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Gender based within-household inequality in immunization status of children: some evidence from South Asian countries

Ashish Singh
Indian Institute of Technology Bombay, India

Abstract

Using households with a pair of male-female siblings from DHS surveys, this paper estimates gender based within-household inequality in immunization status of children (aged 1-5 years) from Bangladesh, India, Nepal and Pakistan. I find substantial level of gender based within-household inequality in immunization status (with large inter-country variations) in the countries studied. Further, I estimate household fixed-effects models for immunization status and find significant difference between the immunization status of male and female children (with female children at a disadvantaged position) in India and Nepal.

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Contact: Ashish Singh - singhmb.ashish@gmail.com.
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1. Introduction

Pronounced male bias exists and boys and girls within the same household are not treated in an egalitarian manner in most of the countries of South Asia (Holmes, 2006), where sons are preferred over daughters for a number of economic, social and religious reasons including old age security, property inheritance, marriage costs and dowry, family lineage, social prestige, religious rituals and beliefs about religious duties (Agrahari and Singh, 2009; The World Bank, 2001). There is compelling evidence of boys being preferred over girls in South Asian countries when it comes to providence for basic necessities like preventive health care and nutrition, which results in gender based inequality among children in these necessities (Basu, 1989; Borooah, 2004; Chen et al., 1981; Das Gupta, 1987; Gangadharan and Maitra, 2000; Griffiths *et al*., 2002; Holmes, 2006; Kishor, 1993; Kurz and Johnson-Welch, 1997; Mishra *et al*., 2004; Pande, 2003; Sen, 1988; Singh, Hazra and Ram, 2008; Masud and Farooq, 2012; Singh, 2013; Ahuja *et al*., 2014; Prusty and Kumar, 2014; Rammohan *et al*., 2014). Past studies have also associated the phenomenon of daughters receiving less health care than sons to the patriarchal nature of these societies which leads to differential social evaluation of sons and daughters (Basu, 1989).

The role of gender becomes even more important, if seen in the light that the discrimination due to gender takes place within the household (in addition to outside of house) unlike other factors, for example religion which results in discrimination outside the house. I searched for studies which could provide some evidence on the contribution of gender based within-household inequality to the total inequality in immunization and nutrition among children of South Asian countries, but to the best of my search I could not find even a single study which has estimated this contribution for South Asian countries.

Immunization status is an indicator of preventive health care received by children and its absence can be linked to increased mortality risks and functional impairments in adulthood. Vaccine-preventable diseases are responsible for nearly 20% of the 8.8 million deaths occurring annually among children under five years of age. An estimated 23 million children under the age of one were not vaccinated in 2009; seventy per cent of these children live in ten countries, two of which are India and Pakistan, countries from South Asia (The WHO, 2011). Immunization status is also an indicator of progress towards the child health targets established under the Millennium Development Goals (Chowdhury et al., 2003). Moreover, reducing child mortality and achieving the millennium development goal for child survival depends on whether effective and sustainable interventions (including immunization) can be delivered to high proportions of children and mothers (Bryce et al., 2003; Halder and Kabir, 2008).

Given the importance of immunizations in a child's life and the lack of evidence on gender based within household inequality in immunization status of children, I in this paper, estimate gender based within-household inequality in immunization status of children (below five years of age) belonging to four South Asian countries. The South Asian countries included in this study are Bangladesh, India, Nepal, and Pakistan. Immunization status is chosen because it is an indicator of preventive care received by children and its absence can be linked to increased mortality risks and functional impairments in adulthood. Simple but innovative inequality decomposition techniques have been used to carry out the decomposition of overall inequality in immunization status of children into within households and between households components (for each country separately).

The paper is organized as follows. Section 2 discusses the details of the preventive immunizations which the children receive against various vaccine preventable diseases. The section also compares the condition of Bangladesh, India, Nepal and Pakistan in terms of the immunizations received by the children. Section 3 describes the datasets used in the estimation as well as the analysis plan adopted in this paper. Section 4 presents the descriptive statistics and the main findings of this study. Section 5 provides some discussion on the results and the conclusion.

2. Immunization Status

The outcome of interest in the present study is immunization status of children aged twelve months to five years. A child requires at least nine months to receive immunizations for the six vaccine-preventable diseases (namely, tuberculosis, diphtheria, whooping cough, tetanus, polio, and measles). BCG (for tuberculosis) should be given at birth or at first clinical contact, DPT (for diphtheria, whooping cough and tetanus) and Polio require three dosages at approximately four, eight and twelve weeks of age, and measles should be given at or soon after reaching nine months of age (IIPS & ORCMacro, 2007). The Demographic and Health Surveys (DHS) which are conducted in many countries collect information on the immunizations received by all the children (of the households covered in the surveys) born in the five years preceding the surveys. In the case where a child has received all of the above mentioned dosages (totally eight), s/he is said to have received full immunization (Central Bureau of Statistics, 2004; Ahmed, 2010; Halder and Kabir, 2008; Singh, 2011a).

There are a few studies which document the immunization status of children in the South Asian countries. Singh (2011a) finds that in 2005-06, of the total Indian children in the age group of 1-5 years, only 44% had received full immunizations. The author also finds that among boys 45% were fully immunized whereas the same figure for girls was 43%. Similarly, for Pakistan, Ahmed (2010) reports that 47% of all the children in the age group 12-23 months (in 2006-07) had received all recommend vaccines. As in the case of India, in Pakistan also boys were more likely to be fully immunized than girls (50 verses 44). The situation in Bangladesh in terms of full immunization of children was better than both, India as well as Pakistan. As per Halder and Kabeer (2008), almost 73% of children in the age group 12-23 months in 2004 were fully immunized. The gender gap in full immunization (1%; boys 73.3% and girls 72.2%) in Bangladesh was also lower than that of India and Pakistan. As far as full immunization of children is concerned, Nepal lies in between India and Pakistan at one hand and Bangladesh at the other. The percentage of fully immunized children (aged 4 years or younger) was a little more than 59% for Nepal in the year 2003-04 (Central Bureau of Statistics, 2004). The gender gap in full immunization of children in Nepal was 5% (boys – 62%, girls – 57%), a figure comparable to Pakistan but higher than Bangladesh as well as India. Though, the studies discussed above provide details about the immunization status of children by their socio-economic characteristics (including gender), they fail to capture the gender based inequality in immunization status of children in general and gender based within-household inequality in immunization status in particular. This study therefore focuses on gender based within-household inequality in immunization status of children from South Asian countries and provides the first estimates and new insights on the same.

3. Data and Methodology

3.1. Data

The data for the present study comes from the country specific Demographic and Health Surveys (DHS). The details of the years of surveys are as follows: Bangladesh – 2006-07; India – 2005-06; Nepal – 2005-06; and Pakistan – 2006-07. The Demographic and Health Surveys (DHS) use standard model questionnaires designed for, and widely used in, developing countries (Measure DHS, 2006). They use stratified multi-stage sampling design. The surveys provide information on demographic and health parameters as well as data on various socioeconomic and program dimensions, which are critical for implementing the desired changes in demographic and health parameters of a country. To be specific, DHS provides information on reproductive history, family planning use, fertility preferences, antenatal care, postnatal care, breastfeeding and weaning practices, vaccination and health of children under the age of five, causes of death of children under age five etc.

The specified rounds of DHS have data on each of the eight dosages (against the six vaccine preventable diseases), that is, for every dosage, DHS have information whether a child (born in the five years preceding the survey) received that dosage or not. The immunizations received by the children are recorded only for those children who were alive at the time of survey. Using the information on the individual immunizations received by the children (1-5 years), I measure immunization status by immunization scores, which I compute based on the count of immunizations received by a child. The count includes three dosages each of DPT and Polio and one dosage each of BCG and Measles. For any country, the immunization scores of children range from 0 to 8. The immunization score will be 0 when a child has not received even a single dose of any of the above mentioned immunizations and it will be 8 when s/he has received all the 8 dosages of the specified immunizations.

For reasons already explained, the analysis is limited to children twelve months to five years. Since, the interest of the study lies in gender based within-household inequalities, the eligible sample comprises of those households which have at least one pair of male-female children. For India, the total numbers of households with at least one male-female pair of children were 3930 (eligible sample), of these there were 3653 households with exactly one male-female pair of children. These households which comprise of nearly 93 percent of the eligible sample are used in the analysis. Similar strategy has been adopted for Bangladesh, Nepal and Pakistan also. The samples included in the analysis for Bangladesh, Nepal and Pakistan comprise of 97% (eligible sample – 267 households), 95% (eligible sample – 417 households) and 88% (eligible sample – 845 households) of the eligible samples, respectively. The inclusion of households with exactly one male-female pair of children is done in order to meaningfully interpret the results.

3.2. Analysis Plan

To begin with, I analyze whether girls are discriminated against boys within households when it comes to providence for immunizations. To check for the existence of within household discrimination, I run a multiple linear regression model with household fixed effects for each of the countries included in the analysis. The immunization status (IS, measured by the immunization scores) of a child depends not only upon his/her personal characteristics (such as gender, birth order and age) but also on household characteristics which includes parental characteristics as well as other socio-economic characteristics of the household, that s/he resides in. Some of these household characteristics might be observed while the others may not. Use of household fixed effects makes it possible to control for all unobserved and observed household-level variables which are common to the children (for example, parental education) within a household. Formally the model can be written as:

$$IS_{ij} = \alpha + \beta Female_{ij} + \gamma Age_{ij} + \delta Age^2{}_{ij} + \lambda Birthorder_{ij} + H_j + \varepsilon_{ij} \quad (1)$$

where, i stands for the male (= 0) or female (= 1) child within the household and j stands for the household. "*Female*" stands for the dummy for the sex (male as reference) of the child; "*Age*" and "*Birth order*" for age (in months) and birth order of the child respectively; and "*H*" stands for household fixed effects. In this analysis all the household-level variables that are invariant across children (H) will automatically drop out. Similar kind of modeling (in different contexts) is used in past studies (Chudgar, 2011; Motiram and Osberg, 2010; Singh, 2011b).

As, the primary objective of this study is to estimate the extent of gender based within-household inequality in immunization status of children, I use a simple but innovative technique whose basic intuition lies in the fact that the difference between the immunization status (measured by the immunization scores) of boys and girls (within a household) can be due to gender, birth order or age. This is so, because all the other factors like parental education are same for both the children within a household. Once the immunization scores are corrected for birth order and age, the sole difference in the corrected immunization scores of the children within a household can be attributed to their gender. If the overall inequality in the corrected immunization scores is now decomposed into within household and between household components, the within household component can be safely attributed to gender based within-household inequality in immunization status. A ratio of within household inequality to the overall inequality will give the contribution of gender based inequality to the total inequality.

To correct (or control) the immunization scores for age and birth order of children, I regress the actual observed immunization scores on age (and age squared) and birth order of the children and take the residuals from this regression. This variable represents the immunization score of children of an "average" age and an "average" birth order. The corrected immunization score is then used in the inequality decomposition exercise. The exact mechanism for carrying out the decomposition is as follows:[1]

The decomposition of overall inequality in immunization status into gender based within household (within-household) and between household (inter-household) components is carried out separately for Bangladesh, India, Nepal and Pakistan. For ease of explanation, consider the case of India. The total sample is partitioned into groups based on households. That is, each household is considered as a group in itself. So, there are totally 3653 groups (as there are 3653 households). Each group (household) contains the immunization scores (corrected) of the male-female pair of children present in the group (household). With such a partitioning, the difference in the immunization scores within a group (household) can be considered as the result of difference in the gender of the children in the household. The overall inequality in immunization scores is now decomposed into within-group (within-household) and between-group (between-household) components. The resulting within-group component in this decomposition is nothing but the gender based within-household inequality in immunization scores (or immunization status).

The overall inequality in immunization scores is decomposed into the above mentioned components using mean log deviation as the inequality measure (for similar decompositions, see,

[1] Since the residuals obtained from the regressions used for correcting the immunization scores for age and birth order are centered around zero, constants have been added to the residuals for each country, so that the corrected immunization scores match the actual series. The constants have been added in such a way, that the minimum value of the corrected immunization scores for each country is slightly greater than zero. For example, in the case of Bangladesh, the minimum value of the residuals obtained from the regression was -7.333, so we added a constant 7.34 to each of the residuals to obtain the final corrected immunization scores. Details are provided in the section on results. This helps in computation also, as mean log deviation (inequality measure) which is used for carrying out the decomposition cannot be applied in the case of negative or zero values.

e.g., Checchi and Peragine, 2010; Singh, 2010; Singh, 2011b). Mean log deviation (MLD) is additively decomposable and can be decomposed meaningfully into two components; first being the within-group component which is nothing but a weighted average of subgroup inequality values and second being the between-group component, representing the level of inequality obtained by replacing the immunization scores of each child with the mean immunization score of his/her respective group (household mean). MLD is also a path independent measure. If the interest is in obtaining the within-group component, it can be obtained in two ways. First, replace the individual immunization score of each child with the product of individual immunization score and the ratio of overall mean immunization score to mean immunization score of his/her group. This operation will suppress all between-group inequality (as the mean of all the groups will be same now and equal to the sample mean), leaving only inequality within groups. If MLD is now applied on this "standardized" distribution, it will give the within-group component directly.

Instead, if the immunization score of each child in every group is replaced with the group-specific mean, then all the within-group inequality will be eliminated, and the resulting "smoothed" distribution will have only the between-group component (as the group means are different). The within-group component can now be obtained (indirectly) from subtracting the inequality in above "smoothed" distribution from the overall inequality in the actual distribution. If the within-group component obtained from the above two processes is same, then the inequality measure is said to be path independent.

In addition, MLD also satisfies the four basic properties (anonymity or symmetry; population replication or replication invariance; mean independence or scale invariance; and Pigou-Dalton principle of transfers) applied to inequality measures. It is worth noting that it is the only inequality measure which satisfies the above six properties (four basic properties and the properties of subgroup additive decomposability and path independence). The literature on inequality measures and the above properties is fairly developed and the details can be referred from the past studies (e.g., see Shorrocks, 1980; Foster and Shneyerov, 1999, 2000; Shorrocks and Wan, 2005; Ferreira and Gignoux, 2008).[2]

4. Results

Table 1 presents the mean immunization scores for boys and girls for the four countries covered in this study. The mean immunization scores of both, boys as well as girls are highest for Bangladesh. The lowest mean immunization scores for both, boys and girls are observed in the case of India. For all the four countries under study, the mean immunization scores of boys are more than girls. However, the difference between the mean immunization scores for boys and girls is only marginal.

To investigate whether girls are discriminated against boys within households, I estimated a multiple linear regression model with household fixed-effects for each of the four countries. Results (Table 2) reveal that in India and Nepal, the immunization scores of girls are significantly lower than those of boys (at 1% level of significance). Though the coefficient of variable "Female" was negative for Bangladesh as well as Pakistan, it is statistically not significant showing that there is no significant difference between the immunization scores for girls and boys (within the households) in Bangladesh and Pakistan.

[2] The form of MLD and the exact decomposition procedure have been provided in Appendix I.

Table 1: Descriptive statistics: Immunization scores of children by gender (Bangladesh, India, Nepal and Pakistan)

Country	Boys	Girls	All
Bangladesh	7.13	6.89	7.01
	2.06	2.41	2.24
	258	258	516
India	5.92	5.81	5.87
	2.59	2.64	2.62
	3653	3653	7306
Nepal	7.06	6.77	6.92
	2.17	2.38	2.29
	398	398	796
Pakistan	6.05	5.96	6.01
	2.51	2.60	2.55
	740	740	1480

Notes: First row – mean; second row – standard deviation; third row – number of observations.
Source: Author calculations based upon DHS.

Table 2. Ordinary least square estimates (95% confidence intervals) of multiple linear regression models of the dependent variable "Immunization status" with household fixed effects.

	Bangladesh	India	Nepal	Pakistan
Female	-0.214	-0.123***	-0.291***	-0.095
	(0.147)	(0.028)	(0.073)	(0.058)
Birth order[1]	0.600	-0.130	-0.006	0.100
	(0.490)	(0.083)	(0.188)	(0.169)
Age (in months)	-0.009	0.019**	-0.001	0.034**
	(0.047)	(0.008)	(0.020)	(0.015)
Square of Age	0.000	0.0002***	0.000	0.0004**
	(0.001)	(0.000)	(0.000)	(0.000)
Constant	5.548**	6.144***	7.422***	5.134
	(2.179)	(0.361)	(0.810)	(0.956)
N	516	7306	796	1480
Mean birth order	2.88	2.78	2.96	3.96
Mean age (months)	35.86	35.59	36.22	35.66

Notes: 1. ***Significant at the 1 percent level; **Significant at the 5 percent level; *Significant at the 10 percent level.
2. Figures in parenthesis are robust standard errors.
Source: Author calculations based upon DHS.

Table 3 documents the results of the decomposition of the overall inequality in immunization status of children into the within-household inequality and between-household inequality components. An important caveat in interpreting the results in Table 3 is that, as I have applied MLD which is a relative index (homogeneous of degree zero) and which is not a translation invariant measure on translated Immunization Scores (scores corrected for birth order and age), the estimates of overall inequalities are likely to be underestimates of actual inequalities. It may be noted from the table that, among the South Asian countries included in the analysis, Nepal has the least inequality in immunization status of the children. It is followed by Bangladesh and India. Whereas, Pakistan has the highest overall inequality in immunization status of children among the countries considered in the analysis.

Table 3. Gender based within-household inequality in immunization status: MLD estimates (Bangladesh, India, Nepal, and Pakistan)

Inequality → Countries ↓	Total Inequality (TI) (1)	Within-Household Inequality (WHI) (2)	Between-Household Inequality (BHI) (3)	WHI/TI (4) = (2)/(1)
Bangladesh	0.150	0.074	0.076	0.491
India	0.155	0.028	0.126	0.184
Nepal	0.111	0.020	0.091	0.179
Pakistan	0.167	0.033	0.134	0.199

Notes: 1. Inequality has been estimated on Immunization status corrected for age and birth order of children. That is, the residuals from the following regressions:

(a) Bangladesh: Immunization score = 8.0900 – 0.1973 Birth order - 0.0150Age – 0.0001Age squared.

Since the residuals are centered around zero (with a minimum value of -7.333), they have been added a constant (7.34) in order to match the actual series.

(b) India: Immunization score = 7.2940 – 0.4168 Birth order + 0.0032Age – 0.0001Age squared.

Since the residuals are centered around zero (with a minimum value of -6.686), they have been added a constant (6.69) in order to match the actual series.

(c) Nepal: Immunization score = 7.7372 – 0.2731 Birth order + 0.0081Age – 0.0002Age squared.

Since the residuals are centered around zero (with a minimum value of -7.541), they have been added a constant (7.550) in order to match the actual series.

(d) Pakistan: Immunization score = 5.8655 – 0.1530 Birth order + 0.0510Age – 0.0007Age squared.

Since the residuals are centered around zero (with a minimum value of -6.592), they have been added a constant (6.600) in order to match the actual series.

Source: Author calculations based upon DHS.

Not only Nepal has the lowest levels of overall inequality in immunization status, but also has the least gender based within-household inequality in immunization status. It has the lowest gender based within-household inequality both in terms of absolute level (column (2)) and as a proportion of overall inequality (column (4)). In absolute terms, Bangladesh has the maximum gender based within-household inequality in immunization status of children, whereas, India and Pakistan are placed in between Nepal and Bangladesh as far as the absolute levels of gender based within-household inequality in immunization status of children is concerned.

Findings further reveal that Bangladesh also has the maximum within-household inequality in immunization status of children when measured as a proportion of total inequality in immunization status. Almost half of the total inequality in immunization status among Bangladeshi children is contributed by gender based within-household component. Nepal has the lowest contribution of within-household component (17.9%) to the overall or total inequality in immunization status of children. India and Pakistan are close to Nepal in terms of the contribution of the gender based within-household component to the total inequality in immunization status of children (India – 18.4% and Pakistan – 19.9%). These results have been further discussed in the following section which also concludes the present study.

5. Discussion and Conclusion

This study provides the first estimates of gender based within-household inequality in immunization status of children for the specified countries, both in absolute terms as well as, as a proportion of total inequality in immunization status. The study also tests the existence of gender based within-household difference (or discrimination) in immunization status of children in these countries using household fixed effects models.

Though the results have already been presented in previous section, some of them need to be further discussed. The first being the findings related to the immunization status of children in Bangladesh. Among all the countries considered, Bangladesh has the highest mean immunization scores for both girls as well as boys. Household fixed-effects analysis also shows that there is no significant difference between the immunization scores of girls and boys within the households. However, the gender based within-household inequality is highest for Bangladesh. It may sound surprising but it should be seen in the light of the fact that gender based within-household inequality captures the overall gender based inequality in the immunization scores of children within households and all the households where the immunization scores of boys are greater than that of girls or the households where the immunization scores of girls are greater than that of boys will contribute to it. It also depends on the extent of the difference between the immunization scores of the children (child of any gender can have the higher immunization score) within the households. Even if in the overall sample there is no systematic difference between the immunization scores of the children of the two genders within households (that is, the immunization scores of children of a particular gender are not systematically higher than the immunization scores of children of the other gender), the gender based within-household inequality component will be high if the difference between the immunization scores of the children within households (with some households having immunization scores of boys higher than girls and some households having immunization scores of girls higher than boys) is large. To check this, for each specified country, I first calculated the difference between the immunization scores of the children for every household and then computed its mean. Indeed, I find that the average difference between the immunization scores of children within households is highest for Bangladesh (1.05). The same figure is lowest for Nepal (0.59) and the figures for India and Pakistan are close to that of Nepal.[3]

[3] I used the actual observed immunization scores and not the corrected ones for this calculation. The details can be provided upon request.

Another piece of finding which needs discussion relates to India; India, after the introduction of New Economic Policy in the 1990s, achieved unprecedented economic growth and made noteworthy advances in the fields of science, agriculture, medicine and information technology (CSNSI, 2008; Pathak and Singh, 2011). Despite such an unprecedented growth and development, the immunization status of Indian children seems far from satisfactory. Among the South Asian countries analyzed in the present study, India has the lowest mean immunization scores for both, boys as well as girls. India also has significant gender difference in the immunization status of children within the households, with the immunization scores of girls being significantly lower than that of boys. Findings of the present study if seen in the light of earlier studies, for example Singh (2011a), which finds that more than 50% of the Indian children in the age group 1-5 years are not immunized fully (44% are fully immunized; figure lower than the corresponding figures for Pakistan, Nepal and Bangladesh) call for two major initiatives on the part of Indian policy makers. First, to increase the focus on full immunization and second to sensitize the Indian populace on the need to give equal importance to girl child as compared to boys when it comes to immunization against the six vaccine preventable diseases.[4]

United Nations Millennium Development Goal (MDG) four "Reduce Child Mortality" aims to reduce under-five mortality by two thirds by 2015. As the vaccine-preventable diseases are responsible for nearly 20% of the 8.8 million deaths occurring annually among children under five years of age, immunization can significantly contribute to achieving this goal (The WHO, 2011). Further, immunization is one of the most successful and cost-effective public health investments, it saves countless lives and is responsible for averting between two and three million deaths each year. Moreover, immunization leads to significant economic benefits as it protects individuals not only against getting an illness but also against the long-term effects of that illness on their physical, emotional and cognitive development. When children grow up healthier, they do better in school and are more productive as adults (The WHO, 2011). Therefore, it is critical that governments place investing in immunization high on their national health agendas. Lessons can also be learnt from the measles campaign (in 2006) of Bangladesh where 33.5 million children between the ages of nine months and 10 years were vaccinated against measles, over a 20-day period (The UN, 2010).

Since in most of the South Asian countries boys are preferred over girls when it comes to provision for health care which includes immunization, the achievement of the above mentioned MDG by the countries of South Asian region will depend on whether the Governments of these countries are able to create an atmosphere where parents pay equal attention to immunization of both, boys as well as girls. As, the studies on South Asian countries (Ahmad et al., 1999; Khan et al., 2006; Prinja et al., 2010) in past have shown that the effectiveness of immunization programmes can be increased through strengthening of health systems, better planning and management, enhancing political commitment, and mass campaigns raising the awareness among the masses; it is high time, Governments of the specified South Asian countries integrate their child immunization initiatives to the various health care programmes and campaigns on health related issues in their respective countries.

As explained in the results section, the estimates of total inequalities presented in this paper are likely to be the underestimates of actual total inequalities and should be taken as

[4] In the past decade, Government of India has paid increased attention to Polio Eradication programme. It has extensively used print and mass media along with the mobilization of various governmental resources to increase the awareness about immunization against polio. Similar kind of drive is needed for ensuring that each child irrespective of her/his gender receives full set of immunizations.

conservative estimates of total inequalities. In one sense this can be taken as a limitation of the paper but in another sense it can be thought of that, since the estimates presented are very conservative estimates of the existence of an undesirable (and an unacceptable) phenomenon, the severity of the problem is even higher and has to be taken even more seriously.

Last but not the least, it is important to discuss how the research agenda presented in this paper (and the findings) can be taken forward. First and foremost, it needs to be investigated in the context of Bangladesh that despite having the highest mean immunization scores for both girls as well as boys (compared to the other South Asian countries studied) and no significant difference between the immunization scores of girls and boys within the households, why gender based within-household inequality is still highest for Bangladesh. That is, why the households do not provide full immunization to all the children within the household. In other terms, why they provide full immunization to one child and not the other? Second, as the mean immunization scores of children is low in India and Pakistan, impact assessment of the various programs launched by the Indian and Pakistan governments to promote full immunization needs to be done and the feedback then can be provided to the relevant agencies for modification of the programs. Finally, more qualitative research needs to be carried out to find out why gender based discrimination in immunizations is so persistent in India (and to some extent in Nepal).

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Appendix I. MLD and the decomposition process

The decomposition procedure used for decomposing the overall inequality in immunization status into within-households and between-households (within-groups and between groups; each household is taken as a group) components is as follows:

Let the mean log deviation (MLD) be represented by *M*, and suppose that the children, *N*, are partitioned into *m* proper subgroups N_k ($k = 1,2, \ldots, m$) based on their household, with respective immunization score vectors y^k, mean immunization score μ_k, population sizes n_k, and population shares $v_k = \frac{n_k}{n}$. Also, let $\bar{y}^k$, denote the distribution obtained by replacing each immunization score in the vector y^k with the subgroup mean, μ_k. Then (following Shorrocks and Wan, 2005),

$$M(y) = M(y^1, y^2, \ldots, y^m) = \frac{1}{n}\sum_{k=1}^{m}\sum_{i \in N_k} \ln \frac{\mu}{y_i}$$

$$= \sum_{k=1}^{m} \frac{n_k}{n}\frac{1}{n_k}\sum\nolimits_{i \in N_k} \ln\frac{\mu_k}{y_i} + \frac{1}{n}\sum_{k=1}^{m}\sum\nolimits_{i \in N_k} \ln \frac{\mu}{\mu_k}$$

$$= \sum_{k=1}^{m} v_k M(y^k) + \sum_{k=1}^{m} v_k \ln\frac{\mu}{\mu_k}$$

$$= W + B$$

where, *W* is the within-group (within-household) inequality and *B* represents the between-group component. *W* is nothing but a weighted average of subgroup inequality values and *B* is the between-group contribution to inequality, representing the level of inequality obtained by replacing the immunization score of each child with the mean immunization status of his/her respective subgroup (household).