CHAPTER FOUR

MEASUREMENT OF INTER-GROUP INEQUALITIES IN HEALTH:
EVIDENCE ON UNDERWEIGHT CHILDREN IN INDIA

'Above all, on humanitarian grounds national health policies designed for an entire population cannot claim to be concerned about the health of all the people if the heavier burden of ill health carried by the most vulnerable sections of society is not addressed. The bias against these social groups in the provision of health care [also] offends many people’s sense of fairness and justice once they learn of its existence.'

- Margaret Whitehead, 1990

4.1. INTRODUCTION

The need to develop group perspective as an area for more comprehensive investigation was earlier discussed by Sudhir Anand and Amartya Sen (1995) in their seminal contribution to the Human Development Reports, where they construct an index of social achievement that accounts both for mean absolute achievement and relative equality. Certainly, health deprivations are always noted to be more acute among certain population groups than others. An approval of this account can be observed in the form of analysis of group deprivation where groups are classified on the basis of age, sex, income, education, place of residence and so on. Most of the available studies on group deprivations tend to organise groups across a single dimension with little appreciation of the fact that health disadvantages gets intensified manifold because of multiple vulnerabilities associated with an individual. For example, health failures among a group of individuals who are poor, illiterate and disadvantaged in terms of place of residence, caste or gender can be much larger then group of individuals disadvantaged across any single dimension. The measurement of group inequality, therefore, can be enhanced by analysing groups formulated as a combination of multiple characteristics/identities. Incorporation of such concerns into the measurement exercise would not only help us to discern the characteristics/identities that are linked with health adversity/privilege, but also informs us on the extent to which the aggregate levels of deprivation masks the observed disparity across groups. Therefore, following the
analysis of inter-individual inequalities in the previous chapter, here we continue with the analysis of inequalities but with a focus on inter-group differences.

4.2. METHODS: ASSESSMENT OF INTER-GROUP HEALTH INEQUALITIES

This chapter advances an important technique to examine inter-group inequalities in health. The results presented here begin with some preliminary analysis regarding inter-group disparities where population is classified into two groups based on gender and place of residence. This descriptive analysis is based on the formulation suggested by Jayraj and Subramanian (2002) for measuring group disparities in the form of an index of relative disadvantage (RDI, see Appendix 4A). This measure employs the deviation from an ideal situation, which says that the population subgroup share should be equal to the share in health outcome vulnerability. From an analytical viewpoint, these subgroups could be conceived of in terms of aggregation of individuals with similar socio-economic status or any other grouping criterion. The RDI displays the relative disadvantage of a specific group with regard to any outcome. RDI follows the popular notion of equity in relative terms and defines a state of zero relative deprivation (neither advantaged nor disadvantaged) if the contribution of a group, say ‘i’, in overall health deprivation is equal to its population share. Group ‘i’ is interpreted to be relatively advantaged if the contribution of group ‘i’ in overall health deprivation is less than its population share and relatively disadvantaged if the contribution is more than its population share. The relative disadvantage index (RDI), can be computed by using the expression (4.1);

\[
RDI = \begin{cases} 
\left( \frac{\theta_i}{1-\theta_i} \right) \frac{U_i - 1}{U} & \forall \theta_i \geq U \\
\left( \frac{U - U_i}{1 - U_i} \right) & \forall \theta_i < U 
\end{cases}
\]

where, \( i \) denotes the number of groups (ranging from \( i=1,2,\ldots,k \)); \( \theta_i \) is the share of group \( i \) in the total population; \( U \) is the aggregate headcount ratio of underweight children and; \( U_i \) is the average underweight outcome of group \( i \). In case of ill health variables, a group is said to be relatively disadvantaged whenever RDI value is positive and is relatively advantaged whenever RDI is negative.
The preliminary discussion on inter-group differentials is further facilitated by providing a common measure of group disparity as discussed in Pande and Yazbeck (2003). Specifically, gender (spatial) differentials as a simple ratio of average health (or ill-health) for boys and girls (urban and rural), multiplied by 100. Thus, a value of 100 implies no gender or spatial differential in the given health indicator while a value above 100 indicates that there is a female or rural disadvantage.

In order to assess inter-group inequalities in health two - distinct but inter-related - methods are explored. These methods obtain a group-analogue of Gini coefficient and thereafter this measure is used for adjusting the average level of health deprivations. The first method is adapted from Subramanian (2009) that accounts for intergroup differentials by means of a graphical device called the group poverty profile, initially discussed by Shorrocks (1995). It is useful to note that this method for adjustment is based on a ‘Gini-type descriptive’ index of dispersion. In general, there are K (≥2) exclusive and exhaustive subgroups or j(j= 1, ..., K) and information is required on \( U_j \), the underweight prevalence level of the \( i^{th} \) group, with groups indexed in non-increasing order of deprivation (\( U_j \geq U_{j+1}, j = 1, ..., K - 1 \)). \( U \) is the headcount ratio or overall (unadjusted) measure of underweight prevalence and is decomposable; i.e., it can be written as the population-share \( (t_k) \) weighted average of the group-specific underweight prevalence.

\[
U = \sum_{j=1}^{k} t_j U_j
\]

(4.2)

It could be easily verified that if all the groups are of the same size then the subgroup underweight outcomes \( U_j \) are accorded the same weight \((1/k)\). In order to develop a group inequality index it is important to devise a weighing procedure wherein subgroups with higher health deprivation are accorded higher weights. Further, let \( T_j \) be the cumulative proportion of population who belong to groups whose nutritional deprivation levels are greater than or equal to the \( j^{th} \) group’s deprivation level. The GUP can be constructed by first arranging the group specific underweight outcomes \( U_j \) in non-increasing order. Thereafter, the population share weighted underweight levels can be cumulated across the subgroups and plotted against the cumulative population shares of the subgroups. Formally, GUP could be written as a plot of points \( \{(T_j, D_j)\}_{j=0,1,\ldots,k} \) where \( T_0 = D_0 = 0 \) and for every \( (j = 1, ..., K) \);
(4.3) \[ D_j(U, T_j) = \sum_{k=1}^{j} t_k U_k \]

Now in the GUP, the diagonal of the unit square can be defined as the line of maximal undernutrition; i.e., the worst case scenario when \( U_j = 1 \), for all \( j \). When GUP is plotted a non-decreasing concave curve is obtained which lies beneath the diagonal of the unit square. It must also be noted that the final point \((T_k, D_k)\) on GUP will be \( U \). Following Subramanian (2009), figure 4.1 presents a typical GUP for a case where \( k=4 \). From the figure it could be revealed that when \( U_j = U \), for all \( j \) then the GUP would be the straight black coloured line connecting the points 0 and \( U \). The actual GUP generally lies above this line (as represented by the piece-wise curve) and an inverted image of GUP could be devised into a measure of group inequality analogous to the familiar Lorenz curve.

**Figure 4.1: Group Undernutrition Profile (GUP)**

As illustrated by Subramanian (2009), now the group undernutrition Lorenz profile (GULP) can be obtained by first ranking the groups in non-decreasing order of their undernutrition levels, and then plotting the cumulative subgroup shares in total undernutrition (on y-axis) against their cumulative population shares (on x-axis).
Figure 4.2, illustrates a typical GULP within the unit square for a special case in which k=4. Formally, GULP could be written as a plot of points \([(1-T_{K+Lj})_{j=0,1,...,K}]\), where \(T_0 = L_0 = 0\) and for every \((j=1, ..., K)\);

\[
(4.4) \quad L_j(U,1-T_{K-1}) = \frac{1}{U} \sum_{k=K-j+1}^{K} t_k U_k
\]

Subramanian (2009) further observes that the GUP and GULP are related and - like Gini coefficient of inequality - a normalized measure of aggregate undernutritional deprivation could be obtained by expressing area beneath the GUP as a proportion of the area beneath the line of maximal undernutrition. Thus arrived measure of aggregate undernutrition is provided by the following expression \(U^*\);

\[
(4.5) \quad U^* = U(1 + G)
\]

where, \(G = 1 + \frac{\sum_{j=1}^{K} t_j^2 U_j - 2 \sum_{j=1}^{K} t_j T_j U_j}{U}

\]

Figure 4.2: Group Undernutrition Lorenz Profile (GULP)
Clearly, U* enhances the average aggregate nutritional deprivation by a factor G that captures the extent of inequality in the inter-group distribution of undernutrition. This chapter uses the expression U* to provide an estimate of group inequality adjusted underweight outcomes in India and its states.

It is discernible that the Gini coefficient of inter-group inequality (G) can be revised such that it satisfies the perfect complementarity axiom as discussed in Chapter 3. The revised Gini coefficient will obtain same values irrespective of inter-group inequality, irrespective of the fact whether one chooses indicators in terms of attainment or shortfall. The revised Gini coefficient of inter-group inequality, G*, can be obtained as follows;

\[
G^* = \frac{4\mu_a}{(b_a - d_a)} G(a) = \frac{4\mu_s}{(b_s - d_s)} G(s)
\]

where, G is the revised Gini coefficient for inter-group inequality; G(a) and G(s) is the Gini coefficient for inter-group attainment and shortfall inequality, respectively, obtained through the group health Lorenz profile; b and d are the respective upper and lower bounds of the health attainment and shortfall variable; and \(\mu\) is the mean of the health attainment and shortfall variable.

Following this procedure, yet another group inequality adjustment procedure suggested by Subramanian and Majumdar (2002) is adopted for empirical illustration. Similar to the previous approach, this method also advances a procedure for 'adjusting' a real valued index of deprivation in such a way that the resulting measure is a summary statistic of both the average level of deprivation and the extent of inequality obtained in its distribution. The 'adjusted' index of deprivation is governed by four important axiomatic properties. First, it satisfies the axiom of linearity between mean level of deprivation and inequality. Second, it meets the normalization condition implying that adjusted index of deprivation coincides with the mean deprivation level when deprivation is distributed equally among the population groups. Third, it responds to weak subgroup consistency demanding that, other things being equal, if deprivation in any subgroup increases, the value of the 'adjusted' deprivation index should not decline. Fourth, it provides increasing non-negative responsiveness to subgroup deprivation, which is to say that when the subgroup population shares are the same, a given increase in subgroup deprivation should
cause a greater increase in ‘adjusted’ deprivation the more deprived the subgroup is. The aggregate society wide index of ‘adjusted’ nutritional deprivation, \( U^*(\delta) \), (underweight outcomes) can be written in the following form (see Subramanian and Majumdar, 2002):

\[
U^*(\delta) = \left[ \frac{1}{(K-1)} \right] \sum_{i=1}^{K} [(K-1-\delta_i)t_i + \delta T_i] U_i
\]

In general, there are \( K (\geq 2) \) groups or \( i (i=1, \ldots, K) \) and we require information on, \( U_i \), the underweight prevalence level of the \( i \text{th} \) group, with groups indexed in non-increasing order of deprivation \( (U_i \geq U_{i+1}, i=1, \ldots, K-1) \). \( U \) is the overall (unadjusted) measure of underweight prevalence for the society as a whole and is decomposable, i.e., it can be written as the population-share \( (t_i) \) weighted average of the group specific underweight prevalence. \( T_i \) is the cumulative proportion of population who belong to groups whose nutritional deprivation levels are not higher than the \( i \text{th} \) group’s deprivation level. The index of ‘adjusted’ deprivation involves the process of adjusting the mean level of deprivation by a factor incorporating the extent of between-group disparity in the distribution of underweight outcomes. In this formulation, \( \delta [0,1] \) is used in the nature of an index of between-group disparity aversion, with aversion being an increasing function of \( \delta \). It could be noted that when \( \delta=0 \), we arrive at a sort of Benthamite (average) utilitarian rule and when \( \delta=1 \) we have a sort of Rawlsian (maximax) rule where the nutritional deprivation for the society as a whole is identified simply with the deprivation level of worse-off group. This chapter presents an application of this measure by employing the latter rule \( (\delta=1) \) which provides for the maximum level of between-group inequality aversion. It is useful, however, to note that Anand and Sen’s (1995) formulation measures between-group disparity in terms of ‘Atkinson (1970) type ethical’ indices of dispersion, whereas the formulations adopted here captures it in terms of a ‘Gini-type descriptive’ index of dispersion.

### 4.3. Results

The results and the discussion presented here are based on the analysis of the NFHS 2005-06 data on nutritional profile of children in India. Following the same procedures as adopted in chapter 3, a child is classified to be underweight if it falls two standard deviations (-2SD) below the median score for children of the same age.
and gender in the reference population. The results are further arranged under three subsections.

4.3.1. Relative Disadvantages across Spatial and Gender Dichotomy

In view of the wide acknowledgment that not all variations in the health status of the population could be interpreted and explained in terms of income, a preliminary account of health disadvantages that manifest along two other important domains are analysed. One of these is the larger issue of gender-based inequities, which can sometimes be independent of the income gradient. However, the other dimension of spatial location (rural-urban areas) of the individual – to some extent - does indirectly overlap with the income domain wherein an individual residing in a disadvantaged location bears a greater burden of ill health outcomes.

From Table 4.1 it could be discerned that around 46% of rural children are underweight compared with 33% of urban children (see columns ii and iii in Table 4.1). Across rural India, around 60% of the children in Madhya Pradesh, Jharkhand, and Bihar are underweight for their age. The urban areas of these states also possess larger nutritional deprivation. The states of Kerala and Punjab have the lowest prevalence of underweight both in rural and urban areas. Perhaps the best result is to observe that only 15% of the children in urban Kerala are underweight which reflects the quality of child health achievement particularly when compared with rest of the country. In terms of spatial differential scores for the indicator of underweight outcomes, almost all of the 18 largest states show some degree of inequality for rural children (see columns iv and v in Table 4.1). This finding is observed in terms of the differential score, which is consistently less than 100 for underweight outcomes (a bad health indicator). Thus, for example, in the state of Chhattisgarh a differential score of 63 for underweight implies that urban children are 37% less likely to be underweight than rural children. Surprisingly, the state of Kerala reflects the highest spatial differentials. Although, the overall prevalence of underweight is lower in both rural and urban areas but the higher differential score primarily arises due to the magnitude of difference across the two sectors. In contrast with Kerala, the states of West Bengal and Uttarakhand presents true picture of location disadvantage wherein the spatial differential are very high and are also accompanied by greater magnitude of differences in prevalence of underweight outcome.
In order to illustrate the relative disadvantages of location, a binary classifications of the child population by sector-of-origin or spatial location (as ‘rural’ and ‘urban’) is made, and RDI for the disadvantaged subgroup (namely, rural) in each pair of population group is computed. As mentioned earlier, if we consider all ill health variables, a group is interpreted as being relatively disadvantaged when RDI value is positive and relatively advantaged when RDI is negative. However, it must be noted that RDI values are not complementary between groups; rather it states the advantage or disadvantage of one group vis-à-vis the other. The RDI values for underweight outcomes for all the major Indian states as well as for all India are also reported (sees column v in Table 4.1). It can be observed that for all India the degree of disparities in underweight is 23%, thus confirming that rural children are at a greater disadvantage compared to their urban counterparts. Further, rural children in almost all the low-income states are facing higher relative disadvantages. For instance, Chhattisgarh obtains a RDI score of 52% suggesting greater divide across rural and urban areas and also greater disadvantage of the rural children. Although, the problem of child under-nourishment is less among the high-income states, such as Kerala, Punjab and Gujarat, but the degree of relative disadvantages engendered by location disparities are by no means insignificant.

Before presenting the results obtained across the gender dimension, it is essential to state that disparities along this divide may not be easily remedied through direct policy prescriptions as they require larger institutional and behavioural changes. Gender concerns vary across sociocultural settings and, therefore, its magnitude across different Indian states is expected to vary accordingly. Table 4.1. reveals that there are no larger sex-wise differences in the prevalence of nutritional deprivation, nonetheless, the prevalence is moderately higher among female children in the states of Northern and Eastern India. These differences though smaller but are still notable in the case of Punjab, Uttar Pradesh, Bihar, West Bengal and Orissa. In other parts of the country, the prevalence is marginally greater among the male children (see, for instance, the figures for Kerala, Tamil Nadu, and Gujarat). Overall, in most of the states girls are at disadvantage compared to boys. The picture does not seem to have improved a lot between NFHS-1 (see Pande and Yazbeck, 2003) and NFHS-3 as the gender differentials continues to be stronger in the northern states such as Uttar Pradesh, Punjab and even in backward states like Bihar and Madhya Pradesh. With the exception of Andhra Pradesh, girls in the other three southern states are better
placed. Even Gaudin and Yazbeck (2006) present similar conclusions regarding gender differentials from their analysis of NFHS-2 data.

Table 4.1. Spatial, gender differentials and relative disadvantages in underweight outcomes, India 2005-06

<table>
<thead>
<tr>
<th>States</th>
<th>Spatial</th>
<th>Gender</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>R(ii)</td>
<td>U(iii)</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>35</td>
<td>28</td>
</tr>
<tr>
<td>Assam</td>
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<tr>
<td>Bihar</td>
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</tr>
<tr>
<td>Chhattisgarh</td>
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<td>32</td>
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<tr>
<td>Gujarat</td>
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<td>39</td>
</tr>
<tr>
<td>Haryana</td>
<td>41</td>
<td>35</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>61</td>
<td>40</td>
</tr>
<tr>
<td>Karnataka</td>
<td>41</td>
<td>31</td>
</tr>
<tr>
<td>Kerala</td>
<td>26</td>
<td>15</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>63</td>
<td>51</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>42</td>
<td>31</td>
</tr>
<tr>
<td>Orissa</td>
<td>43</td>
<td>30</td>
</tr>
<tr>
<td>Punjab</td>
<td>27</td>
<td>21</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>43</td>
<td>31</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>33</td>
<td>27</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>44</td>
<td>35</td>
</tr>
<tr>
<td>Uttarakhand</td>
<td>42</td>
<td>24</td>
</tr>
<tr>
<td>West Bengal</td>
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</tr>
<tr>
<td>CV</td>
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</tr>
</tbody>
</table>

Source: Author, using NFHS 3, 2005-06
Note: M-Male, F-Female, R-Rural, U-Urban, SD-Spatial Differential, GD-Gender Differential

In addition, unlike the rural disadvantage which is consistent, the gender disadvantage for female children seems to be conditioned by the type of indicator in question. For objective indicators, like underweight, the disadvantage that female children have is consistent across the North Indian states of Uttar Pradesh, Punjab and Madhya Pradesh as well as with Jharkhand and Bihar in the East. But Joe et al (2010) note that such consistency is not observed in the case of other indicators that are subjective in the sense that they may suffer from bias in reporting – for instance
diarrhoea. Based on this observation they raise a hypothesis regarding the nature of bias in subjective vis-à-vis objective indicators.

4.3.2. Unadjusted and Group Inequality Adjusted Nutritional Deprivation

An Illustration Using Gini Coefficient of Group Inequality Adjustment

The above descriptive analysis identified place of residence and gender as two major factors that affect the nutritional status of children. Apart from these factors, several studies in the Indian context have highlighted caste-based disparities in nutritional health (see Thorat and Sadana 2009). This subsection unravels the magnitude of the problem that emerges by classifying children into groups on the basis of these three dimensions. To discern the magnitude of such burden across the major states of India, this group-based analysis cross-classifies the entire (sampled) child population children into eight mutually exclusive and completely exhaustive sub-groups; namely:

- Rural, Male, Scheduled Caste/Scheduled Tribe (RMSCST)
- Urban, Male, Scheduled Caste/Scheduled Tribe (UMSCST)
- Rural, Male, Others (RMO)
- Urban, Male, Others (UMO)
- Rural, Female, Scheduled Caste/Scheduled Tribe (RFSCST)
- Urban, Female, Scheduled Caste/Scheduled Tribe (UFSCST)
- Rural, Female, Others (RFO)
- Urban, Female, Others (UFO)

Alternatively, this analysis could also be seen as an illustration of the methodology of adjusting inter-group differences by means of a group-analogue of Gini coefficient proposed by Subramanian (2009).

The group-specific magnitude of child underweight prevalence, as measured by the simple headcount index is presented in Table 4.2. It is immediately discernible from the table that the magnitude of underweight outcomes across India is unacceptably high and there are large and systematic differences between population groups in the country, as a whole (see Figure 4.3) as well as across its states. The data reveals that the average underweight outcomes are relatively lower in states of Kerala (23
percent), Punjab (25 percent) and Tamil Nadu (29 percent), while in Madhya Pradesh (59 percent), Jharkhand (56 percent) and Bihar (56 percent) more than one-half of the under-five child population is found to be under-weight (see Table 4.2, column (x)). The nutritional deprivation according to the underweight criterion presents a wider range (Kerala to Madhya Pradesh) of 36 percent across the major states.

Figure 4.3. Group-specific prevalence of child underweight, India 2005-06

![Graph showing group-specific prevalence of child underweight, India 2005-06](image)

Source: Author, based on NFHS 2005-06
Note: R-Rural, U-Urban, F-Female, M-Male, SCST - Scheduled caste and Scheduled Tribes, O-Others

Evidently, the problem of nutritional failure is severe when the child belongs to a SC/ST category residing in rural area (RMSCST and RFSCST group). For all India, around 50 percent of the RMSCST and RFSCST children are observably underweight (Figure 4.3). All the states of India have similar and appalling levels of underweight children in these groups (see Table 4.2, column (ii) and (vi)). According to the adopted grouping criteria, Bihar, Madhya Pradesh, Jharkhand and Chhattisgarh have the highest proportion of underweight children (around 60 percent and more). Nutritional deprivation in this weakest group is by no means acceptable in states, which are denounced for failures in the field of health and education. One of the explanation for such fact stems from the evidence that most of the rural regions in the country are burdened with twin problems of privation and backwardness. This
not only restricts individual private incomes but also constrains effective healthcare service delivery and provision of other allied services (education) for child health. There are apparently several problems attached with delivery of child care services some of which have been briefly reviewed in chapter 2.

| Table 4.2. Group specific child underweight prevalence (in %), India, 2005-06 |
|-----------------|--------|---------|-------|---------|---------|---------|---------|---------|---------|
| States          | RMSCST | UMSCST | RMO   | UMO    | RFSCST  | UFSCT   | RFO     | UFO     | U       |
| (i)             | (ii)   | (iii)   | (iv)  | (v)    | (vi)    | (vii)   | (viii)  | (ix)    | (x)     |
| Andhra Pradesh  | 34     | 35      | 33    | 28     | 41      | 45      | 35      | 24      | 32      |
| Assam           | 47     | 23      | 33    | 24     | 42      | 32      | 39      | 27      | 36      |
| Bihar           | 70     | 68      | 52    | 48     | 68      | 62      | 57      | 44      | 56      |
| Chattisgarh     | 58     | 45      | 49    | 31     | 35      | 39      | 53      | 30      | 47      |
| Gujarat         | 44     | 57      | 50    | 39     | 44      | 30      | 47      | 36      | 44      |
| Haryana         | 49     | 37      | 39    | 36     | 51      | 38      | 36      | 33      | 40      |
| Jharkhand       | 71     | 64      | 61    | 38     | 55      | 44      | 60      | 37      | 56      |
| Karnataka       | 46     | 29      | 40    | 33     | 43      | 28      | 39      | 29      | 37      |
| Kerala          | 39     | 34      | 26    | 15     | 26      | 39      | 24      | 11      | 23      |
| Madhya Pradesh  | 64     | 45      | 62    | 49     | 73      | 54      | 60      | 53      | 59      |
| Maharashtra     | 45     | 39      | 38    | 29     | 51      | 22      | 39      | 29      | 36      |
| Orissa          | 41     | 37      | 41    | 27     | 49      | 51      | 42      | 27      | 40      |
| Punjab          | 36     | 25      | 19    | 17     | 36      | 37      | 18      | 19      | 25      |
| Rajasthan       | 50     | 43      | 41    | 30     | 48      | 27      | 40      | 29      | 40      |
| Tamil Nadu      | 41     | 49      | 31    | 22     | 34      | 39      | 26      | 23      | 29      |
| Uttar Pradesh   | 46     | 28      | 39    | 23     | 55      | 18      | 39      | 26      | 38      |
| Uttaranchal     | 48     | 32      | 41    | 33     | 50      | 43      | 43      | 35      | 42      |
| West Bengal     | 46     | 22      | 39    | 23     | 45      | 33      | 42      | 24      | 38      |
| All India       | 50     | 38      | 43    | 31     | 50      | 38      | 45      | 31      | 43      |

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<th>0.087</th>
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<th>0.098</th>
<th>0.06</th>
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</table>

Note: CV² - Squared Coefficient of Variation.
Source: Author's computation using NFHS 2005-06.

Yet another disquieting observation emerges in the form of underweight differentials observed along the gender divide. It is interesting to note that the pattern of gender differentials across rural SC/ST households varies across the
states. For example, in Andhra Pradesh, Haryana, Madhya Pradesh, Maharashtra, Orissa, Uttar Pradesh and Uttarakhand proportion of underweight children is higher among RFSCST group than compared to RMSCST group. But in states like Assam, Chhattisgarh, Jharkhand, Karnataka and Kerala the proportion underweight children is higher among RMSCST group than compared to RFSCST group. Although nothing definitive could be inferred from these results yet they are suggestive of considerable gender discrimination in the former set of states. States where the proportion of underweight outcomes among RFSCST and RMSCST is similar can also be considered to present minor disadvantages for the female children because biologically female children are less prone of undernourishment than males (Van de Poel and Niko 2009).

Further comparisons of groups reveal that children belonging to non-SC/ST households tend to have relatively better nutritional health irrespective of their place of residence or gender. This observation holds true not only for the country as a whole but for most of the major states of the Indian union. However, as evident from the table urban location demonstrates considerable advantage over rural place of residence. The UMO and UFO groups have an average underweight prevalence of 31 percent compared to 43 percent and 45 percent prevalence among RMO and RFO. Although, underweight outcomes are observed to be the lowest in these groups (UMO and UFO) that are advantaged in compared to other 6 groups but even by this criterion as well, around one-third of the children belonging are classified as underweight at the national level (see Table 4.2, column (v and ix)). In fact in states such as Madhya Pradesh, and Bihar, around 50 percent of the children belonging to these better-off groups are undernourished.

Furthermore, for all of India, the incidence differential between the most advantaged group (UMO) and the most disadvantaged (RFSCST) groups is 19%. Across states, the widest differential of 32 percent is observed for the state of Uttar Pradesh. Still on the pattern of differentials, we notice that all the states tend to have differences in the pattern of disadvantages across groups. For instance, by comparison of group differences based on the above classification Gujarat appears to be more equal but it is interesting to note that UFSCST in Gujarat has an underweight prevalence of 30 percent in comparison to 57 percent prevalence found in the group UMSCST. Likewise, in Kerala the largest differential of 28 percent is noticed between the groups UFO and RMSCST, with the former being at an advantage (see Table 4.2). To
gain insights into the acute sub-national welfare divisions, one has only to compare the lot of the UFO in Kerala with the RFSCST children in Madhya Pradesh; for the former subpopulation, the underweight prevalence at 11 percent exceeds that of the latter subpopulation at 73 percent, by over six and a half times. Another important thing is to note that as the average income of the state increases, the undernutrition levels declines, but the worst-off groups tend to gain lesser than compared with the best-off groups. To give a quick illustration, we can select a richer state such as Punjab and contrast its information with a poorer state such as Bihar. The ratio of the underweight prevalence for Bihar RFSCST to that for Punjab RFSCST is, at 187 percent, much lower than the ratio of the underweight prevalence for Bihar UMO to that for Punjab UMO, at 282 percent.

**Figure 4.4. Group underweight profile for Bihar, Punjab and All India, 2005-06**

So far this analysis makes it clear that the characters of these health disparities are not only inter-state in nature but also have significant intra-state dispersion. Indisputably, the impairments of *rural residence* or *SC/ST identity* or *female* pose its own disadvantages for nutritional status of the child, but the union of these three adversities poses even greater threats to child health. Given such stark group disparities, it is imperative to punish inter-group inequities as it can sensitize the average measure that otherwise is insensitive to the distribution of nutritional failure
across subgroups. For visualising inter-group inequalities we plot the group underweight profile (GUP) for Bihar, Punjab and India in figure 4.4.

The GUP is constructed by first arranging the group-specific underweight outcomes $U_j$ in non-increasing order. Thereafter, the population share weighted underweight outcomes are cumulated across the identified subgroups and plotted against the cumulative population shares of these subgroups. In each case the line without any markers represent the line of equality where each subgroup would share the average underweight level of the respective region. Thus in case of India if all the groups had an average underweight outcome of 43 percent then the GUP would coincide with the line of equality. But, in reality, we find that the distribution of underweight outcomes is unequally shared by various population subgroups. This fact is reflected by the GUP curve which lies above the line of equality and is represented by a line with markers. The area between the GUP and the line of equality if each group were to share the overall average deprivation expresses the extent of inequality in the distribution of underweight outcomes across groups. Since the actual GUP generally lies above the line of equality, therefore, an inverted image of GUP could be devised into a measure of group inequality analogous to the familiar Lorenz curve.

**Figure 4.5. Group underweight Lorenz profile for Bihar, Punjab and All India, 2005-06**

*Source: Author, based on NFHS 2005-06*
The group undernutrition Lorenz profile (GULP) is obtained by first ranking the groups in non-decreasing order of their undernutrition levels, and then plotting the cumulative subgroup shares in total undernutrition (on y-axis) against their cumulative population shares (on x-axis). The GULPs for Bihar, Punjab and India which present an account of inter-group inequalities in underweight outcomes are shown in figure 4.5. The GULP for these three cases suggests that inter-group inequalities based on the identified dimensions of caste, gender and place of residence are higher in Punjab. Inter-group inequalities for Bihar and all India appear to be quite similar in magnitude although a careful scrutiny would discern that Bihar might possess relatively lesser inequality.

The above insights are confirmed by computing the inter-group inequalities (area lying between the line of equality and respective GULPs) for each of these regions (see Table 4.3). Table 4.3 exposes this desolate picture of inequities in subgroup underweight outcomes by presenting data on both the 'unadjusted' ($U$) and between-group disparity 'adjusted' ($U^*$) values of underweight outcomes, for each major state and for the country as a whole (see Table 4.3, columns (ii) and (iv)). Notice that the index $U^*$ expresses the average underweight prevalence in a state enhanced by a factor that captures the extent of inequality in the inter-group distribution of poverty (i.e., just twice the area between the line of equality and the GULP). At the all-India level, the 'adjusted' underweight headcount ratio climbs to a value of 45 percent from its 'unadjusted' value of 42 percent — making for an escalation by a factor of 107 percent. Five out of the selected 18 major states present an escalation factor of 110 percent and above.

A glance at the 'adjusted' underweight incidence suggests that the high-income states of Kerala and Punjab are also marked with highly inequitable inter-group distribution of underweight outcomes across these population subgroups. In particular, the 'adjusted' estimate of underweight incidence gets inflated to the extent of around 116 percent and 117 percent, respectively. One indisputable truth that emerges is that there is a wide disparity in the prevalence of underweight outcomes between the states at the two extremes of income (high-income and low-income). Further, the squared coefficient of variation is suggestive of the fact that the disparities between the groups and within the states tend to increase as we move from the most disadvantaged to the least disadvantaged groups.
Table 4.3. Underweight and the effect of adjustment for intergroup inequalities: India and major States (NFHS 3, 2005-06)

<table>
<thead>
<tr>
<th>States</th>
<th>Underweight incidence (U)</th>
<th>Rank (in ascending order) according to U</th>
<th>Inequality adjusted U* = U(I+G)</th>
<th>Gini coefficient (G) for intergroup inequality</th>
<th>Rank (in ascending order) according to G</th>
<th>Revised Gini coefficient (G*) for intergroup inequality</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i)</td>
<td>(ii)</td>
<td>(iii)</td>
<td>(iv)</td>
<td>(v)</td>
<td>(vi)</td>
<td>(vii)</td>
</tr>
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</tr>
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<td>6</td>
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</tr>
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</tr>
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</tr>
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<td>Haryana</td>
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<td>42</td>
<td>0.070</td>
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<td>Jharkhand</td>
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<td>Uttaranchal</td>
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<td>All India</td>
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<td>45</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

CV² = 0.062

Source: Author using NFHS 3 (2005-06)

CV² - Squared Coefficient of Variation.

Ranking is given in terms of performance with rank 1 being given to the best performer.

The low-income states though depict higher levels of 'unadjusted' underweight outcomes but do not show larger inequities in their distribution. This is due to the fact that this particular problem of undernourishment is present in greater proportions across all the subgroups. We can obtain a more comprehensive and closer view of the inequality situation if this approach is replicated and certain other population grouping criteria are adopted (see Sengupta et al 2008) or the present groups are further disaggregated to include other important determinants such as...
sex of the child, availability of child healthcare facilities or hygiene conditions at the household level.

The worst performers in terms of the index $U$ continue to be the worst ones in terms of $U^*$. For instance, compare the figures for Madhya Pradesh, Jharkhand, Bihar, Chhattisgarh, Gujarat, Uttar Pradesh and Orissa. Perhaps the case of Gujarat, a richer state, demands some more analytical efforts to understand the causes for its poor performance in terms of child nutrition. Nevertheless, this illustration gives us a disconcerting message that group distribution of child nutrition is much worse than what it is projected to be through inequality blind sub-national averages. Adjustments of this average level of underweight incidence to reflect inter-group disparities in the distribution of underweight outcomes could, potentially, alter the ranking of the states. As observed in Table 4.3, the extent of rank reversal is not drastic perhaps — except in the case of Maharashtra, Uttarakhand and Rajasthan, which lose one place each in the $U^*$ as compared with from its top rank in terms of $U$. The states of Punjab, Tamil Nadu and Andhra Pradesh gain a place each in the rankings obtained after adjusting the outcomes. Nevertheless, these adjustments have not led to any alterations in the rankings obtained for the five poorest performing states.

An Alternative Approach to Group Inequality Adjustment

In the foregoing subsection, it was verified that place of residence, caste and sex of the child were important factors can significantly affect child nutrition. However, these attributes are not easily amenable to policy and moreover the inter-group disparities observed via this classification are confounded with certain other important aspects such as behavioural characteristics and resource endowments of the households. Therefore, this subsection adopts an alternative grouping criterion to highlight how nutritional deprivation manifests across factors which are considered to be more closely and directly associated with child health. This analysis could also be viewed as an illustration of an alternative method to adjust inter-group inequalities. This method attempts to adjust inter-group disparities by means of a factor which bears close resemblance with the Gini-type coefficient discussed in the previous section (see section 4.2).
From the literature, it is discerned that household’s economic status, maternal education and nutritional health are the key determinants that significantly affect child nutrition (see Wagstaff et al 2003, van de Poel and Speybroeck 2009). But what picture of social reality emerges among groups disadvantaged in these three identified dimension? To discern the magnitude of such burden across the major states of India, a group-based analysis is performed by cross-classifying children as per household’s wealth status, maternal educational attainment (primary and above as educated) and her nutritional health (assessed by means of a BMI).

Similar to the previous approach, the entire child population is divided into eight mutually exclusive and completely exhaustive sub-groups; namely children belonging to:

- Poor household–Uneducated mother–Low maternal BMI (PUL)
- Poor household–Uneducated mother–Normal maternal BMI (PUL')
- Poor household–Educated mother–Low maternal BMI (P'UL)
- Poor household–Educated mother–Normal maternal BMI (P'UL')
- Rich household–Uneducated mother–Low maternal BMI (P'UL)
- Rich household–Uneducated mother–Normal maternal BMI (P'UL')
- Rich household–Educated mother–Low maternal BMI (P''U'L)
- Rich household–Educated mother–Normal maternal BMI (P''U'L')

The group-specific magnitude of underweight, as measured by the simple headcount index, is presented in Figure 4.6 and Table 4.4.

Evidently, the problem of nutritional failure is severe when the child belongs to a poor household with uneducated and undernourished mother (PUL group). For all India, around 60 percent of the PUL group children are observably underweight. With the exception of Tamil Nadu, all the states of India have similar and appalling levels of underweight children (see Table 4.4, column (ii)). According to the PUL grouping criteria, nine of the 18 selected states have over 60 percent underweight children. In fact, the magnitude is noted to be 100 percent in case of Kerala (which had a small sample according to the PUL criterion). However, in states of Madhya Pradesh and Bihar, the proportion of undernourished children in the PUL group was noted to be 72 percent and 70 percent, respectively. Nutritional deprivation in this weakest
group is by no means acceptable in states, which are denounced for failures in the field of health and education.

**Figure 4.6. Group specific prevalence of underweight among Indian children, 2005-06**

Yet another disquieting observation emerges in the form of underweight differentials observed along the lines of poverty status of the household. A comparison of groups involving children from poor households suggest that one possible way to improve child health amidst poverty is to improve mothers education and her health status. This observation holds true not only for the country as a whole but most of the major states of the Indian union. If nutritional disadvantage is considered in terms of any two of the three grouping criterion (i.e. groups PUL', PU'L, P'UL) then for all of India the magnitude of the underweight children is reported to be 50-52 percent.

Given such systematic patterns, the states of Madhya Pradesh, Bihar, Jharkhand, Chhattisgarh and Orissa are observed to possess greater levels of this misfortune (see Table 4.4, columns (iii), (iv) and (vi)). It is of some interest to observe that in Madhya Pradesh, Orissa and Tamil Nadu, the underweight proportion is higher according to the PU'L criteria then compared with all three disadvantages (PUL).
Further, at the national level a 50 percent incidence level in the group P'UL is suggestive of the fact that income alone cannot make a big difference to child health promotion. We can contrast this information with the group PU'L' to argue that, despite belonging to poorer households, a child’s nutritional status can be better if the mother is advantaged in terms of nutritional and educational status (see Table 4.4, column (v)).

### Table 4.4. Group specific underweight indices: India and major States (NFHS 2005-06)

<table>
<thead>
<tr>
<th>States</th>
<th>PUL (i)</th>
<th>PUL' (ii)</th>
<th>PU'L (iii)</th>
<th>PU'L' (iv)</th>
<th>P'UL (v)</th>
<th>P'UL' (vi)</th>
<th>P'U'L (vii)</th>
<th>P'U'L' (viii)</th>
<th>U (ix)</th>
<th>CV^2 (x)</th>
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<td>46</td>
<td>36</td>
<td>29</td>
<td>29</td>
<td>37</td>
<td>21</td>
<td>32</td>
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<tr>
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<td>51</td>
<td>31</td>
<td>51</td>
<td>42</td>
<td>38</td>
<td>22</td>
<td>36</td>
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<td>50</td>
<td>49</td>
<td>37</td>
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<td>50</td>
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<td>28</td>
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<td>39</td>
<td>38</td>
<td>24</td>
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</tr>
</tbody>
</table>

Note: CV^2- Squared Coefficient of Variation, NA-In case of Kerala, none of the children belonged to P'UL group whereas the sample size was 10 each in case of children belonging to groups PUL and P'UL'.

Group description:
1-Poor household-Uneducated mother-Low maternal BMI (PUL), 2-Poor household - Uneducated mother -Normal maternal BMI (PUL'), 3-Poor household -Educated mother -Low maternal BMI (PU'L), 4-Poor household -Educated mother -Normal maternal BMI (PU'L'), 5-Rich household -Uneducated mother -Low maternal BMI (P'UL), 6-Rich household -Uneducated mother -Normal maternal BMI (P'UL'), 7-Rich household -Educated mother -Low maternal BMI (P'U'L), 8-Rich household -Educated mother -Normal maternal BMI (P'U'L').

Source: Computed by authors using NFHS 3 (2005-06) unit level records.
Underweight outcomes are observed to be the lowest in the groups that are advantaged in terms of all three criteria, namely the P'U'L' group. But even by this criterion as well, around one-quarter of the children belonging to this group are underweight at the national level (see Table 4.4, column (ix)). In states such as Madhya Pradesh, Jharkhand and Bihar, around 40 percent of the children belonging to the better-off groups are also undernourished. Furthermore, for all of India, the incidence differential between the most advantaged (P'U'L') and the most disadvantaged (PUL) groups is 36 percent. The widest differential of 84 percent is observed for the state of Kerala, whereas Tamil Nadu has the lowest differential of 17 percent. To gain insights into the acute sub-national welfare divisions, one has only to compare the lot of the PUL and P'U'L' children in Punjab or Kerala; for the former subpopulation, the underweight prevalence (at 51 percent and 100 percent, respectively) exceeds that of the latter subpopulation (at 14 percent and 16 percent, respectively) by a factor of over 350 percent and 600 percent, respectively. Another important thing is to note that as the income of the state increases, the undernutrition levels declines, but the worst-off groups tend to gain lesser than compared with the best-off groups. To give a quick illustration, one can select a richer state such as Punjab and contrast its information with a poorer state such as Bihar. The ratio of the U-values for Bihar PUL to that for Punjab PUL is, at 136 percent, much lower than the ratio of the U-values for Bihar P'U'L' to that for Punjab P'U'L', at 262 percent.

So far this analysis makes it clear that the characters of these health disparities are not only inter-state in nature but also have significant intra-state dispersion. Indisputably, the impairments of poor household or uneducated mother or undernourished mother pose its own disadvantages for nutritional status of the child, but the union of these three adversities pose even greater threats to child health.

Table 4.5 exposes this desolate picture of inequities in subgroup underweight outcomes by presenting data on both the 'unadjusted' (U) and between-group disparity 'adjusted' (U*) values of underweight outcomes, for each major state and
for the country as a whole (see Table 4.5, columns (ii) and (iv)). The ‘adjusted’ index $U^*$ is ‘welfare-equivalent’ to the situation where the ‘simple’ average underweight incidence is distributed as inequitably as it is across the considered subgroups (Majumdar and Subramanian, 2001). In other words, it is that level of underweight outcomes that, if attained equally by all the groups, would provide similar level of social welfare as one obtained in the case of actually observed nutritional failures.

Table 4.5. Underweight and the effect of adjustment for intergroup inequalities: India and major States (NFHS 3, 2005-06)

<table>
<thead>
<tr>
<th>States</th>
<th>Underweight incidence (U)</th>
<th>Rank (in ascending order) according to U</th>
<th>Inequality adjusted U*</th>
<th>Rank (in ascending order) according to U*</th>
<th>Factor (in percent) by which underweight is adjusted due to intergroup inequalities (U*/U)</th>
<th>Rank (in ascending order) according to U*/U</th>
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</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
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</tr>
</tbody>
</table>

$CV^2$ = 0.063 0.029

Source: Author, using NFHS 3 (2005-06) unit level records.

$CV^2$ - Squared Coefficient of Variation, Ranking is given in terms of performance with rank 1 being given to the best performer.
At the all-India level, the ‘adjusted’ underweight headcount ratio climbs to a value of 45 percent from its ‘unadjusted’ value of 42 percent — making for an escalation by a factor of 107 percent. The ‘adjusted’ underweight incidence suggests that the high-income states of Kerala and Punjab have highly inequitable distribution of underweight outcomes. These two top performing state in terms of the index ($U$) turn out to be the worst performers in terms of the index $U^*/U$ (see Table 5, column (vii)). Indeed, there is a strong inverse relationship between the ranking of states by $U$ and by $U^*/U$: Spearman’s rank correlation coefficient, computed for the two sets of rankings, is highly negative, at 0.893 (significant at 1% level).

Box: Social group disparities in prevalence of child undernutrition, All India, NFHS 2005-06

<table>
<thead>
<tr>
<th>SC/ST</th>
<th>Muslim OBC</th>
<th>OBC</th>
<th>Muslim</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top level states (Prevalence of underweight less than 36%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assam (33), Punjab (35)</td>
<td>Tamil Nadu (9), Punjab (19), Kerala (23), Andhra Pradesh (26), Chhattisgarh (29),</td>
<td>Kerala (15), Punjab (15), Tamil Nadu (27), West Bengal (27), Assam (30), Maharashtra (31), Andhra Pradesh (33),</td>
<td>Kerala (23), Andhra Pradesh (26), Chhattisgarh (26), Punjab (27), Maharashtra (27), Himachal (35),</td>
<td>Tamil Nadu (11), Punjab (18), Kerala (21), Andhra Pradesh (24), Orissa (27), Himachal Pradesh (27), Bihar (28), Chhattisgarh (28), Uttar Pradesh (29), All India (30), Karnataka (31), Haryana (31), West Bengal (32), Maharashtra (33), Gujarat (34), Jharkhand (34), Assam (35),</td>
</tr>
</tbody>
</table>

| **Middle level states (Prevalence of underweight between 36-48%)** | | | | |
| Kerala (38), Andhra Pradesh (40), Tamil Nadu (41), Himachal Pradesh (43), Karnataka (43), West Bengal (45), Rajasthan (46), Haryana (47), Uttarakhand (47) | Maharashatra (36), Karnataka (38), Rajasthan (42), Uttar Pradesh (43), Gujarat (44), All India (44), Uttarakhand (46), | Rajasthan (36), Karnataka (37) Orissa (38), Haryana (42), All India (43), Uttar Pradesh (44), Uttarakhand (47), Chhattisgarh (47), | Karnataka (37), Gujarat (39), Uttar Pradesh (39), West Bengal (40), All India (40), Assam (43), Uttarakhand (43), Rajasthan (44), Haryana (47), | Rajasthan (36), Madhya Pradesh (43), |

| **Middle level states (Prevalence of underweight in 48% and above)** | | | | |
| Uttar Pradesh (48), Maharashatra (48), Orissa (50), All India (50), Chhattisgarh (51), Gujarat (52), Jharkhand (64), Bihar (68), Madhya Pradesh (68), | Jharkhand (50), Haryana (59), Bihar (62), Madhya Pradesh (62), Himachal Pradesh (100), Orissa (100) | Gujarat (48), Bihar (55), Himachal Pradesh (55), Madhya Pradesh (56), Jharkhand (58) | Jharkhand (51), Orissa (52), Madhya Pradesh (58), Bihar (59), Tamil Nadu (74) | |

Note: Groups are classified on the basis of the prevalence level. For classification in top, middle and lower level prevalence the benchmark is selected by dividing the range of the underweight prevalence across states (Kerala 23% to Madhya Pradesh 59%). The performance is considered Top level: If child underweight prevalence is less than 36 percent, Middle level: If child underweight prevalence is between 36 to 47 percent, and Lower level: If child underweight prevalence is above 47 percent.

Source: Author, based on NFHS 2005-06.
Following Sengupta et al (2008), yet another group classification can be based on the social identity of the religion (see above box). These groups, Scheduled Castes Scheduled Tribes (SC/ST), Other Backward Castes (OBC), Muslims, Muslim OBCs and Others follow a particular gradient across various socioeconomic indicators irrespective of the place of residence or states (see Sengupta et al 2008). The SC/ST population is generally noted to be at the bottom of the hierarchy, followed by the Muslim OBCs, Other OBCs, Muslims and the remaining population. In case of prevalence of child undernutrition as well similar social hierarchy is observed and it offers deep insights on group inequalities. For instance, in the box, the population group belonging to ‘others’ category is at the top of the rankings irrespective of the state of residence. Similarly, across the states, the SCST group is generally observed at the bottom as lower level performers. The Muslim and OBC are noted at the middle of the group hierarchy with some rank reshufflings. This is indeed an interesting group classification and can be further studied using the group inequality measures discussed in this chapter.

4.4. CONCLUSION

This chapter undertakes a preliminary assessment of group inequalities in childhood undernutrition in India and highlight its distributional features and major determinants. The findings reveal of alarming proportions of undernutrition among Indian children and whose concentration is among groups marked by disadvantages in terms of place of residence, income, maternal education and caste identity. The methods suggested by Subramanian and Majumdar (2002) and Subramanian (2009) emerge to be interesting approaches to capture inter-group inequalities. Such analysis helps us to identify and evaluate the inter-group inequalities in health outcomes. The group profile of nutritional deprivation and the distribution-sensitised deprivation levels across the groups were effective in exposing the stark inequalities therein which clearly reflects more disappointment. This analysis, however, was restricted to examine disparities along few identified population groups but from a policy perspective it would be equally helpful if distribution-sensitive measures are obtained for other important dimensions associated with child health such as child morbidity or child mortalities and across characteristics like household hygiene, healthcare utilisation, and other community level correlates such as environmental conditions (safe water and sanitation) and availability of health facilities.
Appendix 4A

Relative Disadvantage Index (RDI)

Following Jayraj and Subramanian (2002), we begin with a measure, which provides the incidence of health deprivation in the population and term it as the Ailment Prevalence Rate (APR). For a given population it is defined as the ratio of the number of ailing persons to the total population and is analogous to the poverty headcount ratio. The decomposability of APR allows us to write it as a population weighted sum of the group specific APRs.

\[
\text{APR} = \sum_{i=1}^{n} \theta_i \text{APR}_i \quad \cdots (i)
\]

where, \( \theta_i \) is the share of group \( i \) in the total population; \( \text{APR}_i \) is the ailment prevalence rate (such as undernutritional outcome) of group \( i \); and \( i \) denotes the number of groups (ranging from \( i=1,2,\ldots,k \)). A simple manipulation of (i) provides with the contribution (\( \omega_i \)) of each group to total APR as

\[
\omega_i = \frac{\theta_i \text{APR}_i}{\text{APR}} \quad \cdots (ii)
\]

This measure follows the popular notion of equity in relative terms and defines a state of zero relative deprivation (neither advantaged nor disadvantaged) if the contribution of group \( i \) in APR is equal to its population share, i.e., \( \omega_i = \theta_i \) if \( \omega_i < \theta_i \), group \( i \) is relatively advantaged and if, \( \omega_i > \theta_i \) the group concerned is relatively disadvantaged. These deviations from zero relative deprivation is written as

\[
\delta_i = \frac{\omega_i - \theta_i}{\theta_i} \quad \cdots (iii)
\]

To normalize, \( \delta_i \) is divided by \( \delta_i^{\max} \), the maximum value that these deviations can attain. From (iii) it is evident that \( \delta_i \) is maximum when \( \omega_i \) attains its maximum value \( (\omega_i^{\max}) \) for any given \( \theta_i \). In order to derive the value \( \omega_i^{\max} \) equation (ii) is expressed in an alternative form as

\[
\omega_i = \frac{n_i \times a_i}{n \times n_i} = \frac{a_i}{a} \quad \cdots (iv)
\]
where, \( n_i \) is the population of group \( i \) and \( n \) is the aggregate population, therefore 
\[ n_i/n = \theta_i \]
and \( \alpha_i \) is the number of ailing individuals in group \( i \) and hence \( \alpha_i/n_i = APR_i \). From (iv) it follows that \( \omega_i \) is maximized when \( \alpha_i \) is maximum. Note that \( \alpha_i \) attains the maximum value of \( \alpha \) if \( n_i \geq \alpha \) and the maximum value of \( n_i \) when \( n_i < \alpha \), that is 
\[ \omega_i^{\text{max}} = \begin{cases} 1 & \forall n_i \geq \alpha \quad \text{(v - i)} \\ \theta_i/\text{APR} & \forall n_i < \alpha \quad \text{(v - ii)} \end{cases} \]

Since now we have defined the maximum values for \( \omega_i \) we can proceed further to define \( \delta_i^{\text{max}} \), as follows;
\[ \delta_i^{\text{max}} = \frac{1}{\theta_i} \quad \text{\( \forall n_i \geq \alpha \)} \quad \text{(vi - i)} \]
\[ \delta_i^{\text{max}} = \frac{1}{\text{APR}} - 1 \quad \text{\( \forall n_i < \alpha \)} \quad \text{(vi - ii)} \]

Finally, the normalized value of the index of relative deprivation (RDI) is given by,
\[ \delta_i^* = \frac{\delta_i}{\delta_i^{\text{max}}} = \frac{\theta_i - \alpha_i}{1 - \theta_i} \quad \text{\( \forall n_i \geq \alpha \)} \quad \text{(vii - i)} \]
\[ \delta_i^* = \frac{\delta_i}{\delta_i^{\text{max}}} = \frac{\theta_i - \alpha_i}{\theta_i} \times \frac{\text{APR}}{1 - \text{APR}} \quad \text{\( \forall n_i < \alpha \)} \quad \text{(vii - ii)} \]

In order to express \( \delta_i^* \) in terms of group specific population shares and ailment prevalence rates as well as APR for the aggregate population we use (ii) to write
\[ \theta_i - \alpha_i = \theta_i \left( \frac{\text{APR}_i}{\text{APR}} - 1 \right) \quad \text{(viii)} \]

The manipulation done in (viii) allows for the following desired expression of \( \delta_i^* \) as,
\[ \delta_i^* = \left( \frac{\theta_i}{1 - \theta_i} \right) \left( \frac{\text{APR}_i}{\text{APR}} - 1 \right) \quad \forall \theta_i \geq \text{APR} \quad \text{(ix - i)} \]
\[ \delta_i^* = \frac{\text{APR}_i - \text{APR}}{1 - \text{APR}} \quad \forall \theta_i < \text{APR} \quad \text{(ix - ii)} \]

Equation (ix) finds an easy and interesting interpretation in the sense that a group is said to be relatively disadvantaged whenever \( \delta_i^* \) is positive and is recognized relatively advantaged whenever \( \delta_i^* \) is negative.