Gender inequity in child survival
Travails of the girl child in rural north India

Anand Krishnan
To

All the women in my life –
they were someone’s daughters.

My Mother, who gave me all the right values and
is entirely responsible for what I am today

My wife Prema, for bearing with me and all my faults
for twenty years and still wanting to stay with me!

Finally to my two wonderful daughters Kritika and Keertana,
who have made all the difference to my life by the love they
brought in it and for proving that love is endless...

A special remembrance for my Father, who despite having
three sons, always had the softest corner for his daughter!
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ABAD</td>
<td>Apni Beti Apna Dhan</td>
</tr>
<tr>
<td>AIIMS</td>
<td>All India Institute of Medical Sciences</td>
</tr>
<tr>
<td>ANC</td>
<td>Antenatal Care</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>BCG</td>
<td><em>Bacillus Calmette–Guérin</em></td>
</tr>
<tr>
<td>CCT</td>
<td>Conditional Cash Transfer</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>CRHSP</td>
<td>Comprehensive Rural Health Services Project</td>
</tr>
<tr>
<td>CSMR</td>
<td>Cause Specific Mortality Rates</td>
</tr>
<tr>
<td>DHS</td>
<td>Demographic and Health Surveys</td>
</tr>
<tr>
<td>DLHS</td>
<td>District Level Household Survey</td>
</tr>
<tr>
<td>DTP</td>
<td>Diphtheria, Tetanus and Pertussis</td>
</tr>
<tr>
<td>GACVS</td>
<td>Global Advisory Committee on Vaccine Safety</td>
</tr>
<tr>
<td>HDSS</td>
<td>Health and Demographic Surveillance System</td>
</tr>
<tr>
<td>HMIS</td>
<td>Health Management Information System</td>
</tr>
<tr>
<td>ICD-10</td>
<td>International Classification of Diseases 10th Version</td>
</tr>
<tr>
<td>ICDS</td>
<td>Integrated Child Development Services</td>
</tr>
<tr>
<td>IGME</td>
<td>The UN Inter-agency Group for Child Mortality Estimation</td>
</tr>
<tr>
<td>IMR</td>
<td>Infant Mortality Rate</td>
</tr>
<tr>
<td>INDEPTH</td>
<td>International Network for the Demographic Evaluation of Populations and Their Health</td>
</tr>
<tr>
<td>MDGs</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>NFHS</td>
<td>National Family Health Survey</td>
</tr>
<tr>
<td>NGOs</td>
<td>Non-Governmental Organizations</td>
</tr>
<tr>
<td>NMR</td>
<td>Neonatal Mortality Rate</td>
</tr>
<tr>
<td>NSE</td>
<td>Non-Specific Effects</td>
</tr>
<tr>
<td>OPV</td>
<td>Oral Polio Vaccine</td>
</tr>
<tr>
<td>ORS</td>
<td>Oral Rehydration Salt</td>
</tr>
<tr>
<td>PNDT</td>
<td>Pre-Natal Diagnostic Techniques Act</td>
</tr>
<tr>
<td>PSU</td>
<td>Primary Sampling Units</td>
</tr>
<tr>
<td>RR</td>
<td>Rate Ratio / Relative Risk</td>
</tr>
<tr>
<td>SES</td>
<td>Socio Economic Status</td>
</tr>
<tr>
<td>SRB</td>
<td>Sex Ratio at Birth</td>
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<tr>
<td>SRS</td>
<td>Sample Registration System</td>
</tr>
<tr>
<td>U5MR</td>
<td>Under-Five Mortality Rates</td>
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<tr>
<td>UNFPA</td>
<td>United Nations Population Fund</td>
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<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<td>WHO</td>
<td>World Health Organization</td>
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</table>
ABSTRACT

**Background:** While substantial progress has been made globally towards achieving United Nations Millennium Development Goal 4 (MDG 4) on child mortality, the decline is not sufficient to reach the targets set for 2015. The South Asian region, which includes India, was to achieve the MDG 4 target of 39 deaths per 1000 live births by 2015 but was estimated to have reached only 61 by 2011. A part of this under-achievement is due to the gender-differentials in child mortality in South-Asia. The inherent biological advantage of girls, reflected in lower mortality rates as compared to boys globally, is neutralized by their socio-cultural disadvantage in India. The availability of technology for prenatal sex determination has promoted sex-linked abortions. Current government efforts include a law that regulates the use of ultrasound and other diagnostic techniques for prenatal testing of sex and a conditional cash transfer (CCT) scheme that invests a certain amount of funds at the birth of a girl child to attain maturity when the girl turns 18 years of age. This thesis describes the trends in gender-specific mortality during the period 1992-2011 and gender differentials in causes of death among children (paper I), compares gender differentials in child survival by socio-economic status of the family (paper II), explores the contribution of non-specific effects of diphtheria-tetanus-pertussis (DTP) vaccination to the excess mortality among girls (paper III), and evaluates the impact of CCT schemes of the government and explores community attitudes and practices related to discrimination of girls (paper IV).

**Methods and Results:** This study is set in Ballabgarh Health and Demographic Surveillance System (HDSS) of Haryana State in North India that covered a population of 88,861 across 28 villages in 2011. This study uses the electronic database that houses all individuals enumerated in the HDSS for the period 1992-2011 along with other demographic, socio-economic and health utilization variables. Sex ratio at birth (SRB) was adverse for girls throughout the study period, varying between 821 to 866 girls per 1000 boys. Overall, under-five mortality rates during the period 1992-2011 remained stagnant due to the increasing neonatal mortality rate and decreasing mortality in subsequent age groups. Mortality rates among girls were 1.6 to 2 times higher than boys during the post-neonatal period (1-11 months) as well as in the 1-4 year age group. Girls reported significantly higher mortality rates due to prematurity (relative risk of 1.52; 95%CI = 1.01-2.29); diarrhoea (2.29; 1.59-3.29), and malnutrition (3.37; 2.05-5.53) during 2002-2007. The SRB and neonatal mortality rate were consistently adverse for girls in the advantaged groups. In the 1-36 month age group, girl children had higher mortality than boys in all SES groups. The age at vaccination for and coverage with
Bacillus Calmette–Guérin, DTP, polio and measles vaccines did not differ by sex. There was significant excess mortality among girls as compared to boys in the period after immunization with DTP, for both primary (hazard ratio of 1.65; 95% CI 1.17-2.32) and DTPb (2.21; 1.24-3.93) vaccinations until the receipt of the next vaccine. No significant excess mortality among girls was noted after exposure to BCG (1.06; 0.67-1.67) or measles (1.34; 0.85-2.12) vaccine. A community survey showed poor awareness of specific government schemes for girl children. Four-fifths of the community wanted government to help families with girl children financially. In-depth interviews of government programme implementers revealed the themes of “conspiracy of silence” that was being maintained by general population, underplaying of the pervasiveness of the problem coupled with a passive implementation of the programme and “a clash between politicians trying to cash in on the public sentiment of need for subsidies for girl children and a bureaucratic approach of accountability which imposed lot of conditionalities and documentations to access these benefits”. While there has been some improvement in investment in girl children for immunization and education during the period 1992 to 2010, these were also seen among boys of the same houses and daughters-in-laws who come from outside the state where such schemes are not in place.

Conclusions: In the study area, girl children continue to be disadvantaged at all periods in their childhood including in utero. In the short run, empowerment of individuals by education and increasing wealth without a concomitant change in culture of son-preference is harmful as it promotes the use of sex determination technology and female feticide to achieve desired family size and composition. There is a need to carefully review the use of health-enhancing technologies including vaccines so that they do not cause more harm to society. Current government efforts to address the gender imbalance are not working, as these are not rooted in a larger social context.

Keywords: Conditional cash transfers, girl child, inequities, gender, prejudice, mortality, non-specific effects, sex, socio-economic, vaccines
GLOSSARY OF TERMS
AND DEFINITIONS USED

Sex and Gender

“Sex” refers to the biological and physiological characteristics that define men and women. “Gender” refers to the socially constructed roles, behaviours, activities, and attributes that a given society considers appropriate for men and women. “Male” and “female” are sex categories, while “masculine” and “feminine” are gender categories. Aspects of sex will not vary substantially between different human societies, while aspects of gender may vary greatly. (http://www.who.int/gender/whatisgender/en/)

Health Inequality and Inequity

“Health inequalities can be defined as differences in health status or in the distribution of health determinants between different population groups. For example, differences in mobility between elderly people and younger populations or differences in mortality rates between people from different social classes. It is important to distinguish between inequality in health and inequity. Some health inequalities are attributable to biological variations or free choice and others are attributable to the external environment and conditions mainly outside the control of the individuals concerned. In the first case it may be impossible or ethically or ideologically unacceptable to change the health determinants and so the health inequalities are unavoidable. In the second, the uneven distribution may be unnecessary and avoidable as well as unjust and unfair, so that the resulting health inequalities also lead to inequity in health.” (http://www.who.int/hia/about/glos/en/index1.html)

Child Survival Indicators

1. Neonatal mortality rate (NMR): Deaths occurring among live-born babies within 28 days of birth per 1000 live births in a given period of time.

2. Post-neonatal mortality rate (PNMR): Deaths occurring after 28 days and within 365 days of birth per 1000 live births in a given period of time.

3. Infant mortality rate (IMR): Deaths occurring before 365 days of birth per 1000 live births. This would be the sum of the previous two rates in a given period of time.
4. **Child mortality rate (CMR):** Deaths occurring more than 365 days after birth and within five years of birth per 1000 live births in a given period of time.

5. **Under-five mortality rate (U5MR):** Deaths occurring among live-born babies before five years of age per 1000 live births in a given period of time. This would be the sum of infant and child mortality rates.

6. **Cause specific mortality rate (CSMR):** CSMR is calculated as deaths attributed to a particular cause in a particular age group per 1000 live births in a given period of time.

7. **Sex ratio at birth (SRB):** Number of live-born boys per 1000 live-born girls. Internationally it is described as boys per 100 girls.
This thesis is based on the following papers, which will be referred to in the text by their roman numerals.


III. Krishnan A, Srivastava R, Dwivedi P, Ng N, Byass P, Pandav CS. Non-specific sex-differential effect of DTP vaccination may partially explain the excess girl child mortality in Ballabgarh, India. (Accepted for publication in Tropical Medicine and International Health)

IV. Krishnan A, Amarchand R, Byass P, Pandav CS, Ng N. “No one says ‘No’ to money” – A mixed methods approach for evaluation of Conditional Cash Transfer schemes for improving girl children’s status in Haryana. (Submitted Manuscript)

Media Links

1. Featured in BMJ - India’s problem with girls (http://www.bmj.com/content/347/bmj.f4149)

2. Interviewed in CNN - Indian father accused of killing baby ‘for being a girl’ (http://edition.cnn.com/2012/06/14/world/asia/india-female-infanticide/)

3. Refers to the CNN Interview - Sex selective abortion isn’t the real reason why India is the worst country for women - (http://bit.ly/LNDIMJ)
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GENDER INEQUITIES IN CHILD SURVIVAL

Infant Mortality Rate (IMR) and Under-five Mortality Rate (U5MR) are globally recognized as good summary measures of health of a nation’s children. They measure the probability of dying before age one and five, respectively, and are expressed as per 1000 live births. The levels of mortality are surrogate measures of the quality and coverage of essential health care interventions in a community. These indicators are also sensitive to socio-economic and cultural factors in a community. It is not surprising therefore, to note that child mortality is one of the primary indicators for health as a part of measuring progress in global development under the United Nations Millennium Development Goals (MDGs).

Global progress in childhood mortality reduction

The MDG4 aims to reduce child mortality with a target of reducing under-five mortality rates by two thirds over the period 1990–2015 (http://www.un.org/millenniumgoals/). The UN Inter-agency Group for Child Mortality Estimation (IGME) led by Unicef and the World Health Organization (WHO) was formed in 2004 to share data on child mortality, harmonize estimates within the UN system, improve methods for child mortality estimation, report on progress towards the MDGs and enhance country capacity to produce timely and properly assessed estimates of child mortality (http://www.childinfo.org/mortality_igme.html).

IGME estimates that substantial progress has been made towards achieving MDG4. Since 1990, the under-five mortality rate has declined by 41% globally from 87 deaths per 1000 live births in 1990 to 51 in 2011. The annual rate of reduction accelerated from 1.8% in the decade of 1990-1999 to 3.2% in the next decade of 2000-2011 (1). These decreases are, however, insufficient to reach MDG4 in large parts of the world including south-Asia. The south Asian region which includes India was to achieve the MDG4 target of 39 deaths per 1000 live births by 2015 (from a baseline of 116 in 1990) but was estimated to have reached only 61 by 2011 with an annual rate of reduction of about 3% (1).

Progress in childhood mortality reduction in India

For India, Pandey et al. estimated that following the rapid decline in the seventies, U5MR stagnated for almost a decade and then started declining further. It reached a level of 118 per 1000 live births in 1990, 93 in 2000 (a decline of 25 per 1000 in a decade) and 66 in 2009 (27 per 1000 in nine years). Simultaneously, IMR fell from 80 in 1990 to 68 in 2000 (12 per 1000 in 10 years) and 50
in 2009 (18 per 1000 in 9 years). The decline in neonatal mortality (within first month of life) and early neonatal mortality (within first week of life) were much slower than the post-neonatal mortality for all periods. As a result, the proportion of infant deaths occurring within first month is now 66% of all deaths and almost 75% of neonatal deaths are estimated to occur in the first week of life (2). IGME estimates are in the similar range and reports that infant mortality in India declined from 81 per 1000 live birth in 1990 to 47 by 2011 and neonatal mortality declined far more slowly from 47 per 1000 live birth in 1990 to 32 by 2011 (1). The National Institute of Medical Statistics used the three rounds of National Family Health Survey (NFHS) data to construct cohort of birth and used it to estimate mortality rates for different time-periods (3). Their results, which confirm the rate of decline estimated above, are summarized in Table 1.

### Table 1. Sex-specific decline in under-five mortality rates (per 1000 live births) in India as derived from three rounds of NFHS surveys

<table>
<thead>
<tr>
<th>Period</th>
<th>Neonatal mortality rate (0-1 month)</th>
<th>Post-neonatal mortality rate (1-11 months)</th>
<th>Child mortality rate (1-4 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Girls</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981-86</td>
<td>50.6</td>
<td>43.8</td>
<td>46.6</td>
</tr>
<tr>
<td>1987-92</td>
<td>46.8</td>
<td>32.4</td>
<td>37.4</td>
</tr>
<tr>
<td>1993-98</td>
<td>44.5</td>
<td>26.8</td>
<td>33.8</td>
</tr>
<tr>
<td>1999-2005</td>
<td>38.7</td>
<td>21.1</td>
<td>22.7</td>
</tr>
<tr>
<td><strong>Boys</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1981-86</td>
<td>62.1</td>
<td>37.4</td>
<td>31.9</td>
</tr>
<tr>
<td>1987-92</td>
<td>54.3</td>
<td>29.0</td>
<td>27.4</td>
</tr>
<tr>
<td>1993-98</td>
<td>48.8</td>
<td>24.4</td>
<td>21.6</td>
</tr>
<tr>
<td>1999-2005</td>
<td>42.7</td>
<td>17.4</td>
<td>14.8</td>
</tr>
</tbody>
</table>

Source: National Institute of Medical Statistics (3)

### Inequities in childhood mortality reduction in India

India is a large and diverse country and national averages do not capture the entire picture. Inter-state, rural-urban and gender differentials could be quite large. Table 2 shows the childhood mortality rates for some of the larger states selected from different regions in India (3). The southern states clearly have much lower child mortality rates than the rest of the country, while North and West India lag behind. Haryana, the state where this thesis work is based, has rates that are close to the national averages.
GENDER INEQUITIES IN CHILD SURVIVAL

Table 2. Components of childhood mortality rates (per 1000 live births) in selected states of India in 2010

<table>
<thead>
<tr>
<th>State</th>
<th>Neonatal mortality rate</th>
<th>Infant mortality rate</th>
<th>Under-five mortality rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>R</td>
<td>U</td>
</tr>
<tr>
<td>India</td>
<td>33</td>
<td>36</td>
<td>19</td>
</tr>
<tr>
<td>North India</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haryana</td>
<td>33</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>Punjab</td>
<td>25</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>42</td>
<td>45</td>
<td>27</td>
</tr>
<tr>
<td>West India</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rajasthan</td>
<td>40</td>
<td>45</td>
<td>23</td>
</tr>
<tr>
<td>Gujarat</td>
<td>33</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>22</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>South India</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>16</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>Kerala</td>
<td>7</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>East India</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Bengal</td>
<td>23</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>Assam</td>
<td>33</td>
<td>36</td>
<td>13</td>
</tr>
</tbody>
</table>

T = Total; R = Rural; U = Urban
Source: National Institute of Medical Statistics based on Sample Registration System reports (3)

Gupta et al. ranked Indian states in terms of decline in infant mortality rates and income growth during the period 1978-2005. While in general they found a good correlation between these two variables, two states Karnataka and Haryana seemed to buck the trend and showed that despite being ranked fourth and third respectively in the income growth, they were the lowest in the rate of IMR decline. Kerala was another outlier which showed a poor ranking in income growth but ranked first in the IMR decline (4).

During the period 1976-2008, rural childhood mortality rates were considerably higher than urban mortality rates. IMR in rural areas was 139 per 1000 live births in 1978 (as compared to 80 in urban areas) and came down to 58 in 2008 (as compared to 36 in urban areas). Thus, the decline during this period was 58% in rural areas as compared to 55% in urban areas. The U5MR in urban areas came down by 67% from 129 in 1978 to 43 per 1000 live births in 2008 and in rural areas it declined by 66% from 226 to 76 during the same period. Thus, despite their similar rate of decline to the urban areas, rural areas have consistently higher mortality rates by about 1.6 times. After adjustment for socio-economic demographic and coverage with child survival programs, the authors found that
the difference in child mortality between urban and rural areas largely disappeared, expect for neonatal mortality (3). As can be seen from Table 2, even in 2010, rural areas had higher child mortality rates than urban areas, and this was more pronounced for neonatal mortality. The states that had higher mortality rates (especially Rajasthan and Assam) also had the highest rural-urban differences.

While making gender comparisons, it is important to note that equity in survival between females and males does not imply equality in mortality rates. Under circumstances where boys and girls have the same access to resources such as food and medical care, boys have higher mortality rates than girls during childhood and the examined ratios would overall be expected to be greater than 100 (5). Similarly, naturally more boys are born than girls with a ratio around 1.05, probably a long-term adaptation to compensate for this higher biological mortality among boys.

However, in India boys have consistently reported lower under-five mortality rates than girls. The data in Table 1 confirm the higher girl child mortality and narrowing of its gap over the years. In the neonatal period, however, boys consistently showed a higher mortality that in a way reflects the natural biological girl child advantage without interplay of social factors. The subsequent increase in the girl child mortality in the higher age groups is probably a reflection of cultural disadvantage and discrimination against the girls. The IGME also estimates that, between 1990 to 2011, the under-five mortality among boys in India came down by 51 per 1000 (from 110 to 59) as compared to 55 (from 119 to 64) among girls, indicating a narrowing of the gender gap (1).

The specific aspect of girl child discrimination and survival is only a component of a larger context of lower status of women in the Indian society. While acknowledging this, the subsequent sections will focus only on inequities in girl child survival until five years of age, which forms the core of this thesis. While traditionally child survival has been talked about in terms of survival following live birth, recent evidence has shown that it is important to discuss about survival between conception and birth as well (6). This thesis, therefore, includes the pre-natal component of child survival as well.

**Gender differences in childhood mortality**

The debate on missing women in the world took centre stage when Nobel Prize winning Indian Economist Amartya Sen wrote in New York Review of Books in 1990 that globally 100 million women were missing, largely contributed by China and South Asia (7). He used a simple method by looking at population sex
ratio in these countries compared to what he considered to be optimal, as in sub-Saharan Africa (a ratio of 1.05). This estimate has been subsequently questioned and refined further using more complex methodologies but the estimates of missing women remain in the range of 60 millions to 107 million (8).

The most recent 2011 Indian census shows that the overall female-male sex ratio marginally improved from 933 women per 1000 men (107 boys per 100 girls) to 940 per 1000 (106 boys per 100 girls) during the last decade. However, the number of girls to boys in the youngest age group (0-6 years) fell sharply from 927 per 1000 (108 per 100 girls) to 914 per 1000 (109 per 100 girls) during the same time period (9). This decline in sex ratio in childhood can be attributed both to less girls being born as well as lower survival of girl children after birth. The standard international way of reporting sex ratio at birth is number of boys per 1000 girls, but in India it is usually reported as number of girls per 1000 boys. Unless otherwise stated, this thesis will express sex ratio at birth as per 1000 boys. Thus, an increase in sex ratio would mean more girls are being born.

Oster used data from the first two rounds of NFHS and found a significant excess female mortality in childhood, particularly between the ages of 1 and 5, and argued that the sex imbalance by age 5 was large enough to explain virtually the entire imbalance in the population. She also estimated that, in the under-five age group, sex differences in vaccinations (girls being less likely to be vaccinated) explained between 20 and 30% of excess female mortality, under-nutrition explained an additional 20% and differences in treatment (girls less likely to receive treatment) for illness played a smaller role. Together, the differences in investments in vaccination, nutrition and health care seeking explained approximately 50% of the sex imbalance in mortality (10). The national level data show that the ratio of female to male IMR for India was less than unity during 1981 (0.981) and 1991 (0.988), whereas during 1998 it exceeded unity. In other words, during 1981 and 1991 more male than female infants died during infancy whereas the reverse was true for the year 1998. More recently, the 2010 data show that infant mortality rate was 49 per 1000 live birth for girls as compared to 46 for boys. All states in India had higher mortality rate for girls (2).

A survey of recently delivered women in Tamil Nadu showed that while the sex ratio at birth was 107 boys per 100 girls, there was increased neonatal mortality among girls. This was more so for multiparous women with no living sons, indicating the possibility that these girls were being “killed” (11). A gender difference in late neonatal mortality has also been reported from Pakistan that shares a similar cultural practice of female neglect (12). Later, in an editorial in British Medical Journal in 2003, Sen remarked on the change in cause of missing women in India from child mortality to sex-linked abortions and the splitting of
India (North and West vs South and East) on this score. More insightfully, he commented that the known conundrums of access to health care, income, education levels and religion did not explain this split adequately. He ended by saying “Sex bias in natality calls for intensive research today in the same way that sex bias in mortality—the earlier source of ‘missing women’—did more than a decade ago” (13).

**Levels of gender inequality in pre-natal period**

The estimates of missing women comprise those lost before birth due to sex-linked abortions and those lost after birth due to higher mortality rates among girls as compared to boys. One of the hypotheses, initially proposed by Sen, was that pre-natal sex selection will replace post-natal discrimination (13). Goodkind (1996) also suggested that if abortion technology was available, accessible, and acceptable to all biased parents, then pre-natal sex selection will reduce the chances of excess female infant mortality, thus supporting Sen’s thesis (14). Using data from NFHS, Chaudhri tested this hypothesis. He concluded that once individual, household and regional factors are controlled, an increase in SRB significantly reduced the likelihood of excess female infant mortality. It was also estimated that pre-natal sex selection contributed to 37% of ‘missing girls’, while post-natal discrimination contributed to the rest 63% (15).

In 1999, Alaka Basu argued that the sharp decline in fertility rates in India was not due to improvements in the status of women, but in fact due to the worsening status of women. This, she said, was due to the fact that pressures to lower fertility driven by development and the need to have small families were occurring without a change in underlying son preferences. Therefore, the falls in fertility were being aided by technologies that allowed one to manipulate the sex composition of children as yet unborn. This was also true for southern Indian states such as Tamil Nadu where women’s status is believed to be better than in their northern counterparts, such as Haryana, questioning the north-south divide on gender proposed by Sen above (16). A community-based study in western Maharashtra interviewed 1,409 women who underwent induced abortion during 1996-98 and found that 18% of these abortions were for averting the birth of female babies (17).

UNFPA reported that the lowest sex ratio at birth in India was observed in 2003-2005, since when some improvements have occurred. They estimated that 0.6 million girls were lost at birth every year in India and the situation was worst in Punjab followed by Delhi, Jammu, Kashmir, Haryana and Rajasthan (18). An analysis of 133,738 births from the Special Fertility and Mortality Survey in India in 1997 showed that the sex ratio at birth was 132 per 100 girls for the second
birth when the preceding child was a girl and was 139 for the third birth if the first two children were girls. By contrast, adjusted sex ratios for second or third births if the previous children were boys were about equal. On the basis of the survey data, the authors estimated that there were 0.5 million “missing females” annually and more than 10 million missing females over the course of the previous two decades (6).

Jha et al. analysed three rounds of NFHS data covering the period 1990 to 2005. The conditional sex ratio for second order births when the firstborn was a girl fell from 906 per 1000 boys in 1990 (99% CI; 798–1013) to 836 in 2005 (99% CI; 733–939); an annual decline of 0.5% (p for trend=0.001). In contrast, no significant declines were noted in the sex ratio for second order births if the firstborn was a male, or for firstborns. They also used data from 2001 and 2011 censuses and found that during the intervening decade, the number of districts that showed decline in the child sex ratio had doubled. After adjusting for excess mortality rates in girls, the estimated number of selective female abortions was 0 to 2.0 millions in the 1980s, 1.2 to 4.1 millions in the 1990s, and 3.1 to 6.0 millions in the 2000s (19).

Similar problems have existed in many countries in Asia, for example China, Vietnam and South Korea (20,21). Since the onset of the one-child policy in China, there has been a steady increase in the reported sex ratio, from 106 boys for 100 girls in 1979, to 111 in 1988 and 117 in 2001 (22). A national level household-based cross sectional population survey was done in China in November 2005 and covered 4,764,512 people under the age of 20. The results showed that overall sex ratios were high across all age groups and residency types, but they were highest in the 1-4 years age group, peaking at 126 in rural areas. Six provinces had sex ratios of over 130 in that age group. The sex ratio at birth was close to normal for first order births but rose steeply for second order births, especially in rural areas, where it reached 146. Nine provinces had ratios of over 160 for second order births. It was estimated that in 2005, males under the age of 20 exceeded females by more than 32 millions in China, and more than 1.1 million excess births of boys occurred (23). Similarly in Vietnam, the sex ratio at birth in 2006 was reported to be 110 boys per 100 girls with some regions reporting as high as 122 (24).

Incidentally, the knowledge of sex of the unborn child is also altering the preference for health care during antenatal period. Using data from the DHS surveys, Bharadwaj and Nelson examined whether sex-selective prenatal care occurs in countries of South and Southeast Asia, with an emphasis on India. They found significant differences in utilization of antenatal care when women were pregnant with boys as compared to when they were pregnant with girls. In India, women
were 1.8% more likely to have at least two antenatal visits when pregnant with a boy and received a significantly greater number of tetanus immunizations. In northern India, where sex discrimination is known to be more prevalent, women were 4.6% more likely to seek antenatal care and 3% more likely to receive tetanus immunizations if they were pregnant with a boy. In the same region, women were 16% more likely to have institutional delivery if pregnant with a boy. These differences were more in women whose previous children were girls and the current foetus was a boy. They also found that this discrimination in the antenatal period occurred largely among mothers who reported having received an ultrasound during pregnancy. Evidence of differentials in antenatal care based on the sex of foetus was also seen in other countries of South and Southeast Asia where sex discrimination has been documented. For example, in China, women pregnant with boys were 4.6% more likely to seek prenatal care. Mothers in Pakistan were 2.6% more likely to take iron supplements and mothers in Bangladesh attended antenatal care 7% more frequently when pregnant with a boy (25). It is pertinent to note here that, by this time, the government of India had already banned prenatal sex determination.

Medical and social audit of deaths in children

The Registrar General of India conducted a survey of all deaths occurring in 2001-03 and applied this to 2005 UN population estimates to derive the cause-specific mortality rates for 2005. Trained physicians reviewed verbal autopsy forms of 10,892 deaths in neonates and 12,260 deaths at ages 1-59 months and assigned causes of death using ICD-10 codes. The under-five mortality rate per 1000 live births was 81.8 for boys and 90.2 for girls (26). Three causes accounted for 78% of all neonatal deaths in India: prematurity and low birth weight; neonatal infections/sepsis; and birth asphyxia/trauma. All-cause neonatal mortality rate was about 20% higher among boys (40.1) than girls (33.5), and mortality rates were higher for most causes among boys than girls. Pneumonia and diarrhoeal diseases accounted for 50% of all deaths at ages 1-59 months. All-cause mortality rate at ages 1-59 months was about 36% higher among girls (56.7) than boys (41.7) and most of the leading causes of death were between 12% and 72% higher in girls than boys, with the exception of injuries and meningitis/encephalitis. Pneumonia and diarrhoeal diseases accounted for about two-thirds of the 160,000 excess deaths from all causes among girls at ages 1-59 months (26).

Logically, differences in causes of death between population sub-groups can be due to difference in incidence or difference in case fatality rates. Incidence of a disease is affected by differences in its determinants (for example, source and quality of water for diarrhoea) or adoption of preventive measures (vaccination for tetanus). The case fatality rate is determined by a combination of three factors: health seeking behaviour, availability and access to health services and
quality of care provided in the health services. While medical audits focus on clinical symptomatology to arrive at medical cause of death, social audit or autopsy is done to arrive at an improved understanding of cultural, social, and health system factors affecting the delay in utilization of health care (27,28). The lessons from such audits can be used both by the community itself as well as programme manager to improve child health and prevent deaths.

Despite its importance, social autopsy has not been widely practiced and still lacks standard methods for data collection and analysis. Two key models, known as “Pathway to Survival” and “Three Delays”, have been used to organize the care-seeking data generated by social autopsy (29-31). Two African HDSS sites (Dodowa and Iguanga) under the INDEPTH Network conducted social autopsies of child deaths and concluded that in Iguanga the main delays were caused by inadequate case management by the private health providers, while in Dodowa HDSS the main delays were in the home (28). While investigating 64 neonatal deaths in Iguanga, Waiswa et al. found that the major contributing delays to new-born deaths were caretaker delays in problem recognition or in deciding to seek care (50%), delays to receiving quality care at a health facility (30%) and transport delays (20%) (30). In a study also on neonatal deaths in Ballabgarh, Upadhyay et al. reported delays contributing to neonatal death were related to caretaker’s delays in deciding to seek care (44%) and delays in reaching a health care facility, i.e. transport delays (34%) (32). Using the NFHS III data for child deaths in India, Malhotra et al. reported that mother’s education to higher secondary and above, being in the richest group by wealth index, and possession of a health card by the mother, significantly increased the odds of seeking treatment. Reported distance to a health facility was also a significant determinant of seeking treatment (33).

Of the 430 deaths that occurred during a zinc supplementation trial by Bhan et al. in a low-income setting of New Delhi, 230 were female (57%, (p<0.02). Of the 4,418 children who were hospitalized at least once, 2,854 (64.6%) were males, indicating a significantly lower rate of care-seeking for females (p<0.00) (34). Malhotra et al. analysed the NFHS 3 data for identifying determinants of delay in seeking outside treatment of diarrhoea which they defined as more than one day since the onset of illness. They reported that a male child had lower odds of experiencing a “delay” in seeking treatment, compared to a female child (OR 0.71; 95% CI, 0.55 – 0.92) (33). In a study by Pandey et al. in a rural community of West Bengal, there were no significantly higher rates of childhood illnesses including diarrhoea and respiratory infections reported among girls. However, at the household level, girls were less likely to get home fluids and oral rehydration solutions (ORS) during diarrhoea. Parents travelled longer distances for treatment (3.3 km vs 1.6 km) and spent more per treated episode (Rs 76.8 vs Rs 44.7)
for boys in comparison to girls. The boys were 4.9 times (95% CI 1.8-11.9) more likely to be taken early for medical care and 2.6 times (95% CI 1.2-6.5) more likely to be seen by qualified allopathic doctors compared to girls (35).

A study from Matlab, in rural Bangladesh, showed that female children aged 1 to 4 years had 1.8 times higher risk of dying than male children. The risks of dying due to severe malnutrition and diarrhoeal diseases were 2.5 and 2.1 higher for female than for male children (36). There was no gender difference in incidence of severe diarrhoeal diseases, but female children with diarrhoea were taken to the hospital significantly less often than male children. In contrast, there was a higher incidence of severe malnutrition in female than male children, and a lower rate of hospital admission (36). Using data from a survey of deaths of children less than 5 years old conducted in 1997 in a county in Shaanxi Province in China, Li et al. reported that the likelihood of receiving medical treatment before death for a female child was only 73% of that for a male child, and compared with a male child, a female child was 76% more likely to have died at home (21).

Social determinants of gender inequality

Gender inequalities in health have been a major area of sociological research since the 1970s globally, largely driven by the feminist movement in the West. A distinction between sex (biology) and gender (social) constructs was essential to this tradition of research since it made clear that gender inequalities in health were in the most part socially produced, rather than biologically driven. Therefore, they could be ameliorated, even eradicated, through changes in the gender order. A culture “against women” exists in all societies. In more developed parts of the world, the degree of discrimination against women has been mitigated by centuries of education, tradition, economic growth, modernization topped by the movement for emancipation of women’s rights (37). However, in less developed countries, the pattern of high fertility, high rates of illiteracy, and a low share of paid employment is seen resulting in the lower health status of women (38).

Zaidi summarizes the main causes of ill-health and gender in underdeveloped countries, into five broad themes which capture most of the relevant arguments put forth by a host of researchers (37).

1. Lack of resources and poor access: lack of access to health care; few opportunities to earn income; poor access to education opportunities; poor communication and transport; lack of prenatal and medical care during pregnancy and; insufficient nutrition.

2. Legal constraints: a male-oriented legal system; property rights which do not recognize women as equal partners; laws which do not consider men and women as equal.
3. Lack of participation: women are not part of health (or any other) planning and participatory process; most decisions related to women made by male health administrators and professionals.


5. Values and norms: social values, customs, cultural traditions, religious indoctrination that discriminates against and restricts the contribution and role of women in the society.

Thus, male domination becomes “culturally sanctioned” and gender based subordination is reinforced by religious systems resulting in it being “ingrained in the consciousness of both men and women and ... viewed as a natural corollary of the biological differences between them”, thus killing the “biological” versus “social” debate. The concepts of gender roles, desirable behaviours and expectations, which are appropriate to cultural and religious traditions, are learnt from an early age so that gender becomes an integral part of a person’s identity and gender roles are seen to lie at the centre of people’s “cultural and religious heritage”, and thus not subject to question or challenge (37).

A socio-cultural study from Delhi and Haryana confirmed the strong undercurrent of women’s subordination, the need for at least one son resulting in women going to any extent to beget a son, and the continued and even increasing role of dowry in contributing to families not wanting daughters. Economic considerations (sons more likely to earn and take care of parents in old age, property staying within the family) were seen to be driving the strong son preference. Other contributing factors to the son preference were religious (son lights the parental funeral pyre), security concerns around young girls, social customs of marriage (women marry out of the house and move to husbands’ house while sons stay with parents) (39). While these factors are true for the whole country, they are more entrenched in North and North West India where the status of women has been poor for centuries. Such cultural issues also play a major role in East Asia, for example in China and Vietnam, where Confucianism, a major influence in these societies, promotes the superiority of sons for cultural, economic and social reasons (24, 40).

Social status in Indian conditions can be measured in different ways – education, income and caste being among some of the possible and most often used indicators. Caste is a traditional measure of social position in India and differs from other indicators in that it is both endogamous and hereditary (41). National and State Governments classify castes into Scheduled Caste and Other Backward Castes for affirmative action. Caste is generally unchanging throughout the life course and is a good measure of social status and may largely define customs and
social mores, even though these are also shared across castes. Wealth index is based on material possessions and measures relative and absolute economic standing, indicating the resources available to the parent/family for childcare including health care. Parental education is basically a measure of empowerment and how parents are able to negotiate for a better outcome given their social and economic status. These measures of socioeconomic position are not interchangeable and show the complex interplay of varied forces which determine health (42).

**Education**

Education is the most studied social determinant of child mortality since Caldwell first reported an association between maternal education and childhood mortality based on World Fertility Survey data from ten developing countries (43). Research on child mortality suggests parental education is associated with better child care, better health care utilization, and higher value being placed on children, with greater autonomy (44-46). Education may be considered an instrument of preference change, due to enhancement of freedom and power to question and reassess the prevailing son preference (46).

In their analysis using village level census data, Deolikar et al. found a strong negative effect of female literacy rates on child sex ratios, with a 1% increase in female literacy reducing the sex ratio in a village by as much as 6 per 1000 boys (47). Echavarri et al., based on modelling of district level data from the 1991 census of India, showed that there was an inverted U relationship between literacy rates and juvenile sex ratios. They reported that as the share of the literate population increased, more boys were born but beyond levels of literacy around 55% of the total population, a negative correlation between education and the sex ratio at birth was found.

Using a large household dataset from a special fertility and mortality survey conducted in India in 1998, Jha et al. reported that declines in sex ratio at birth were much greater in mothers with 10 or more years of education as compared to illiterate mothers, and in wealthier households compared to poorer households (19). In the study by Bhan et al. the gender bias in seeking care was noted to be highest amongst highly educated mothers and decreased steadily for children of mothers with a middle school education, a primary school education, and was lowest amongst mothers with no formal education. Economic status and paternal education were not found to affect the association of gender and hospitalization (34).
Basu noted that the core level of son preference in India may actually be strengthened by “modernization” (e.g. education) of women (16). In order to achieve desired family size that optimizes the efficient use of family resources, educated parents use sex-selective abortion technologies (48-50). This suggests that education increases individuals’ freedom and power to access prenatal sex-detection technologies (48). The reverse association between female literacy and SRB may have other explanations as well. First, female education and literacy are one of the strongest determinants of fertility decline in India, as in other developing countries (51). Secondly, smaller family size is typically associated with lower numbers of girls. Dasgupta and Bhat identify two opposing effects of fertility decline on sex ratios: a positive “parity” effect whereby fertility decline results in fewer births at higher parities where discrimination against girls is strongest, which would result in improved sex ratios. This is in contrast to a negative “intensification” effect, whereby parity-specific discrimination against girls becomes more pronounced at lower levels of fertility (52). In India, at least during the recent past, the intensification effect has dominated the parity effect, with the sex ratio among children worsening as fertility has declined.

Thus overall, it can be concluded that education, while empowering mothers, can also be detrimental to the health of girl children or a foetus due to persistence of strong boy preference attitudes.

**Income/Economic status**

Previous studies have shown that material factors can fully explain the association between education and child mortality (53). Some previous studies have shown that the degree of gender bias is not correlated with economic conditions, such as poverty and income level, but is determined by social norms and customs (50,54). On the contrary, using a panel data set of DHS surveys across Asian and African countries, Ueyama showed that income growth is positively associated with a reduction in anti-female bias in child mortality in most developing countries. Therefore, he postulated that we can expect anti-girl bias in South Asia to decline at a rate similar to those in other regions as income rises (55).

In India, given the strong male preference in the community, parents are not ready to commit resources to girl children. Traditionally this has been seen in terms of denial of curative health care (35,56-57). The higher the “cost of treatment” (distance to health facility, treatment in private sector), the more likely the denial will occur. In prenatal sex determination, it is the cost of sex determination by ultrasound followed by an induced abortion which is likely to be much
higher than cost of treatment of most childhood illnesses like diarrhoea or pneumonia. There have been documented examples of parents taking loans for getting sex determination followed by abortion, as this saves them taking a much higher loan later for marriage expenses. The awareness, accessibility (transport) and affordability of sex determination and abortion services is likely to better among more educated and wealthy. In an interesting study from Brazil, authors analysed poor municipalities that either did not have ultrasound equipment or had recently introduced it. After adjustment for confounding, they did not find any statistically significant difference in sex ratio at birth between the two populations with different access to ultrasound technology. Thus, they showed that just the availability of an ultrasound facility to poor people, by itself, did not result in higher rates of sex-selective abortions as it was not accompanied by cultural son preference (58). In other words, this is not merely an economic issue but also a social one.

Caste
At village level, Deolalikar reported that villages with higher scheduled caste population had higher child sex ratios (47). Echavarri et al. in their analysis alluded above, did not find caste as a significant determinant of sex ratio at birth (48). The benefits of adult education for child mortality have been previously found to be similar across caste groups (46). In NFHS 3, wanting to have at least one male child (an indicator of son preference) was more uniform across caste groups as compared to across education or wealth index groups (59). The use of ultrasound during pregnancy (a proxy for foetal sex determination) has been shown to be strongly related to parental education and wealth index and less so for caste (11,60). Also, it has been shown that Haryana state, despite having a high per capita income, has the poorest record among the states for bridging the caste and sex disparities (41,54).

Technological determinants of gender inequality
Sex determination technology
Sex-selective abortion occurs in two steps. The first step is to assess the sex of the foetus which is followed by seeking an abortion, if the foetus is not of the desired sex. Three methods are commonly used for determining the sex of the foetus. They are amniocentesis (normally performed after 15-17 weeks of pregnancy) chorionic villus sampling (expensive and normally performed around 10th week of pregnancy) and ultrasound. The first two are invasive techniques and are done only if a defect in the foetus is suspected. However, many new non-invasive technologies using mothers’ blood are now available (61,62) These raise many ethical questions on the use and misuse of technology for prenatal sex
determination (63). Unlike these technologies, ultrasound is routinely advised for all pregnancies for assessing foetal and maternal health and to detect congenital abnormalities. The first ultrasound is usually recommended in the first trimester to detect serious congenital abnormalities in the foetus (so that the foetus can be aborted within the legally permissible term). Unfortunately, through the availability of high-resolution equipment, it is possible to identify its sex as well. This makes it difficult to differentiate between the legitimate and illegal use of ultrasound. An ultrasound scan typically costs between US$ 7-10 in most Indian cities.

Arnold et al. analysed the NFHS 3 data and reported that overall 24% of pregnancies had an ultrasound done during their antenatal period. It was much higher in urban areas (45%) as compared to rural areas (17%). The ultrasound use was heavily influenced by mother’s education and economic status, which are also related to each other. While only 9% of the mothers with no education had got an ultrasound done, 66% of mothers with more than 12 years of education had got it done. Similarly, only 5% of mother in the lowest wealth quintile had an ultrasound done as compared to 63% in the highest wealth quintile. Within each parity level, ultrasound was done most for woman with no sons and decreased steadily with an increasing number of sons. The sex ratio at birth was 117.7 boys for 100 girls for the pregnancies where ultrasound was done as compared to 106.1 when no ultrasound was performed – a clear indicator of the role of ultrasound in determining the sex ratio at birth. Based on this data, they estimated that about 10% of all ultrasound tests in India are used for sex-selection purposes, even during the period when the use of ultrasound for sex determination had been banned by the Government of India (64).

Unisa et al. reported the total use of ultrasound in the sample population as one out of eight women in Jind district of Haryana, India, out of which one-third had undergone this to know the sex of foetus. Similarly, around one-fifth of women had abortions, of which more than one-third were sex-selective abortions. Maximum pregnancy wastage was noticed for no son or one son category, which was probably due to sex selective abortions. Overall, it was estimated that 2.7% sex selective abortions had occurred per 100 live births (65). In Vietnam, ultrasound is easily affordable (US$ 2.5 – 3.5 per scan) and accessible, with women on an average reporting 6.6 scans per pregnancy. Most (86%) of the urban mothers and 63% of the rural mothers reported knowing the sex of the child (24).

**Role of vaccines**

Traditionally sex differentials in vaccine effects were largely explained by lower vaccine coverage among girls, which has been well documented in different NFHS surveys in India. Chaudhri et al. estimated that 25% of excess female deaths in Bihar
were caused by gender gaps in childhood vaccination (15). However, studies suggest that vaccines included in current global vaccination schedules may influence child mortality in ways that cannot be ascribed to their impact on the target diseases. For example, measles and BCG vaccines may reduce mortality to a larger degree than expected due to prevention of measles and tuberculosis deaths respectively, and DTP vaccines might be associated with increased mortality (66-68). These observations have attracted attention to the possibility of important vaccine effects beyond those on the target diseases (called ‘non-specific effects’, NSEs). It has also been reported in several studies that NSEs differ according to sex. This is especially true for DTP vaccination, which results in higher mortality for girl children (69,70) An HDSS site in rural Western India has reported higher female mortality and linked it to DTP vaccination (71).

However studies that have reported NSEs of vaccines as well as associated gender differentials have attracted lot of controversy and criticism. (66) Studies assessing NSE have been criticized for having multiple biases, especially as most of the data are based on observational studies. Two biases have been particularly commented upon. A selection (frailty) bias (children at higher risk of mortality being not vaccinated) or as a form of confounding by factors associated with both receipt of vaccination and mortality and a survival bias which arises if ‘missingness’ of the vaccination records is associated with the outcome (namely, death). This can arise, for example, if dead children’s cards are destroyed soon after death, as is the case in some of the studies undertaken in West African countries (72-73). This would occur if the data on vaccination is collected retrospectively.

A biological basis for higher mortality after DTP vaccination and for differences in response to DTP vaccination by sex has been postulated. The pertussis component of the vaccine and aluminium-based adjuvant has been identified as the possible culprits (74). DTP vaccination has been shown to result in increased incidence of colonization and infections with endemically occurring rotavirus and Cryptosporidium parvum in girls, organisms that cause extensive diarrhoea, dehydration, and death (75-76). Increased risks of growth retardation, Chlamydia pneumoniae infections, and morbidity (diarrhoea) in girls who had received a DTP booster vaccine were recently reported from a trial (77). Intramuscular DTP injection, which leads to a Th2-dominated protective antibody response, and a macrophage reprogramming toward a type 2 macrophage profile which in concert with the Th2-polarizing effect of aluminium phosphate might be the root of the problem (78-80). Females have been shown to mount higher innate and adaptive immune responses to pathogen challenge than do males (81-82). In addition to having higher immune responses, females also experience more adverse events following vaccination. These could be due to both different threshold of pain/discomfort among the sexes as well as differences in their build and fat distribution where these injections are given. The extent to which NSE of vaccines might contribute to higher mortality among
girls and boys depends upon the sequence of vaccination, age or schedule of vaccination and vaccine coverage. In real life, it is often seen that the sequence of vaccination as envisaged in a national immunization schedule is not followed. This is due to operational reasons of the timing of contact, child’s health, availability of vaccines etc. Thus, a child may end up receiving BCG and DTP at the same visit or BCG might even be given after DTP. This would modulate the NSE of DTP. Receiving DTP and measles together has been shown to accentuate the adverse impact of DTP (70, 83, 84) Similarly, it has been shown that administration of early measles vaccine (at 4 months) resulted in much higher rates of mortality among girls (85).

The current national immunization schedule for children in India is as below in Table 3. Hepatitis B and *Haemophilus influenza* b (Hib) vaccines have been recently added in many states including Haryana and in some states these have been given together with DTP as a pentavalent vaccine since last year. However, the implication for NSE of these vaccines being given together has not been studied.

<table>
<thead>
<tr>
<th>Age at vaccination</th>
<th>Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td>At birth</td>
<td>BCG/OPV0</td>
</tr>
<tr>
<td>6 weeks</td>
<td>OPV1/DTP1</td>
</tr>
<tr>
<td>10 weeks</td>
<td>OPV2/DTP2</td>
</tr>
<tr>
<td>14 weeks</td>
<td>OPV3/BCG3</td>
</tr>
<tr>
<td>9-12 months</td>
<td>Measles</td>
</tr>
<tr>
<td>16 to 24 months</td>
<td>OPVb/DTPb</td>
</tr>
</tbody>
</table>

Thus, the higher girl child mortality in Asia is driven by a cultural son-preference. With the advent of technology for prenatal sex determination, this situation has worsened. This adverse child sex ratio comprising of both prenatal and after-birth girl child losses is a complex phenomenon that is driven by biological differences overlaid by social and economic considerations as well access to different technologies, including vaccines, which have the ability to potentiate these differences. Promotion of equity in the society is one of the mandates of government. The Government of India is also cognizant of the matter and has acted in recent years to promote girl child survival. These policies are described in the next section.
GOVERNMENT POLICIES ON GIRL CHILDREN IN INDIA

Government policies to promote the survival of girl children span on two major domains – demand side (increased status of girl children which will lead to more balanced demand for services) and supply side (regulate the availability of technology and improve access to health services). Currently, the Government of India’s efforts to address the issue of sex-linked abortion have focused more on controlling access to sex-determination technology or abortion services. There are, however, examples of conditional cash transfer schemes to girl children on attaining different milestones (complete immunization, enrolment in school, education) as well as media campaigns that address the demand side of the problem.

Supply side interventions
Several countries in Asia including India, Nepal, China have banned prenatal sex detection (40,86). In addition, approaches include limiting ultrasound use to authorized clinics, reporting requirements on procedures being made tighter and mandatory, and making it illegal to reveal foetal sex. In India, all diagnostic clinics need to have visible signage stating that sex detection tests are not performed (see Figure 1 below). Sale of ultrasound machines is allowed only to registered health facilities. Despite these measures to limit ultrasound use, the availability of ultrasound has increased in all of these countries. The low cost of the technology, and growing commercialization of services in the unregulated private sector, have fuelled an already high demand for prenatal sex detection.

Figure 1. A signboard in an Indian hospital on prenatal sex determination
The Pre-Natal Diagnostic Techniques (PNDT) Act, 1994 and its more recently amended version, the Pre-Conception and Pre-Natal Diagnostic techniques Act, 2003 are federal legislations enacted by the Parliament of India to stop female foeticides and arrest the declining sex ratio in India. The main purpose of the act is to ban the use of sex selection techniques before or after conception and prevent the misuse of prenatal diagnostic technique for sex selective abortion. Offences under this act include conducting or helping in the conduct of prenatal diagnostic technique in the unregistered units, sex selection, conducting PNDT for any purpose other than the one mentioned in the act, sale, distribution, supply, renting etc. of any ultrasound machine or any other equipment capable of detecting sex of the foetus. It regulates the use of pre-natal diagnostic techniques, like ultrasound and amniocentesis by allowing their use only to detect genetic abnormalities, metabolic disorders, chromosomal abnormalities, certain congenital malformations, haemoglobinopathies, and sex linked disorders. No laboratory or centre or clinic can conduct any test including ultrasonography for the purpose of determining the sex of the foetus. No person, including the one who is conducting the procedure as per the law, can communicate the sex of the foetus to the pregnant woman or her relatives by words, signs or any other method. Any person who puts an advertisement for pre-natal and pre-conception sex determination facilities in the form of a notice, circular, label, wrapper or any document, or advertises through interior or other media in electronic or print form or engages in any visible representation made by means of hoarding, wall painting, signal, light, sound, smoke or gas, can be imprisoned for up to three years and fined US$ 200. The Act mandates compulsory registration of all diagnostic laboratories, all genetic counselling centres, genetic laboratories, genetic clinics and ultrasound clinics. The punishments under the act include imprisonment for up to 3 years and a fine up to Rs.10,000 (approx. US$ 200); cancellation of licence of clinic and suspension or even cancellation (if repeated offence) of Registration of Medical Practitioner (http://www.pndt.gov.in/).

Although official accurate figures are hard to come by, recently the health minister of India said that 436 cases have been registered against violation of the PC & PNDT Act in last two years as against 789 cases between 1996 and 2010. Out of 288 cases filed last year, 116 convictions have been secured under PC&PNDT Act and licenses of 53 doctors have been suspended by State Medical Councils. (http://m.risingkashmir.in/news/ministry-addressing-hurdles-in-implementation-of-pc-pndt-act-azad-51931.aspx accessed 13th August 2013) This indicates a more rigorous implementation in more recent times. While the law has been generally welcomed by the medical professionals, the law has created genuine problems for many health care practitioners due to its wide ranging provisions (87).
An evaluation of this act identified weak implementation structures and systems, conflicting priorities for implementers, irregular meetings and monitoring of the implementation, inadequate and slack paper work resulting in poor conviction rates. The penalties imposed under the act are not sufficient deterrent to the wrongdoers as these are small as compared to profits and demands and low conviction rates further compound the matter (88). Subramanian et al. performed time series analysis from a nationally representative sample of households with infants and found that the odds of having a male infant were similar in the pre- and post-PNDT periods. In the post-PNDT period, the income gradient in the odds of having a male infant was substantially weakened. They concluded that neither improvements in socioeconomic circumstances nor introducing policies that are not aligned with societal norms and preferences are likely to normalize the sex imbalance in India (89).

Recognizing the potential adverse consequences for China’s sex ratio at birth, the Chinese government has also outlawed prenatal sex selection. In May 1989, the Ministry of Health issued an emergency notice to all health administrative organization and institutions that no health institution including private practitioners be allowed to perform prenatal sex determination by medical technology for any reason other than diagnosing hereditary diseases (79). However, as evidenced by the widespread practice of prenatal sex determination using ultrasound scans and sex-selective abortions, governmental interventions on this issue have not yet succeeded (25).

While measures for controlling access to sex determination technology have been tried with little success, one could also question the need for such measures. The increased access to ultrasound technology is essential for improving maternal care and only a small proportion of ultrasound use is linked to sex determination. As already reported above, ultrasound availability and use is higher in south India than in the north which is reverse of the situation related to sex ratio at birth. Routine overuse of ultrasound in pregnancy is also becoming increasingly common. Overall, an analysis of the NFHS data showed that in India, the majority of women who have an ultrasound in pregnancy do not appear to be using it for sex selection (64).

The other approach is to regulate the availability of abortion services. India has very liberal abortion laws, an outcome of a strong feminism and activist movement. Attempt to tighten it have been not successful. China has imposed restrictions on abortions after 14 weeks. Strict monitoring of pregnancies in their early stages to detect any sex-linked abortions has been tried out in a severely affected district in Punjab, India, but was not sustained despite an initial success. About
10% of all abortions are sex-linked. Ganatra et al. therefore, caution against restricting the availability of abortion services in India to address this problem. While access to safe abortion is widely available in East Asia, the situation is different in India. Despite a policy that allows for abortion on a broad range of medical and social grounds, access to safe services is limited, there are vast rural–urban and geographic discrepancies, and morbidity from unsafe abortion is still a serious problem. Access to safe second trimester abortion remains problematic. She says that while those keen on sex-selection will manage to access sex selection technologies clandestinely despite legal restrictions, other more vulnerable groups might not get access to address their legitimate needs (90).

Demand side interventions

The interventions on the demand side are equally complex. While policies restricting family size increase a demand for sex determination, schemes that incentivize on birth of girl children try to limit the demand.

One of the ways that sex-selection is worsened is when there is a pressure to limit the number of children that a couple has. While in most countries this is affected by general socio-economic development, some countries have national policies that restrict the number of children a couple can have, of which China is a leading example. The skewed sex ratio at birth in China is because some urban Chinese make the choice to perform sex selection with the first pregnancy, since they are allowed only one child. In rural areas, most couples are permitted to have a second child, especially if the first is female. So if the second (or subsequent) child is female, the pregnancy often “disappears,” allowing the couple to have another child in an attempt to have a son. In India, till about a decade back, there was some government pressure to push contraception and limit children and health workers had targets to achieve for “family planning”. However, a coercive family planning programme in late seventies had resulted in a severe backlash and most politicians now are not interested in coercive methods. Currently, there has been an easing of pressure on the workers and removal of top-driven targets to health workers (91). Thus, in India, the current movement of family size restriction is driven by aspirations to have a better life as well as the fact that child survival is much higher.

Conditional cash transfers (CCT) as a tool to promote equity by governments have received sufficient attention among academics and policy makers in the recent past (92-94). There has been a growing interest in CCTs as a result of their well-documented impact on poverty and inequality as well as on education and health indicators of beneficiaries in line with its human capital accumulation objectives. Most CCT schemes use a well-defined and short-term condition (im-
munization, schooling) for receiving benefits. A conditional cash transfer programme between 2003-05 targeting girls beyond class five in Bangladesh was successful in increasing girl child enrolment and in fact reversed the gender balance with girls exceeding boys in the middle schools (95).

Table 4. Summary of Conditional Cash Transfer schemes for girl children in Haryana State

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Apni Beti Apna Dhan (Our daughter, our wealth)</th>
<th>Laadli (Favourite girl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneficiary/felony listed</td>
<td>Disadvantaged groups (Scheduled and backward castes and Below Poverty line)</td>
<td>Resident of Haryana on the birth of a second girl child conditional to completion of immunization and schooling.</td>
</tr>
<tr>
<td>Benefits/penalties</td>
<td>Rs. 500/- (US $ 10) to the mother within 15 days of birth. Bonds of Rs. 2,500/- (US $ 50) in the name of Child within 3 months to mature to Rs 25000 (US$ 500) by year 18. In 1995, scheme expanded to offer a higher maturity amount for girls willing to defer redeeming their securities: Rs. 30,000 (US$ 600) for 2 yrs, or Rs. 35,000 (US$ 700) for 4 yrs.</td>
<td>US$ 100 per family per year up to 5 years invested in Government Bonds. Given at the age of the second girl attaining the age of 18 (matures to around US$ 2000).</td>
</tr>
<tr>
<td>Actual beneficiaries/achievements</td>
<td>2003-04 – 52501 mothers enrolled in the state</td>
<td>2007-08 : 49558 enrolled in Haryana (US$ 5 million) and 2239 in Faridabad District Cumulatively up to March 2010-1,03,613 families have benefited and US$ 24 million spent</td>
</tr>
</tbody>
</table>

Haryana state in India was the first state to launch a CCT programme for girl children in 1994. This scheme has been subsequently replicated with some modifications by most states in India. There were two main schemes launched in Haryana as described in Table 4. The first one started in 1994, and was appropriately labelled as “Apni Beti Apna Dhan” (“our daughter, our wealth”) to address girls being treated as “paraya dhan” (“Someone else’s wealth”). It was aimed at socially disadvantaged populations and government bonds (Indira
Vikas Patra) worth US$ 50 (INR 2500) were purchased at the time of birth and subsequent every five years so that beneficiaries would get about US$ 500 (INR 25,000) when the girl became 18 years old. A bonus of US$ 100 was awarded if the girl received at least a Standard 5 education, and a further US$ 20 was awarded if she studied up to Standard 8. In 1995 the Haryana government expanded the scheme by offering a higher maturity amount for girls willing to defer redeeming their securities: Rs. 30,000 (US$ 600) for two years, or Rs. 35,000 (US$ 700) for 4 years. In addition, they would also receive a credit subsidy for entrepreneurship loans.

This scheme was replaced by “Laadli” scheme in 2005 by a new state government, which restricted the benefit to the second girl child, removed restrictions to disadvantaged and increased the incentive at maturity to about US$ 2000 (INR 100,000). Applicants now needed to submit four documents (domicile certificate, caste certificate (even though it is not a criterion), birth certificate of both girl children and ration card). Also, to be eligible to claim, beneficiaries have to fulfill conditionalities like completing immunization and schooling (with documentation) and remain unmarried at 18 years. Both the schemes were implemented through Integrated Child Development Services (ICDS) Scheme, whose anganwadi workers were entrusted with the responsibility of identifying the beneficiaries and facilitating paper work.

The Apni Beti Apna Dhan (ABAD) programme is different from most well-known CCT programmes in both the type of conditionality (daughter’s birth and marriage delay) and the long 18-year period over which transfers are made. In its first avatar as ABAD scheme focused on disadvantaged families and included all girls. This contrasts with the evidence that the practice of sex determination was more among educated and wealthy people. When the scheme was revised, it did away with targeting the disadvantaged but made it applicable only for second girl child. While this is supported by data, the fact that the focus is only on the second child means that the scheme is not looking at changing the community’s mind set (which needs a broader and universal approach). The general perception of the community is that these schemes are for child’s marriage in poor families. A study reported that only some believed that this was aimed at correcting the sex ratio at birth and very few believed that this was for better education and employability of the girl so as to improve her social status (96).

The main problems in implementation have been identified by different evaluations (97-99). These are ambiguous and complicated application processes and delays in receipt of certificates. A common complaint from the beneficiaries across the states is the difficulty of obtaining various documents required to apply and receive benefits under the scheme such as birth certificates, income certificates,
immunization certificate, school attendance certificates and sterilization certificates. Likewise, domicile certificates are mandatory for many schemes and poor migrant families are likely to be excluded from the schemes. Poor involvement of the health department, local governments (Panchayats), NGOs, and women’s groups has also been reported by others.

The overall impact of supply and demand side interventions depends upon how they support each other. The Government of India is addressing both sides simultaneously so as to quickly and effectively address this issue. The experience of South Korea presents an interesting contrast, where public policies sought to uphold the patriarchal family system but the cultural underpinnings of son preference decreased due to industrialization and urbanization. For years, sex ratios at birth kept rising in South Korea despite rapid development indicating a lag period between development and change in community attitudes. The underlying son preference fell with development, but the effect of son preference on sex ratios at birth rose until the mid-1990s as a result of improved sex-selection technology. Decomposition analysis indicates that development reduced son preference primarily through triggering normative changes across society—rather than just in individuals whose socioeconomic circumstances had changed (100).

Thus, it can be said based on the South Korean experience that even without any governmental intervention targeting the demand side, development itself could gradually bring better gender equity. It is difficult to predict how long would it take in India in the current interplay between rapid developmental changes, introduction of government initiatives to promote girl child survival, availability of newer technologies for sex determination and persistence of cultural son preference.
DATA SOURCES FOR MEASURING INEQUITIES IN CHILD MORTALITY IN DEVELOPING COUNTRIES

Generating accurate estimates of child mortality poses considerable challenges because of the limited availability of valid data in many developing countries. Vital registration systems are the preferred source of data on child mortality because they collect information as events occur and they cover the entire population. However, many developing countries lack fully functioning vital registration systems that accurately record all births and deaths. In low resource settings, however, these systems are notoriously inadequate: almost no country with an under-five mortality rate over 25 per 1000 population has a virtually complete vital registration system (101).

Measuring inequalities in childhood mortality require one more layer of information – and therefore requires more detailed information not only on births and deaths or survival time but also on other determinants such as socio-economic position, usually of the parents or household, immunization history etc. In the vital registration systems, it is usually the births in poorer households and by less educated mothers that are least likely to get registered. Therefore, household surveys, surveillance sites and population censuses are the three main data sources for health inequalities research in these countries. The additional advantage of these data sources could be the availability of information at the individual level. The main differences between them relates to the frequency with which the outcomes are measured, their geographical spread and sample size.

In India, while the census has an obvious advantage of covering everybody and a large sample size, it is done once every ten years and is not suitable for a timely review of policies. Vital registration of births and deaths is still incomplete. Currently the two best sources of demographic data in India are Sample Registration System (SRS) and Demographic Health Surveys (DHS). This thesis will frequently use data or quote from studies which used these two sources as these two sources are the best nationwide sources for demographic and health data. That is why these have been described in some detail here.

The Sample Registration System (SRS) has been set up to provide reliable estimates of birth and death rates at the national and sub-national levels in the absence of a fully functional vital registration system. The SRS is one of the largest continuous demographic household sample survey system in the world covering 1.2 million households and 6.3 million people. SRS is a dual reporting system
of continuous and retrospective recording of the events by two independent functionaries. The annual estimates of births, deaths and infant deaths are based on a sample of about 150,000 births, 50,000 deaths including 10,000 infant deaths at national level (102).

The **Demographic and Health Surveys (DHS)** programme has collected, analysed, and disseminated accurate and representative data on population, health, HIV, and nutrition through more than 300 surveys in over 90 countries. (www.measuredhs.com). DHS contains full birth histories, i.e. birth and death information for all children ever born to the respondent, as well as information on socio-economic and geographic stratifiers including household ownership of assets, maternal education and rural/urban residence. It also includes direct mortality determinants, mother’s fertility history, water and sanitation facilities, housing characteristics, health care use and childhood malnutrition. Information on births and deaths is reported retrospectively by the mother. The Indian DHS, known as National Family Health Surveys (NFHS), were held in 1992-93 (round I), 1998-99 (round II) and 2005-06 (round III). Data on several aspects had been collected. A uniform sample design adopted in each state is a systematic, stratified sample of households, with two stages in rural areas and three stages in urban areas. The rural and urban samples within states were drawn separately and, to the extent possible, sample allocation was proportional to the size of the rural and urban populations (103). Some common problems identified with the NFHS are that it only includes women who were present at the time of survey and misses women who go to their maternal home for delivery, a common occurrence in India especially for the first delivery. Also, children who were born and died are likely to be not reported by their mothers as well as children of mothers who have died would also be missed (102). Patra et al. compared data on IMR from NFHS and SRS for the same period and concluded that NFHS in general gives a lower estimate of IMR and the difference was more marked for girl deaths. The probable reasons given by him were due to sampling variations of the two surveys or due to the longer recall period in NFHS (up to five years) resulting in underreporting of all deaths, especially of girls by mothers (104). Narsimhan et al. compared fertility data from the NFHS 1 with SRS and found discrepancies between the two. While for the most recent five-year period, 1988–92, estimates of the general fertility rate derived from the two sources coincided, for earlier years the rate estimated from the NFHS was progressively higher than the rate estimated from the SRS (105).

Another source of population health data is provided by localised Health and Demographic Surveillance Systems (HDSSs) in Africa and Asia, such as those affiliated to the INDEPTH Network (http://www.indepth-network.org). The International Network for the Demographic Evaluation of Populations and their
Health (INDEPTH) Network, founded in 1998, is an umbrella organization for a group of independent health research centres operating HDSS sites in low- and middle-income countries (LMICs) (106). HDSS sites are those in which geographically defined populations in particular localities are followed in detail on a longitudinal basis. This approach yields rich and detailed data, which are otherwise unavailable on a national scale in these countries. While these data, at the individual level, are comparable in quality to corresponding national data in well-established settings, they only relate to discrete populations in relatively small areas, especially in large countries like India. Consequently, the criticism is repeatedly raised that such data are “only local” or “unrepresentative”, a viewpoint that is hard to refute in absolute terms in low-resource countries because of the a priori lack of reliable data on a wider scale for comparison. However, Byass et al. recently used data from national and county level in Sweden in early twentieth century to show that the criticism of unrepresentativeness of local area estimates is overdone (107).

A comparison of HDSS data on childhood mortality from Butajira in Ethiopia with two rounds of DHS birth history data showed broadly comparable mortality rates over time. The DSS data were more susceptible to local temporal variations, while DHS data tended to smooth out local variation, but were more subject to recall bias (108). In Mozambique a three-way comparison between HDSS, DHS and national census data on mortality were used to estimate the levels and trends of fertility, mortality and migration in Manhiça, between 1998 and 2005. The estimates from Manhiça were compared with estimates from Maputo province using the 1997 National census and 1997 DHS. The authors concluded that the Manhiça DSS provided estimates which were applicable to southern rural Mozambique (109). At Matlab in Bangladesh, a comparison was made between HDSS and DHS data on reproductive health. It suggested that the DHS accurately estimated fertility for the Matlab area, lending confidence to the fertility estimates obtained from the national DHS. The study also suggested that the DHS may have underestimated contraceptive prevalence, particularly for modern temporary methods (110). Fottrell et al have also shown that minor errors in demographic surveillance do not affect the population estimates or their determinants in a major way (111).

However, all of these comparisons are less than definitive, because at best they make comparisons with sampled national data that are not demonstrably more reliable than the HDSS data themselves, and usually less detailed. In many settings, this kind of joint-source data analysis could offer significant added value to results. Data triangulation of the HDSS and other available data could assist in monitoring progress towards achieving MDGs since HDSS as well as census or survey data would provide an opportunity to measure
and evaluate interventions through longitudinal follow-up of populations. Ballabgarh HDSS is one of the two HDSS located in India and provides detailed demographic data and is the setting for this thesis. The site is described in detail later in the next section.
STUDY OBJECTIVES AND FRAMEWORK

Objectives

Overall Objective: To document the gender differentials in child survival in the study area and to study the role of different factors responsible for these differentials.

Specific Objectives: The thesis is in the form of four papers that address the issues identified in the framework shown in Figure 2. The first paper documents the extent of the gender inequality in child mortality and the differences in causes of death among girls and boys. The subsequent two papers address socio-economic factors, role of vaccines in child survival and the final paper is the evaluation of governmental schemes for promotion of girl children. The specific objectives are:

1. Describe the decadal trends of level and causes of death among under-five children of the study population by sex for the period 1972-74 to 2002-04.
2. Compare gender differentials in childhood mortality by socio-economic status of the family.
3. Determine whether the non-specific effects of DTP vaccination is contributing to the excess mortality among girls in the study population.
4. Explore community attitudes and practices related to discrimination of girls and evaluate the impact of government policies and programmes addressing this issue.

Framework

The study has used both prenatal and postnatal mortality as components of child survival. The gender differentials in child survival are measured by sex ratio at birth (prenatal sex discrimination) and by different mortality rates after birth until five years of age (neonatal, post-neonatal and 1-5 year mortality). As described in the previous section, the gender differentials in child survival are mediated either by biological (innate) or by non-biological (induced) factors.

Biological factors:

- The biological advantage of females at birth is best illustrated by higher life expectancies for females in the whole of the developed world as well as lower neonatal mortality rates among girls even in developing countries.
- Differences in the immune response of girls as compared to boys have been demonstrated.
Non-biological factors: These form the main crux of this thesis and include many sub-components that have been alluded to in the preceding pages.

- There are many behaviours which govern the survival of a child into adulthood. The behaviours include those related to seeking sex determination of unborn foetus, child rearing practices related to nutrition and education and health care seeking in times of illnesses.
- The preference for sons underlies most of the social factors responsible for poor girl child status.
- Economic considerations include sons being seen assets and girls seen as liabilities, affordability of services be it technology of sex determination and abortion or for treatment of illnesses.
- Technological factors like easier availability of ultrasound machines have been implicated for the rise in sex-linked abortions. Vaccines have also been shown to have sex-differential effects, the extent to which this gets manifested depends on national immunization schedule and its coverage.
- The Government of India has introduced many legislations and series of measure for the protection and promotion of the girl child. It has also launched social mobilization efforts and a communication campaign to address this social evil. The reach, uptake and effect of these measures are not well evaluated.

The factors and the pathways through which these act are summarized in Figure 2. This conceptual framework provides the necessary basis for this research work.
### Conceptual Framework of the Thesis

**Figure 2.**

**Role of Government**
- Supply reduction – Technology regulation
- Demand reduction - Increase Awareness

**Social Factors**
- Income, education, caste

**Non-Biological Biological**
- Conception in Womb
- Prenatal sex determination
- Cultural son preference
- Abortion
- Preventive Care
- Child rearing/nutrition
- Occurrence of disease
- Health care seeking in illness
- Causes of Death
- Fatality rate

**Biological Biological**
- Girls stronger biologically
- Vaccination sequence and coverage
- Sex-differentials in Non-specific effect of vaccines on mortality

**Survival to 5 years**

---

Paper 1: Sex ratio At Birth

Paper 2: Preventive Care
Child rearing/nutrition

Paper 3: Survival to 5 years

Paper 4: Demand reduction - Increase Awareness
Cash transfer scheme for girls

Cultural son preference

Availability of technology

Preventive Care
Child rearing/nutrition

Health care seeking in illness

Causes of Death

Fatality rate
This study is set in Ballabgarh Block of Faridabad District of Haryana State in India. In 1961, with the help of the Rockefeller Foundation, the All India Institute of Medical Sciences (AIIMS), New Delhi in collaboration with the state government of Haryana, began the Comprehensive Rural Health Services Project (CRHSP) Ballabgarh. The objectives of this project were to demonstrate a model health-care delivery system for rural India, to orient and train medical students in primary health care and to identify and conduct priority operational research to help address the needs of all of India. The project is managed by the Centre for Community Medicine of AIIMS and includes a secondary level hospital at Ballabgarh town and two primary health centres at Chhainsa and Dayalpur which cover 28 villages. Ballabgarh is situated between 28°25′16″ north latitude and 77°18′28″ east longitude in the National Capital Region of India. It is bound by the state of Delhi to the north, Gurgaon district of Haryana state on the west, and the state of Uttar Pradesh on its eastern and southern sides. It is about 35 km from AIIMS and lies on the Delhi–Mathura National Highway-2, and is also well-connected through the rail network. This is shown in the Figure 3 below.
In addition to this, CRHSP provides the HDSS population and that of the surrounding areas with health services in the form of health education, preventive services such as immunization and disease screening, and curative services for most of the diseases. After joining INDEPTH in 2003, it is also known as the Ballabgarh Health and Demographic Surveillance System (HDSS). This demographic surveillance system has now been in operation for more than 45 years (112).

### Demographic surveillance activities

During monthly visits by multi-purpose field workers, relevant health information and vital statistics data are collected. These include demographic changes such as marriages, deaths, abortions, births etc. As these are the same workers who also provide health and preventive care like antenatal care and immunization, the workers keep track of pregnant women, usually from the first trimester. In addition, a full house to house census is carried out in December every year to supplement the demographic data. For the last five years, the Primary Health Centres (PHCs) also serve as the place for birth and death registration. Full details of this HDSS can be accessed in a previous publication (113).

### Computerized Health Management Information System

The process of computerizing the population database into a Health Management Information System (HMIS) began in 1988 (114). The primary purpose of the HMIS was to support health workers in delivering health-care services to the population served by the Ballabgarh HDSS. It also supports programme managers in monitoring and supervising the workers. The HMIS has undergone three generations of evolution over the years of its existence, reflecting the advances made in information technology during that time, as well as the changing needs of the users of the HMIS. Currently its database is in MySQL, and Java (J2SE) is the programming language.

The HMIS database has a relational design. The data is stored in 86 tables which can be broadly divided into the following types: (1) Data-entry tables, where data of different modules such as demographic, antenatal care (ANC) etc. are saved (2) System tables where the codes for village, education, caste and other variables used in the program are stored (3) Archive tables, where old data after events such as pregnancy termination, death (demographic data) are maintained (4) Report tables where reports are stored temporarily for printing. Every individual in the project area has been assigned an unique identification number which is also used as a primary key in the database. Fresh births and in-migrants are
automatically assigned new primary keys. Being a relational database, data entry through one module automatically updates the linked fields in other modules. The interface includes consistency checks for data quality, drop down menus for simplifying data updating and provision for addition of variables.

A data entry operator updates the data with the assistance of the health workers once a month. Each worker is assigned one day a month on which to enter the data collected during the previous months’ house visits. The HMIS is also updated after the annual census. Thus, the Ballabgarh HDSS database is updated 13 times in a year. In the earlier version of the HMIS, there was no provision for identifying a resident as a migrant or native. In order to correct this anomaly, in 2009, all houses were visited and data on their year of migration were collected and entered into the database. The main output of the HMIS is the work plan generated each month after the data has been updated. This lists activities to be carried out by workers in each house. Other HMIS outputs include monthly reports, lists for immunization and contraceptive services, and performance indicators of workers, subcentres and PHCs.

There are inbuilt systems to crosscheck the completeness and accuracy of data. The reliability and validity of data are regularly verified by external users. In an on-going project, research workers independently collected detailed demographic data in three villages and comparison with the database showed agreement in more than 95% of the fields. Also, in 2009, a sample of 100 infants was randomly selected and it was observed that except in one case where the gender of the child was not correct; there was no other discrepancy.

**Method of ascertainment of causes of death**

Until 1995, multi-purpose workers identified death and informed the health assistant who was trained to fill the death card with description of events at the time of death (narrative). Finally a physician assigned the cause of death. In 1995, a new verbal autopsy tool was introduced but the system of data collection and assignment of cause of death remained the same. The current verbal autopsy tool has retained the narrative component but added questions/checklist of symptoms for disease-specific modules and has been validated (115). The Medical Officer of the PHCs reviews both the narrative component and the data from the relevant modules to arrive at causes of death. These are sent to the project headquarter at Ballabgarh where a second physician reviews them. In case of differences, one of the faculty members is called in to provide a final cause of death. Results based on these verbal autopsy forms have been published earlier (116).
Key demographic and MCH statistics of Ballabgarh HDSS, India

The key demographic and MCH statistics of this population are shown below in Table 5. The study area has an IMR of 40 per 1000 live births (which is close to the MDG target for India) and almost 70% of its IMR is due to neonatal mortality. High vaccination coverage is present both for maternal tetanus immunization as well as childhood vaccines. Recently, Hepatitis B and Hib have been added to routine immunization, but the coverage rates are not yet available. Most of the deliveries are now occurring in institutions and about half of the eligible couples are using a contraceptive method.

Table 5. Key demographic and MCH Statistics for the period April 2011 – March 2012 of Ballabgarh HDSS

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population (provisional)</td>
<td>91,362</td>
</tr>
<tr>
<td>Birth rate per 1000</td>
<td>22.5</td>
</tr>
<tr>
<td>Death rate per 1000 population</td>
<td>6.2</td>
</tr>
<tr>
<td>Neonatal mortality rate per 1000 live births</td>
<td>28.7</td>
</tr>
<tr>
<td>Infant mortality rate per 1000 live births</td>
<td>40.4</td>
</tr>
<tr>
<td>Maternal mortality rate per 100,000 live births</td>
<td>146</td>
</tr>
<tr>
<td>Total antenatal cases (new registration)</td>
<td>2,259</td>
</tr>
<tr>
<td>Proportion of pregnant women receiving antenatal care</td>
<td>100%</td>
</tr>
<tr>
<td>Proportion of pregnant women receiving Tetanus Toxoid</td>
<td>100%</td>
</tr>
<tr>
<td>Proportion of all deliveries which are institutional</td>
<td>88.6%</td>
</tr>
<tr>
<td>Proportion of eligible couples using contraception</td>
<td>47.3%</td>
</tr>
<tr>
<td>Immunization coverage for 12 to 23 months of age:</td>
<td></td>
</tr>
<tr>
<td>BCG</td>
<td>97.2%</td>
</tr>
<tr>
<td>OPV (3 doses)</td>
<td>98.5%</td>
</tr>
<tr>
<td>DTP (3 doses)</td>
<td>98.0%</td>
</tr>
<tr>
<td>Measles</td>
<td>95.5%</td>
</tr>
</tbody>
</table>

Summary of studies on gender differential in child survival at Ballabgarh

In the 1960s, when this project had just started (and included some villages beyond those currently included), the neonatal mortality rate was around 41 per 1000 live births and infant mortality was 102 per 1000 live births. Neonatal mortality rates were slightly lower among girls (95% of boys) but infant mortality rates among girls were higher (135% of boys) (117). Neonatal mortality rates by sex have not been regularly reported since then and therefore, it is difficult to comment on the trend. In a subsequent paper, sex-specific IMR and child mortal-
ity rates for the periods 1972-74 and 1982-84 were reported (118). A higher infant mortality rate among females was reported (130% to 135%), as were higher child mortality rates (200-225%)

Ballabgarh HDSS in the late 1990s reported a decreasing trend in infant mortality from 1972 to 1997 and concluded that selective child survival interventions (immunisation, oral rehydration therapy) had brought down the IMR to around 40 per 1000 live births, a level similar to the present (119). However, this paper did not focus on sex differentials in mortality, since gender discrimination was not yet identified as a major determinant of mortality, even though a slight excess of female mortality during childhood was known. In 2004, the site published data on sex ratio at birth from 1991 to 2002, which showed a regular decline from an already low ratio of 884 girls per 1000 boys in 1991 to 832 in 2001 (120). These data, along with a stagnant childhood mortality rates, forced a relook at sex differentials in mortality at the site. This thesis marks the culmination of this effort

Some data on gender-specific health care seeking are also available from Ballabgarh. A community based study done in eighties in this study area, reported similar incidence rates for boys and girls for diarrhoea and pneumonia but a higher case fatality rate among girls (121,122) Data from emergency consultation for pneumonia and diarrhoea among under-five children as well as a review of all admissions due to pneumonia to the secondary level hospital at Ballabgarh showed a preponderance of boys (123-124) Gender difference in care seeking for neonatal illnesses was also reported in a recent study in Ballabgarh which showed that sick male neonates were more likely to be taken to a health facility especially to a private one, which is perceived by community to be better than public ones (125)

These studies establish that the study area has a history of girl child discrimination. However, no detailed study has been done in this area specifically focusing on this aspect. Review also showed that most studies have looked at only one aspect of girl child discrimination as in mortality, care seeking, sex ratio etc. Nobody has studied this phenomenon in a comprehensive manner as is proposed for this thesis. The fact that Haryana ranks high among states with low status of women in the country; was also the first state to introduce schemes for girl children and; the existence of a HDSS in Haryana provided a wonderful opportunity to go deeper into this issue. The use of good quality HDSS site data, mixed methods approach, a comprehensive framework including evaluation of existing government schemes makes this study unique.
**METHODS**

The overview of the methods used in the study is given in Table 6.

**Table 6.** Overview of the study aims, subjects and methods

<table>
<thead>
<tr>
<th>Aim</th>
<th>Study design</th>
<th>Study population</th>
<th>Source of data</th>
<th>Primary analysis mode</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe the decadal trends of causes of death among children of the study population by sex for the period 1972-74 to 2002-04.</td>
<td>Demographic surveillance</td>
<td>All deaths in the study period</td>
<td>Published literature for previous years. Electronic database for 2002-04.</td>
<td>Descriptive analysis and testing for significance of proportions</td>
<td>I</td>
</tr>
<tr>
<td>Determine whether the non-specific effect of DTP vaccination is contributing to the excess mortality among girls in the study population</td>
<td>Cohort study</td>
<td>Under-five children divided into immunized and unimmunized group</td>
<td>Electronic database 2006-2012</td>
<td>Survival analysis</td>
<td>III</td>
</tr>
<tr>
<td>Explore community attitudes and practices related to discrimination of girls and evaluate different government policies and programmes addressing this issue.</td>
<td>Mixed methods approach</td>
<td>Parents living in the community</td>
<td>Primary data collection</td>
<td>Descriptive quantitative analysis</td>
<td>IV</td>
</tr>
<tr>
<td></td>
<td>Programme implementers &amp; beneficiaries</td>
<td>In-depth interviews</td>
<td></td>
<td>Qualitative analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All population</td>
<td>Electronic database 1992-2010</td>
<td></td>
<td>Secondary data analysis for trend</td>
<td></td>
</tr>
</tbody>
</table>

**Ethical issues:** The use of secondary data for all papers and collection of primary data (for paper 4) was cleared by AIIMS ethics committee. Written consent was taken from people who were interviewed after assuring them of confidentiality. Secondary data were anonymized before sharing with people outside the HDSS system.
**Methods**

**Measuring trends in child mortality (I)**

**Data sources**

*Estimation of mortality rates*: This study uses secondary data from the Ballabgarh HDSS electronic database. All births which occurred in the study area of Ballabgarh block and which were entered into the database during the period 1st January 1992 to 31st December 2011 were included. This database was treated as a cohort as date of entry and exit for every individual was available. The data on causes of death for the year 2002-04 were extracted from HDSS database. For previous time periods, both the cause specific mortality rates were calculated from published literature (119,126). For the assessment of sex differentials in causes of death, the period was extended to include all deaths in 2002-07 to increase the sample size and improve its contemporariness.

**Methods of analysis**

Three-year moving averages were used and sixteen points of mortality were plotted on a scatter plot with year in x-axis (from 1992 to 2011). Linear regression was applied with each year as predictor variable and crude mortality rate as dependent variable to measure the slopes of trends in mortality rate and their significance. The significance of differences in mortality rates between boys and girls in each of the three-year periods was tested using chi-squared tests after Bonferroni correction for multiple comparisons. The time trend of CSMR was tested for significance using chi-square for trend. The gender differential in causes of death was assessed by calculating rate ratio (RR) with 95% Confidence Interval (CI) using Statcalc function of EpiInfo.

Excess female ante-partum mortality was estimated to assess the sex-specific rate of pregnancies not ending in live births. Making the assumption that the natural F:M birth ratio for this population would be 952 per 1000 equivalent to 105 boys per 100 girls (7, 127), the excess rate of female ante-partum deaths per 1000 live births was defined as :

\[
\frac{(0.952 \text{ – F:M birth ratio}) \times 1000}{(1 \text{ + F:M birth ratio})}
\]
Methods

Gender differential in child survival and socio-economic status (II)

Data sources
A cohort of all native-born children in the HDSS area between 1st Jan 2006 – 31st Dec 2011 (six years) was used. Children who immigrated in between were not included. Information on date of birth, date of death, date of emigration, caste, education of mother and father, birth order of child and wealth index were assembled. It was expected to have about 12,000 births (2000 per year). As all the three SES indicators were divided into three groups each group was expected to have about 4000. This was calculated to be sufficient to estimate a relative risk of 1.6 between high and low SES categories (as seen in NFHS data for states with higher development index as compared to lower) with an expected excess girl child mortality of 15 per 1000 live births in the high SES category as seen from our data before, with a power of 80% and an alpha error of 5%.

Measurement of socio-economic status
Three indicators were used to measure socio-economic status - caste, parental education and wealth index and each was divided into a three-tiered classification. For caste, it was scheduled, backward and forward castes as per Haryana Government’s notification on classification of caste. Parental education index was created by combining years of schooling of mother and father and divided into tertiles. Wealth index is a pure economic variable and measures relative economic standing and has been used in NFHS 3 (128). It uses information on household assets and utility services to construct a score with relative weights derived through Principal Component Analysis. This procedure first standardizes the indicator variables (calculating z-scores); then the factor coefficient scores (factor loadings) are calculated; and finally, for each household, the indicator values are multiplied by the loadings and summed to produce the household’s index value. The resulting sum is itself a standardized score with a mean of zero and a standard deviation of one. Based on the distribution of the population, the cohort was divided into tertiles. Data on wealth index were separately collected in 2009-10 and linked with the demographic database. Information on wealth index was available for 91.5% of the houses.

Measuring association between SES and child survival
The analysis compares sex ratio at birth, sex specific neonatal and 1-36 month mortality rate (per 1000 live births) for three strata by each of the three SES indicators. Right censoring was done at completion of age 3 or 31st December
2011 or death or date of emigration. Kaplan Meier survival curves were generated by sex for different strata of each SES indicator and log-rank test was applied for testing the significance of difference. Cox Proportional Hazard Ratios with 95% confidence interval of mortality for girls (boys as reference group) were calculated for children in stratum of each SES indicator after adjustment for birth order, distance to Ballabgarh, presence of health facility and other two SES indicators. The tests for collinearity and interaction between the three indicators of SES did not indicate any problems that need to be taken care of.

Role of non-specific effects of vaccines in gender difference in mortality (III)

Data sources
The same database of the cohort of all native-born children in the HDSS area between 1st Jan 2006 – 31st Dec 2011 with the list of confounders was the starting point. The children whose dates of immunization were not available were excluded. It was estimated that this would give us sufficient sample size with an alpha error of 5% and power of 80% using mortality rates in the study area (15-30 per 1000 child years for these vaccines and an estimated higher mortality among girls especially for DTP of 40% - 60% (hazard ratio of 1.4 – 1.6) as reported previously in a review article (129).

Measurement of gender differential in non-specific effects of vaccines
All live births in the study area from 2006 to 2011 were followed till 31st December 2011. The unexposed group was defined as children who had not received any vaccine. This number was very small in higher age groups due to high vaccination coverage in the study area. The exposed group was defined separately for each vaccine and corresponded to the period between the receipt of the said vaccine until another vaccine was received or any of the other exit criteria were satisfied – like achieving the age of three years, or 31st December 2011 or migration.

Mortality was taken as the outcome of interest (see Table 7). As mortality is age dependent and vaccine eligibility also varies with time, the time period of 0-36 months was divided into four periods – 0-6 weeks (corresponds to the period between BCG eligibility and DTPp eligibility), 6 weeks to 8 months (corresponds to period between DTPp eligibility and Measles eligibility), 9 months – 15 months (corresponds to Measles eligibility and DTPb eligibility) and finally 16 months to 36 months – corresponds to DTPb eligibility and end of the designated study period). As an example, for DTPp analysis, the children would become eligible
at 6 weeks of age (42 days) (they will be ineligible for the first time frame) and then will continue to contribute to different age groups depending upon when they receive the measles vaccine. If a child received two vaccines together (BCG and DTP or DTP and measles), then such children were excluded from either of the vaccine exposed group. If a child received vaccines in a different sequence than as per schedule, then the child was included and contributed time periods based on the vaccine last received. For example, if a child received BCG after DTP, then the child would contribute the intervening period of DTP exposed group and once immunized with BCG, the child will contribute to BCG exposed group. Thus the BCG exposed group includes those who have received only BCG and also those who received BCG after DTP. The impact of BCG alone can be assessed based on the first time frame when the children were ineligible for DTP.

Table 7. Plan of survival analysis of the cohort (birth until 36 months) for different vaccines at different time frames

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>No Vaccination received</th>
<th>Vaccine exposed group*</th>
<th>Eligible vaccines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Entry</td>
<td>Exit</td>
<td>Entry</td>
</tr>
<tr>
<td>0-5 weeks</td>
<td>Birth</td>
<td>Receipt of any other vaccines</td>
<td>Receipt of corresponding vaccine in this time frame</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Death</td>
<td>Emigration 5 weeks 31 December 2011</td>
</tr>
<tr>
<td>6 weeks - 8 months</td>
<td>Not vaccinated till 6 weeks</td>
<td>Receipt of any other vaccines</td>
<td>Receipt of corresponding vaccine in this time frame or received before and exited because of age limit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Death</td>
<td>Emigration 8 months 31 December 2011</td>
</tr>
<tr>
<td>9-15 months</td>
<td>Not vaccinated till 9 months</td>
<td>Receipt of any other vaccines</td>
<td>Receipt of corresponding vaccine in this time frame or received before and exited because of age limit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Death</td>
<td>Emigration 15 months 31 December 2011</td>
</tr>
<tr>
<td>16-36 months</td>
<td>Not vaccinated 16 months</td>
<td>Receipt of any other vaccines</td>
<td>Receipt of corresponding vaccine in this time frame or received before and exited because of age</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Death</td>
<td>Emigration 36 months 31 December 2011</td>
</tr>
<tr>
<td>0-36 months</td>
<td>At Birth</td>
<td>Receipt of any other vaccines</td>
<td>Receipt of corresponding vaccine in this time frame</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Death</td>
<td>Emigration 36 months 31 December 2011</td>
</tr>
</tbody>
</table>

*The exposure is defined by the last vaccine received by the child.
Combined analysis of all the periods (0-36 months) was also undertaken. Mortality rates (deaths per 1000 child months) for each vaccinated and unvaccinated group were calculated for each sex. Cox proportional hazards regression was used to assess the association between sex and risk of mortality by vaccination status (BCG, DTPp, Measles and DTPb). Wealth index, access to health care, presence of a health facility in the village, parental education, type of family, birth order of the child and year of birth were included as covariates for adjustment. As mortality is strongly related to age, age was taken as the time scale in survival analysis (130). Hazard ratios with 95% confidence intervals were calculated using the Cox proportional method for girls versus boys for vaccinated and non-vaccinated children, including an interaction term of sex and vaccination status to test whether sex was an effect modifier for the analysis between vaccine receipt and mortality. The Proportional Hazards assumption was evaluated by Schoenfeld residual plots. All statistical analyses were performed with Stata release 11.1 software (Stata Corp., College Station, TX, USA).

Sensitivity analysis was carried out to test the robustness of the results. First, as vaccines take some time to show both their specific and non-specific effects, a lag period of two weeks after vaccination was considered. In this staggered analysis, children moved into the exposed group two weeks after the vaccination date and the exit date was also postponed by two weeks (after the receipt of the next vaccine). In order to adjust for frailty bias, all children who died within 30 days (neonates excluded for this analysis) of being eligible for vaccination were not included in the analysis.

Evaluation of government policies/programmes – quantitative component (IV)

Data sources
This included collection of primary data through interviews and analysis of secondary dataset. Community perspective was assessed through a survey in eight randomly selected villages of Ballabgarh block. Assuming an awareness level of 50% (maximizes sample size) with an error of 10% and a design effect of 2 we arrived at a sample size of 200. Hundred males and 100 females were interviewed from among the houses that had children aged less than or equal to 18 years. In each village, the first respondent was selected randomly from the centre of the village and 25 consecutive houses were selected moving outwards with males and females being studied in alternative houses. The study tool included questions on the background characteristics of the interviewee, community perceptions on girl child discrimination, its reasons, awareness and utilization of government
schemes on girl children. It was pilot tested in non-study villages and then modified accordingly. Data collection was done during early 2012. For impact evaluation, the full HDSS database for the period 1992-2010 was used. The database did not have the information on the utilization of the government schemes. The dataset from 1992 to 2010 was divided into four time periods dependent upon the introduction of the schemes. 1992-1994 served as the baseline as no programmes had been yet introduced. 1994-2004 was the period when ABAD Scheme was launched (including its modification in 1999). 2005-2010 served as the period when Laadli scheme was launched.

**Method of analysis**

The outcome variables whose changes were to be measured were - sex ratio at birth, immunization coverage, mean age at marriage and education beyond 10\textsuperscript{th} class. These were based on the conditionalities imposed and expected impact of the programme. Sex ratio at birth is inherently a comparison and does not require a control group. Boys of the same cohort served as the controls for immunization coverage. The hypothesis was that the improvement in immunization coverage of girl children over time would be steeper as compared to boys. As there are large boy-girl differences in the age of marriage and education, boys would not serve as a good control. Instead, we used daughters-in-law who come from outside Haryana (where there are no such schemes) as controls and compared their age at marriage and education levels to the daughters of the house at the time of marriage. The significance of changes in mean ages observed during these time periods was tested using ANOVA and chi-squared for trend was used for all proportions.

**Exploring stakeholders perspective – qualitative component (IV)**

**Data sources**

In-depth interviews were conducted among two blocks and three village level implementers of the government schemes and two beneficiaries of ABAD and Laadli schemes. The interviews were conducted after taking consent from the officials and were audio taped. The interview guide had open-ended questions on presence of girl child discrimination in the community, effectiveness of the schemes, barriers for their implementation and suggestions for improvement. The interviews were conducted in Hindi, transcribed and translated into English
**Method of analysis**

Data from in-depth interviews were analysed using qualitative content analysis approach that allowed researchers to group codes and categories that are similar into themes that reflect specific patterns in the data. All transcripts were initially read repeatedly to get a sense of the whole and diverseness of the response. Subsequently the free text was coded into meaningful units grounded in the text. These were subsequently categorized manually through an interactive process between the researchers. The categories were then linked into themes and later corroborated by close scrutiny of the transcribed data (131,132).
The results are organized under four major sections each referring to one of the four objectives of the thesis.

**Temporal trends in sex specific child mortality in Ballabgarh (I)**

There was persistent adverse sex ratio at birth and higher childhood mortality rates throughout the period 1992-2011. The worst period of sex discrimination was in 2004-2006, after which there has been some improvement. Higher mortality among girls in neonatal period was also reported for the first time. Diarrhoea, malnutrition and low birth weight-related deaths were more frequent in girls, probably due to poor child-care and treatment seeking.

Table 8 and 9 below display the key demographic indicators for the entire time period. The same data is shown in the Figure 4 as three year moving averages for infant and under-five mortality rates. There was a major decline in fertility (crude birth rate) from 31.9 to 23.6 per 1000 population during this period. The sex ratio was adverse for girls throughout the period with the worst period being 2004-06. Using a global norm of 952 girls per 1000 boys (105 boys per 100 girls), it was estimated that during this period of two decades, on an average 58 girls were lost for every 1000 births.

**Table 8.** Number of births and sex ratio at birth in rural Ballabgarh from 1992 to 2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Mid-period population</th>
<th>Births</th>
<th>Annual Crude Birth Rate per 1000 population</th>
<th>Sex Ratio females per 1000 males</th>
<th>Excess female antepartum mortality per 1000 births</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992-94</td>
<td>68,260</td>
<td>3,500</td>
<td>3,032</td>
<td>6,532</td>
<td>31.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>866.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45.9</td>
</tr>
<tr>
<td>1995-97</td>
<td>72,995</td>
<td>3,464</td>
<td>2,948</td>
<td>6,412</td>
<td>29.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>851.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54.5</td>
</tr>
<tr>
<td>1998-00</td>
<td>76,138</td>
<td>3,428</td>
<td>2,875</td>
<td>6,303</td>
<td>27.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>838.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>61.6</td>
</tr>
<tr>
<td>2001-03</td>
<td>79,697</td>
<td>3,355</td>
<td>2,858</td>
<td>6,213</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>851.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>54.1</td>
</tr>
<tr>
<td>2004-06</td>
<td>82,612</td>
<td>3,314</td>
<td>2,720</td>
<td>6,034</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>820.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.1</td>
</tr>
<tr>
<td>2007-09</td>
<td>85,795</td>
<td>3,258</td>
<td>2,733</td>
<td>5,991</td>
<td>23.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>838.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>61.5</td>
</tr>
<tr>
<td>2010-11</td>
<td>89,996</td>
<td>2278</td>
<td>1915</td>
<td>4193</td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>840.6</td>
</tr>
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<td></td>
<td>60.5</td>
</tr>
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<td>844.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>58.3</td>
</tr>
</tbody>
</table>
MAIN FINDINGS

The girl child mortality was higher at all age groups throughout the study period. The gender differential in infant mortality was highest during 2001-2006 (Figure 4). Under-five mortality showed more or less similar differential during the entire period with a slight narrowing at the later period (Figure 4). Neonatal mortality showed a significant increasing trend, post-neonatal mortality showed a non-significant decrease, whereas 1-4 year mortality showed a significant declining trend. There was a sharper increase in neonatal mortality among girls but a steeper decline in the 1-4 year old girls as compared to boys of the same age group.

Neonatal period can be divided into two broad periods – early neonatal (1st week) and late neonatal (7-28 days). The deaths in the early period are largely due to causes emanating from before birth or during birth (asphyxia, severe congenital abnormalities and tetanus). The deaths in the later period are mainly due to infections/sepsis. Low birth weight related deaths could span both the periods, as they are also susceptible to infections. A look at these two rates in the Ballabgarh population shows a divergent pattern in the pre-2001 period and post-2001 (Figure 5). In the post neonatal period, until 2001 the rates for boys and girls were similar, only to increase for girls subsequently but they came down and equalled boys in 2008. In the early neonatal period, things are less clear. A higher mortality among males (the global norm) was reported in some years before 2001, only to move to higher rates among girls in the 2001-2006 period.
### Table 9. Sex-specific childhood mortality rates (95% C.I.) expressed as per 1000 live births in rural Ballabgarh from 1992 to 2011

<table>
<thead>
<tr>
<th>Time period (years)</th>
<th>Neonatal mortality rate (0-28 days)</th>
<th>Post neonatal mortality rate (29 days – 365 days)</th>
<th>Child mortality Rate (1-4 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
</tr>
<tr>
<td>1992-1994</td>
<td>9.4</td>
<td>8.9</td>
<td>9.2</td>
</tr>
<tr>
<td></td>
<td>(3.9-15.0)</td>
<td>(3.1-14.7)</td>
<td>(5.2-13.2)</td>
</tr>
<tr>
<td>1995-1997</td>
<td>8.1</td>
<td>9.2</td>
<td>8.6</td>
</tr>
<tr>
<td></td>
<td>(2.9-13.1)</td>
<td>(3.2-15.1)</td>
<td>(4.7-12.5)</td>
</tr>
<tr>
<td>1998-2000</td>
<td>19.5</td>
<td>12.2</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>(11.4-27.7)</td>
<td>(5.2-19.2)</td>
<td>(10.7-25.6)</td>
</tr>
<tr>
<td>2001-2003</td>
<td>17.9</td>
<td>22.7</td>
<td>20.1</td>
</tr>
<tr>
<td></td>
<td>(10.0-25.7)</td>
<td>(13.2-32.3)</td>
<td>(14.0-26.2)</td>
</tr>
<tr>
<td>2004-2006</td>
<td>16.3</td>
<td>29.0</td>
<td>22.0*</td>
</tr>
<tr>
<td></td>
<td>(8.7-23.8)</td>
<td>(18.0-40.1)</td>
<td>(15.6-28.5)</td>
</tr>
<tr>
<td>2007-2009</td>
<td>25.2</td>
<td>23.8</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>(13.5-31.2)</td>
<td>(13.8-33.8)</td>
<td>(17.7-31.4)</td>
</tr>
<tr>
<td>2010-2011</td>
<td>25.9</td>
<td>29.8</td>
<td>27.7</td>
</tr>
<tr>
<td></td>
<td>(16.5-35.2)</td>
<td>(18.8-40.6)</td>
<td>(20.5-34.8)</td>
</tr>
<tr>
<td>Linear Slope (p value for trend)</td>
<td>0.972</td>
<td>1.316</td>
<td>1.130</td>
</tr>
</tbody>
</table>

* Sex differences statistically significant at 0.003 level (0.05 for 18 comparisons using Bonferroni correction)
Figure 4. Child mortality rates per 1000 live births (three year moving averages) by sex in Ballabgarh HDSS (1992-2011)
Figure 5. Early and late neonatal mortality rates per 1000 live births (three year moving averages) by sex in Ballabgarh HDSS (1992-2011)
Due to a lack of data on causes of death by sex from the past periods, the trend in sex differential in causes of death could not be studied. However, the data for the most recent period was available and this aspect was explored for the period 2002-2007 (Figure 6). Overall, there was an excess of 67% (95% CI; 46% to 92%) deaths among girls as compared to boys. The specific diseases that caused significantly more deaths among girls were (in order of magnitude) malnutrition (3.37 times more), diarrhoea (2.29 times more), and preterm/low birth weight (1.52 times more). Unclassified deaths and deaths due to other causes were also more in girls. No disease had higher mortality among boys.

Figure 6. Mortality Rate Ratio (95% CI) by cause among under-five girls compared to boys at Ballabgarh HDSS (2002-07)

Role of socio-economic status in gender differentials in child mortality (II)

The main findings were that the sex ratio at birth was lower and neonatal mortality was higher among families with higher parental education, family wealth or among higher castes. In the post-neonatal period, there was higher mortality in girls among disadvantaged groups.

A total of 12,517 native born children were enrolled in the study during the six-year period (2006-2011) providing a total of 25,797 child years. During this period, 479 (3.8%) children migrated out of the study area. A total of 710 children
died during this period giving a mortality rate of 56.7 per 1000 live births in the under-three year age group and 27.5 per 1000 child years. This cohort was divided into three groups for each of the three indicators of the socio-economic status—caste, parental education and wealth index.

As expected, children in higher levels of SES showed lower mortality by all the three indicators (Table 10). The differential between highest and lowest SES levels was greatest for parental education and least for caste. The sub-group with highest parental education had the lowest mortality rate (11.7 per 1000 live births) followed by the wealthiest sub-group (16.1 per 1000). The opposite was seen when sex ratio at birth was studied in the population. (table 10) The group with highest parental education had the lowest SRB (745 per 1000 boys) followed by the wealthiest group (768 per 1000 boys). The poorest group by all the three indicators had the similar and much higher SRB (886-895 per 1000 boys), but this was still much lower than the global norm of 952 per 1000. This testifies to the fact that the practice of sex-determined foeticide was all-pervasive and paradoxically was more among the advantaged groups of the community.

Table 10. Sex ratio at birth and mortality rate in different socio-economic groups in the study cohort from birth to three years at Ballabgarh (2006-2011)

<table>
<thead>
<tr>
<th>Socio-economic status</th>
<th>Total Births</th>
<th>Sex ratio at birth (95% CI)</th>
<th>Mortality rate per 1000 child years (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caste</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheduled (Low)</td>
<td>3677</td>
<td>895 (837-953)</td>
<td>38.1 (33.6 – 42.5)</td>
</tr>
<tr>
<td>Backward Middle</td>
<td>3132</td>
<td>799 (743-855)</td>
<td>23.1 (19.4 – 26.8)</td>
</tr>
<tr>
<td>Forward (High)</td>
<td>5708</td>
<td>801 (759-842)</td>
<td>23.3 (20.5 – 26.0)</td>
</tr>
<tr>
<td><strong>Parental Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest tertile</td>
<td>4790</td>
<td>886 (835-937)</td>
<td>42.4 (38.4 – 46.5)</td>
</tr>
<tr>
<td>Middle tertile</td>
<td>3578</td>
<td>851 (795-906)</td>
<td>25.4 (21.8 – 29.0)</td>
</tr>
<tr>
<td>Highest tertile</td>
<td>4149</td>
<td>745 (700-791)</td>
<td>11.7 (9.4 – 14.1)</td>
</tr>
<tr>
<td><strong>Wealth Index</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest tertile</td>
<td>3557</td>
<td>895 (836-954)</td>
<td>41.3 (36.7-46.0)</td>
</tr>
<tr>
<td>Middle tertile</td>
<td>3572</td>
<td>822 (768-877)</td>
<td>23.5 (20.0 – 27.0)</td>
</tr>
<tr>
<td>Highest tertile</td>
<td>4268</td>
<td>768 (722-815)</td>
<td>16.1 (13.5 – 18.7)</td>
</tr>
<tr>
<td><strong>Overall mortality rate</strong></td>
<td>12517</td>
<td>827 (798-856)</td>
<td>27.5 (25.5 – 29.6)</td>
</tr>
</tbody>
</table>

*Information on wealth index was available only for 11,260 (91%) of the households, hence 84 deaths could not be classified in any wealth index tertile.

The Kaplan Meier survival curves for boys and girls in the cohort were plotted (Figure 7). Except for the initial few weeks, there was clearly a better survival for boys. A closer look at the initial weeks of life shows that until about three weeks of life there was a higher survival of girls after which the rates between the two groups were similar and by about 12 weeks, the lines of boys and girls clearly diverged, girls having poorer survival rates.
The mortality ratio among girls as compared to boys by SES category in neonatal and 1-36 month age group are shown in Table 11. In the neonatal period, for all the lower SES categories, mortality rates among males were higher than females with RR of less than one, as is to be expected biologically. However, in the high SES categories, the RR was reversed and higher for girls. This was statistically significant only for caste, probably due to higher numbers in that group. In the 1-36 month age group, there was higher death rate among girls in all SES categories but this was statistically significant only in low parental education and low wealth index sub-groups. (Table 11) Thus, in neonatal period, there were excess girl deaths among high SES groups (similar to what is seen in sex ratio at birth) and after one month, more girls died among lower SES groups. This difference indicates that the pathway to excess girl deaths is different in the two age groups. In both cases, poorer people do not use technology due to non-affordability. In the antenatal period it could be due to decreased access to life-taking technology, while in the childhood it could be due to life-saving health care.

Survival analysis confirmed that by all the three indicators, in the neonatal period girls had higher survival rates as compared to boys only in lowest SES category, though it was significant only for caste (HR 0.55; 0.33 – 0.91). Survival rates were consistently in favour of boys in 1-36 months age group and more likely to be significant in the lower SES groups (Table 12).
Table 11. Mortality rate ratio (95% CI) of girls as compared to boys by SES group

<table>
<thead>
<tr>
<th>SES Category</th>
<th>Neonatal mortality</th>
<th>1-36 months mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caste</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.55 (0.35 - 0.88)*</td>
<td>1.37 (0.95 - 1.98)</td>
</tr>
<tr>
<td>Middle</td>
<td>1.10 (0.53 - 1.90)</td>
<td>1.24 (0.72 - 2.15)</td>
</tr>
<tr>
<td>High</td>
<td>1.55 (1.05 - 2.30)*</td>
<td>1.48 (0.96 - 2.30)</td>
</tr>
<tr>
<td><strong>Parental Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.86 (0.58 - 1.28)</td>
<td>1.36 (1.01 - 1.8)*</td>
</tr>
<tr>
<td>Middle</td>
<td>0.87 (0.54 - 1.39)</td>
<td>1.48 (0.85 - 2.58)</td>
</tr>
<tr>
<td>High</td>
<td>1.54 (0.86 - 2.76)</td>
<td>1.05 (0.52 - 2.10)</td>
</tr>
<tr>
<td><strong>Wealth Index</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.66 (0.42 - 1.05)</td>
<td>1.65 (1.15 - 2.37)*</td>
</tr>
<tr>
<td>Middle</td>
<td>1.22 (0.75 - 2.02)</td>
<td>1.12 (0.70 - 1.79)</td>
</tr>
<tr>
<td>High</td>
<td>1.39 (0.83 - 2.34)</td>
<td>1.04 (0.54 - 2.00)</td>
</tr>
</tbody>
</table>

*statistically significant at 5% level

Table 12. Adjusted Hazard Ratio (95% CI) for girls compared to boys by SES group

<table>
<thead>
<tr>
<th>SES Category</th>
<th>Neonatal mortality</th>
<th>1-36 months mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caste</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.55 (0.33 - 0.91)*</td>
<td>1.71 (1.24 - 2.36)*</td>
</tr>
<tr>
<td>Middle</td>
<td>1.09 (0.56 - 2.10)</td>
<td>1.23 (0.78 - 1.93)</td>
</tr>
<tr>
<td>High</td>
<td>1.41 (0.89 - 2.22)</td>
<td>1.51 (1.06 - 2.13)*</td>
</tr>
<tr>
<td><strong>Parental Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.77 (0.52 - 1.13)</td>
<td>1.45 (1.11 - 1.89)*</td>
</tr>
<tr>
<td>Middle</td>
<td>1.29 (0.75 - 2.2)</td>
<td>1.85 (1.23 - 2.77)*</td>
</tr>
<tr>
<td>High</td>
<td>1.59 (0.75 - 3.37)</td>
<td>1.41 (0.75 - 2.63)</td>
</tr>
<tr>
<td><strong>Wealth Index</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>0.78 (0.50 - 1.22)</td>
<td>1.85 (1.38 - 2.48)*</td>
</tr>
<tr>
<td>Middle</td>
<td>0.91 (0.52 - 1.56)</td>
<td>1.22 (0.82 - 1.80)</td>
</tr>
<tr>
<td>High</td>
<td>1.30 (0.74 - 2.7)</td>
<td>1.29 (0.81 - 2.06)</td>
</tr>
</tbody>
</table>

*statistically significant at 5% level

Gender differentials in childhood mortality due to vaccines (III)

A total of 12,412 (99.2%) births whose immunization details were available were included initially in the cohort. This included 5,479 girls and 6,663 boys. A total of 702 deaths (332 boys and 370 girls) occurred among these children in the three years of follow up. The three-year cumulative mortality rate was 57.8 per 1000 live births with 35% excess girl child mortality. A total of 11,390 (91.8%) children for whom complete information on confounders, especially SES, was available were taken up for further analysis. There were 691 deaths among these children with a total follow up of 24,459 child years. There was no difference in the mean
age of vaccination between boys and girls for any of the vaccines. Vaccination coverage was almost the same for boys and girls at all ages for various vaccines. There was some vaccination delay with median age of vaccination being about two weeks later than the date of eligibility (Table 13). About 6% of children did not follow the scheduled sequence of vaccination as per the national immunization programme for India.

Table 13. Mean age at vaccination and vaccination coverage for different vaccines at various age groups

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Sex</th>
<th>Mean age of vaccination (95% CI)</th>
<th>At Birth (48hrs)</th>
<th>6 wks</th>
<th>14 wks</th>
<th>9 mths</th>
<th>12 mths</th>
<th>18 mths</th>
<th>24 mths</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCG (in days)</td>
<td>Boy</td>
<td>16.9 (16.3-17.5)</td>
<td>13.2</td>
<td>90.9</td>
<td>98.2</td>
<td>98.8</td>
<td>98.9</td>
<td>99.1</td>
<td>99.2</td>
</tr>
<tr>
<td></td>
<td>Girl</td>
<td>17.0 (16.0-18.0)</td>
<td>12.9</td>
<td>90.1</td>
<td>98.1</td>
<td>98.8</td>
<td>98.9</td>
<td>99.2</td>
<td>99.2</td>
</tr>
<tr>
<td>DTPp (in weeks)</td>
<td>Boy</td>
<td>8.3 (8.2-8.5)</td>
<td>-</td>
<td>12.2</td>
<td>93.6</td>
<td>98.6</td>
<td>98.7</td>
<td>98.9</td>
<td>98.9</td>
</tr>
<tr>
<td></td>
<td>Girl</td>
<td>8.7 (8.5-8.8)</td>
<td>-</td>
<td>11.2</td>
<td>92.4</td>
<td>98.7</td>
<td>98.8</td>
<td>98.9</td>
<td>98.9</td>
</tr>
<tr>
<td>Measles (in months)</td>
<td>Boy</td>
<td>9.4 (9.3-9.5)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16.7</td>
<td>85.2</td>
<td>86.7</td>
<td>88.1</td>
</tr>
<tr>
<td></td>
<td>Girl</td>
<td>9.4 (9.3-9.6)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>15.7</td>
<td>84.9</td>
<td>86.6</td>
<td>88.0</td>
</tr>
<tr>
<td>DTPb (in months)</td>
<td>Boy</td>
<td>17.7 (17.6-17.8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>45.8</td>
<td>76.5</td>
</tr>
<tr>
<td></td>
<td>Girl</td>
<td>17.7 (17.6-17.8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>45.7</td>
<td>75.9</td>
</tr>
</tbody>
</table>

Mortality rates were much higher in the unvaccinated group when compared with vaccinated group for all vaccines (Table 14 and Figure 8). This very high apparent degree of protection could reflect the actual protective effect of vaccines and also selection bias due to children dying early having no or lower chance (if they die before becoming eligible or before being vaccinated) of getting immunized. Crude mortality rate was higher in girls among all groups except for BCG exposed group in the time frame of 6 weeks to 8 months. The crude mortality rate ratio was adverse for girls for all vaccine groups and increased as the age increased.
The adjusted hazard ratios for girls as compared to boys among the vaccinated and unvaccinated are presented in Table 15. In the unvaccinated group, the slight advantage in mortality for girls in the first six weeks was reversed in the next time frame, though this was not statistically significant. Receiving BCG however, resulted in a change in the adjusted hazard ratio in favour of girls, but again this was not statistically significant. Significantly higher girl child mortality was noted after receipt of DTPp (1.65; 1.17-2.32) and DTPb (2.21; 1.24-3.93) but not after being exposed to measles (1.34; 0.85-2.12) in children up to three year of age. In a sensitivity analysis, the results were stable to the assumptions (Table 16).

![Survival curves for the cohort, by different exposures to vaccines](image_url)
Table 14. Crude mortality rates (per 1000 child months) by sex for different vaccine exposed groups at various time frames

<table>
<thead>
<tr>
<th>Time Frames</th>
<th>Indicators</th>
<th>No Vaccination received</th>
<th>BCG exposed group</th>
<th>DTPp exposed group</th>
<th>Measles exposed group</th>
<th>DTPb exposed group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Boy</td>
<td>Girl</td>
<td>Boy</td>
<td>Girl</td>
<td>Boy</td>
</tr>
<tr>
<td>0-5 Weeks</td>
<td>Child months</td>
<td>3685</td>
<td>2968</td>
<td>4878</td>
<td>4039</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Deaths</td>
<td>152</td>
<td>133</td>
<td>18</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Mortality Rate</td>
<td>41.2</td>
<td>44.8</td>
<td>3.7</td>
<td>6.7</td>
<td>NA</td>
</tr>
<tr>
<td>6 weeks - 8 Months</td>
<td>Child months</td>
<td>754</td>
<td>627</td>
<td>3273</td>
<td>2936</td>
<td>37572</td>
</tr>
<tr>
<td></td>
<td>Deaths</td>
<td>8</td>
<td>15</td>
<td>25</td>
<td>19</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>Mortality Rate</td>
<td>10.6</td>
<td>23.9</td>
<td>7.6</td>
<td>6.5</td>
<td>1.7</td>
</tr>
<tr>
<td>9-15 Months</td>
<td>Child months</td>
<td>346</td>
<td>262</td>
<td>57</td>
<td>42</td>
<td>3735</td>
</tr>
<tr>
<td></td>
<td>Deaths</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Mortality Rate</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>16-36 Months</td>
<td>Child months</td>
<td>917</td>
<td>798</td>
<td>72</td>
<td>31</td>
<td>2082</td>
</tr>
<tr>
<td></td>
<td>Deaths</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Mortality Rate</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>0-36 Months</td>
<td>Child months</td>
<td>5431</td>
<td>4429</td>
<td>8452</td>
<td>7189</td>
<td>41118</td>
</tr>
<tr>
<td></td>
<td>Deaths</td>
<td>162</td>
<td>149</td>
<td>43</td>
<td>46</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Mortality Rate</td>
<td>29.8</td>
<td>33.6</td>
<td>5.1</td>
<td>6.4</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>Mortality rate ratio (G/B)</td>
<td>1.12</td>
<td>1.25</td>
<td>1.53</td>
<td>1.50</td>
<td>2.33</td>
</tr>
</tbody>
</table>
**Table 15.** Unadjusted and adjusted* hazard ratios for girls compared to boys among children vaccinated or not vaccinated with various vaccines

<table>
<thead>
<tr>
<th>Time frame</th>
<th>Hazards Ratio</th>
<th>No Vaccination received</th>
<th>BCG exposed group</th>
<th>DTPp exposed group</th>
<th>Measles exposed group</th>
<th>DTPb exposed group</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 Weeks</td>
<td>Unadjusted</td>
<td>0.92 (0.69-1.21)</td>
<td>1.55 (0.83-2.86)</td>
<td>NA</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Adjusted</td>
<td>0.89 (0.66-1.20)</td>
<td>1.33 (0.69-2.55)</td>
<td>NA</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6 weeks - 8 Months</td>
<td>Unadjusted</td>
<td>2.51 (1.03-6.18)#</td>
<td>0.85 (0.45-1.57)</td>
<td>1.46 (1.04-2.05)#</td>
<td>0.65 (0.06-7.26)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Adjusted</td>
<td>2.20 (0.87-5.57)</td>
<td>0.85 (0.43-1.66)</td>
<td>1.55 (1.08-2.24)#</td>
<td>NA</td>
<td>-</td>
</tr>
<tr>
<td>9-15 Months</td>
<td>Unadjusted</td>
<td>NA</td>
<td>NA</td>
<td>1.70 (0.65-4.47)</td>
<td>1.63 (0.97-2.75)</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Adjusted</td>
<td>NA</td>
<td>NA</td>
<td>1.91 (0.67-5.43)</td>
<td>1.42 (0.83-2.43)</td>
<td>NA</td>
</tr>
<tr>
<td>16-36 Months</td>
<td>Unadjusted</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1.23 (0.46-3.29)</td>
<td>2.58 (1.49-4.46)#</td>
</tr>
<tr>
<td></td>
<td>Adjusted</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>2.21 (1.24-3.93)#</td>
<td>2.21 (1.24-3.93)#</td>
</tr>
<tr>
<td>0-36 Months</td>
<td>Unadjusted</td>
<td>0.99 (0.76-1.29)</td>
<td>1.12 (0.73-1.72)</td>
<td>1.54 (1.12-2.12)#</td>
<td>1.49 (0.95-2.34)</td>
<td>2.58 (1.49-4.47)#</td>
</tr>
<tr>
<td></td>
<td>Adjusted</td>
<td>0.96 (0.72-1.27)</td>
<td>1.06 (0.67-1.67)</td>
<td>1.65 (1.17-2.32)#</td>
<td>1.34 (0.85-2.12)</td>
<td>2.21 (1.24-3.93)#</td>
</tr>
</tbody>
</table>

*Adjusted for wealth index, access to health care, presence of a health facility in the village, parental education, type of family and birth order of the child.

#Significant at 0.05 level

**Table 16.** Adjusted Hazards ratio (95% CI) for girls compared to boys among children vaccinated or not vaccinated with various vaccines (0-36 months) for different case scenarios

<table>
<thead>
<tr>
<th>Case Scenarios</th>
<th>No Vaccination received</th>
<th>BCG exposed group</th>
<th>DTPp exposed group</th>
<th>Measles V exposed group</th>
<th>DTPb exposed group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frailty Bias</td>
<td>0.91 (0.63-1.21)</td>
<td>1.13 (0.71-1.77)</td>
<td>1.60 (1.15-2.28)</td>
<td>1.46 (0.89-2.19)</td>
<td>2.23 (1.25-3.97)</td>
</tr>
<tr>
<td>Lag time</td>
<td>0.99 (0.78-1.31)</td>
<td>1.04 (0.65-1.65)</td>
<td>1.59 (1.14-2.26)</td>
<td>1.39 (0.86-2.16)</td>
<td>2.25 (1.26-3.96)</td>
</tr>
</tbody>
</table>

*Adjusted for wealth index, access to health care, presence of a health facility in the village, parental education, type of family and birth order of the child.
Community perceptions of girl children (IV)

About half of the respondents believed that the community discriminated against the girl child mainly in the form of not providing them with education and nutrition (Table 17). The main driving force for this was that the girls were perceived as “others assets” as they would get married and move to husbands’ family. About a third of them believed that more than 50% of the families indulged in the practice of sex determination, which a pregnant woman was forced to undergo at the behest of her husband or in-laws. The community members perceived that the practice of sex determination was more common among poor and uneducated while 10% believed that this was done by all sections of the society. Four fifths of the respondents wanted government to provide financial support to families with girls.

Table 17. Community perceptions about girl child discrimination (n = 200)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belief that society differentiates in bringing up of boys and girls</td>
<td>47.0</td>
</tr>
<tr>
<td>Ways in which girl children are discriminated against:</td>
<td></td>
</tr>
<tr>
<td>Poor investment in education</td>
<td>43.0</td>
</tr>
<tr>
<td>Poor nutritional intake</td>
<td>7.0</td>
</tr>
<tr>
<td>Poor health care</td>
<td>1.0</td>
</tr>
<tr>
<td>Reasons for girl child discrimination:</td>
<td></td>
</tr>
<tr>
<td>Believed to be “Paraya Dhan” (others’ wealth)</td>
<td>41.0</td>
</tr>
<tr>
<td>Patri-lineal inheritance and religious rites</td>
<td>7.0</td>
</tr>
<tr>
<td>Dowry</td>
<td>3.0</td>
</tr>
<tr>
<td>Perception that that pregnant women is pressurized by her spouse/in laws</td>
<td>77.0</td>
</tr>
<tr>
<td>Estimate that more than 50% of the families in their villages go for sex determination tests</td>
<td>36.0</td>
</tr>
<tr>
<td>Perceptions as to community groups who practice in sex determination</td>
<td></td>
</tr>
<tr>
<td>Poor people</td>
<td>42.5</td>
</tr>
<tr>
<td>Uneducated people</td>
<td>19.5</td>
</tr>
<tr>
<td>Rich people</td>
<td>13.0</td>
</tr>
<tr>
<td>Everybody</td>
<td>10.0</td>
</tr>
<tr>
<td>Suggested measures that government can take to address this issue</td>
<td></td>
</tr>
<tr>
<td>Financial help to the families with girl children</td>
<td>79.0</td>
</tr>
<tr>
<td>Penalties for those going for sex determination</td>
<td>25.0</td>
</tr>
</tbody>
</table>

Evaluation of government schemes on girl children (IV)

The evaluation of girl child schemes had three components – measurement of awareness of the schemes by survey, impact assessment by looking at trends of change in the intended outcome of the schemes and understanding programme implementers’ perspectives using qualitative methods.
Awareness of schemes: While half of the community level respondents were generally aware about the existence of girl child schemes, only 15% and 9% were aware of the specific conditional cash transfer schemes related to girl children – ABAD and Laadli respectively (Table 18). The awareness of the details of these schemes was much less. The awareness of a law that penalized sex determination was much higher at 80%. Even while majority felt that there was an improvement of communities’ attitudes towards girl children, they also reported that neither the Government nor community-level stakeholders had done much in this regard.

Table 18. Awareness and perceived impact of government schemes on girl children among community level respondents (n = 200)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of any girl child related Schemes</td>
<td>56.0</td>
</tr>
<tr>
<td>Awareness of Apni Beti Apna Dhan (ABAD)</td>
<td>15.0</td>
</tr>
<tr>
<td>Laadli</td>
<td>9.0</td>
</tr>
<tr>
<td>Awareness of PNDT Act</td>
<td>80.0</td>
</tr>
<tr>
<td>Perception that government has not done enough for improving girl child status</td>
<td>68.0</td>
</tr>
<tr>
<td>Perception that community level organizations and Panchayats have not done enough for improving girl child status</td>
<td>97.5</td>
</tr>
<tr>
<td>Perception of improvement in the attitude towards girl child in last few years</td>
<td>72.5</td>
</tr>
</tbody>
</table>

Evaluation of impact: The short-term impact of the CCT schemes was assessed by estimating the difference in four cohorts of births covering four different periods of the schemes (Table 19). It has already been shown that the sex ratio at birth declined during the entire period despite the implementation of CCT schemes, providing evidence of lack of impact on the primary outcome measure. The sex ratio at birth declined much more sharply for the children with birth order of two or more in contrast to the first born where the situation showed improvement. The Laadli scheme (after 2005) in fact focused on second girl child and despite that the sex ratio was the worst in that time period in that group, clearly indicating that the improvement at the first born was driven by a more reasoned and sophisticated use of technology of sex determination by parents desirous of at least one boy. The coverage with different vaccines showed an increase over the time period but was similar for boys and girls.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Study Children</th>
<th>Cohort of births occurring in the given time period</th>
<th>P value for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td></td>
<td>(n = 6532)</td>
<td>(n = 8480)</td>
</tr>
<tr>
<td>Sex ratio at Birth (girls per 1000 boys)</td>
<td>All</td>
<td>866</td>
<td>862</td>
</tr>
<tr>
<td></td>
<td>Firstborn</td>
<td>827</td>
<td>912</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>896</td>
<td>846</td>
</tr>
<tr>
<td>Completely immunized by 12 months (%)</td>
<td>Girls</td>
<td>59.8</td>
<td>70.1</td>
</tr>
<tr>
<td></td>
<td>Boys</td>
<td>62.0</td>
<td>71.5</td>
</tr>
</tbody>
</table>

The sex ratio at birth shows a worsening trend, though there were ups and downs (Figure 9). The period immediately following PNDT Act and ABAD implementation in 1994 showed a decline as during this period the district authorities strictly implemented the PNDT Act which slackened once the district chief medical officer retired (personal information).

Figure 9. Temporal relationship between government interventions and sex ratio at birth in Ballabgarh HDSS 1992-2011
The long-term impact was evaluated by measuring changes in investment in girls measured through levels of education and the age at marriage. These are the intended long-term impacts and are among the conditions to be fulfilled for availing the maturity benefits of the girls born in these villages. These were compared with daughters-in-law who came from outside Haryana where such schemes were not in place. For both education and age at marriage, a low but significant trend of improvement in the long-term was noted (Table 20). The rate of increase in investment in girl child education was much higher among daughters of these villages (a ten times increase to 27.9% from a baseline low of 2.5% as compared to a three times increase among daughters-in-law from 13.8% to 42.2%). However, even in the most recent time period, the daughters were still lagging behind daughters-in-law in terms of education.

**Table 20.** Comparison of trend in gender differentials among daughters and daughter-in-laws during 1992-2010 to assess the long-term impact of government interventions

<table>
<thead>
<tr>
<th>Intervention Status</th>
<th>Study Group</th>
<th>Marriages occurring in the given time period</th>
<th>P value for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>Daughters</td>
<td>1370</td>
<td>2298</td>
</tr>
<tr>
<td></td>
<td>All DILs</td>
<td>1583</td>
<td>2242</td>
</tr>
<tr>
<td></td>
<td>Non-Haryana DILs</td>
<td>476</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>Study Group</td>
<td>Daughters</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All DILs</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Haryana DILs</td>
<td>15.8</td>
</tr>
<tr>
<td></td>
<td>Mean age at marriage in years</td>
<td>Daughters</td>
<td>18.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All DILs</td>
<td>19.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Haryana DILs</td>
<td>19.1</td>
</tr>
</tbody>
</table>

DIL – Daughters-in-law

**Programme implementers’ perspectives**

The programme implementers had a general assessment that these programmes were successful in reducing the girl child discrimination. Increase in registration of birth of girls was reported. However, this was felt to be primarily for parents to avail the benefits under the schemes.
“Of course, earlier, people would not come forward, they would not even tell that a girl child had been born in their house, they would not even celebrate the birth, because of the scheme they at least come forward and register the birth. Some do this to get benefit of registering for this scheme, some register on their own otherwise too. There are changes, but mostly they come forward (to register) to get these benefits”

– Block level implementer

“Yes the scheme is good, The main benefit is if there are no girls then how would boys get girls (for marriage) earlier people used to practice foeticide , but this has now come down – no case in my area till now.”

– Community level implementer

Two broad themes emerged during the analysis as shown in Table 21. “Conspiracy of Silence”- a tendency to underestimate the seriousness of the problem in the community was noted. This occurred either in the form of complete denial or more likely by restricting the problem to a specific sub group – rural, poor, slums, uneducated etc. It was not seen as a problem of the whole community by anybody. This reinforced the finding of the community survey.

“...discrimination is too much, it is that there are some families which are reluctant to change their practices”

– Block level implementer

A corollary of this was that the programme was in fact being implemented surreptitiously. There was no community participation. Local panchayats or health functionaries were not involved in its implementation. Anganwadi workers went house to house and filled the forms for the identified beneficiaries and sent it forward for registration in the scheme. Even the listed beneficiaries who were interviewed did not know the details of the benefits or conditionalities involved, except that they would come in for some money when the girl becomes 18 years old. Obviously there was no community level discussion or mobilization occurring on the issue of girl children.

“We don’t know when we get benefits, we will see. (After prompts about what they were told when the forms were filled) Yes we will get money after 18 years”

- A listed beneficiary
### Table 21. Themes identified from programme implementers’ experiences of implementing conditional cash transfer schemes for girl children in Ballabgarh

<table>
<thead>
<tr>
<th>Themes identified</th>
<th>Categories</th>
<th>Subcategories</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Conspiracy of silence”</td>
<td>Undervalue the seriousness of problem</td>
<td>• Restrict the problem to specific groups (Only those with many girls discriminate; This is not seen in urban areas etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• This is seen only in slums due to lack of awareness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Complete denial of its presence (Have not seen this problem in my area).</td>
</tr>
<tr>
<td></td>
<td>Passive involvement of community in the</td>
<td>• Lack of awareness about the programmes</td>
</tr>
<tr>
<td></td>
<td>programme</td>
<td>• Anganwadi workers filling the forms house to house</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No community-based activities</td>
</tr>
<tr>
<td>Clash between subsidy and</td>
<td>A culture of subsidies</td>
<td>• Nobody says no to free money</td>
</tr>
<tr>
<td>accountability</td>
<td></td>
<td>• Mainly come forward to claim money, no real change</td>
</tr>
<tr>
<td>“Politicians giveth away</td>
<td></td>
<td>• Why not give it to first child also</td>
</tr>
<tr>
<td>but Bureauocracy taketh</td>
<td></td>
<td>• Girl child registration has increased to get enrolled for the scheme</td>
</tr>
<tr>
<td>away”</td>
<td></td>
<td>• Presence of other schemes like free education, Kanyadaan etc. which also give free subsidies</td>
</tr>
<tr>
<td></td>
<td>Bureaucratic approach of the programme</td>
<td>• Too many conditionality’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Need for documentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Delay in release of certificates</td>
</tr>
</tbody>
</table>

The other theme that emerged was “clash between subsidy and accountability”. A culture of giving subsidies was being promoted by political class in keeping with the desire of the community members. It appeared that the community generally wanted to get as much subsidy as possible from the government without in any way this being linked to any change.

“No such thing, no one says no to money, all types of people come forward, if they have a daughter they would come for the scheme. When we go to houses................. we tell them that you will get these benefits then they are more than willing and then we tell them get these papers ready – birth certificates of both girls, domiciles, ration cards and schedule caste certificate”

– Community level implementer
However, this was being diluted by imposing too many conditionalities and requirements for documentation to avail the benefits of these schemes. This resulted in not all beneficiaries getting registered or delay in registration as well as delays in getting the benefits accrued. Even after five to six years after sending the required certificates, the beneficiaries had not got their government bonds. Also, the first batch of ABAD’s beneficiaries who had their pay-out scheduled in 2012, had yet to receive their final payments.

“In the ratio of 40:60 there would be 60 who do not have the necessary documents, only 40% would be having the relevant documents”.

– Urban implementer

Overall the impression given by the evaluation was of a passively implemented programme with little community mobilization. The scheme itself had flaws in the identification of beneficiaries, structuring and scale of incentives. The bureaucratic requirements and delays nullified whatever little gains were possible to be achieved with the scheme.
Summary of the main findings
Adverse sex ratio at birth as well as higher girl child mortality has been documented since the mid-1960s in this study area. What this study found is the continued severity of adversity. For during two entire decades (1992-2011), higher mortality rates for girls were reported, and for the first time in the neonatal period in some years. This in fact signals a worsening of the situation. Another key finding was that this sex differential in the prenatal period and neonatal period was more pronounced among the educated and wealthier families. As this period accounts for most of the missing girls, it is clear that, contrary to the conventional wisdom, education and development were making the situation worse for the girls. Use of ultrasound for sex-determination showed that the use of technology has the potential to further hinder gender equity if it not aligned with social realities and culture. Sex differentials in non-specific effects of DPT vaccine further showed that the use of technological fixes can have unintended consequences which need to be factored in when making decisions on immunization schedules and programmes. Government efforts to improve the status of girl children have not met with success due to faulty design of the schemes and more importantly because of a lack of community mobilization.

Changing gender differentials with decline in childhood mortality
The worst period of adversity for girls in terms of SRB was between 2001 and 2007. Improvements since 2007 are probably due to a better and more refined use of technology. As we reported earlier and others have shown, in the initial periods of availability of the new technology of ultrasound, most pregnant women underwent sex determination tests followed by female foeticide, resulting in even first order births showing skewed sex ratios. However, later on this was not practised for the first child and the use of this practice increased for subsequent pregnancies, especially if the previous one was a girl (19,120). A stringent implementation of the PNDT Act in this area for a short period between 1995-97 also resulted in more girls being born (120).

Once born, newborn girls have a biological advantage in survival over newborn boys, with less vulnerability to perinatal conditions (including birth trauma, intrauterine hypoxia and birth asphyxia, prematurity, respiratory distress syndrome and neonatal tetanus), and infectious diseases such as intestinal infections and lower respiratory infections. However, beyond early infancy, girls do not
enjoy the same advantage in relation to certain infectious diseases, which are the primary causes of death in later infancy and early childhood in settings where overall mortality is high. As living conditions improve, infectious diseases recede as a cause of death. As this occurs, perinatal and congenital causes form an increasing share of total mortality among infants, while external causes, more typically affecting boys, form an increasing share of mortality for children between ages 1 and 5. Hence, as overall levels of mortality fall, female advantage in infant and child mortality would normally increase assuming no sex-specific changes in the treatment of children (5). The female advantage in survival, however, can erode if girls are deprived, relative to boys, in access to health care or to proper nutrition, as has been seen in the study area. If such deprivation occurs, higher girl child mortality would be seen as in this study area. Higher rates of causes of death among girls due to diarrhoea and malnutrition has been reported before from India and Bangladesh and has been shown to be related to neglect in child care and feeding as well as delay in seeking treatment for girls (36,133).

The period of the study from 1992-2011 was characterized by rapid decline in both fertility rates and child mortality rates and an increase in neonatal mortality rates. The decline in childhood mortality rates has been largely brought about by improved coverage with selective primary health care (immunization especially with tetanus and measles vaccine in childhood; access to oral rehydration therapy) and an expansion of health care infrastructure especially in the private sector in that area. These interventions primarily addressed diseases seen in the post-neonatal period. There were no interventions aimed at the neonatal period except tetanus immunization of pregnant mothers. Neonatal intensive care services are still poor in Ballabgarh Block. Sick newborns including preterm or low birth weight babies have to be taken to higher centres in Faridabad or Delhi for expensive intensive care management. This could explain the higher mortality among girls in the neonatal period as parents may not be ready to spend so much on girls (125). Also, as reported by Bharadwaj et al., mothers invested more in terms of nutrition and antenatal care during pregnancy for boys which would mean that there is even a higher risk of girls having low birth weight (25). Higher rates of death due to diarrhoea and malnutrition among girls are well documented in South Asia and are a combined effect of neglect in childcare along with lower seeking of care for girls (19,36,49).

It is generally believed that the sex differential in India is narrowing based on the NFHS data on child mortality. However, a close look at the NFHS dataset for whole of India shows a worsening sex differential across all the three age groups (Table 22). How does then one explain that the gender gap in under-five mortality is narrowing while at the same time gender gap is worsening in its individual components?
This is explained by two facts:
1. Firstly, gender differential is not same throughout the period and generally worsens as age increases;
2. Secondly, the decline in mortality is not uniform and in fact goes in the reverse direction i.e. the decline is greatest in the later age groups and least in the neonatal age group.

<table>
<thead>
<tr>
<th>Period</th>
<th>Neonatal mortality rate ratio (0-1 month)</th>
<th>Post-neonatal mortality rate ratio (1-11 months)</th>
<th>Child mortality rate ratio (1-4 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981-1986</td>
<td>0.82</td>
<td>1.17</td>
<td>1.46</td>
</tr>
<tr>
<td>1987-1992</td>
<td>0.86</td>
<td>1.12</td>
<td>1.37</td>
</tr>
<tr>
<td>1993-1998</td>
<td>0.91</td>
<td>1.10</td>
<td>1.57</td>
</tr>
<tr>
<td>1999-2005</td>
<td>0.91</td>
<td>1.21</td>
<td>1.53</td>
</tr>
</tbody>
</table>

*derived from data shown in Table 1

As a result, the mortality in 1-4 year period, when the higher girl child mortality peaks, has declined much faster than in the neonatal period where there is still lower girl child mortality, even though the difference is narrowing. This results in an artificial decrease in overall sex differential in childhood mortality. In Ballabgarh, the decline in mortality rates during 1-59 months have been much sharper in girls but have been compensated by higher rates of increase in neonatal mortality rate.

**Role of socio-economic status in gender differential in child mortality**

Our study showed increasing sex discrimination at prenatal and neonatal stages followed by narrowing of the sex differential in the higher age groups in the high SES population. This could be due to a survival bias, as in high SES, girl children who survive the neonatal period are likely to be wanted babies, and are therefore less likely be discriminated against.

Of the existing explanatory frameworks for health inequality, the model by Mosley and Chen is probably the most often used in the context of child health in developing countries (134). They combined socio-economic determinants and biological determinants of childhood mortality into a single framework, arguing that socio-economic determinants, such as maternal education, can only exert an effect on childhood mortality through more proximate, or direct, determinants of mortality. Most proximate determinants of childhood diseases, such as access to safe water and sanitation, birth weight, nutritional status etc., show poor lev-
els among lower socio-economic groups. It is generally believed that better socio-economic situation exerts its influence through increased status and decision-making power of care-givers within the household, increased willingness and ability to travel outside the community, more timely use of health care, greater negotiating power with health care providers, increased knowledge, skills and identification with modern health systems (134).

However, this study questions the assumption that better decision-making ability is always used for the betterment of the child. It shows that increasing education and income levels occurring in the context of pre-existing feudal social structures and attitudes could result in the use of newfound knowledge and wealth results for adoption of “inappropriate” practices like sex determined abortions. Similar evidences exist in the area of non-communicable diseases where, as SES improved, initially the families and individuals were more likely to have higher risk behaviours like smoking, alcohol use and inappropriate diets. After some time, this social gradient is reversed and higher socio-economic status regain their “healthy” status (133,135). It is difficult to predict the time frame for such a reversal in the case of sex-linked abortions.

Another more recent model, which is relevant to this work, is the one proposed by the WHO Commission on Social Determinants and Health (CSDH). This framework suggests that interventions can be aimed at taking action on the circumstances of daily life: differential exposures to disease-causing influences in early life, the social and physical environments, and work, associated with social stratification. Depending on the nature of these influences, different groups will have different experiences of material conditions, psychosocial support, and behavioural options, which make them more or less vulnerable to poor health; health-care responses to health promotion, disease prevention, and treatment of illness. Another set of actions need to address the structural drivers: the nature and degree of social stratification in society – the magnitude of inequity along the dimensions listed; biases, norms, and values within society; global and national economic and social policy; processes of governance at the global, national, and local levels (136).

Our study has also shown that childhood mortality inequities are found along many dimensions of social stratification. This implies that policies aimed at addressing inequities in childhood mortality should not only focus on strict economic criteria, but also give particular attention to families who are disadvantaged in other social aspects as well, for example caste. Currently in the Indian context, caste-based policies are preferred over class-based policies due to their political implications. However, these have divided the society into caste lines. The gains
of empowering the lower castes may take time to show results. This study adds one more level to this discussion by demonstrating that significant inequity itself can co-exist in multiple domains i.e. not only in socio-economic domain but also in gender. As gender inequities in neonatal and post-neonatal mortality in the study area were in different socio-economic strata, this further complicates the response to the problem as well. Efforts to improve child mortality through socio-economic development could end up worsening inequities due to gender, at least in the short run.

Both universal and targeted strategies have been advised to effectively address health inequities in child mortality (137). Although targeted interventions may be considered, in a situation where multiple deep-seated inequities coexist, strategies which aim for universal coverage of services may be the best option for improving overall levels of health. Universal access should not be restricted to health care alone but should also include proximate determinants such as access to piped water and sanitary facilities and basic nutrition and transport. However, this will not address the issue of sex-linked abortions.

**Gender differentials in childhood mortality due to vaccines**

This study showed that in the period with exposure to DTP immunization (both primary and booster), mortality among girls was significantly higher among vaccinated children in the study area.

Other studies looking at gender differences in NSEs of vaccines have shown varied results. Lehman et al. did not find any evidence of sex differentials in mortality due to NSE of vaccines in their study in Papua New Guinea nor did they report any significant two-way interaction between sex and BCG, DTP or measles vaccine (138). Vaugelade et al. reported significant NSE of BCG and DTP from a cohort study in Burkina Faso. The protection was much lower for girls (RR of 0.31) as compared to boys (RR of 0.14) even though the difference was not statistically significant (139). Chan et al. in their study in Cebu, Philippines, reported that the increased female–male mortality ratio was associated with reduced mortality among males following DTP vaccination rather than increased mortality among female children (67). It should be noted that two thirds of the children in this study in Cebu had received DTP along with BCG unlike in Ballabgarh, where the majority of children received BCG before getting DTP. They also reported a significant interaction between sex of the child and DTP, which was not seen in our study. Aaby et al. showed that NSE of a measles vaccine on mortality was significant for girls but not significantly different for boys (140).
In a re-analysis of a vitamin supplementation trial in South India, Moulton et al. reported that receipt of BCG or DTP vaccine was associated with significant reductions of one-half to two-thirds of mortality hazards. Among girls, those who received both BCG and DTP experienced higher mortality than those who received only one of these two vaccines (hazard ratio 2.4; 1.2–5.0) confirming the interaction between the non-specific effects of vaccines and their sex differentials (141). Another study in Western India also reported a higher female to male mortality in under-five children (1.29 times vs. 1.24 reported in our study). They also reported differences in access to vaccines for girls, not seen in Ballabgarh. Their study further showed that the sex differentials in child mortality differed by age. A higher male mortality was shown in the period following measles, which was contrary to the higher girl child mortality both before measles as well as after DTP booster (71).

It is clear that the extent to which the sex differentials in NSE of vaccines play a role depends upon the immunization schedule and its actual implementation – what vaccines are given at what age. Data from India show that only one-third of the children received measles and DTP vaccines at the recommended age (142). With the introduction of first Hepatitis B vaccine and now, pentavalent vaccine (including *Haemophilus influenzae* B), the extent of NSE and its gender differential is likely to be modulated (143,144). When immunization schedules are revised, programme managers only consider the effects of specific vaccines. However, as shown in this thesis, non-specific effects of vaccines and their sex differentials also need to be considered as inadvertently, such changes can have impact on both the child mortality level as well as sex inequities.

Allegations of negative effects of vaccines have an adverse impact on their population coverage rates. Outbreaks of epidemics following drastically reduced vaccination coverage resulting in higher morbidity and mortality have been reported (145,146). Therefore, while science demands that allegations of adverse effects of vaccines should be openly and properly addressed in order to maintain and improve research on vaccines, this needs to be approached very cautiously and carefully (147). The Global Advisory Committee on Vaccine Safety (GACVS), which has looked into the nonspecific adverse effects of DTP vaccine, believes that this set of theories raises critical issues pertaining to the safety of vaccines and immunization practices and that there is a need for further systematic research in the area of vaccine safety. For the time being, the GACVS has found that the reported results and conclusions are not without potential bias and that others have not confirmed the results in different settings (148). More recently in 2008, it again reiterated its willingness to keep a watch on this issue (149). Our study keeps the debate open and provides one more piece of evidence that supports the contention that DTP vaccination could be partially responsible for higher girl child mortality.
Government schemes and community perceptions on girl children

While studies have proved the impact of CCT programmes on poverty and inequality in social sectors (92-94), the schemes evaluated in this thesis differ in both the type of conditionality (daughter’s birth, education and marriage delay) and the long 18-year period over which transfers are made. Overall, our study found that while there has been some improvement in the indicators used to measure investment in girl children by parents, these were seen among boys as well. This indicates no specific impact of these schemes in raising the status of the girl child in this community. Our study also raises questions about the programme design and implementation.

Haryana pioneered this kind of scheme, which has since been replicated in most states of India, and there appears to be a political recognition of the problem. The change from ABAD to Laadli was driven by political reasons as the party in power changed in 2005 and wanted to derive political mileage out of this scheme by launching a new scheme after tweaking an old one. There seems to be community expectation for financial benefits for families with girls, which is being politically exploited. These schemes also fit in with the current scenario in India where political parties are vying with each other to dole out subsidies and incentives to win votes. The subsidy-based schemes are being seen as means to electoral victory and the social change maybe an unintended by-product.

In its first avatar as ABAD, the scheme focused on disadvantaged families and included all girls. This contrasts with the evidence including from Ballabgarh that the practice of sex determination was more among educated and wealthy people (120). When the scheme was revised, it did away with targeting the disadvantaged but made it applicable only for second girl child. While this change is supported by data, the fact that the focus was only on the second child meant that the scheme was not looking at changing community’s mindset, which needs an universal approach. For a programme centred on financial incentives to change social behaviour, the quantum of benefit has to be sufficiently large to induce a change in mindset. The maturity amount of US $500 would be insufficient for marriage of a girl child even among the poor segments of the population and would be considered too small by the richer segments to effect any behaviour change. The difficulty of CCT programmes to address social issues such as gender discrimination has been recognized by the government of India as reflected its report on Gender and the Sex Ratio, which says “This situation poses a formidable challenge to public policy. It is not a phenomenon restricted to the very poor, which governments can attempt to solve through cash transfers or through the banning of medical diagnostic technologies alone. Clearly something is wrong, and successive governments have been unable to put their finger on the pulse of
the problem. While it is difficult to tackle a problem that essentially stems from social and cultural attitudes as well as prejudices through State-led intervention alone, equally no nation can afford to not intervene when natural demography is tampered with in a manner that is unprecedented” (150).

People have also questioned the wisdom of bribing parents to keep their daughters, thereby reinforcing stereotypes that they are liabilities (151,152). Others have also voiced concerns that providing gifts in kind to the girl at the time of her marriage may send out a wrong message to the community as an implicit involvement of the state in covering marriage related financial transactions (153). Incidentally, there is also a government scheme called “Kanyadan” in which disadvantaged people are paid US$ 600 at the time of marriage. The fact that the community wants government to take care of their girls indicates that they are abdicating this responsibility. By agreeing to such a demand, government is in fact encouraging communities and parents to do so which can have adverse consequences on many other health related issues.

Lack of community awareness and participation of panchayats was also reported by Paruthi et al. in a survey in neighbouring district of Gurgaon, where only 53% 60 panchayat members were aware of ABAD (154). Our study as well as previous evaluations of such schemes in other states of India have highlighted the problems of ambiguous and complicated application process, delay in receipt of certificates (98,99) A common complaint from the beneficiaries across the states has been the difficulty in obtaining various documents required to apply and receive benefits under the schemes, especially the domicile certificates. This calls for simplification of the scheme.

Even though, full impact evaluation of these schemes is not possible within the current timeframe, there are two studies which have tried to evaluate the impact of these schemes using secondary data. A World Bank Evaluation of ABAD scheme using NFHS data estimated the early intent-to-treat programme effects on mothers (sex ratio among live children, fertility preferences) and investment in girl child (nutritional status, immunization, and schooling) and survival at the end of five years. The results show that ABAD had a positive effect on the sex ratio of living children, but inconclusive effects on mothers’ preferences for having female children as well as total desired fertility. They also reported that parents made greater post-natal health investments in eligible girls, with some mixed evidence of improving health status in the short and medium term. It also reported that the early cohort of eligible school-age girls were not significantly more likely to attend school; however, conditional on first attending any school, they were more likely to continue their education. The survival of girl children improved during the period 1993-2006 at a much higher rate as compared to boys. Among girls,
the improvement in ABAD eligible families (disadvantaged) was more than that of non-eligible families indicating a positive programme impact (155).

Laadli Scheme was evaluated by Mazumdar using two rounds of District Level Household Surveys (DLHS) 2002-04 (baseline) and 2007-08 (post-intervention) which are done in all districts of India for evaluation of reproductive health programme. They used data from Punjab (a neighbouring state of Haryana which also has gender based discrimination) as a control. A difference-in-difference analysis showed that the increase in percentage of women who had at least one daughter between the two periods was not significantly different between Haryana and Punjab. Even in the restricted analysis of neighbouring districts of the two states, the likelihood of having a second daughter did not show any statistically significant improvement. The difference was much lower if the sample was restricted to women who already had a girl child (intended beneficiary of Laadli). The authors concluded that the improved sex ratio may not be attributable to Laadli Scheme and also raise the possibility that the scheme may not have been equally effective in all parts of the state (156).

The differences in the results of the previous two evaluations and this study need careful scrutiny. While both the above-mentioned studies included whole of Haryana and used secondary data that was periodically collected, we restricted our analysis to one block in a district of Haryana but used a better quality longitudinal dataset where all births and deaths have been counted for many decades. One possible reason for difference could be differential implementation and effectiveness of schemes in different parts of the state. There were no controls in the study by the World Bank whereas the other two studies had concurrent controls. Our study used daughters-in-law from outside Haryana as control and Mazumdar et al. used a neighbouring state as a control. We used data up to 2010, which meant giving a longer time for programmes to show impact as compared to others. Increase in girl child registration to avail benefits is a positive fallout of these interventions, and this need not mean that greater numbers of girls are actually being born. Our study along with the above two studies also highlights the challenges in evaluating such schemes which include the lack of a control group, existing secular trends of development in the community with rapid changes in social structures and environment in the last decade, and absence of a database that includes beneficiary status. These methodological constraints prevent a clear attribution of the changes to such schemes.

Different versions of this scheme have been launched by many states without proper evaluation or learning from experience of this scheme. The conditionalities have been changed in some (adoption of family planning, removal of immunization etc.) without any clear rationale or justification (98). While these
point to a much wider political recognition of the problem, which is welcome, there needs to be more debate and involvement of community and other stakeholders in this movement. Ultimately, it can only be hoped that the problem of skewed sex ratio at birth in most states of India is a temporary situation created by an unholy combination of rapid socio-economic development fuelling a desire for small families, availability of technology and persistence of feudal way of thinking. While socio-economic development should in general be welcomed, and not opposed, technological development cannot be fully controlled or regulated in an environment of high demand. The way forward is to change the community mindset and reduce the demand. As the South Korean experience shows, the force of development would ultimately over time lead to a change in thinking about girl children (32). It should occur sooner in India as the government is vigorously promoting normative change to reduce son preference. Adoption of appropriate health related behaviour can be expedited by government intervention as has been seen in case of institutional deliveries. The rate of uptake of institutional deliveries has substantially increased in last decade primarily due to interventions which addressed both supply and demand side interventions (157).

Methodological issues

Strengths and limitations of the study

The main strength of the study was the use of good-quality longitudinal individual level data for two decades, which can only come from a fully functional HDSS. The other strengths include use of multiple indicators of SES; continuous prospective collection of data on mortality, cause of death and vaccination status; availability of information on major confounders such as socio-economic status, parental education, birth order and access to health facilities and year of birth in the analysis. The HDSS management is also the health care service provider to the community and enjoys a very good rapport with the community which also contributes to better availability and improved quality of data. For the study on NSE of vaccines, a sensitivity analysis was done to address different possible sources of bias plaguing similar analyses done previously. The study was also adequately powered to answer the research questions. Finally, the use of a comprehensive approach for evaluation of girl child schemes through multiple sources of information using a mixed methods approach makes this study unique.

The limitations of the data were the non-availability of wealth index information for about 10% of the households and for only one point in time (2009-10); the non-availability of information on other possible confounders that might influence child mortality, such as nutritional status, care seeking, receipt of vitamin A, etc.; and non-availability of beneficiary status of government schemes. Re-
peated polio elimination campaigns in India meant that the children have been exposed to repeated doses of polio vaccine which could have modified the NSE of vaccines, especially that of DTP. The qualitative component has been only exploratory in nature and could have been strengthened by more interviews.

Generalizability of this study’s findings

A study from a HDSS Site results is often questioned in terms of its generalizability to the rest of the country. There is no doubt that the study population is not representative of the rest of the country and the experiences shared here may not mirror that of the rest of the country. However, it is also true that in a diverse country like India, no study, unless done at a large nationally representative scale, is truly generalizable. It is not possible to carry out studies such as this at national level. As reported by Byass et al., data from counties can reflect national patterns and the issue of generalizability is often overstated (107). However, this does not pose any technical issue within the HDSS area.

It is clear that the mortality rates of the study population were much lower than the rest of rural India, including Haryana state, in the early 1990s but the differences have narrowed (158). The issues raised in our study are applicable to many parts of northern and western India, which are socio-demographically and culturally similar to the population of Ballabgarh. The strong male child preference is a common feature of whole of north and western India but is stronger in Haryana state, as reflected by its lowest sex ratio nationally. Sex-differential mortality occurs to some extent throughout the country and our findings may be similar or attenuated in other settings. Overall, high gender bias existed in states of Punjab, Rajasthan, Tamil Nadu, Gujarat, Haryana, Uttar Pradesh, Maharashtra and Madhya Pradesh (159). These states are distributed all over India and testify to it being a national problem. It is also clear from the NFHS data that girls in whole of India are at substantial disadvantage compared with girls in the wider global context.

The state of Haryana is one of the richest states in India but among the socially most backward. This is reflected in the absence of community level social movements or empowerment activities and lack of non-governmental organizations. The schemes of Haryana with some minor modifications are now being implemented in about 15 states of India and the results of this evaluation have implications for all of them. The implementing agencies and the problems plaguing such programmes are likely to be similar.
CONCLUSIONS AND RECOMMENDATIONS

Conclusions

• Discrimination against girl children is very strong in the study community. Supporting evidence is available to assume that this problem is common in the other states in northern India as well.

• Girl child discrimination has been traditionally seen in terms of higher child mortality rates for girls, especially after first month of life. Our study shows that this is now also seen in the first month of life. This difference among boys and girls is sufficiently large enough to derail India’s achievement of MDG 4.

• Pervasive prenatal sex determination followed by abortion of girl foetuses has resulted in a skewed sex ratio at birth and added an element of urgency to this issue.

• Higher socio-economic groups, who are usually the innovators for change in a community, are among the worst perpetrators of this discrimination. Increasing education and wealth have become tools for empowerment of women for fertility control through the use of prenatal sex selection.

• Higher girl child mortality after DTP vaccination seems to contribute partly to the excess girl child mortality seen in this population.

• The Conditional Cash Transfer based schemes being implemented by Government to improve the status of girl children have been ineffective in changing the mindset of the community. These are due to problems in their selection of beneficiaries, structuring and scale of benefits and conditionalities imposed for receiving benefits.

• Availability of longitudinal demographic surveillance data is very useful in answering many relevant public health questions including programme implementation.
Recommendations

- India needs to tackle gender differentials in child survival more aggressively. A multi-component approach is needed to succeed. This should include:
  
  - Universal access to basic services including health care: If all key services are available free and within easy reach, girls are more likely to get similar treatment as boys. This was seen in the study population in similar coverage for different immunizations, whereas in most parts of the country, coverage for girls is much lower. The services should include not only health but also education, water-supply and sanitation, housing etc.
  
  - Regulation of technology use: Technology is a double-edged sword and needs to be carefully regulated so that its advantages to the society outweigh its disadvantages. The technologies in question here are current and future sex-determination technologies.
  
  - Social mobilization: Communities and individuals must take responsibility for their health and not expect governments to do all. While programmes like Laadli or ABAD are perhaps needed in the short run to push society to change in the intended direction, they are not substitutes for social mobilization and in fact, as this study shows, will fail if the social context is not taken into account.
  
  - Schemes targeted at girls: The current schemes need to be improved in terms of their inclusiveness but it should be remembered that these are short-term measures to accelerate changes while more long-term measures like universal access and social mobilization are being implemented.
  
  - Vaccines have played an important role in reducing child mortality. While burden of disease, effectiveness and cost of vaccine considerations drive the decisions on inclusion of a vaccine in national immunization schedules, it is important that non-specific effects of vaccine are also studied during vaccine trials and their consequences considered during the cost-benefit calculations.
  
  - Governments incur a lot of expenditure on social schemes. There is a strong case for evaluating their public programmes so that the resources are wisely spent. This should include investment in HDSS sites so that they can collect wide-ranging information and also add depth to the results.
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