (22, 204)	60.16 (6, 151)	46.55 (11, 103)
Percent of adults literate	27	34.93 (7.73, 81.66)	51.16 (19.01, 95.72)	63.82 (25.74, 96.51)	73.59 (37.22, 98.76)
Percent of female adults literate	27	23.50 (2.88, 79.35)	38.09 (7.68, 94)	52.49 (17.45, 96.26)	64.91 (30.97, 98.28)
Percent rural	63	79.03 (0, 100)	77.37 (0, 100)	75.97 (0,100)	73.46 (0,100)
Percent Scheduled Caste	34	14.37 (0, 49.85)	14.77 (0, 51.76)	15.61 (0, 82.58)	15.24 (0, 56.27)
Percent Scheduled Tribe	33	16.27 (0, 97.17)	16.37 (0, 98.11)	16.70 (0, 98.10)	17.5 (0, 99.64)

Table 2.2: Ordinary least squares regression of the change in sex ratio in a 10 year period and the sex ratio 10 years prior. Indian children under 6.

	Change in Girl:Boy Sex Ratio		
	A: 1981-1991	B: 1991-2001	C: 2001-2011
Sex Ratio Lagged	-0.3***	0.28***	-0.235***
	(0.03)	(0.04)	(0.018)
Percent of adults literate	-0.85***	0.21	-3.89***
	(0.29)	(0.41)	(0.38)
Percent of female adults literate	0.94***	-0.31	3.38***
	(0.26)	(0.38)	(0.33)
Percent rural	0.16***	-0.02	0.13***
	(0.05)	(0.05)	0.04)
Percent Scheduled Caste	-0.23*	0.08	0.17
	(0.13)	(0.14)	(0.11)
Percent Scheduled Tribe	0.22***	-0.14**	-0.06
	(0.06)	(0.07)	(0.05)
Total Fertility Rate	-4.52***	4.16***	-1.22
	(1.20)	(1.55)	(1.20)
Infant Mortality Rate	0.02	-.017	0.15***
	(0.03)	(0.05)	(0.05)
Constant	273.89	-294.68	262.20
N	573	552	590
Adjusted R squared	0.2761	0.1586	0.3441

*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Coefficient (Standard Error)

Table 2.3: Population weighted Fixed effects Models: Testing robustness by adding and removing variables, Models A-F

	A	B	C	D	E	F
Sex Ratio Lagged	-0.617*** (-0.016)	-0.812*** (-0.042)	-0.839*** -0.023	-0.802*** (-0.025)	-0.840*** (-0.025)	-0.772*** (-0.045)
Percent of adults literate				2.254*** (-0.452)	1.594*** (-0.455)	1.779*** (-0.487)
Percent of female adults literate				-2.433*** (-0.384)	-1.474*** (-0.402)	-1.482*** (-0.44)
Percent rural				-0.015 (-0.085)	-0.049 (-0.083)	-0.051 (-0.084)
Percent Scheduled Caste				0.128 (-0.252)	0.167 (-0.247)	0.193 (-0.248)
Percent Scheduled Tribe				0.342** (-0.151)	0.404*** (-0.149)	0.464*** (-0.15)
Time Trend		1.173 (-1.23)				2.732** (-1.311)
Time Trend* Sex Ratio Lagged		-0.002* (-0.001)				-0.003** (-0.001)
Total Fertility Rate			10.115*** (-0.89)		8.105*** (-1.211)	6.764*** (-1.345)
Infant Mortality Rate			0.023 (-0.03)		0.028 (-0.031)	0.016 (-0.032)
Constant	566.000*** (-15.47)	769.439*** (-40.874)	741.491** (-19.909)	722.248*** (-28.349)	721.509*** (-27.932)	656.326*** (-49.093)
Observations	1,748	1,748	1,744	1,718	1,715	1,715
R-squared	0.554	0.602	0.61	0.602	0.619	0.622
Number of id	590	590	590	590	590	590

*** p<0.01, ** p<0.05, * p<0.1
Coefficient (Standard Error)

Appendix
Table 2.1: Data Sources

	1981	1991	2001	2011
CSR	E	E	B	B
IMR	D	D	F	G
TFR	D	D	H	H
Population Size	A	A	B	B
Percent SC	A	A	C	C
Percent ST	A	A	C	C
Literacy (total and female)	A	A	B	B
Percent Rural	A	A	C	C

A: Directly from the Indian Census, sent in a STATA file by Vinod Mishra (General, 1981, General, 1991)

B: 2011 Indian Census: Primary Census Abstract (online) (Office of the Registrar General, 2013a)

C: Census of India Website (Office of the Registrar General, 2013c)

D: "Occasional paper No 1 of 1997, District Level Estimates of Fertility and Child Mortality for 1991 and their inter relation with other variables", Registrar General, India (Office of Registrar General, 1997)

E: Hand entered from Census Records in University of California, Berkeley library (General, 1981, General, 1991)

F: "Birth History data of RCH, or District level estimates of child mortality in India based on the 2001 Census data". Imprint New Delhi : Office of the Registrar General, India, Ministry of Home Affairs, Govt. of India, [2009] (Office of the Registrar General, 2009)

G: Annual Health Survey 2010 (Andhra Pradesh, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Punjab, Tamil Nadu, West Bengal, Himachal Pradesh) (Office of the Registrar General, 2013b) or Sample Registration Survey 2011 (Daman and Diu, Dadra and Nagar, Chandigarh) (Office of the Registrar General, 2013d) or state level Census data 2011 where could not find district-level estimates (Goa, Mizoram, Meghalaya, Manipur, Sikkim, Tripura, Arunachal Pradesh) (Office of the Registrar General, 2013c)

H: "Fertility at District Level in India: Lessons from the 2011 Census", Christophe Z Guilmoto, and Irudaya Rajan (Guilmoto and Rajan, 2013)

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CHAPTER 3

PAPER 2:

DECOMPOSING EQUALIZING CHILD SEX RATIOS IN INDIA INTO FERTILITY

AND MORTALITY RELATED COMPONENTS: GEOGRAPHIC REGIONS AND

URBAN/RURAL POPULATIONS

"The tragedy of the world's 160 million missing girls isn't that they're 'missing.'

The tragedy is that they're dead."

(Douthat, 2011)

ABSTRACT

Despite an overall downward trend in child sex ratios in India between the 2001 and 2011 censuses, a few of the districts that were the most imbalanced in 2001 (fewer girls than boys) showed signs of equalization in 2011. This analysis looks in depth at these districts to better understand the nature of the equalization. First I decompose the equalization into (1) equalization due to less pre-birth events (presumably from sex-selective abortion) and (2) equalization due to improved girl child mortality compared to boy child mortality. To decompose the trends, I use data from life tables to reverse-survive the populations of children alive in 2001 and 2011, applying information on ratios of child survival at a district compared to state level to estimate district-level trends. I find that most of the equalization is due to reductions in pre-birth events, although these events still make up the majority of the cause of imbalanced sex ratios. There are four main clusters of districts where the sex ratios are beginning to equalize: in the north in Punjab, Haryana, Delhi, and Chandigarh; the west around the capital of Gujarat; the south from Tamil Nadu up through Karnataka; and in the northeast states. I explore the trend in the decomposition by these geographic clusters and find little difference between clusters. I then decompose the child sex ratio in rural and urban areas of each district and find that equalization is happening in both rural and urban areas in most areas, but there has been a greater increase in the amount of the contribution to imbalance from excess female mortality in urban areas over time. Finally, I test whether there is an association between the level of child mortality and the percent of the imbalanced child sex ratio that is from pre-birth events. This analysis finds that the higher the female child mortality, the lower

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the contribution from pre-birth events in 2001, but there is no relationship in 2011. Declines in pre-birth events and excess female mortality are contributing to the equalization in child sex ratios, but pre-birth events still make up the majority of the cause of missing girls, and female child mortality still lags behind male child mortality.

INTRODUCTION

The most recent Indian Census (2011) showed that the country as a whole had a lower child sex ratio than in previous years, having fallen from 928 girls/1000 boys in 2001 to 914 girls/1000 boys in 2011 (Registrar General of India, 2011). However, some of the districts with the most imbalanced child sex ratios in 2001 showed signs of equalization in 2011. This analysis looks in depth at the districts that showed evidence of equalization to understand the trends and causes of the equalization. I decompose the child sex ratio into fertility and mortality related components, and explore these by geographic clusters and urban/rural areas.

The child sex ratio is defined as the number of girls divided by the number of boys under the age of five (unless otherwise stated, sometimes ages 0-6 are included to take age heaping on age five into account). Child sex ratios are the result of two components: the sex ratio at birth and differentials in child mortality by sex (in this case, higher mortality for girls). Imbalanced sex ratios at birth in India are most likely due to sex-selective abortion, while differentials in mortality are due to gender-based differences in feeding practices, health care seeking behavior, and immunization rates that counteract an underlying frailty disadvantage of males (Mishra et al., 2004, Arnold et al., 1998, Claeson et al., 2000). In populations without gender preference, male infants have higher rates of mortality than female infants in general, especially in the neonatal period (Wells, 2000). Therefore, we would expect female children to have better mortality rates than male children, rather than worse, as is seen in India by the imbalanced child sex ratio.

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There is evidence that environmental stresses differentially affect human fetuses by sex, for example, terrorism, extreme temperatures, and economic instability can lead to the spontaneous abortion of male fetuses and thus alter the sex ratio (Catalano et al., 2008, Catalano et al., 2006, Catalano, 2003). However, we have no reason to believe that some sustained environmental pressures have imbalanced the sex ratio in India in the past in one direction and are now acting in the opposite direction (evening out the child sex ratio). If anything, over the last 15 years India has seen more of its population escape poverty than ever before in history (Ravallion, 2009). If there is a biological basis for pre-birth influences on the sex ratio it would be a case where economic stressors became less prevalent. It is simply unknown whether these economic improvements for India's poor lowered the number of spontaneous abortions for male infants. At the same time, there is literature to support the hypothesis that sex-selective abortions are an important cause of the imbalanced sex ratio at birth in India (Oomman and Ganatra, 2002, Arnold et al., 2002). However, in this analysis I am only able to estimate the sex ratio at birth, and not its cause, therefore, I will refer to the causes of the imbalanced sex ratio at birth as "pre-birth events."

Work by Jha et al. in 2012 suggested that much of the dramatic decline in child sex ratios seen in the 2011 census was due to increases in sex-selective abortions (assuming that all of the cause of imbalanced sex ratio at birth was due to abortion), rather than increases in excess female child mortality (Jha et al., 2011). However, this finding was for the country as a whole where sex ratios are falling overall. It is not yet clear if the districts that showed signs of equalization in child sex ratios did so more because of changes in the sex

ratio at birth or because mortality for girls (relative to boys) has improved. There have

been substantial reductions in child mortality in India over the past decades, but a

mortality gap between females and males still exists in many states (Ram et al., 2013).

Past literature has shown that girls receive less/poorer quality nutrients, are breastfed for

less time, taken to health facilities less frequently when ill, and receiver fewer

immunizations, all of which lead to excess mortality of girls under age five (Mishra et al.,

2004, Arnold et al., 1998, Claeson et al., 2000). Therefore, despite improvements in

child mortality overall, females are still disadvantaged compared to males, contributing to

the child sex ratio differential.

India's current population is over 1.2 billion, divided into 35 states and territories and

over 600 districts. Districts range in population from 7,948 (Dibang Valley, Andhra

Pradesh) to over 11 million (Thane, Maharashtra), with over 70% of districts having

more than a million people (Registrar General of India, 2011). Therefore, examining

district-level trends and breaking up districts into rural/urban components are important

because many contain large and diverse populations. Past literature has stressed the

importance of considering indicators such as mortality, fertility, and gender preference at

the district-level for understanding trends and patterns in India (Murthi et al., 1995).

Not only is India very large, but it is also extremely heterogeneous. There is a strong

cultural divide between the north and south, and other regions of the country are defined

by very different languages, practices, and socio-economic situations (Dyson and Moore,

1983). Urban/rural differences have been well documented in India for various indicators

of health and development. For example, rural women have been found to want more sons and have higher fertility than urban women, and people living in rural areas have less access to health care (Clark, 2000, Jeffery and Jeffery, 2000, Balarajan et al., 2011). Child sex ratios first began becoming imbalanced in urban areas, where people were more educated, had lower fertility, and had more access to sex-selective technologies (Bhat and Zavier, 2007, Das Gupta and Bhat, 1997). Over time, child sex ratios began falling in rural areas as well, with the introduction of mobile ultrasound clinics, increases in education, wealth, and declining fertility (Retherford and Roy, 2003, Bardia et al., 2004, Khanna, 1997). Therefore, exploring geographic and urban/rural differences is important for understanding any trend in India.

DATA AND METHODS

This analysis relies on data from the Indian censuses of 2001 and 2011 and the Indian Sample Registration System in various years (Office of the Registrar General, 2011, Registrar General of India, 2001, Office of the Registrar General, 2013d). Between 2001 and 2011, 47 new districts were formed in India (increasing the number of districts from 593 to 640). In some cases districts split into two parts, and in other cases pieces of older districts were pulled off and a new conglomeration of a district was created. In situations where the district split into two parts, data from the 2001 census are applied to both new districts in 2011. In cases where a new district was formed from pieces of multiple former districts, information from 2001 about the district that made up the largest percent of the

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new district in 2011 is applied to the new 2011 district. This did in some cases lead to

problems in calculations, which are discussed below.

I. Decomposition Methods

District-level estimates of child sex ratios are published for the 2001 and 2011 censuses.

Sex ratios at birth are back calculated from life table estimates calculated from the

Sample Registration System for 1996-2000 and 2006-2010 (Registrar General, 2013). For

2001, the following equation is used for back calculation (this was done for males and

females separately) to estimate the number of births, and then the sex ratio at birth is

calculated from that. Equations 1-3 are shown for males (m):

$$_5L0_m = {_1L0_m} + {_4L1_m} \tag{Eq 1}$$

Where:[2]

$_1L0$ = person years lived from age 0 to 1

$_4L1$ = person years lived from age 1 to 5

$$\text{Survival ratio}_m = {_5L0_m}/(5 \times l0_m) \tag{Eq 2}$$

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[2] The notation for the life table variables is as follows: the subscript on the right is the start age, and the subscript on the left is how many years the interval covers. So, $_5L0_m$ is the person years lived from age 0 to age 5, for males.

Where:

l_0 = radix population at age 0 (100,000)

$$\text{Number of births}_m = (1/\text{Survival ratio}_m) \times (\text{Population}_m \text{ age 0-4 in 2001})$$

(Eq 3)

Equation 1 calculates the person years lived up to age 5 by adding together $_1L_0$ and $_4L_1$. Equation 2 then calculates the survival ratio, which is the person years lived up to age five ($_5L_0$), divided by 5 times l_0. This lets us know what proportion of those born survived to age five. Equation 3 calculates the number of births in that time period by multiplying the inverse of the survival ratio (which could be thought of as the mortality ratio) by the population aged 0 to 4 in 2001 (5 years). This is done separately for males and females and the sex ratio at birth is the number of females born in that time period divided by the number of males born in that time period.

The Sample Registration System life tables are currently only estimated at a state level. Therefore, to estimate the district-level l_0 and $_5L_0$, I employ the method used by Kumar and Sathyanarayana (2012), where the ratio of child mortality at a district-level to the state level child mortality is applied to the state level life table functions (Kumar and Sathyanarayana, 2012). District-level child mortality (CMR) estimates by sex from the 2001 census were published by the Registrar General (Registrar General of India, 2008). The ratio of district to state (θ) is calculated for each district using equation 4:

$$\theta = (1000\text{-CMR\_ district})/ (1000\text{-CMR\_state})$$

(Eq 4)

Then, the district-level survival ratio is calculated using the following equation:

$$_5L^D_0 = \theta \times {}_5L^S_0 \qquad\qquad\qquad\qquad (Eq\ 5)$$

Where the superscript D=district and S=state. This equation is calculated separately for males and females for each district that had showed evidence of equalization in sex ratio. From these calculations, the survival ratio and then the number of births are calculated for each district and sex as shown in equations 2 and 3.

The same procedure is used to estimate the sex ratio at birth in 2011, except that since the child population data is given for ages 0-6 instead of 0-4, the survival ratio must take that into account. Therefore, the following equation is used:

$$\text{Survival ratio}_m = {}_7L0_m/(7 \times l0_m) \qquad\qquad\qquad (Eq\ 7)$$

In order to calculate $_7L0_m$ I need to add together the person years lived up to age six (L's) from the life table for 0-1, 1-5 and a portion of 5-10. I assume that deaths were evenly distributed between the ages of 6-10, therefore, 2/5 of $_5L5_m$ is added to the other two values.[3] The following equation is used to calculate $_7L0_m$:

$$_7L0_m = {}_1L0_m + {}_4L1_m + ({}_5L5_m \times (2/5)) \qquad\qquad\qquad (Eq\ 8)$$

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[3] Model life tables do not break down the 5-10 age group into single year survival probabilities, so we were unable to apply a more nuanced distribution (UNITED NATIONS 1982. *Model Life Tables for Developing Countries.* , New York, United Nations).

Estimates of child mortality at a district-level are not yet available for the 2011 census. The Annual Health Survey of India (collected in 2010) publishes estimates of child mortality at a district-level but only for a few states (relevant to this study: Assam, Bihar, Madhya Pradesh, Jharkhand, Orissa, and Rajasthan) (Registrar General and Census Commissioner, 2012). Therefore, these data are used to calculate the ratio (θ) in equation 4, and $_7L^D_0$ in equation 5.

For the remaining states (Gujarat, Punjab, Haryana, Kerala, Karnataka, Tamil Nadu, West Bengal, Himachal Pradesh and Maharashtra) only state level data on child mortality were available from the Sample Registration System for 2011(Office of the Registrar General, 2013d). Therefore, the 2001 child mortality ratio (θ) is used to estimate the appropriate district to state ratio in for those districts in 2011.

Once the estimated sex ratio at birth is calculated, the contribution to the imbalanced sex ratio from child mortality is calculated by subtracting the child sex ratio from the estimated sex ratio at birth. The contribution to the imbalanced sex ratio from pre-birth events is 1000 minus the sex ratio at birth. I look at trends over time in the contribution of these various components to understand if the equalization is due to changes in child mortality or pre-birth events.

i. Decomposition: Urban/Rural

The 2001 census published data on the child population aged 0-4 by sex in urban and rural areas by district (Registrar General of India, 2001). However, thus far, the 2011 census has only published data on the child population aged 0-6 in rural and urban areas per district. Due to lack of other data sources, these two populations are compared, despite the slightly different age group (Registrar General of India, 2011). I assume that the ratio of children aged 0-6 and 0-4 will be the same, even though the population sizes most likely differ. This assumption would not hold if there were differences in the female mortality rate relative to males pre-age four and post age four. While we do not have age and sex specific mortality rates post age five for India, I have no reason to believe that there is a radical shift in female mortality compared to male mortality for the age group 5-6 compared to 4-5. Data were not available for the urban/rural contribution for the following smaller states: Andaman and Nicobar, Chhattisgarh, and Pondicherry, therefore, these were dropped from the analysis.

District-level child sex ratios are calculated for rural and urban populations. The urban and rural child sex ratios are first compared to their respective child sex ratio in 2001/2011, to see if urban or rural areas generally have higher or lower child sex ratios than the population as a whole. Then, the change in child sex ratios between urban and rural areas over time is calculated, to see if the equalization found is only occurring in urban or rural areas, or in both. I then decompose the child sex ratio from rural and urban

areas into the fertility and mortality components, using the methods described above (Eqs 1-8).

ii. Decomposition: Geographic Clusters

Changing child sex ratios and the decomposed contribution from pre-birth events and mortality are then examined based on spatial clusters of equalizing districts identified when looking at the geographic pattern of where districts are equalizing in India. The goal of this is to explore whether there are differences in the contribution to the changing child sex ratio in different regions of the country (spatially). I look at these three indicators in the four identified clusters of equalization, and explored whether there are differences in the four geographical clusters.

iii. Decomposition: Is there a tradeoff?

Finally, I explore whether there is a tradeoff occurring between declines in mortality and changing pre-birth behavior with the changing nature of child sex ratios. To do this, I create quartiles of child mortality for males and females in both 2001 and 2011. I then see if these quartiles are associated with the percent of the imbalance that is due to pre-birth events in a regression for each year, controlling for the child sex ratio.

Of the 640 districts in India in 2011, 153 of them show signs of equalization (the remainder worsened) in their child sex ratios between 2001 and 2011 (Table 3.1).
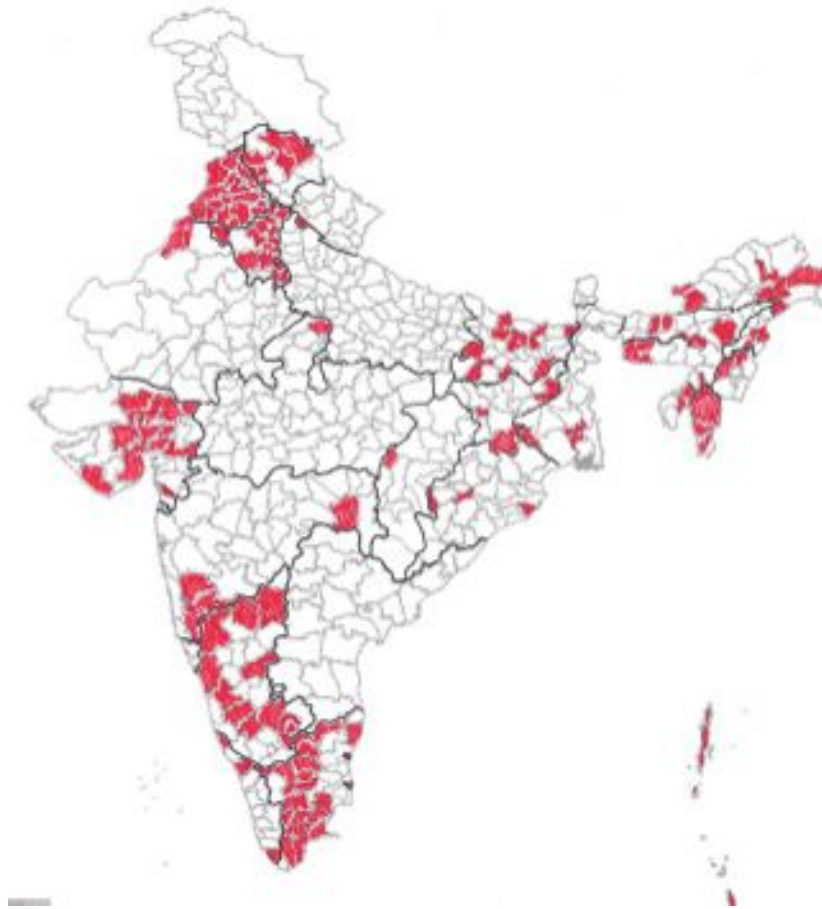
Fig 3.1. Map of India with districts in which the child sex ratio equalized between 2001 and 2011, shown in red.

Figure 1 shows the districts that showed equalization in child sex ratio between 2001 and 2011 in red, in all other districts the child sex ratio fell between the two time points. Some of the districts that equalized are clustered in four regions, while the rest are scattered. Starting at the North, many of the districts that showed equalization are in

Haryana, Punjab, Himachal Pradesh, and the territories of Delhi and Chandigarh. There is some spill over into Rajasthan and Uttrakhand. Seventeen out of the 21 districts in Haryana showed equalization, and 20 of the 22 districts in Punjab showed equalization. This cluster also includes much of New Delhi and Chandigarh.

The second cluster of districts is in Gujarat, in western India. Twelve of the 32 districts in Gujarat showed equalization, and these are clustered around the capital of Gujarat, Ahmedabad. The third cluster is in the south, mostly occurring in Tamil Nadu and Karnataka, with some spill over into Kerala and Maharashtra, although not all districts in these states have shown equalization. The fourth cluster is the Northeastern region, on the eastern side of Bangladesh, and includes districts in Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, and Nagaland, but not all districts in any one of these states.
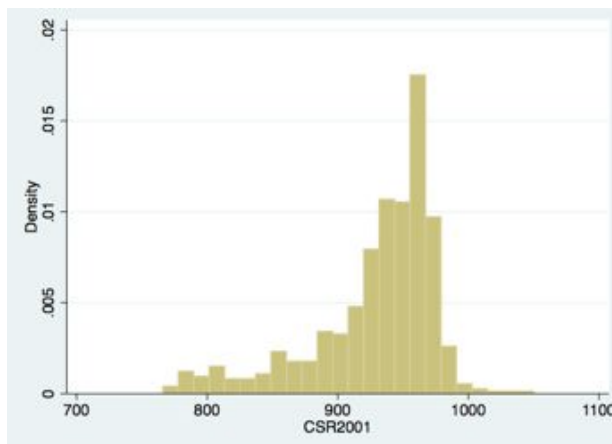
Fig 3.2: Histogram of child sex ratios in 2001
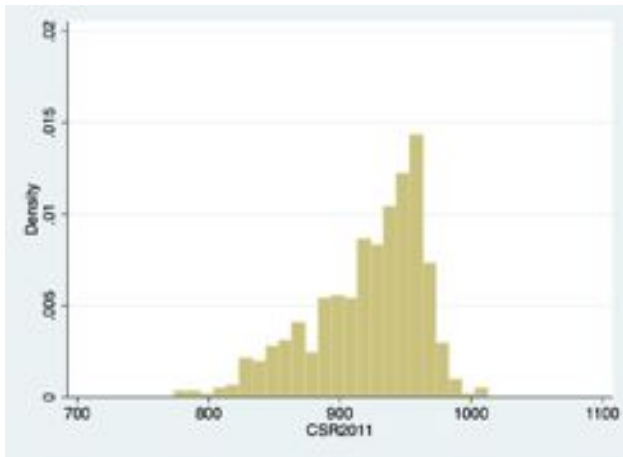
Fig 3.3: Histogram of child sex ratios in 2011

Figures 2 and 3 show the distribution of child sex ratios in India as a whole in 2001 and

2011. While the peak density of child sex ratio level did not shift much, it did become

less dense. The left tail became more dense and the right tail shorter in 2011 compared to

2001, showing that most districts in India have become more imbalanced in their child

sex ratio.
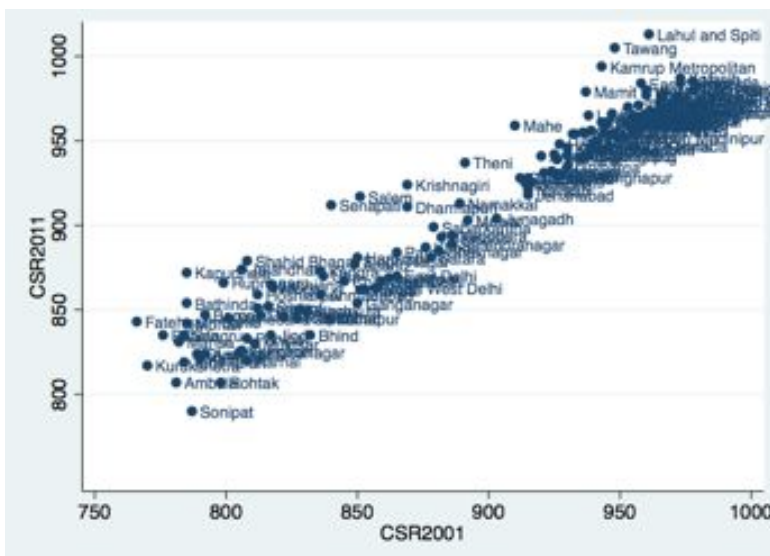
Fig 3.4: Scatterplot of the child sex ratio in 2001 vs 2011

Figure 4 shows the child sex ratio in 2001 compared to the child sex ratio in 2011 for every district in India. The districts that showed equalization in their child sex ratio stand out by being above the 45 degree line that the majority of districts lie along.

The mean child sex ratio in 2001 for the 153 districts that showed equalization was 885, ranging from 766 to 979. In 2011, this group of districts had a CSR of 905, ranging from 790 to 1013. The over all mean change in child sex ratio was 22, ranging from 1 to 87 (Table 3.1). As a comparison, in India as a whole child sex ratios fell by a mean of 8 (8 fewer girls in 2011 than in 2001), ranging from -98 to 87 between 2001 and 2011. For these analyses, I needed to use data on children under five by rural/urban, and by population size. The Registrar General of India publishes population data by age and sex for ages 0-4 in 2001 and 0-6 in 2011, these are also available by urban/rural status. Therefore, I constructed my own child sex ratios from these data. The difference between the child sex ratios I constructed and the official published child sex ratios are shown in Table 3.1. My estimates had the same child sex ratio in 2001, and a child sex ratio 2 points higher in 2011.

I. Decomposition

The Sample Registration System only constructed life tables for the larger states in India, therefore, I was unable to look at the districts from smaller states in this analysis. Districts from following states were dropped from the analysis: Andaman and Nicobar, Arunachal Pradesh, Chhattisgarh, Chandigarh, Delhi, Jharkhand, Manipur, Mizoram,

Nagaland, Pondicherry, and Tripura. For twenty-one of the districts, the child sex ratio I constructed from the available data (as discussed above) did not show signs of equalization. Of these, the majority were within 5 points of each other, so I kept these in the analysis, however, I dropped the data for 11 districts where the 2001 child sex ratio was more than 5 points greater than the 2011 child sex ratio. Some of these districts were districts where boarders changed over time, so larger district data from 2001 were applied to smaller districts in 2011 (Table 3.2).

The mean district-level survival ratios for both males and females fell between 2001 and 2011 (Table 3.3). This makes sense because the survival ratios for 2001 are for children 0-4 and the survival ratios for 2011 are for children 0-6, therefore, I would expect more children to die by age six than by age four. Since these survival ratios are applied to a larger population in 2011 than 2001, the smaller size of the 2011 survival ratio is taken into account.

In 2001, the mean contribution to the imbalanced sex ratio from events prior to birth was 114 (ranging from 16 to 236), and the contribution from differentials in child mortality was about 7 (ranging from -14 to 33) (Table 3.4). In 2011, the mean contribution from events prior to birth was 93 (ranging from 4 to 200), and the contribution from child mortality was about 4 (ranging from -16 to 29). In both years, events prior to birth played a larger role in the imbalanced sex ratio, although this was on average lower in 2011 than 2001. The contribution from differentials in child mortality was larger in 2001 than 2011, although of much smaller magnitude. The negative values indicate that in

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some state girls have better survival than boys in under 5, therefore, differences in mortality actually acts as a way for girls to catch up from imbalance due to pre-birth events in these districts. Between 2001 and 2011, the contribution to the sex ratio from excess child mortality increased by an average of about -3 girls, and the contribution from events prior to birth fell by an average of about 20 girls.

Percentage-wise, the average percent of imbalance due to events prior to birth was 93.7% in 2001, and dropped to 92.5% in 2011 (Table 3.5). The percent of imbalance due to excess female child mortality increased slightly from 6.3% in 2001 to 7.5% in 2011.

i. Decomposition: Urban/Rural

When I created child sex ratios for rural and urban populations separately by district, there were 17 districts that showed negative change in child sex ratios in both rural and urban areas. A closer examination of these districts showed that they were districts that either split into parts over the time period, so the values in 2001 refer to a larger population than the data in 2011, or these were districts with very small populations in either urban or rural areas. As mentioned above, child populations 0-4 in 2001 were compared to child populations 0-6 in the 2011 census. Theoretically, when looking at ratios alone, this should not result in too big of a problem, however, in some of the districts with very small urban or rural populations, it is possible that some problems may arise. These 17 districts were therefore dropped from the analysis. Furthermore, there

were 7 districts that were either completely rural or completely urban, or missing all data, and these were also dropped from the analysis (Table 3.2).

Table 3.6 shows the change in the child sex ratio from 2001 to 2011 in rural and urban areas in the 123 remaining districts. Urban areas equalized by a larger magnitude than rural areas. The average change in urban areas was 26.3, and was 17.26 in rural areas. Eighty-one (66%) of the districts showed equalization in both rural and urban areas. Seventeen (13%) showed equalization only in rural areas, and 25 (20%) in only urban areas.

The contribution to the child sex ratio from child mortality in 2001 was about 17 in rural areas and -2 in urban areas (Table 3.7). The contribution to the child sex ratio from per-birth events was higher in urban areas than rural areas in 2001, with about 111 and 130 missing girls in rural and urban areas, respectively. The contribution from child mortality in 2011 was almost three times higher in rural than urban areas in 2011 (about 12 and 4 missing girls respectively). The contribution from pre-birth events in 2011 was higher in urban compared to rural areas, at 91 and 99 missing girls respectively. The contribution from child mortality in rural areas decreased by about 6 female child deaths, however in urban areas it increased by about 5 female child deaths. The contribution from pre-birth events fell by almost 30 in urban areas and about 20 in rural areas between 2001 and 2011.

ii. Decomposition: Geographic Clusters

Four clusters were analyzed. The "North" cluster included all districts that showed equalization in Punjab, Haryana and Rajasthan, because all of these are contiguous. The "West" cluster included all the districts that showed equalization in Gujarat, with the exception of Navsari, which was separated from the main cluster by more than one other district. The "South" cluster included all districts that showed equalization in Tamil Nadu, Kerala, Karnataka, and Maharashtra, except for Chandrapur in Maharashtra because, again, it was distinct from the main cluster. The "Northeast" cluster was dropped from this analysis because data was only available for 4 districts in Assam. The other states in this region do not have the necessary life table estimates available to do the decomposition. The most concentrated part of the equalization in the northeast was in Mizoram, Manipur, and Nagaland, which would have been excluded from this analysis.

The mean child sex ratio was much lower in the north and west clusters in both 2001 and 2011, with the northern cluster having a child sex ratio of 803 and 842 in 2001 and 2011, respectively, and the western cluster a child sex ratio of 861 and 879 in 2001 and 2011 (Table 3.8). These two clusters are below the national average child sex ratio in both years. Child sex ratios were not as severely imbalanced in the southern and northeastern clusters, with the southern cluster having child sex ratios of 929 and 942 in 2001 and 2011 respectively, and the northeast cluster child sex ratios of 951 and 957 in 2001 and 2011. These two clusters are above the national average child sex ratio in both years.

In all clusters, pre-birth events made up the majority of the contribution to the imbalanced sex ratio (Table 3.8). It appears that mortality makes up a large percent of the distribution in the West compared to the north and south. The percent of the contribution from mortality fell over time in the south and west, however, it increased in the north. Overall, the differences by region were not dramatic.

iii. Decomposition: Is there a tradeoff?

Quartiles of the child mortality rate for males and females in 2001 and 2011 were constructed and regressed on the percent of the imbalance in the child sex ratio that was due to pre-birth events, controlling for overall level of the child sex ratio. The higher the male child mortality quartile (a higher quartile means higher child mortality rate), the greater the percent of the imbalance from pre-birth events in 2001 ($p<0.01$) (Table 3.9). Conversely, the higher the female child mortality quartile, the lower the percent of the imbalance from pre-birth events in 2001 ($p<0.000$). However, there was no association between the level of either male or female child mortality and the percent of the imbalance from pre-birth events in 2011. The level of the child sex ratio was not significantly associated in either year.

DISCUSSION

In the districts that showed signs of equalization in child sex ratios between 2001 and 2011, pre-birth events are the primary cause of the imbalanced child sex ratio, both in 2001 and 2011. Pre-birth events contributed on average about 113 excess missing girls in 2001 in these districts, and about 93 excess girls on average in 2011. Therefore, although the magnitude of imbalance due to pre-birth events is still very large, it has declined in these districts between 2001 and 2011. The contribution to the imbalanced child sex ratio from excess female child mortality fell between the two time periods (from about 7 in 2001 to about 4 in 2011), and the magnitude of this contribution is still very small. Overall, the change in the contribution from child mortality between 2001 and 2011 was not large, decreasing by 3 (meaning there were 3 fewer excess girls per 1000 boys due to mortality), while the contribution from pre-birth events fell by about 20. Percentage-wise, the majority of the cause of imbalance was due to pre-birth events and it fell only slightly between the two time points (from about 94% to 92.5%). Child mortality contributed about 6-7% of imbalance. Therefore, although the magnitude of contribution from pre-birth events and from mortality fell over time, the relative contribution from each remained fairly stable.

The districts in which child sex ratios equalized between 2001 and 2011 were mostly clustered in four regions: the north around Punjab, Haryana, Delhi, and Chandigarh; the west around the capital for Gujarat; the south extending contiguously from southern Tamil Nadu up through Karnataka; and the northeastern region, east of Bangladesh. The

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north and west two clusters are similar in that their child sex ratios had become extremely low (very imbalanced)—they were in fact two of the most imbalanced regions in the country in 2001. Child sex ratios in the south and northeastern clusters were not as imbalanced in 2001 (or 2011)—they are higher than the national average. These areas have traditionally had much lower rates of son preference and less imbalanced sex ratios (or not imbalanced at all) compared to the rest of the country (Dyson and Moore, 1983). That the south and northeast clusters declined a little in the 2001 census but begun to equalize by the 2011 census suggests that these areas might not actually have the same sloping downward trend seen in other parts of India, and might stabilize back at more even sex ratios in the years to come. There was no clear trend in differences in the decomposition between clusters, except perhaps evidence that the west had a higher proportion of the imbalance due to mortality.

The pattern of the southern cluster is interesting because it is fairly narrow and follows the contours of the West Ghats, which are a north to south mountain range separating much of Kerala and Tamil Nadu. Past literature has described an "infanticide belt" in Tamil Nadu, which is very similar to the stretch of equalizing districts found in this analysis in the south (Chunkath and Athreya, 1997, Vella and Oliveau, 2005). Vella and Oliveau (2005) argue that infanticide spread from a few specific areas in Tamil Nadu to contiguous districts through social diffusion. Specifically, they suggest that the Kongu Vellalar Gounders caste had high son preference and infanticide because of their work in agricultural, and since this is a high caste, these practices were spread via social propagation to lower castes in nearby districts (Vella and Oliveau, 2005). Much attention

has been paid to the high levels of infanticide in this region, and therefore many programs and government efforts have focused on reducing female infanticide in this region (Athreya and Chunkath, 2000). Perhaps, therefore, the equalization in the child sex ratio in this area is due to reductions in infanticide following the same diffusion pattern along the "infanticide belt" as in the past (Srinivasan and Bedi, 2008, Vella and Oliveau, 2005). More research on this is needed.

In northeast India, the districts that have shown equalization are not as contiguous as the other clusters, and are scattered amongst a number of states. It is possible that this does not actually represent a cluster of equalization. These states have a very different culture than the rest of India, have higher proportions of tribal populations, and have experienced political unrest and violence in the recent decades due to a separatist movement (Shimray, 2004). Due to the unrest, conducting research in this area has been difficult, and very little research on gender preference or child sex ratios has occurred in this region. Interestingly, some states in the northeast, such as Meghalaya, have a tradition of daughter preference, which could help explain the rebound from the slightly imbalanced sex ratios seen in the past (Narzary and Sharma, 2013). More research on gender preferences in this part of the country could help us understand the trends in child sex ratios seen today.

On initial inspection it appears that the cluster of equalizing districts are grouped around urban centers. The northern cluster is the densest, with nearly every district in Punjab and Haryana, as well as much of Delhi and Chandigarh showing equalization. These are two

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of the most developed, modern, and richest cities in India. The western cluster, in

Gujarat, includes the capital of Gujarat (Ahmedabad) and Vadodara, the third largest city

in Gujarat. In southern India, the cluster of districts includes Madurai, which is the third

largest city in Tamil Nadu; Thiruvananthapuram, which is the capital of Kerala; and

Bangalore, the capital of Karnataka, as well as other big cities in each of these states.

Most of the districts that showed equalization in the northeastern cluster are not in urban

centers, except for Aizawl, the capital of Mizoram, and Kohima, the capital of Nagaland.

Other social trends in India, and elsewhere, have been shown to be spatially continuous,

for example, the Indian fertility decline and imbalanced sex ratios (missing daughters)

(Guilmoto and Rajan, 2001, Kuzhiparambil and Rajani, 2012, Guilmoto, 2008). These

past studies have suggested that because spatial variations in social variables are not

random and are geographically related, this provides evidence that processes at the micro

level, rather than factors such as programs/campaigns or changes in economic

development, are more important drivers of these trends.

As discussed above, sex ratios first began becoming imbalanced in urban areas, and this

spread to rural areas, therefore it is perhaps unsurprising that many of these clusters

surround urban centers (Das Gupta and Bhat, 1997, Bhat and Zavier, 2007). However,

not all of the clusters included urban centers, so this is not the driving force uniformly.

Interestingly, the clusters in the north and west, which differ from the other clusters in

that they have the most imbalanced sex ratios, were more focused around urban areas

than the other clusters. Perhaps the relationship between social trends initiating in urban

settings and the subsequent diffusion of behaviors plays a larger role in areas of extreme

sex ratio imbalance, and is less important in areas where the child sex ratio was not as imbalanced to begin with.

There was not a large difference in child sex ratios between rural and urban areas, although urban areas equalized slightly more than rural areas between 2001 and 2011. The majority of the districts explored at the urban/rural level showed equalization in both rural and urban areas, suggesting that this trend is not restricted to only certain sub-populations. Of the districts that only showed equalization in either urban or rural areas, more showed equalization in urban areas, suggesting that the trend may be originating in these areas first. Other related trends in India (such as fertility decline and imbalanced child sex ratios) originated in urban areas, so we hypothesized that the same trend would occur with equalization in child sex ratios. Many of the districts that showed equalization are in more developed states, and closer to major metropolitan centers (such as Delhi). These findings support past findings that these trends often originate in urban settings or near urban centers, but the equalization in child sex ratios is not limited to urban areas.

Child mortality contributed to the child sex ratio by about 17 female child deaths in 2001 in rural areas, however, child mortality in 2001 in urban areas was actually a corrective force, reducing the imbalance by about 2 births. In 2011, child mortality contributed to the imbalance in both rural and urban areas, although more so in rural than urban areas. Pre-birth events made up the majority of the imbalance in both rural and urban areas in 2001 and 2011, and the magnitude was less in 2011 and greater in urban areas in both years.   The amount of imbalance due to mortality declined in rural areas between 2001

and 2011, meaning there was less excess female mortality, however, it increased in urban areas.

This could be reflective of past findings that the child mortality rate has slowed, stagnated, and even increased in India in recent years (Saikia et al., 2010, Saikia et al., 2009). There was a greater decline between 2001 and 2011 in the amount of the contribution due to pre-birth events in urban areas compared to rural, however, the overall magnitude of the contribution is still larger in urban compared to rural areas. In summary, rural and urban areas differ slightly in the make up of their imbalanced child sex ratio, and there is evidence that the contribution to the imbalance from excess female mortality has actually increased in urban areas (the mortality situation for girls has worsened in urban areas).

These findings highlight that the decline in child mortality for girls lags behind the decline for boys, as has been noted elsewhere (Ram et al., 2013). Hill and Upchurch (1995), using Demographic and Health Survey data from around the world to look at gender differences in child mortality, found that when male child mortality declines, the female advantage in under 5 mortality declines (Hill and Upchurch, 1995).Therefore, in the absence of gender preference and uneven care-giving practices, with development, we would expect it to appear that girls fare worse. Future research should focus on the reasons that improvements in mortality for girls under age five lags behind improvements in mortality for boys.

While it is possible that the imbalance in the sex ratio at birth is due to environmental or biological causes, much past literature has suggested that sex-selective abortion is the primary cause (Oomman and Ganatra, 2002, Arnold et al., 2002). Sex-selective abortion has been illegal in India for almost 20 years, and there are many efforts to reduce access to sex determination techniques (it is important to not restrict access to abortion itself, which has been legal in India, since the 1970s). Additionally, there have been a plethora of efforts in India aimed to reduce the preference for sons or increase the preference daughters—from education/media campaigns to programs that offer incentives for families to have daughters (Sekher, 2010, Sekher, 2012). Assuming that most of the imbalance at birth is due to abortion, the finding that the magnitude of sex-selective abortion has gone down provides evidence that either families are not seeking sex-selective abortions, or they are less able to determine the sex of their fetuses even if they do want to. Changing preferences would indicate a possibility of more equalization in the future in a potentially larger geographic area, as social trends and preferences often spread. However, even if the change is due to better restrictions on sex-selective abortions (and not on changing preferences), this is still an improvement on previous decades of poor success in restricting sex-selective technology. Future research should aim to understand whether changing preferences or reduced access to sex-selective abortions are responsible for the equalization in the sex ratio at birth.

It is possible that as child mortality falls (especially for females), families who do not want daughters are more likely to rely on pre-birth sex-selective abortion as a means of achieving their desired family composition. Conversely, others have argued that access to

pre-natal sex determination and abortion should allow those girls that are born to be more "wanted" and therefore excess girl-child mortality would decrease with increasing sex-selective abortion (Sudha and Rajan, 2003). Additionally, others have argued that these two practices are additive, or even re-enforce and strengthen each other, and that this is why we have seen increasingly imbalanced sex ratios in children in countries like India and China recently (Goodkind, 1996). This analysis provides evidence in 2001 that the percent of imbalance due to pre-birth events increases with higher male child mortality and decreases with higher female child mortality, however, this does not appear to be the case in 2011. Therefore, this analysis does not provide evidence that a tradeoff between mortality and pre-birth events is occurring at this point in time.

I. Limitations

One set of limitations in this study comes from lack of complete and consistent data for all districts at the two time points. Age-data by sex and rural/urban status was only available for ages 0-4 in 2001 and 0-6 in 2011. This leads to some potential for errors when comparing these two age groups. Substantial evidence exists for age-heaping on age five in the censuses of India and National Family Health Surveys in India (Retherford and Mishra, 2001, Bhat et al., 1984). Generally, it is accepted that using the 0-6 age group is better than the 0-4 age group because it helps account for age-heaping (Guilmoto and Rajan, 2002). This is part of the reason that the 2011 child population data is given in 0-6, as opposed to 0-4 in 2001 (Kulkarni, 2013). However, as long as people do not differentially age-heap boys compared to girls, this should not bias these results since I

am primarily interested in comparing ratios. Data on age structure is not yet published for all districts in 2011, therefore, some districts had to be dropped from the analysis.

District-level life tables have not yet been calculated, therefore, I had to estimate person-years lived up to various ages at a district-level by applying ratios of child mortality at a district-level compared to the state level. This method was used by Kumar and Sathyanarayana (2012), and should not introduce too much error since life table estimates are derived from child mortality estimates (Kumar and Sathyanarayana, 2012). Additionally, district-level child mortality estimates are not yet available for the 2011 census, therefore, I had to use Annual Health Survey (AHS) estimates from 2010 for the states from which these data were available. However, AHS is not collected in all states, therefore, in those without AHS data, 2001 child mortality ratios were applied to 2011. Kumar and Sathyanarayana (2012) state that, "at moderate levels of mortality, birth rate estimates from the reverse survival procedure are not that sensitive to errors in child mortality estimates" (p. 68) (Kumar and Sathyanarayana, 2012). They also cite work by Bhat (1996) that showed that in India a 10% error in child mortality estimates only resulted in a 2% error in the estimates of crude birth rate, suggesting that even if there are small errors introduced by applying child mortality ratios from 2001 to 2011, this should not affect subsequent estimates too much (Bhat, 1996).

Additionally, there was no life table information for smaller states, namely Andaman and Nicobar; Arunachal Pradesh, Chandigarh, Delhi, Chhattisgarh, Jharkhand, Manipur, Meghalaya, Mizoram, Nagaland, Pondicherry, Tripura, and Uttarakhand. Therefore, these

had to be dropped from the decomposition analysis. Many of these states are in the northeast region, hence the regional analysis of this cluster only had four districts in it from Assam. These reflect a small part of this region, and therefore the findings may not be reflective of the overall trends in that area.

Another source of bias in the analysis is that districts have changed between 2001 and 2011, and new districts have been created. As discussed above, in the cases where one district split into two parts, the same information from the larger district in 2001 was applied to both of the smaller new district in 2011. In the cases where a new district was created from pieces of multiple former districts, the information from whichever district contributed the largest to the new district was applied to the new district. Both of these situations are potentially problematic. I ended up deciding to drop many of these districts from this analysis, since in initial analysis they often showed sex ratios becoming more imbalanced, when I expected them to be less imbalanced. Dropping these from the analysis should not bias the results in any way, as I have no reason to think that these districts are different in terms of their son preference, fertility-decision making, access to sex-selective abortion, or child mortality rates and differentials. Dropping them reduces the sample size, but should not have any other systematic impact.

CONCLUSION

Almost 25% of districts in India showed signs of equalization in their child sex ratio in 2011, although the national child sex ratio became more imbalanced. This analysis looks in depth at the districts that showed signs of equalization by decomposing the equalization into fertility and mortality related change and exploring that by rural/urban status and by geographic clusters.

Overall, both the contribution from excess mortality and pre-birth events fell between 2001 and 2011, but the relative contribution (percent of each) stayed roughly the same. Pre-birth events make up the vast majority of the cause of imbalanced sex ratios in both time periods. There were no major differences in the decomposition between the four main clusters of equalization around the country (north, west, south, and northeast). While much of the equalization seemed centered around urban centers, in the majority of the districts that showed equalization, the equalization was happening in both rural and urban areas. When rural and urban child sex ratios were decomposed, the magnitude of the contribution from pre-birth events decreased over time in both rural and urban areas, however, the contribution from excess girl child mortality increased in urban areas, while it decreased in rural areas. This suggests that stagnation or increases in child mortality might be occurring in urban areas more than rural ones.

The equalization in child sex ratios are due to both reductions in pre-birth events and improvements in girl child mortality relative to boys, and there is no evidence in 2011 of

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a relationship between improvements in mortality and percent of imbalance due to pre-birth events (a tradeoff). Pre-birth events still make up the majority of the cause of missing girls, therefore, efforts to restrict access to sex-selective technology are still essential, as are efforts to improve people's view of the value of girls throughout their life course, thereby reducing the desire for sex-selective abortions and excess girl-child mortality.

This analysis has shed light on the pattern and composition of the 153 districts that showed equalization in child sex ratios between 2001 and 2011. The equalization in these districts (the 106 with full data) resulted in an estimated >280,000 girls being alive in 2011 who would have not been had the child sex ratio not equalized (remained at the 2001 level, taking population growth into account). This is an astounding number of saved lives. While we do not yet know if the equalization seen will be sustained over time, these findings have helped us understand this new phenomenon, which has today been little explored.

Table 3.1: The Child Sex Ratio in 2001 and 2011 in districts that showed equalization, official and estimated mean ratios and mean change

		Mean	Range
Official Rates	Child Sex Ratio 2001	879	766 to 979
	Child Sex Ratio 2011	900	790 to 982
	Change in Child Sex Ratio	21.8	1 to 87
Rates calculated using available data	Child Sex Ratio 2001, ages 0-4	879	761 to 989
	Child Sex Ratio 2011, ages 0-6	902	798 to 985
	Change in Child Sex Ratio	23.4	-5 to 92

Table 3.2: Number of districts per state in each analysis

State	Total number districts with equalization	Total number in Analysis Part 1	Total number in Analysis Part 2
TOTAL	153	123	106
Andaman and Nicobar	2	0	0
Arunachal Pradesh	6	6	0
Assam	7	5	4
Bihar	12	7	8
Chhattisgarh	1	0	0
Chandigarh	1	1	0
Delhi	3	3	0
Gujarat	12	12	12
Haryana	16	15	15
Himachal Pradesh	6	5	5
Jharkhand	3	2	0
Karnataka	11	10	11
Kerala	4	4	4
Madhya Pradesh	1	1	1
Maharashtra	4	4	4
Manipur	2	0	0
Meghalaya	3	3	0
Mizoram	6	4	0
Nagaland	3	2	0
Orissa	3	3	3
Pondicherry	2	0	0
Punjab	20	17	19
Rajasthan	1	1	1
Tamil Nadu	18	14	16
Tripura	2	2	0
Uttarakhand	1	1	0
West Bengal	3	1	3

Table 3.3: District-Level Survival Ratios for 2001 and 2011

	Mean	Range
District-Level Survival Ratio 2001, Males	0.937	0.874 to 0.987
District-Level Survival Ratio 2001, Females	0.929	0.867 to 0.995
District-Level Survival Ratio 2011, Males	0.952	0.908 to 0.994
District-Level Survival Ratio 2011, Females	0.948	0.895 to 0.992

Table 3.4: Decomposition of sex ratio into pre-birth events and child mortality, 2001 and 2011

	Mean	Range
Contribution To Child Sex Ratio From Child Mortality, 2001	7.2	-14 to 33
Contribution To Child Sex Ratio From Pre-Birth Events, 2001	113.6	16 to 236
Contribution To Child Sex Ratio From Child Mortality, 2011	4.18	-16 to 29
Contribution To Child Sex Ratio From Pre-Birth Events, 2011	93.1	4 to 200
Difference In Child Mortality Contribution Between 2001 And 2011	-3.0	-32 to 26
Difference In Pre-Birth Events Contribution Between 2001 And 2011	-20.39	-88 to 28

Table 3.5: Percent of missing girls due to pre-birth event and excess mortality

	Mean Percent	Range
Percent Of Missing Girls Because Of Pre-Birth Events, 2001	93.7 %	46% to 141%
Percent Of Missing Girls Because Of Excess Mortality, 2001	6.3%	-41% to 53%
Percent Of Missing Girls Because Of Pre-Birth Events, 2011	92.5%	10% to 153%
Percent Of Missing Girls Because Of Excess Mortality, 2011	7.5%	-53% to 89%

Table 3.6: Child Sex Ratios by Rural and Urban Status, 2001 and 2011

	Rural Mean (range)	Urban Mean (range)
Child Sex Ratio, 2001	893 (759 to 1017)	882 (755 to 1080)
Child Sex Ratio, 2011	910 (716 to1004)	909 (793 to 1128)
Difference In Child Sex Ratio	17.3 (-217 to 92)	26.3 (-140 to 179)

Table 3.7: Rural/Urban decomposition of sex ratio into pre-birth event and child mortality, 2001 and 2011

	Rural, mean (range)	Urban, mean (range)	Rural, mean (range)	Urban, mean (range)
	Contribution To Child Sex Ratio From Child Mortality		Contribution To Child Sex Ratio From Pre-Birth Events	
2001	17.2 (-75, 111)	-1.5 (-32, 102)	110.7 (27, 230)	129.1 (-3, 256)
2011	11.8 (-37, 74)	3.48 (-31, 110)	91.4 (0, 197)	99.4 (21, 206)
Difference	-5.75 (-68, 91)	4.99 (-33, 49)	-19.6 (-86, 24)	-29.8 (-117, 38)

Table 3.8: Mean child sex ratio, percent contribution from mortality and pre-birth events by cluster

	Mean Child Sex Ratio	Mean Percent Contribution from Mortality	Mean Percent Contribution from Pre-birth Events
North (N=35)			
2001	803	3.6	96.4
2011	842	5.1	94.9
West (N=11)			
2001	861	12.9	87.1
2011	879	8.8	91.2
South (N=34)			
2001	929	5.6	94.4
2011	942	3.3	96.7

*North=all districts with equalization in Haryana, Punjab and Rajasthan

*West=all districts with equalization in Gujarat except Navsari

*South= all districts with equalization in Tamil Nadu, Kerala, Karnataka and Maharashtra except Chandrapur

Table 3.9: Regression output of the percent of the imbalance in child sex ratio due to pre-birth events on the level of male and female child mortality in 2001 and 2011.

Regression Equation (estimated separately for 2001 and 2011):

Percent of the child sex ratio due to pre-birth events $_{(2001)}$ = C + B$_1$x(Quartile of male child mortality$_{(2001)}$) + B$_2$x(Quartile of female child mortality$_{(2001)}$) + B$_3$x(child sex ratio$_{(2001)}$) + error

	2001	2011
Male Child Mortality Quartile	4.25**	-0.55
Female Child Mortality Quartile	-6.49***	-2.21
Child Sex Ratio	0.029	-0.02

*$p<0.05$, **$p<0.01$, ***$p<0.000$

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CHAPTER 4

PAPER 3:

WHY ARE SEX RATIOS BEGINNING TO EVEN OUT IN INDIA?

A TEST OF SUPPLY- AND DEMAND-SIDE FACTORS INFLUENCING

SON PREFERENCE

"There is an expression in India that

'bringing up a daughter is like watering a neighbor's plant'"

(Anderson and Moore, 1993)

ABSTRACT

Evidence from the most recent India census suggests that despite a country-level downward trend in child sex ratios (fewer girls than boys), the states and districts that have in the past had the most imbalanced sex ratios are beginning to show evidence of slowing of decline and even turn-around. This paper explores possible demand- and supply-side factors that could influence son preference and sex-selective behavior. The marriage market, labor market, and social norms are explored as possible demand-side factors, and supply-side factors relating to availability of medical professionals are explored, at varying individual-, community-, and state-levels. A lower community level child sex ratio (fewer girls compared to boys) is not associated with an individual woman having a lower odds of having a boy. When more women were in advanced labor opportunities in the community and more women had access to doctors and nurses, there was a lower odds of having a boy. Community level labor market was also associated with the overall community level child sex. These findings suggest that community factors relating to supply and demand of boys compared to girls may be influencing decision-making. More research on possible mechanisms for equalization in sex ratios is necessary, particularly using data sources that allow for integration of other district-level data.

INTRODUCTION

The most recent Indian census (2011) showed the child sex ratios (the number of girls under age five divided by the number of boys under age five) are more imbalanced to disadvantage girls than in recorded history (Registrar General of India, 2011). However, recent analysis by Diamond-Smith and Bishai (2013) found evidence that child sex ratios in the districts of India that have previously had the most imbalanced sex ratios were beginning to equalize, even though child sex ratios in the country as a whole worsened (Diamond-Smith and Bishai, 2013). This suggests that in districts with a long history of increasingly imbalanced sex ratios, some type of feedback mechanism is at play that is changing behavior so people are discriminating less against female children.

The initial analysis by Diamond-Smith and Bishai used data from 1981-2011 to look at the state-level, and found that this reversal was visible in the states and territories of Haryana, Punjab, Delhi, Chandigarh, and to some extent Gujarat (Diamond-Smith and Bishai, 2012). Using fixed effects models, they found evidence of this trend at a district-level throughout the country as a whole over this time period (Diamond-Smith and Bishai, 2013). Diamond-Smith and Bishai's analysis used census data, so all correlations were at a population level. Therefore, while the trends are suggestive of district-level trends affecting individual behavior, population level analysis cannot make strong claims of this relationship at an individual-level.

If indeed some type of correction mechanism is starting to occur in Indian districts with very imbalanced sex ratios, it is important to explore potential drivers of this reversal. The results of Diamond-Smith and Bishai (2013) suggest that the quantity of sex-selective abortions might be decreasing, because the sex ratio is falling. It is also possible that excess female mortality is declining because people are providing better care for their girls. There are a number of factors that could be leading to these changes, both from the supply- and the demand-side. In this paper I will look at those that can be measured in the National Family Health Survey of India, round 3 (NFHS-3). These data were collected from a representative sample of households in India in 2005-2006.

Possible drivers of equalization in the child sex ratio include tensions in the marriage market, which would make having a male child less attractive; improvements in women's opportunities in the labor market, which would make having a female child more attractive; the success of certain government programs and laws that have been enacted to improve the status of girls and restrict sex selection; among others. On the supply-side, I explore access to sex-selective technology, which could be decreasing due to increased government regulation. On the demand-side, I explore tensions in the marriage market, opportunities in the labor market and social norms, as factors that would make people desire fewer sons, and therefore seeking fewer sex-selective abortions.

I.   *Theory*

There is a plethora of evidence in India for a demand for sons (Pande and Astone, 2007, Diamond-Smith et al., 2008, Arnold et al., 1998, Clark, 2000, Dyson and Moore, 1983). Historically, child sex ratios in India have been slightly imbalanced because people practiced female infanticide (Das Gupta and Bhat, 1997, Dyson and Moore, 1983). However, in the mid 1980s, when ultrasound technology and abortions became widely available in India, there was a method for people to act on their son preference more easily (supply increased to meet demand), and sex ratios became increasingly imbalanced (Das Gupta and Bhat, 1997).

In this paper, I conceptualize the situation of son preference and sex ratios in India in terms of a market. This is a useful way of understanding this phenomenon because it allows us to see how different development might affect the sex ratio in a population. For example, as family planning access expanded, the "price" of controlling fertility declined. As access to abortion and sex-selective technology then expanded, the price of selecting a son also dropped.

Market explanations can be visualized on a supply and demand curve (see below). When the demand curve shifts right, the price goes up, the quantity goes down. When the demand curve shirts left, the price goes down and the quantity goes down. When the supply curve shifts right the price goes down and the quantity goes up, and when the supply curve shifts left, the price goes up and the quantity goes down.
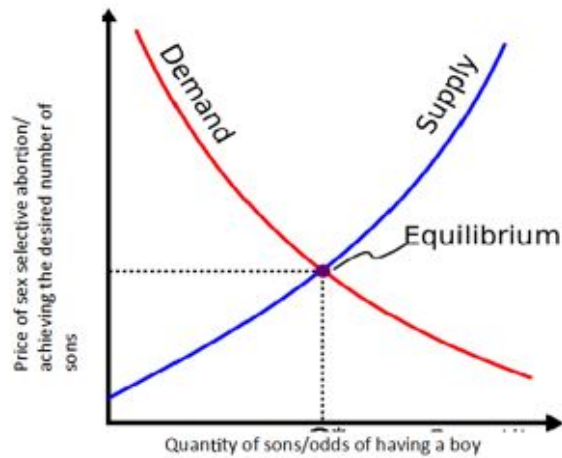
Fig 4.1: Supply and Demand Curve

In this framework, we can think about the various ways that the supply or demand curve might shift. Access to technology or regulation of technology might shift the supply curve right or left. Changes in education level, social contagion, complementarity of the good to other up trending goods, substitutability of the good to other down-trending goods or norm changes might shift the demand curve left or right (among other possibilities).

Before ultrasounds and sex-selective abortion, the cost (emotional, societal) of removing an unwanted female fetus was high, so very few people would use that/demand that, so the quantity was low, and sex ratios at birth were only slightly imbalanced. However, with an increased supply of sex-selective technology, the cost of having a son was lower (less emotional burden, less social stigma, however, an added financial cost). This shifted

the supply-side right. Therefore, the number of sex-selective abortions increased as supply met demand, and the sex ratio became more imbalanced.

The finding by Diamond-Smith and Bishai (2013) that child sex ratios are increasing in some states could suggest that the quantity of sex-selective abortions is decreasing. This could be due to a left shift in demand, or a left shift in supply. There are a number of factors that could be leading to this change, both from the supply- and the demand-side.

i.   Demand Shifts

Demand-side shifts in this situation are centered on a parental utility function, where parents derive utility from children based on both their quality and quantity, and often have to make a tradeoff between the two.

U(Quality, Quantity)

In the Indian setting, I propose four main factors affecting child quality. The first is social status enhancement of children, which can be accomplished through the child marrying up, excelling in school or their career, etc. Second, quality rests in old age support, for example, the ability of the child to work in the household or on a family farm, or the child to migrate and send remittances to the parents. Old age support can be either or both financial or emotional. A third measure of quality might be the child's own happiness and health, which would bring the parents happiness. The fourth measure of quality can be through the children providing their parents with grandchildren, thereby maintaining the family and the genetic line.

In India, the ability for a child to be of high quality can be determined by factors in the marriage market, such as marriage squeezes, which will either allow or prohibit children from marrying up or producing grandchildren. Educational or labor opportunities can affect a child's ability to succeed in their career, and be able to provide monetary old age support. Discrimination against girls entering the labor force, or the decline of such discrimination can also affect the potential quality.

ii. Supply Shifts

There are three ways that people can have more boys (increase their odds of having a boy), all of which have become more effective in recent decades. The first is to become pregnant again if the desired number of boys has not been achieved, or to stop having children if the family has enough boys. Family planning options have made this easier than historically. Second, if a woman is already pregnant, she can choose to not abort a boy fetus (or abort a girl fetus and then become pregnant again more quickly with a boy). Access to ultrasounds has made this option more realistic. Finally, if a boy has already been born, a family can work harder to keep him alive, and immunization, better nutrition, and the child survival revolution in general have made this step more effective than before.

In this paper I will look at those that can be measured in the NFHS-3 data. On the supply-side, it is possible that access to sex-selective technology could be decreasing, perhaps due to increased government regulation. On the demand-side, it is possible that people are desiring fewer sons, and therefore seeking fewer sex-selective abortions. Or, people might be demanding more daughters, so once people have a child, they provide equal

quality care to girl and boy children. These changing preferences could be due to changing social norms, changes in the marriage market, the labor market, or some other factors affecting behavior.

II.   Demand-side Factors

i.   Marriage market

It is safe to assume that most people in India wish to marry someone of the opposite gender, which implies that in the population as a whole it would be beneficial to have an equal number of girls and boys (sex ratios here being seen as a public good). Most societies, including India, often have an age gap between the bride and groom, with the groom being slightly older. In these cases, as long as the population is still growing, even if there are uneven sex ratios, each man will be able to find a wife, because he can seek a wife in the larger pool of women in the cohort below him. In most of India, despite fertility decline, the population is still growing due to population momentum (Bhaskar, 2011).

India (and China) are at the cusp of a huge problem due to uneven sex ratios in their marriage markets as their population pyramids begin to even out. Previously, because of population growth, the size of the cohort below any given cohort was larger, however, in China today and in India in the coming decades, it is predicted that the cohort sizes will have the opposite trend, with larger cohorts above, and smaller cohorts below (see Fig 2).

Projections by Guilmoto (2012) suggest that there will be as many as 40 million men remaining single between 2020-2080 in India, and 32 million in China in that same time period (Guilmoto, 2012). These projections assume that most women will want to marry, however, if India and China follow the trend in other countries during development, and a sub-population of women begin to opt out of marriage, there will be even more bachelors.

**NUMBER OF PEOPLE (MILLIONS) BY AGE GROUP**
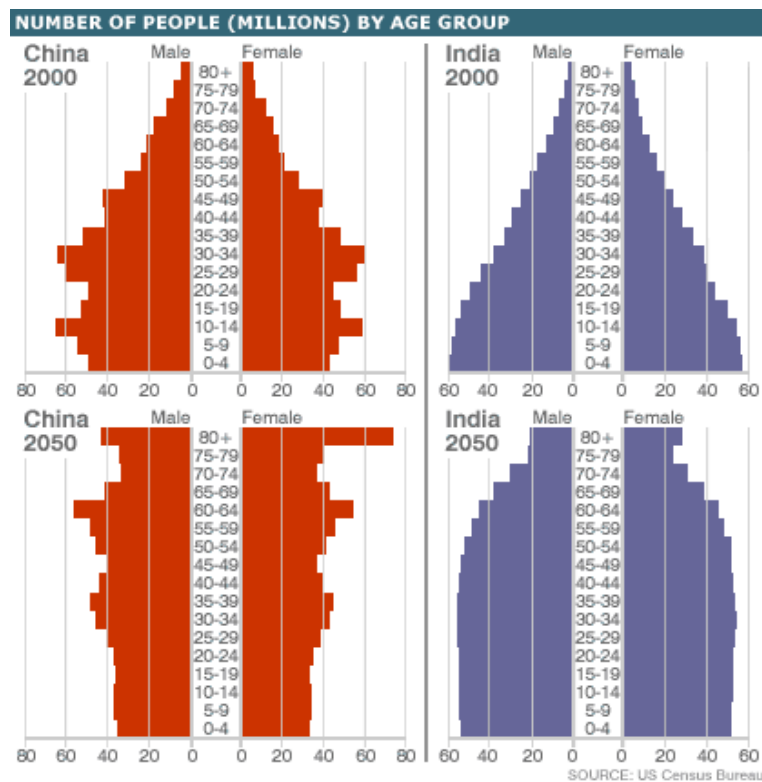
Fig 4.2. Population pyramids of India and China in 2000 and 2050 (Lewis Historial Society, 2012)

It is possible that such large numbers of unmarried men will lead families to revise their preferences for sons. If families derive benefit not just from having a son, but from having a grandchild (via a married son), then there might be an increased utility of having

a daughter. Additionally, not only do married sons provide benefit because they can produce grandchildren, but they may also provide benefit through the additional support that a daughter-in-law provides. For example, evidence from China suggests that not only do sons send money back to support parents in old-age, but daughter-in-laws also contribute a significant proportion of their income to their husband's parents (Bhattacharjya et al., 2008). Therefore, it is possible that an unmarried son could be less valuable if he cannot marry, and parents, and when faced with the option of having a son who might never marry or a daughter who would marry, the family might not prefer the son. For this to be true, parents would have to value having a grandchild above other possible child quality related factors.

Another possibility is that as women become a scarce resource they will be able to compete more on the marriage market, and either demand higher quality husbands, which might have some long-term benefits to parents of daughters, or be required to pay a lower dowry, because men are so desperate for wives that they will not demand as high of a dowry. There has been debate in the literature as to what uneven sex ratios and squeezes in the marriage market will do to dowry. An economic perspective suggests that dowries should fall with increasingly imbalanced sex ratios, however, Bhaskar (2011) has shown that as long as social disparities widen, dowry prices should rise (Bhaskar, 2011). Dowry is the bride's family's opportunity to move upwards, so it can be seen as the cost of a higher-class groom. Therefore, even in a situation with an excess of men, dowries may rise because families still must compete for high-class grooms. Recently dowries have been increasing in India, even in regions that historically did not have a tradition of

dowry. Some have even suggested that the declining position of women in India is due to the marriage squeeze, as states that previously relied on bride price (the grooms family paying the bride's family) have now switched to dowry (Bhat and Halli, 1999).

While the concept of a marriage market is easy to understand, actually measuring the marriage market is more complex. Part of the problem with measuring the marriage market in a place like India, which has a growing population, and a tradition of men being older than their wives, is that even if in a given age group there are more men than women, if men marry younger wives, the pressures on the marriage market will remain low. Other factors that complicate the measurement of the marriage market in India is the tradition of exogamous marriage, which makes defining the potential pool of marriage partners difficult. Some literature has suggested that using larger measures of the marriage market (such as district or state) can help account for marriage migration and provide a reasonable measure of the marriage market (Caldwell et al., 1983).

In theory, when there is a shortage of women in an age group, men will reach farther down into younger age groups to find wives. Therefore, one way of measuring pressures on the marriage market could be through the size of the age gap between husbands and wives. In theory, the more stressed the marriage market is, the larger the marriage gap would be. Edlund (1996) showed how son preference increases the age gap in marriage, and how the lowest ranking males will have the largest age gap in marriage (in other words, a sign of a low-quality marriage is a large age gap) (Edlund, 1999). Cross

sectional data suggest that where there is an excess of men, the marriage gap is bigger (Edlund, 1999).

Tucker and Van Hook (2013) proposed a method for projecting the marriage market in China using data on the sex ratio at birth, the rate of growth, the marriage age gap, and the life expectancy of men and women to the average age at marriage (Tucker and Van Hook, 2013). This model is based purely on demographic information, but provides valuable information about the magnitude of marriage market imbalance in different future population growth or son preference regimes.

ii. Labor Market

When there is a shortage of women it is possible that the lack of sufficient workers to fill occupations where women have higher productivity could change the value of women. This mechanism can only work through occupations that exclude men (in other words, occupations that men can/will not fill when there are not enough women around, even if the wage is high). In this case, labor markets would have to compete more for the smaller pool of women, and therefore wages would rise. If female wages rose faster than male wages, then a family deciding whether to have a boy or a girl might see the potential earnings of a daughter being higher than the earnings were before, and therefore wish to have a daughter. Of course, this would only act in the short run, because if everyone started having girls, and the market was flooded with women, female wages would fall again.

Past research has suggested that in regions of India that are dominated by rice cultivation, instead of wheat, female survival is enhanced (Kishor, 1993). This is thought to be because women are more productive in rice fields than in wheat fields, therefore their economic value is higher. This argument has been used to help explain some of the historical trend of lower son preference in the South (rice producing) states of India. Research by Qian (2008) in China found that holding male income constant, female survival increases when female wages rise, and vice versa (female survival declines when male wages rise, holding female wages constant) (Qian, 2008).

There is mixed evidence about the role of women's wages and labor force participation on sex ratios or other measures of gender preference in India. Cross-sectional data have found that in states where more women work sex ratios are less imbalanced (less disadvantageous for women) (Kishor, 1993). However, others have pointed out that because of the practice of exogamous marriages, the labor market in a specific community should not have much impact on gender preferences or differentials (Foster and Rosenzweig, 2001, Drèze and Sen, 1998). Sophisticated models that take into account marriage migration have suggested that when the destination of marriage migration is to areas where technology changes favor opportunities for women, there is relative preference for girls and improvement in female survival (Foster and Rosenzweig, 2001).

The labor market is changing in India, with an increase in jobs in the global technology

sector. There is evidence that returns to middle and upper schooling for women have increased in the past few decades (although they have not improved for primary schooling) (Duraisamy, 2002). An interesting experiment in New Delhi found more discrimination based on caste than on gender in the hiring market (Banerjee et al., 2008). This suggests that labor market opportunities for women in India may be opening up due to reductions in discrimination against women in general.

iii. Social Norms

It is also possible that sex ratios are equalizing because social norms about preferences for boys or girls are changing. There is no clear evidence as to why norms about gender would be changing now in India, since efforts have been made for many decades by NGOs and the government to improve the status of women. Chung and Das Gupta (2007) have suggested that changes in social norms were responsible for much of the decline in son preference in South Korea, however, why and how social norms changed is not clearly understood (Chung and Das Gupta, 2007). A myriad of programs and schemes have been instituted by the Government of India and various NGOs and other interested organizations across the country, aiming to reduce discrimination against females. It is possible that these programs and schemes have influenced people's views and led to changes in behavior. For example, many states have used conditional cash transfer programs to improve the status of girls, whereby if the family complied with a certain aim (birth registration, immunization, registration in school, or delaying age of marriage), they would receive a financial incentives (Sekher, 2010). Some of these schemes are

supported by the central government, while others either are eventually taken over by states, or initiated by states. Some schemes target the whole state, while others only specific groups, such as those in backwards classes or in the lowest wealth quintiles. Many of the schemes have met with problems in implementation, lack of central/state support and too many restrictions and criteria for membership (Sekher, 2012). A recent report by the National Advisory Council of India stated (p. 7) "There is no field-based impact-assessment of these schemes, in the absence of which there is no evidence regarding the desired objective of reducing sex selection. Clearly, there is a need for a systematic evaluation before these schemes are articulated or promoted as the center-piece of the fight against the declining sex ratio" (Naqvi and Kumar, 2012).

Past research looking at social norms and son preference in India found that religion and caste were associated with son preference, but other measures of social norms, such as territorial and kinship endogamy, were not associated (Pande and Astone, 2007). There are pervasive differences between religious groups in India, with Muslims generally having higher son preference, having higher fertility, and being less likely to use contraception than Hindus (Clark, 2000, Pande and Astone, 2007, Dharmalingam and Morgan, 2004). There are also regional variations in factors related to religion, for example, in some states Muslims and Hindus are equally likely to practice purdah (a certain set of behaviors revolving around women being restricted in their movement), while in other parts of the country Muslims are much more likely to practice purdah than Hindus (Rahman and Rao, 2004). However, this does not necessarily equate to women's

decision-making power, as this same study found Muslim women generally have more decision-making power than Hindu women (Rahman and Rao, 2004).

Analysis of panel data in India found that an individual's exposure to cable TV was associated with a decrease in the acceptability of son preference, in addition to decrease in the acceptability of violence against women (Jensen and Oster, 2009). This suggests that exposure to modern ideas can change people's norms, which can perhaps in turn impact behavior. I was unable to find any papers that looked at the role of community-level norms on son preference or sex ratios in India, but research on other related topics has found that, for example, community-level opinions about the importance of delivering in a facility (the percent of the community who thinks delivering in a facility is important) is related to an individual's probability of facility based delivery (Moyer and Mustafa, 2013). The theory is that women will be influenced by the views of the community around them—these are the norms they are subjected to and which affect their behavior.

III. Supply-side Factors

There has been a proliferation of mobile ultrasound clinics, which offer (and even advertise aggressively) a relatively inexpensive way of finding the sex of a fetus (Retherford and Roy, 2003). Once the sex has been determined, people have little trouble obtaining an abortion (not explicitly for sex selection, but for another reason). Since sex-selective abortion is technically illegal in India since 1994 (although abortion itself has

been legal since the 1970s), there are very few data about exactly how accessible sex-selective abortions are throughout India (Naqvi and Kumar, 2012). Since direct evidence about availability of sex-selective technology is limited, one way to estimate the supply of sex-selective services could be by using the number of clinics or physicians in a community as a proxy. Since sex-selective abortion is illegal, it might be hypothesized that most sex-selective abortions happen in non-formal settings, however, there is evidence of strong sex preference among physicians (stronger even than in the community as a whole), suggesting that physicians might be willing to facilitate or turn a blind eye to sex determination and sex-selective abortions in their clinics (Patel et al., 2013).

Conceptual and Analytical Frameworks

We conceptualize a woman/family's decision-making along the process shown below in Fig 4.3. After a woman becomes pregnant, she and her family can decide whether to test for the sex of the fetus. If they do not test, they can either have an abortion, the baby can die spontaneously, or they can have the baby. If they decide to test for the sex, they can either find out it's a boy or a girl. At this point, regardless of the sex, they can decide to have the baby, they baby can die spontaneously, or they can have an abortion. In the NFSH-3 data, we are able to only measure babies that are born.
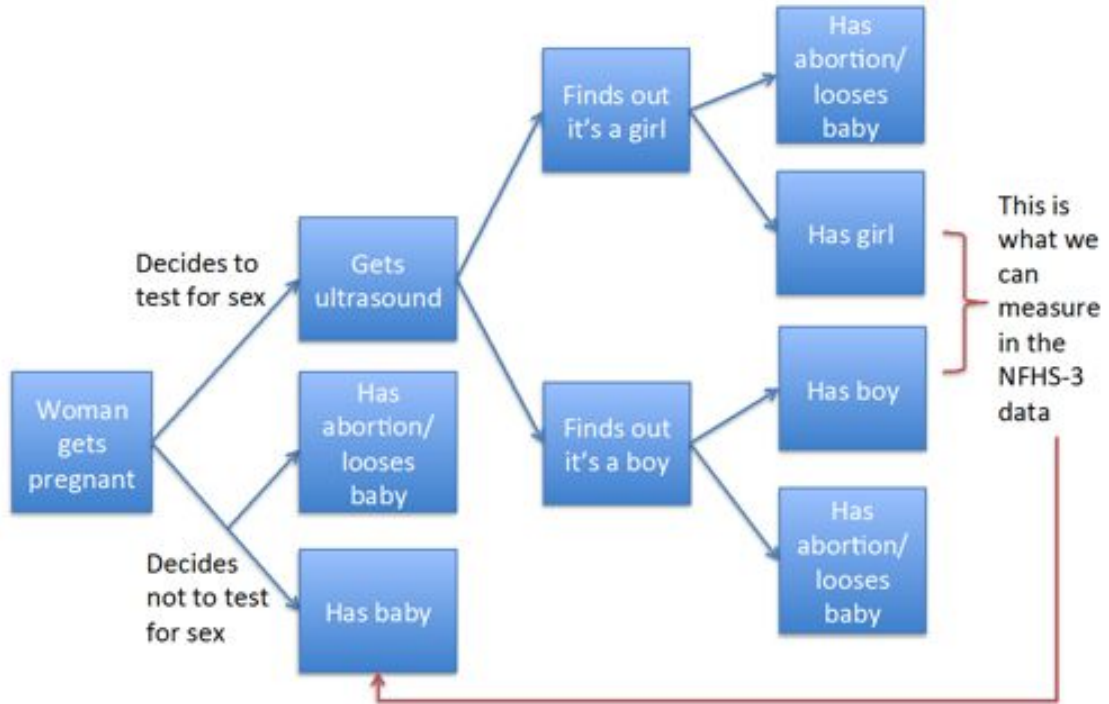
Fig. 4.3: Conceptual framework

We hypothesize that the various community and individual level factors described above influence all stages of this decision making process: from the decision to get pregnant all the way to deciding whether to keep a child of a certain sex or not. The analytical framework below shows how we conceptualize these various factors influencing each other, and how they fit into the two different sets of models (Fig 4.4). We hypothesize that the community level factors are associated with the community level child sex ratio, which we model in Model 2. We hypothesize that both individual and community level factors influence an individual's decision-making process to having a child of a certain sex.
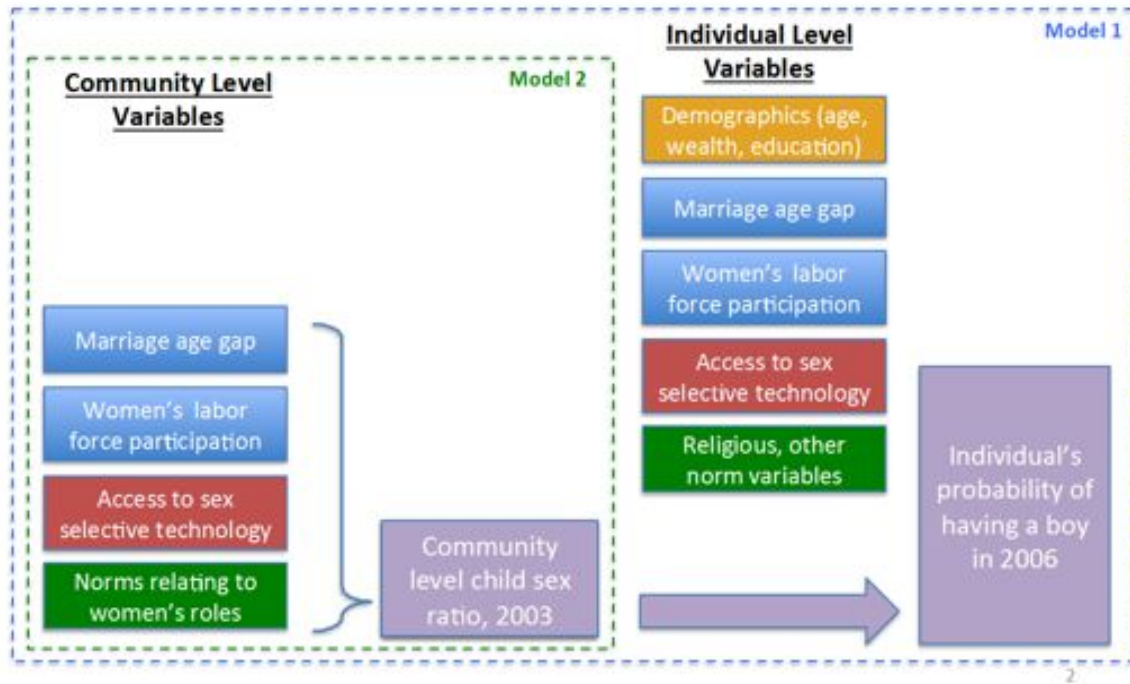
Fig 4.4: Analytical framework

Specifically, we hypothesize that a marriage market that had too many boys in it would make people desire a boy less. We hypothesize that larger age gaps between spouses indicate a marriage market that is less favorable for boys, and which would make families desire a son less. Either the average community level age gap, or the couple's own age gap might influence this. In terms of the labor market, we hypothesize that where more women are in the labor force, especially in more advanced occupations, families might see daughters as having more earning potential or more potential to increase their social standing through a good job, and therefore desire a son less (this could be either individual labor or community level patterns). Relating to access to providers at ANC or delivery, we hypothesize that in communities where women have more access to providers (either at ANC or delivery) or individual women used these services, women would have more access to a sex selective abortion. Finally, communities were social

norms are more favorable to daughters or less favorable to sex selective abortion, as measured by acceptability of wife beating and access to modern thoughts via TV (which presumably are more gender equitable), we hypothesize would be associated with an individual having a lower probability of having a son (these factors could either act at the individual or community level).

DATA AND METHODS:

I. Data

This analysis uses data from the National Family Health Survey of India, round 3 (NFHS-3), which was carried out in 2005-06 (International Institute for Population Sciences (IIPS) and Macro International, 2007). It collected data from individual women and households in a representative sample around the country. The number of women sampled was based on the size of the state, with some adjustments to take HIV prevalence into account (to sample enough women to obtain data on HIV, which was collected in Round 3 for the first time). Sampling was conducted differently for urban and rural areas, and respondents were sampled based on the population of rural and urban areas in each state.   In the rural sample, villages (Primary Sample Units, or PSUs) were selected with probability proportional to size sample (PPS) is the first stage of sampling. Within each PSU, households were randomly selected (second stage). In urban areas, three-stage sampling was used, where wards were selected using PPS first, and then census enumeration blocks were randomly selected, and then within that, households

were randomly selected (International Institute for Population Sciences (IIPS) and Macro International).

The 2001 Census was used as a sampling frame. Stratification of villages was based on geographic area. Villages were then stratified based on village size, percent of males in non-agricultural sector, percent of population of scheduled caste or tribe, and female literacy. Also, since NFHS-3 collected HIV data, high, medium and low HIV prevalence was also used to stratify (International Institute for Population Sciences (IIPS) and Macro International).

For this analysis, I use data from the women's questionnaire. Women were eligible if they were 15-49. NFHS-3 did not publish which district households were living in (due to the HIV data collection), therefore it is not possible to connect these data to other surveys or census data at a district-level. The survey did identify households by "stratum" that was based on geographic areas, and therefore this is used as a proxy for "community" in the creation of community-level variables.

All women who were sterilized more than 2 years before the survey data were collected are removed from the analysis because they were not at risk of having a child (the main outcome of interest in the analysis). I assume that all of the non-sterilized women were at risk of having a child, even if she was using family planning at the time of data collection. For the purpose of this analysis, the sex ratio is calculated as the number of

girls/the number of boys, so a lower value means there are fewer girls, unless otherwise stated.

II. Methods

The first model looks at the impact of various demand-side, supply-side, and demographic variables, on the probability that a woman who had a child in 2005/2006 had a boy, rather than a girl (among women who had a child in those years).

Model 1:

Probability(B|had a birth in 2006)= C+ B1(Stratum-level Child Sex Ratio) + B2(Women's demographic factors) + B3(Stratum-level norm factors) + B4(Stratum-level marriage factors) + B5(State-level marriage factors) + B6(Stratum-level labor factors) + B7(Stratum-level Supply factors) + e

The second model looks at whether the stratum sex ratio of children under 10 was influenced by the stratum- and state-level demand- and supply-side factors.

Model 2:

Stratum-level sex ratio =C+ B1(Stratum-level marriage factors) + B2(State-level marriage factors) + B3(Stratum-level labor factors) + B4(Stratum-level Supply factors) +e

The first model is run using multivariate logistic regression, and the second multivariate linear regression. All models are weighted using svy, and Model 1 is clustered at the stratum-level and Model 2 at the state-level (since the outcome of interest was at the stratum-level). Models are run in a step-wise fashion, where first the bivariate model is run, and then the demographic variables, and various community-level variables (relating to marriage market, labor market, social norms, and access) are each added individually, and then all variables are modeled together.

i. *Demographic variables*

Woman's age, education, religion (Hindu/other), whether she is currently using family planning, and the household wealth index are included as demographic variables in all models. Additionally, the number of boys and the number of girls in the household are included as measures of parity. Other variables relating to demographics are also included, but they are discussed more below as they relate specifically to the marriage market, labor market, norms, and supply of services.

ii. *Marriage market data and variables*

The first way that marriage market is measured is by the age gap between the husbands and wives in the analysis. The age gap between husbands and wives is calculated by subtracting the age of the wife at time of marriage from the age of the husband at time of marriage using the NFHS-3 data (since some husbands may have died I use the gap at

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time of marriage). A stratum specific average age gap is also calculated by averaging the age gaps in each stratum.

iii. Labor market data and variables

The first set of variables used to measure labor market are based on the NFHS-3 data on women's reported occupations at an individual-level. A variable for any labor force participation and participation in high-level occupations (where the categories of professionals, clerical and sales were coded as higher-level occupations) are included. A stratum-level variable for percent of women in the labor force at and a variable to measure the percent of women in a stratum in higher-level occupations are both created.

iv. Norm data and variables

Three different variables are included in the analysis to measure community-level norms that might be related to changing sex ratios. The NFHS-3 included questions about women's ideal number of girls and boys. Both an individual and community-level (stratum) variable is created that measures the ratio of the average ideal number of boys over the average ideal number of girls. In this case, a higher value means more boys are desired than girls. Jensen and Oster (2009) found that women increasing the amount of TV they watched over time was correlated with a decrease in women's son preference, and in their belief that it is alright for a husband to beat his wife (Jensen and Oster, 2009). Therefore, I include a variable from the NFHS-3 for TV watching, where "more than

once a week" and "at least once a week" was coded as "Frequent TV watching." This is an individual-level variable. Finally, five questions in the NFHS-3 were asked about the acceptability of wife beating under various circumstances. I combined these into a score, where a higher score meant that the respondent said wife beating was acceptable under more circumstances. This is then made into a community-level mean score and also included as an individual-level variable.

v. Supply-side data variables

Due to lack of data about access to sex-selective technology specifically, I use percent of women per stratum who deliver with a doctor or a nurse, and the percent of women who see a doctor or nurse for their Antenatal Care (ANC), as a proxies for access to sex-selective technology. This variable is used to estimate the availability of access to modern technology and providers in a stratum. These variables are also included at the individual-level, and all come from the NFHS-3 data.

IV. Robustness Tests

i. Poisson

We re-ran model 1 as a Poisson model. Since the outcome, an individual having a boy in 2005-06) is a count, it is possible that a Poisson model would be a more appropriate model to run.

ii.   Imputations

Since some of the variables differed significantly between the datasets with and without

the missing cases which were dropped due to missingness of some variables (namely,

women's education, age gap between husbands and wives, and ideal number of boy over

girls), we re-ran the models with these values imputed using regression.

RESULTS

I. Description of the data

There were 84,609 women in the 2005-2006 NFHS-3, and 65.5% of them (55,447

women) were not sterilized 2 years before the start of the survey. These women live in 73

strata, which I took as a proxy for "community." Stratum range in size from 169 women

to 5,031 women. Table 4.1 shows the characteristics of all women in the sample

compared to those who were not sterilized 2 years before the survey and those cases for

which there was complete data. The average age of women in the full sample is 33 years,

and in the restricted sample it is 31 years old. They have 5.04 and 5.52 mean years of

school, and 42.13% of all women, compared to 38.15% of the restricted sample of

women, were participating in the labor force at the time of the survey. A larger

percentage of the women in the restricted sample gave birth to a boy in the 2 years before

the survey (11.83% compared to 7.75% of the full sample). The largest difference

between the two samples is in family planning use, which makes sense since the

restricted sample was created by removing all women who were sterilized 2 years before the study.

Stratum- and state-level factors differ little between the two groups. The average stratum-level child sex ratio for children under 10 in 2003 is about 0.70 (ranging from 0.41-1.07). All marriage sex ratios are in the reverse measurement (boys/girls). The stratum estimated marriage sex ratio using the NFHS-3 method is 1.09-1.10 (ranging from 0.74-1.29). The average percent of women in the labor force per stratum is 42 and 41% ranging from 18.69-84.27%), while the percent of women in advanced sectors of the labor force is lower at 6.99 and 7.19% (ranging from 1.17-28.76%).

In terms of norms, the stratum mean ideal number of boys over girls is the same in the two groups, with both groups wanting slightly more boys than girls. Acceptability of wife beating is low, with a mean stratum score of about 1.2 (where a low score represents less acceptability), and the mean stratum percent of frequent TV watchers was about 60%. The non-sterilized women watch TV on average slightly less frequently, and they have slightly lower scores on the acceptability of wife beating scale.

For the supply-side variables, about 34% of women on average per stratum in both samples saw a doctor or nurse for their ANC visits, with this being slightly higher for the smaller sample. Fewer women (about 24% on average per stratum) delivered with a doctor or nurse, and this was slightly lower for the smaller, non-sterilized sample.

There were about 2,748 women who had missing values for one of three variables: women's education, age gap between husbands and wives, and ideal number of boys over girls. When comparing the full non-sterilized sample to the non-sterilized complete sample (no missing data), we can see that these two groups had statistically significantly differed values for some variables. Namely, when women with missing values were removed, the sample was significantly older, poorer, less Hindu, higher stratum level ideal number of boys/girls, less frequent TV watching, fewer women in the labor force, more women seeing a doctor or nurse for both ANC and delivering ($p<0.05$). Additionally, an individual being in the labor force, using family planning and acceptability of wife beating were marginally significantly higher ($p<0.1$).

II. Model 1: Probability of having a boy, given a woman gave birth in 2005-06

In the bivariate model testing the impact of the stratum-level child sex ratio for children under 10 in 2003 on an individual's probability of having a boy, there was no significant relationship (model 1A, Table 4.2). When demographic variables were added to the model (model 1B), using family planning, having a ratio of ideal number boys over girls that favored more boys, having more boys already in the household or fewer girls already in the household were significantly associated with the odds of having a boy ($p<0.001$). The main predictor (stratum-level child sex ratio) was still not associated. Neither the community-level marriage nor labor variables were significantly associated when they were added separately (models 1C and 1D). When the stratum-level norm variables were added (model 1E), a higher the stratum-percent of frequent TV watching was associated

with and increased odds of having a boy ($p<0.05$). Both of the stratum-level access to provider variables were associated with the outcome (1F): access to a provider for ANC decreased the odds of having a boy, and access to provider for delivery increased the odds ($p<0.001$).

In the full model (1G) with all variables included, the higher the stratum-level child sex ratio for children under 10 in 2003 the greater the odds of having a boy ($p<0.1$). This would suggest that when the child sex ratio is lower (fewer girls), women have a greater probability of having a girl. A woman using family planning, having a ratio of ideal number boys over girls that favored more boys, having more boys already in the household, fewer girls already in the household, a lower stratum-level percent of women in advanced labor opportunities, lower stratum-level percent of women who saw a provider for ANC and a higher percent of women who delivered with a doctor/nurse were associated with increased odds of having a boy ($p<0.05$).

III. Model 2: Stratum sex ratio in children under 10 in 2006

The second set of models looks at the predictors of the stratum-level sex ratio in children under 10 in 2006 (Table 4.3). The higher the stratum percent of women in professional occupations, the higher the stratum sex ratio (less imbalanced) ($p<0.01$). Stratum age gap, norm variables and the supply of doctors and nurses, as measured by the stratum percent of women who saw a doctor/nurse for the ANC or delivery, were not associated with the

stratum-level child sex ratio. Additionally, a lower percent of Hindus at the stratum level was associated with a higher stratum child sex ratio.

IV. Robustness Checks:

     i.   *Poisson Model*

We re-ran the bivariate 1A and full model 1G as a Poisson model 1J and 1K (Table 4.4). As can be seen, there was little difference in the significance of the variables between the logistic and the Poisson models, although the magnitude of some of the coefficients changed marginally. therefore, we are confident that we are not gaining any additional information by using the logistic model. Additionally, since we are modeling all women who had a birth in 2006 in this analysis, and roughly half of them had a boy, although this is event data or count data, it is not rare, and Poisson models are generally more applicable for rare events.

     ii.   *Imputations*

When we imputed the missing values for education, mean ideal number of boys over girls and age gap between husbands and wives, and re-ran the model as model J (Table 4.5), the main predictor was no longer even marginally associated with the odds of having a boy. None of the other variables changed their relationship with the outcome of interest when values were imputed.

DISCUSSION

In the bivariate model for the relationship between the stratum-level child sex ratio for children under 10 in 2003 and an individual woman's odds of having a boy were not associated. Nor were they associated when demographic factors, or stratum-level factors relating to the marriage market, labor market, social norms or access to providers were added to the models separately. Use of family planning, ideal number of boys over girls, and the number of girls and boys in the household were robustly associated with a woman's probability of having a boy. We would expect that families with a higher ideal number of boys compared to girls to have more boys, as we find in this analysis. The number of boys in a household was associated with increased odds of having a boy, while the number of boys in the household was associated with decreased odds. It appears that these variables might be picking up on a family's preference for boys compared to girls—families with many boys want more boys and are more likely to have another boy, whereas families with more girls have less son preference and therefore are less likely to use sex selection to select for a boy.

A greater percent of women in advanced labor in the stratum is associated with a lower probability of having a boy. Also the higher the percent of women in the stratum who watched TV frequently, the higher the odds of an individual having a boy, however, this lost significance in the full model. Past research suggested that TV watching was associated with less son preference, the opposite of what was found here. Perhaps in this case TV is enforcing gender norms and preferences.

When only access related factors were added, a higher stratum percent of women who saw a doctor or nurse for ANC reduced the odds of having a boy, while a higher stratum percent of women who saw a doctor or nurse for delivery increased the odds of having a boy, and this remained true in the full model. Perhaps in communities where more women see highly trained providers for ANC, they are less likely to get information about the sex of their fetus in the ultrasound than in communities where more women see less-well trained/non-professional providers. It is also possible that communities with less son preference or sex-selective abortion are also communities with more use of or access to highly trained providers—we do not know the causality in this relationship. It is surprising that the two access variables seemed to act in opposite directions, as we would expect them to act in the same direction. It is important to note that the individual measures of these two factors were not associated, which suggests that it is not actually an individual woman's access to providers that is associated with the probability of having a boy, but instead the community level access. This suggests that there is something about communities in which more women see providers or there is more access to providers for ANC that is also associated gender preference or the ability to act on that preference.

The second set of models looking at the predictors of the stratum-level sex ratio in children under 10 in 2006 found that in stratum with more women in high professional degrees, the sex ratio is less imbalanced (more girls). Perhaps women in communities where more women have good occupations see more value in having daughters, whereas

any type of labor force opportunity does not have the same effect. There is some evidence that strata that have a higher percent of Hindus have lower sex ratios (more imbalanced, suggesting more son preference), as has been found in other literature (Clark, 2000). Interestingly, the supply of doctors and nurses, as measured by the stratum percent of women who saw a doctor/nurse for the ANC or delivery is not associated with the stratum-level child sex ratio.

I. Limitations

This analysis is limited by the fact that the NFHS-3 does not provide code to link individual women, primary sampling units, or stratum to districts in India, so I am not able to merge in any district-level information on labor market (such as wages or occupational structure) or the marriage market (such as the marriage sex ratio of each district as a whole). District-level data might have been strongly correlated with outcomes, especially since many states in India are incredibly large, populous, and diverse. It would have been especially useful to be able to link the NFHS-3 data to districts in order to look specifically at districts that were identified as experiencing equalization in the 2011 census, and see what mechanisms were at play. Other ways of measuring supply of sex-selective technology, either through merging in more data on health care availability from other sources, or data on laws restricting sex determination and their implementation, would have been useful.

I am also limited in my ability to create community/norm variables that might be associated with changes in preference for boys out of the NFHS data. The same is true for variables measuring the supply of sex-selective technology or access to medical care and health facilities. This is partly due to few questions about these topics in the NFHS-3 and partly due to lack of previous research identifying what types of community-level norms that might be important to consider.

Finally, I am not able to include any data on changes in dowry price or practices that could be important factors, nor am I able to include any variables about programs, laws, education campaigns etc., that might have been influencing behavior. Part of this is due to the issues discussed above about lack of precise geographical information about where the sample was drawn from, but also due to poor data on programs, laws, and schemes and their implementation and success rate.

CONCLUSION

This analysis does not find evidence that the community level child sex ratio lagged to 2003 is associated with an individual; woman's probably of having a child of a certain sex in 2006. Unsurprisingly, people's preferences for boys compared to boys, and they gender make0up of the children already in their household influence decision-making. More women participating in higher level jobs in a community appears to be associated with a lower odds of an individual woman having a boy and the overall community level child sex ratio, suggesting that community level labor force opportunities may be

influencing gender composition decision making at both an individual and community level. Finally, access to providers at the community level also appears to be associated with the sex of child an individual woman has, although the direction and mechanism of this relationship is not clear. More research should focus on labor force and supply side variables for understanding changing patterns of sex preference.

More research is needed on factors associated with changing sex ratios to understand what is occurring now, what might occur in the future, and ideally to determine if there are effective ways to encourage communities or individuals to prefer girls more, rather than waiting for all districts to reach very imbalanced levels of child sex ratios before beginning to equalize. This analysis provides initial evidence that looking at community-level factors is important in understanding these trends. The incorporation of other datasets and types of variables will be key to understanding what other demand- and supply-side factors might be associated with changes in sex ratios. This paper provides some possible paths to explore further, particularly relating to marriage age gaps, women's labor force participation (notably women in higher level, professional occupations), and interaction with trained health professionals.

Table 4.1: Difference between main variables of interest in full NFHS-3 sample and sample used in the analysis

	A: Full Sample (N=84,609)	B: Gave birth in 2005-06 (N= 12,789)	C: Sample with full data (N=10,006)
Individual level Factors	**Mean (range) or % (N)**	**Mean (range) or % (N)**	**Mean (range) or % (N)**
Current Age	33.18 (15-49)	25.21 (15-49)	25.26 (15-29) (ND)
Years of Education	5.04 (0-23)	5.43 (0-22)	5.50 (0-19)***
Average age gap between husbands and wives	5.70 (-36-69)	5.31 (-22-69)	5.29 (-22 – 67) (ND)
Ideal number of boys/girls	1.22 (0-8)	1.22 (0-6)	1.23 (0 -6) (ND)
Number boys in household	1.3 (0-11)	0.06 (0-7)	0.06 (0-6) (ND)
Number girls in household	1.17 (0-10)	0.06 (0-8)	0.06 (0-8) (ND)
In the labor force	42.13 % (35,645)	29.8 % (3,812)	30.8 % (3,085)*
Wealth Index	3.41 (1-5)	3.11 (1-5)	3.01 (1-5)***
Percent of women using family planning at time of survey	61.3% (51,863)	30.43% (3,892)	289.25% (2,927)*
Percent Hindu	73.8% (62,440)	67.7% (8,658)	65.9% (6,595)***
Community level factors (*Stratum)***			
Stratum mean ideal number of boys/ideal number of girls	1.08 (0.96-1.30)	1.09 (0.96-1.30)	1.10 (0.96-1.30) ***
Stratum mean percent of women who watch TV frequently	60.1% (13-95)	55.09% (13-95)	53.4% (13-95) ***
Stratum mean score for acceptability of wife beating	1.21 (.18-2.53)	1.26 (0.18-2.53)	1.27 (0.18-2.53) *
Stratum-level child sex ratio (under 10),	0.71 (0.41-1.07)	0.71 (0.41-1.07)	0.71 (0.41-1.07) (ND)

Stratum percent of women in labor force	42.13% (18.69-84.27%)	44.25% (18.69-84.27%)	43.3% (18.69-84.27%) ***
Stratum percent of women in higher level occupations in the labor force	6.99% (1.17-28.76%)	6.79% (1.17-28.76%)	8.15% (1.17-28.76%) (ND)
Stratum percent who saw a doctor or Nurse for ANC	33.7% (19-50)	33.75% (19-50)	34.39% (19-50) ***
Stratum percent who delivered with a doctor or Nurse	24.1% (11-45)	22.88% (11-45)	24.69% (11-45)***

*** p<0.01, ** p<0.05, * p<0.1, ND= No significant difference; for difference between columns B and C

Table 4.2: Individual Model: An individual woman's odds of having a boy in 2006, among women who had a baby in 2006

	A: Basic model	B: Demographics	C: Community level Marriage	D: Community level Labor	E: Community level Norms	F: Community level Access	G: Full Model
Stratum level sex ratio in children under 10, 2003	0.891 [-0.860]	1.059 [0.377]	0.949 [-0.404]	0.918 [-0.645]	0.949 [-0.368]	0.869 [-1.140]	1.329* [1.705]
Woman's age		1.006* [1.731]					1.006* [1.867]
Women's education single years		0.998 [-0.382]					1.000 [-0.075]
Women's labor market participation		0.964 [-1.155]					0.951 [-1.457]
Women's advanced labor market participation		0.893 [-0.850]					0.921 [-0.604]
Wealth Index		1.043* [1.926]					1.034 [1.396]
Using Family Planning		1.257*** [4.507]					1.254*** [4.459]
Ideal number boys over girls		1.397*** [7.215]					1.393*** [7.080]
Number of girls in the household, 2005		0.290*** [-8.597]					0.291*** [-8.566]
Number of boys in the household, 2005		4.050*** [8.443]					4.049*** [8.420]
Hindu		0.986 [-0.310]					0.986 [-0.284]
State		1.004* [1.808]					1.002 [0.783]
Age Gap		0.999 [-0.256]					1.000 [-0.055]
Frequent TV watching		0.934 [-1.186]					0.934 [-1.202]
Saw Doctor/Nurse for ANC		0.986 [-0.268]					1.002 [0.038]
Delivered with Doctor/Nurse		1.029 [0.616]					1.011 [0.228]
Stratum level Average Age Gap			0.983 [-1.088]				0.984 [-0.942]
Stratum Percent Women Labor Force				0.913 [-1.023]			1.217 [1.504]
Stratum Percent				0.862			0.230***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Women Advanced Labor					[-0.468]		[-3.520]
Stratum level Mean Beat Wife Score					0.989 [-0.396]		0.970 [-0.906]
Stratum level Mean Ideal Boys Over Girls					1.013 [0.059]		1.195 [0.756]
Stratum Percent of Frequent TV watching					1.168** [2.098]		1.074 [0.490]
Stratum Percent Hindu					1.106 [1.316]		0.876 [-1.511]
Stratum Percent ANC Doc/Nurse						0.451*** [-3.058]	0.492** [-2.392]
Stratum Percent Deliver Doc/Nurse						2.166*** [3.570]	2.770** [2.547]
Constant	1.143 [1.462]	0.448*** [-4.376]	1.206 [1.634]	1.177* [1.700]	0.935 [-0.247]	1.275** [2.138]	0.399** [-2.306]
Observations	12,789	10,005	12,789	12,789	12,789	12,789	10,005

*** p<0.01, ** p<0.05, * p<0.1, Robust t-statistics in brackets

Table 4.3: Community Model: Factors associated with the stratum-level sex ratio in children under 10 in 2006

	A: Stratum Sex Ratio Under 10 in 2006
Stratum Average Age Gap Between Husband and Wife	0.027 [1.460]
Stratum Average Wealth Index	-0.070 [-1.121]
Stratum Percent of Women in Labor Force	-0.139 [-1.085]
Stratum Percent of Women in Advanced Labor	0.920*** [2.927]
Stratum Mean Acceptability of Beating Wife Score	-0.006 [-0.233]
Stratum Mean Ideal Boys Over Girls	0.036 [0.144]
Stratum Percent Watch TV Frequently	0.026 [0.139]
State Dummy	0.004** [2.342]
Stratum Percent Hindu	-0.152** [-2.450]
Stratum Percent ANC with Doctor/Nurse	-0.059 [-0.229]
Stratum Percent Deliver Doctor/Nurse	-0.207 [-0.721]
Constant	0.930* [1.881]
Observations	73
R-squared	0.505

*** p<0.01, ** p<0.05, * p<0.1, Robust t-statistics in brackets

Table 4.4: Model 1: Poisson model of an individual woman's odds of having a boy in 2006 given that she had a child

	A: Basic Model	G: Full Model	H: Basic Model Poisson	I: Full Model Poisson
Stratum level sex ratio in children under 10, 2003	-0.116 [-0.860]	0.285* [1.705]	-0.056 [-0.857]	0.148* [1.778]
Woman's age		0.006* [1.867]		0.003** [2.059]
Women's education single years		-0.000 [-0.075]		-0.000 [-0.081]
Women's labor market participation		-0.050 [-1.457]		-0.030* [-1.666]
Women's advanced labor market participation		-0.082 [-0.604]		-0.035 [-0.506]
Wealth Index		0.033 [1.396]		0.017 [1.474]
Using Family Planning		0.226*** [4.459]		0.109*** [4.420]
Ideal number boys over girls		0.331*** [7.080]		0.154*** [7.350]
Number of girls in the household, 2005		-1.233*** [-8.566]		-0.418*** [-10.291]
Number of boys in the household, 2005		1.399*** [8.420]		0.343*** [14.579]
Hindu		-0.014 [-0.284]		-0.005 [-0.193]
State		0.002 [0.783]		0.001 [0.835]
Age Gap		-0.000 [-0.055]		0.000 [0.047]
Frequent TV watching		-0.068 [-1.202]		-0.033 [-1.189]
Saw Doctor/Nurse for ANC		0.002 [0.038]		-0.002 [-0.080]
Delivered with Doctor/Nurse		0.011 [0.228]		0.005 [0.214]
Stratum level Average Age Gap		-0.016 [-0.942]		-0.008 [-0.957]
Stratum Percent Women Labor Force		0.197 [1.504]		0.112* [1.711]
Stratum Percent Women Advanced Labor		-1.468*** [-3.520]		-0.766*** [-3.550]
Stratum level Mean Beat Wife Score		-0.031 [-0.906]		-0.018 [-1.080]
Stratum level Mean Ideal Boys Over Girls		0.178 [0.756]		0.072 [0.626]
Stratum Percent of Frequent TV watching		0.072 [0.490]		0.034 [0.442]
Stratum Percent Hindu		-0.132 [-1.511]		-0.069 [-1.619]
Stratum Percent ANC Doc/Nurse		-0.710** [-2.392]		-0.352** [-2.307]

Stratum Percent Deliver Doc/Nurse		1.019**		0.506**
		[2.547]		[2.447]
Constant	0.134	-0.918**	-0.628***	-1.132***
	[1.462]	[-2.306]	[-14.112]	[-5.797]
Observations	12,789	10,005	12,789	10,005

*** p<0.01, ** p<0.05, * p<0.1, Robust t-statistics in brackets

Table 4.5: Model J with imputed missing values for women's education, ideal number of boys/girls and age gap between husband's and wives.

	G: Full Model	J: Full Model with imputations
Stratum level sex ratio in children under 10, 2003	1.329*	1.077
	[1.705]	[0.524]
Woman's age	1.006*	1.002
	[1.867]	[0.705]
Women's education single years /Imputed Women's education single years	1.000	**1.004**
	[-0.075]	**[0.712]**
Women's labor market participation	0.951	0.952
	[-1.457]	[-1.546]
Women's advanced labor market participation	0.921	0.956
	[-0.604]	[-0.379]
Wealth Index	1.034	1.039*
	[1.396]	[1.908]
Using Family Planning	1.254***	1.202***
	[4.459]	[4.102]
Ideal number boys over girls /Imputed Ideal number boys over girls	1.393***	**1.397***
	[7.080]	**[7.281]**
Number of girls in the household, 2005	0.291***	0.277***
	[-8.566]	[-9.535]
Number of boys in the household, 2005	4.049***	3.756***
	[8.420]	[9.133]
Hindu	0.986	1.012
	[-0.284]	[0.261]
State	1.002	1.000
	[0.783]	[0.130]
Age Gap /Imputed Age Gap	1.000	**1.000**
	[-0.055]	**[-0.079]**
Frequent TV watching	0.934	0.937
	[-1.202]	[-1.332]
Saw Doctor/Nurse for ANC	1.002	0.992
	[0.038]	[-0.159]
Delivered with Doctor/Nurse	1.011	1.083*
	[0.228]	[1.721]
Stratum level Average Age Gap	0.984	0.986
	[-0.942]	[-0.782]
Stratum Percent Women Labor Force	1.217	1.271**
	[1.504]	[2.033]
Stratum Percent Women Advanced Labor	0.230***	0.343***
	[-3.520]	[-2.952]
Stratum level Mean Beat Wife Score	0.970	0.969
	[-0.906]	[-1.242]
Stratum level Mean Ideal Boys Over Girls	1.195	0.884
	[0.756]	[-0.581]
Stratum Percent of Frequent TV watching	1.074	1.066
	[0.490]	[0.500]
Stratum Percent Hindu	0.876	0.974
	[-1.511]	[-0.315]
Stratum Percent ANC Doc/Nurse	0.492**	0.522**
	[-2.392]	[-2.265]
Stratum Percent Deliver Doc/Nurse	2.770**	2.137**

	[2.547]	[2.230]
Constant	0.399**	0.668
	[-2.306]	[-1.165]
Observations	10,005	12,789

*** p<0.01, ** p<0.05, * p<0.1

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CHAPTER 5

CONCLUSION:

EQUALIZING CHILD SEX RATIOS IN INDIA:

A NASCENT TREND WITH A YET UNCERTAIN FUTURE

The three papers that make up this dissertation explore various aspects of the emerging trend of child sex ratios beginning to equalize in some districts of India, despite a national downward trend. The dissertation starts with a wide lens, looking at the pattern of child sex ratios in all districts in India in the last four censuses (paper 1), then focuses in on the districts that have shown equalization (paper 2) and finally narrows to explore individual level behaviors related to this trend (paper 3). The first paper tests whether there is district-level evidence for the relationship between extremely imbalanced child sex ratios in one census and the rate of change in child sex ratios 10 years later using data from 1981-2011. I find evidence in support of this hypothesis, even after controlling for other demographic factors such as fertility, infant mortality, rural/urban status, caste, and female and male literacy rates. This suggests that something occurs when child sex ratios become very imbalanced that causes changes in behavior that lead to less imbalanced child sex ratios in the future. In other words—some corrective forces appear to come into play.

The second paper then focuses in detail on the districts that have shown signs of equalization between 2001 and 2011, decomposing the equalization into fertility and mortality related change. This is important for understanding the mechanisms through which child sex ratios are equalizing. I then explore the decomposition by rural/urban areas and geographic clusters of equalization. The contribution from both pre-birth events and excess female child mortality has declined between 2001 and 2011, and the relative contribution from each has remained stable. The simultaneous and proportionate reduction in both pre-birth and post-birth processes that distort the sex ratio is all the

more remarkable because the phenomenon occurs in both rural and urban areas and it occurs all over India. I suggest demand and supply mechanisms that would explain why dynamic changes in female fetus abortion and female child mortality rates could be tied together.

Geographic epicenters of equalization emerge. Two of these clusters of equalization are in the north (most of Punjab and Haryana) and west (in Gujarat), where child sex ratios had dropped to extremely imbalanced levels and now are rebounding. The other two clusters are in the south (mostly in Tamil Nadu and Karnataka), and the northeastern states, where child sex ratios have not fallen to such extreme lows, and yet have rebounded slightly. There were no substantial differences in the contribution to the imbalanced sex ratios or equalization from pre-birth events versus mortality between the different clusters, even though their baseline child sex ratios were very different. The contiguous nature of the equalizing districts suggest that socially contagious forces that drive changing demand for girls and changing supply of medical technology may be a factor in the trend. Some of the clusters of districts are centered around major urban settings, providing some evidence that this trend is initiating in urban centers, as we would expect from past literature on social and demographic trends in India. However, this is not the driving force as there are clusters of equalization that are not centered around urban centers, and there are many urban centers (for example Mumbai or Lucknow) that have shown no evidence of equalization.

In the districts that have shown equalization, it is predominantly occurring in both rural and urban populations. Of the few where it is not in both rural and urban populations, it is mostly in urban areas. There were no substantial differences in the contribution to the child sex ratio from pre-birth events and mortality between rural and urban areas in either 2001 or 2011, except for urban mortality. In 2001, child mortality contributed positively to the child sex ratio in urban areas (meaning that it was a corrective force on imbalanced sex ratios at birth), however, in 2011 child mortality was a negative contributor. This suggests that female mortality advantage relative to males has stagnated or even declined in urban areas. More research is needed to understand why mortality for female children in urban areas might have increased relative to male child mortality.

The majority (about 93-4%) of the contribution to imbalanced sex ratios comes from pre-birth events, and this is also where the majority of the balance is occurring. Assuming that pre-birth events are primarily sex-selective abortion (as is supported by much previous literature in India), this suggests that families are either actively choosing not to abort female fetuses, or restrictions on the supply of sex-selective technology have improved. If the equalization had been due primarily to improved girl child mortality, we might have interpreted the phenomenon as an expected trend with development because reductions in child mortality should favor girls over boys as child mortality becomes more dominated by congenital and gestational problems (Hill and Upchurch, 1995). However, this is not the case—something is actively happening to make girls less disadvantaged before they are conceived or born. Since pre-birth events (most likely sex-

selective abortions) still make up the majority of missing girls, efforts to discourage the desire for and restrict access to sex-selective technology should not be abandoned.

The decomposition also suggests that girls still lag behind boys in mortality rates, and efforts to reduce child mortality still need to target girls, most especially in urban areas. Past evidence is mixed about whether the girls born in areas with more sex-selective abortion are more desired, and therefore have better outcomes, or not (Hu and Schlosser, 2010, Hu and Schlosser, 2012). Ram et al. (2013) found that female under-five mortality was more than 25% higher than male under-five mortality in almost half of districts (Ram et al., 2013). Findings are also mixed about gender disparities in stunting or under nutrition in India, although socio-economic factors (such as birth order, parents education, etc.) have been found to be correlated with stunting in females, but not in males (Mondal et al., 2012, Biswas and Bose, 2010, Subramanyam et al., 2010, Bharati et al., 2009).

If indeed people are beginning to prefer girls more or boys less, and extremely imbalanced sex ratios are linked to equalization in child sex ratio in the future, it is important to consider potential drivers. In other words, what happens with child sex ratios becomes very imbalanced that makes people have more girls? In the final paper I test various demand and supply factors on the probability of having a boy and community level sex ratios. Marriage market, social norm and supply side variables do not seem to be associated with either an individual woman's' probability of having a boy or community level child sex ratios. However, it appears that women's labor force

opportunities, especially more participant in professional occupations, both at an individual- and community-level, are associated with child sex outcomes and child sex ratios.

Much more work is needed in this area, because understanding the drivers of equalizing sex ratios could help policy makers understand where and when sex ratios might begin to equalize elsewhere, and also help policy makers to spur on equalization of sex ratios by targeting factors which are found to most influence people's behavior. For example, if improved labor opportunities cause families to see improved value of having a girl, programs to expand such occupational opportunities for women in areas with imbalanced sex ratios could help slow and reverse the trend.

Only a few potential drivers of equalization were explored in this analysis (labor, marriage, norms and supply), and there are many other potential social trends that might alter people's perceived value of their daughters, such as care giving in old age, and boys labor and earning potential over time. Interviews with parents in India found that people are realizing that daughters actually care more for their parents in old age than sons (Kaur, 2013). Some experts in India believe that the combination of poor marriage prospects, lack of labor force opportunities, and an increase in illegal drug use by young men in Punjab was causing families to prefer daughters over sons (Kaur, 2013). These types of potential drivers deserve much more attention. The lack of data on the efficacy of programs and policies aimed to improve the status of girls through various means (ranging from media and educational to incentive based) and lack of data on the efficacy

of laws restricting access to sex-selective techniques severely limits our understanding of whether such programs, policies or laws are worth continuing or expanding in the future.

Child sex ratios have only begun equalizing between 2001 and 2011 in a minority of districts (<25%). We do not yet know if this trend will be sustained over time in these districts, and if it will spread to other districts in India. Since the next Indian census (2021) is many years away, finding ways to continue to watch this emerging trend using other data sources is key. The Sample Registration System, collected annually, will be a useful place to start. Additionally, confirming this trend in other data sets (including household level) would help validate the findings in this analysis. The National Family Health Survey (the fourth round of which is coming out very soon) and the Indian District Level Household Survey would be ideal for such validation and continued monitoring of these trends, especially relating to individual decision-making. Aside from large household surveys and censuses, qualitative work in the areas that have shown signs of equalization in child sex ratios on whether people are consciously aware of being impacted by very imbalanced child sex ratios and are therefore actively changing their behaviors would help us better understand this phenomenon. Such qualitative work could elucidate other important factors influencing individual decision making, such as those discussed above (old age care and opportunities for sons).

The fact that some districts have begun to show equalization should not be interpreted as an opportunity for the international or Indian communities to pay less attention to child sex ratios in India with the notion that child sex ratios are starting and will continue to

"fix themselves." Even if there is some inflection point at which child sex ratios rebound and begin to equalize, sitting aside and letting sex ratios fall to extremely low levels would cost the lives of many millions of girls, especially since we do not know the rate at which sex ratios would fall and then rebound. Furthermore, at this point we only have evidence of small levels of equalization, and we do not yet know if child sex ratios will rise to parity, or simply level off at some less imbalanced, but still uneven, ratio.

A variety of programs and interventions have been implemented in India to try to equalize the child sex ratio, however there is very little evidence as to whether these programs have had any effect. Table 5.1 lists some of the programs and interventions that have been implemented in India, and other potential types of programs or interventions that might be successful given the findings of this research, all of which require a sturdy evidence base.

In summary, the problem of imbalanced child sex ratios in India has not been solved. More efforts are needed to improve the value of girls so that families provide girls the same resources as boys once they are born, and families perceive equal benefits to having a boy and a girl and therefore do not opt for sex-selective abortion. Alongside working to improve the perceived value of girls, efforts to reduce access to sex-selective technology are key, while ensuring that women still have access to abortion. Many millions more girls are aborted or die before the age of 5 than boys in India. Despite increased discrimination against girls at a national level, pockets of districts in India are starting to

equalize their child sex ratios. This dissertation sheds light on this new phenomenon, and gives us hope that this positive trend will continue in India in the years to come.

Table 5.1: Sample of implemented and potential programs and interventions aimed to equalize the child sex ratio in India (see Hameed et al. 2011 for a more comprehensive review) (Hameed, 2011)

Program/Intervention	Implemented to date?
Conditional cash transfer program where parents receive financial incentive for having a girl who is unmarried by age 18	Yes: Apna Beti Apna Bai, through the Integrated Child Development Scheme program of Haryana Govt. (Department of Women and Child Development)
Media campaigns with Bollywood Stars	Yes: Mandira Bedi (Bollywood star) with the Laadli Campaign
School Vouchers for girls	Yes: example: The School Choice campaign in Delhi
Latrines in schools to halt the drop out of girls	Yes: The Rural Development Ministry has launched the School Sanitation and Hygiene Programme
Conditional cash incentives for registration of a girl child	Yes: The Dhanalaskhmi Scheme gives parents cash to help pay for the birth of a girl child upon birth registration, implemented in 7 states
General Electric role out of new ultrasound technology	No: GE will role out new mobile ultrasound technology, this is an opportunity to have better enforcement of laws to restrict sex determination
Girl wage top-ups	No: this could increase wages for girls relative to boys, which might be effective given the findings about the role of the labor market

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Nadia Griffin Diamond-Smith

Born: April 22, 1984, Honolulu, Hawaii

Education

Post-doctoral Fellow, University of California, San Francisco, Global Health Group, Private Sector Health Care Initiative, August 2013-present (Currently a research analyst until pass final exam)

Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department, PhD, January, 2014

- "Equalizing child sex ratios in India: Understanding the trends, distribution, composition and potential drivers"
- Funded by the National Institute of Child Health and Development for multidisciplinary training in population
- Certificate in Health Economics, completed March, 2012

London School of Hygiene and Tropical Medicine, London, UK, class of 2007

- MSc in Reproductive and Sexual Health Research
- Thesis: "Estimating the Burden of Malaria in Pregnancy in Madhya Pradesh, India." Based on a triangulation of data sources and mathematical modeling

Brown University, Providence, Rhode Island, class of 2006

- Graduated with Honors in Human Biology, emphasis on Human Health and Disease
- Honors thesis: "Too many girls, too much dowry: Son Preference and Daughter Aversion in Rural Tamil Nadu, India." Included sixty qualitative interviews with women in rural India

Work and Research Experience

Research Assistant for Dr. David Bishai, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department

- Study on impact of Mother-in-laws on fertility and female labor force participation in Egypt, November, 2010-August 2013

Research Assistant for Dr. Vladimir Canudas-Romo, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department

- Research on "The masculinization of female mortality and feminization of male mortality: the closing gap in gender mortality patterns", October, 2012-March 2013
- Research on gender based mortality gaps in India, January, 2013-present

Research Assistant for Dr. Caroline Moreau and Dr. David Bishai, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department

- Agent Based Modeling project on contraceptive discontinuation, switching and failure, and unintended pregnancies in France, recently awarded a grant from the Population Center to expand the work to include developing countries. April, 2011-August 2013

Assistant to the President of PAA 2014, each year the president of PAA (this year Robert Moffitt in the Department of Economics at Johns Hopkins University) hires a graduate student as an assistant for organizing PAA, April 2013-present (will finish in May 2014).

Research Assistant for Dr. Amy Tsui, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department,

- "Family Health and Wealth Study", a longitudinal study in 8 countries on fertility, health, and household wealth. Funded by the Bill and Melinda Gates Institute. February, 2011-Sept, 2012

Teaching Assistant for Dr. Nan Astone, graduate level course entitled "The Fundamentals of Population Change", October-December, 2011

Teaching Assistant for Dr. Stan Becker, undergraduate level course entitled "Population, Health and Development", August-October, 2011

Doctoral Committee, student member. Participates in decision-making about the doctoral program in the Department of Population, Family and Reproductive Health, July, 2011-July, 2013.

Research Assistant for Dr. Nan Astone, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department

- Project on homeless youth in Maryland, conducted focus group interviews and data analysis, June, 2011

Global Research Fellow, Venture Strategies for Health and Development, continued projects from previous full time position, June, 2010-January, 2011

Research Analyst, Venture Strategies for Health and Development.

- Focus on bringing population back on the global agenda, organizing a multi-country qualitative study on fertility decision-making and barriers to family planning, and constructing arguments to combat standard economic theory on the relationship between economic development, fertility decline and family planning. September, 2009- June, 2010

Visiting Research Fellow, School of Public Health, Postgraduate Institute of Medical Education and Research, Chandigarh, India.

- Conducted research on causes of persistent maternal anemia, specifically analyzing the government's anemia prevention program. Also taught various MPH courses. January- June, 2009.

Clinical Research Coordinator, GI Division, San Francisco General Hospital. October 2007-December 2008. Research on hepatitis B.

Research Assistant and qualitative data analyst for Population Studies and Training Center, Brown University, supervisor: Dr. Michael White

- Project on Migration, Fertility, Environment and Public Health in Ghana, Spring, 2006.

Teaching Assistant, course entitled "The Global Burden of Disease in Developing Countries", Brown University, Fall 2005.

Research Assistant, University of California, Berkeley

- Project on trends in maternal mortality and contraceptive prevalence in rural Tanzania, Summer 2004, supervisor: Dr. Malcolm Potts

Research Assistant ,University of California, Berkeley

- Project on the health effects of indoor air pollution on women and children in highland Guatemala, Summer 2003.

Publications, conference presentations and abstracts, and awards

Carl Swan Shultz Endowment Fund Award, 2013, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department

Global Health Established Field Placement Award, 2013, for work in India on life table estimates for socio-economic sub-groups

The Caroline Cochran Award, 2012, Johns Hopkins Bloomberg School of Public Health, Population, Family and Reproductive Health Department

Diamond-Smith, N. and D. Bishai. "Self-correction of sex ratios in India. Evidence from the last four censuses" in revise and resubmit at *Demography*

- Presented for oral presentation at the Population Association of America's 2013 meeting.
- 1st dissertation paper

Diamond-Smith, N., D. Bishai and V. Canudas-Romo. "Decomposing equalizing child sex ratios in India into fertility and mortality related components: geographic regions and urban/rural populations"
- Accepted for an oral presentation at the Population Association of America's 2014 meeting
- 2nd dissertation paper

Diamond-Smith, N. and D. Bishai. "Why are sex ratios beginning to even out in India? A test of supply and demand side factors influencing son preference"
- Accepted for an oral presentation at Population Association of America's 2014 meeting
- 3rd dissertation paper

Diamond-Smith, Nadia, El-Gibaly, O., and Bishai, D. "Inter-generational co-residence, women's labor force participation and leisure time in Egypt", in revise and resubmit at *Journal of Marriage and the Family*

- Accepted for poster presentation at the Population Association of America's 2013 meeting.

Canudas-Romo, V., Diamond-Smith, N. and Saikai, N. "Gender Gap in Life Expectancy in India and Bigger States during 1970-2006." Under review at *Population Studies*

Diamond-Smith, N., M. Gupta, M. Kaur and Kumar, R. "The causes of persistent maternal anemia in Chandigarh, India." Preliminarily accepted at *Journal of Public Health Nutrition*

Diamond-Smith, N., Moreau, C. and Bishai, D. "What is the best way to reduce unintended pregnancies? An agent-based simulation of contraceptive switching, discontinuation and failure patterns in France" in revise and resubmit at *Studies in Family Planning*

- Presented for oral presentation at the Population Association of America's 2012 meeting.
- Presented for oral presentation JHSPH Population, Family and Reproductive Health Research Day
- Presented for oral presentation at The European Society of Contraception and Reproductive Health's 2012 conference

Diamond-Smith, N., Perry, E., Shields, W., Gielen, A. and Bishai, D. 2013."Economic evaluation of smoke detector distribution methods in Baltimore, MD" *Injury Prevention.* doi: 10.1136/injuryprev-2013-040885.

Diamond-Smith, N. and Astone, N. "Exploring the gap between achieved and desired fertility in the United States"

- Presented for oral presentation at the Population Association of America's 2012 meeting.

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