

1 **TITLE:**

2 Double burden of malnutrition in children aged 24-59 months by socioeconomic
3 status in five South Asian countries: evidence from Demographic and Health
4 Surveys

5 **SUBTITLE:**

6 Double burden of malnutrition among under-five children in South Asia

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1 **ABSTRACT**

2 Background:

3 Developing countries are now facing double burden of undernutrition and
4 overnutrition among children and adults. We aimed to explore the double burden of
5 malnutrition among children aged 24-59 months by household's socioeconomic
6 status in South Asian context.

7 Methods:

8 Children with valid information on height and weight from the latest Demographic
9 and Health Survey from Bangladesh, India, Pakistan, Maldives, and Nepal were
10 included in this study. Underweight and overweight were defined according to
11 definitions of World Health Organisation and International Obesity Task Force,
12 respectively. We used multiple logistic regressions to estimate the association of
13 socioeconomic status with childhood underweight and overweight.

14 Results:

15 South Asian countries had significant burden of underweight, ranging from 19% in
16 Maldives to 38% in India. Bangladesh, India, and Nepal had prevalence of
17 overweight between 2% and 4%, whereas Pakistan and Maldives had prevalence of
18 7% and 9%, respectively. Households with higher wealth index and education were
19 consistently associated with lower odds of underweight children. When compared to
20 poorest households, richest households had higher odds of being overweight in
21 Bangladesh (OR 1.96, 95% CI 1.27-3.02) and India (OR 1.53, 95% CI 1.41-1.66)
22 while lower odds of being overweight in Pakistan (OR 0.22, 95% CI 0.14-0.34).
23 Households with higher education were more likely to have overweight children in
24 Bangladesh and India.

25

1 Conclusions:

2 Childhood underweight is associated with lower socioeconomic conditions while
3 there is a substantial burden of childhood overweight in higher socioeconomic
4 groups. These disparities by socioeconomic conditions should be considered while
5 developing national nutrition programs and strategies.

6

7 Keywords:

8 Double burden, underweight, overweight, under-five children, South Asia

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11 **KEY MESSAGES**

- 12 • In South Asia, there is a substantial burden of undernutrition among under-
13 five children while a differential burden of overnutrition is also seen.
- 14 • Household wealth and educational attainment were inversely associated with
15 childhood underweight.
- 16 • Children in households with higher levels of wealth and educational
17 attainment were more likely to be overweight in Bangladesh and India, while
18 evidence supporting such association was not clear for other South Asian
19 countries.
- 20 • The urban-rural difference in the burden of childhood underweight and
21 overweight can be explained by the distributions of households'
22 socioeconomic status.

1 INTRODUCTION

2 Double burden of malnutrition implies to the presence of both undernutrition and
3 overnutrition (overweight or obesity) within individuals, households, or populations.¹
4 At the individual level an undernourished child can be overweight or obese when
5 they reach adulthood, whereas at household level coexistence of underweight and
6 overweight children or adults can be possible. At the population level, double burden
7 of malnutrition indicates the prevalence of both underweight and overweight in the
8 same community, country, or region.^{1,2}
9 In low and middle-income countries (LMICs), underweight in children under the age
10 of five years has been a major public health problem historically.^{3,4} South Asia is
11 comprised mostly of LMICs, and had highest numbers of underweight children due to
12 higher prevalence rates and large populations in younger age groups.⁵ However,
13 due to recent economic growth, rapid urbanization, and adoption of western
14 lifestyles, the burden of overweight in this age group is increasing in LMICs,
15 including South Asian countries.⁶⁻⁸ Also, South Asians children living in developed
16 countries have a higher prevalence of overweight than any other ethnic group - a
17 recent study suggests.⁹ So far health systems in South Asia are focusing mainly on
18 prevention of childhood undernutrition, but an increasing trend in overnutrition
19 demands newer approach to tackle double burden of malnutrition among children in
20 this region. Both childhood underweight and overweight are associated with wide
21 range of morbidities in early life as well as in later life.^{6,10}
22 To have better strategies to solve the problem of double burden of disease among
23 children under the age of five years, we need to understand the socioeconomic
24 inequalities in nutritional outcomes. Identifying socioeconomic groups with higher
25 burden of nutritional problems can help tailoring public health prevention

1 interventions. Previous studies have suggested that there can be substantial
2 differences in the burden of malnutrition by household's wealth, education level, and
3 area of residence.^{11–14} Although the double burden of malnutrition has received
4 much attention in recent time, there is no study, to the best of our knowledge, which
5 looked at this problem in relation to various measures of socioeconomic status in
6 nationally-representative samples.
7 In this study, we aimed to quantify the extent of underweight and overweight among
8 children aged 24-59 months in South Asian countries and to estimate their
9 associations with household's socioeconomic status, using the latest nationally-
10 representative surveys.
11

1 **METHODS**

2 **Study design and data sources**

3 This study is based on the latest DHS data from five South Asian countries, namely
4 Bangladesh, India, Pakistan, Maldives, and Nepal. Other countries in the South
5 Asian regions (e.g. Afghanistan, Bhutan, and Sri Lanka) were not included in this
6 study because of either DHS was not conducted, or anthropometric data for children
7 were not available.

8 DHS are nationally-representative household surveys which are usually conducted
9 about every 5 years. These surveys provide data for a wide range of monitoring and
10 impact evaluation indicators in the areas of population, health, and nutrition. A DHS
11 is conducted by a national implementing agency, which can be any bona-fide
12 governmental, non-governmental, or private-sector organization and has enough
13 experience in the execution of surveys that are national in scope. Technical
14 assistances throughout the whole process are provided by the DHS program.¹⁵

15 DHS are usually based on two-stage stratified sampling of households. In the first
16 stage, sampling census enumeration areas are selected using probability
17 proportional to size (PPS) sampling technique through statistics provided by the
18 respective national statistical office. In the second stage, households are selected
19 through systematic random sampling from the complete listing of households within
20 a selected enumeration area.¹⁶

21 Ethical approval for each DHS is taken from the ICF Institutional Review Board as
22 well as by a review board in the host country. More details of such ethical approval
23 can be found in the DHS program website [<https://dhsprogram.com/>]. Informed
24 consent to participate in the study is taken from the participant, or from the parent or
25 guardian if anthropometric measurements are taken from a child. The data files are

1 freely available from the program website. We received authorization from the DHS
2 program for using the relevant datasets for this analysis. The data we received were
3 anonymized for protection of privacy, anonymity and confidentiality.
4 These surveys have very high response rate, usually 90% and above. Detailed
5 questionnaires of included surveys are available in the final report of each survey.
6 We used the children's record (coded as “KR” in DHS program) datasets which
7 contained information about children born in the last 5 years prior to the survey
8 (aged 0-59 months). The present analysis is based on children aged 24 – 59 months
9 who had valid measurement of their weight and height. We excluded children aged
10 less than 24 months because there is no available classification system for defining
11 overweight for them.

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13 **Anthropometric measurement, and defining underweight and overweight**

14 In DHS, height and weight of the children were measured by trained personnel using
15 standardized instruments and procedures. Lightweight SECA scales (Hamburg,
16 Germany) with digital screen, designed and manufactured by the United Nations
17 Children’s Fund (UNICEF), were used to measure weight. The height/length was
18 measured by boards, produced by Shorr Productions (Maryland, USA). In children
19 with height less than 85 centimetres, recumbent length was measured, whereas
20 standing height was measured for those taller than this. Body mass index (BMI) was
21 calculated by dividing body weight (kg) by squared height (m²).

22 Childhood underweight is based on the indicator weight-for-age, which is an overall
23 indicator of population's nutritional status. A child with weight-for-age less than two
24 standard deviations (-2 SD) from the median of the reference population is
25 considered as underweight according to World Health Organization (WHO)

1 guidelines.¹⁷ Underweight is a composite definition which can encompass stunting,
2 wasting, or both.

3 To define childhood overweight, we used the age and sex-specific BMI cut-offs from
4 the International Obesity Task Force (IOTF) classification system.^{18,19} According to
5 IOTF, a child aged between 2 years and 18 years is classified as overweight if their
6 BMI is larger than the age and sex-specific BMI cut-off corresponding to an adult
7 BMI of $>25 \text{ kg/m}^2$. Our definition of childhood overweight also included those with
8 obesity and it is referred to hereafter as “overweight” for simplicity.

9

10 **Socioeconomic factors**

11 DHS collected information on wide range variables from the selected households
12 and the respondents from those households using face-to-face interview conducted
13 by trained personnel. DHS collected information on socioeconomic factors like area
14 of residence and household’s wealth index. Place of residence (rural and urban) was
15 defined according to country-specific definitions. For household’s wealth index, each
16 national implementing agency constructed a country-specific index using principal
17 components analysis from data on household assets including durable goods (i.e.
18 bicycles, televisions etc.) and dwelling characteristics (i.e. sanitation, source of
19 drinking water and construction material of house etc.).¹⁵ This wealth index was then
20 categorized into five groups (i.e. poorest, poorer, middle, richer, and richest) based
21 on the quintile distribution of the sample.

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1 **Statistical analysis**

2 We conducted all analysis following the instructions given in the DHS guide to
 3 analysis.¹⁶ The percent distributions for characteristics of included children are
 4 described as proportions, for each DHS survey. To estimate the prevalence of
 5 childhood underweight and overweight, we used sampling weights given in each
 6 DHS dataset in order to get nationally-representative estimates. 95% confidence
 7 intervals (CIs) for prevalence estimates were calculated using a logit transform of the
 8 estimate. We also estimated the prevalence of childhood underweight and
 9 overweight by the levels of socioeconomic factors to assess the inequalities by those
 10 factors.

11 To examine the associations of socioeconomic factors with prevalence of childhood
 12 underweight and overweight, we used multiple logistic regression, separately for
 13 each included country. These analyses were adjusted for child's age, sex, are of
 14 residence, household's highest education level, household's wealth index, as
 15 appropriate. Considering the two-stage stratified cluster sampling in DHS, we applied
 16 Stata's survey estimation procedures ("svy" command) for regression analyses.²⁰
 17 The results are presented (as in tables and figures) as group-specific 95%
 18 confidence intervals (g-SCIs) for comparisons between more than two categories to
 19 allow comparisons to be made between any two categories, even if neither is the
 20 reference group.²¹ Conventional 95% CIs are provided in case of two categories
 21 being compared. All analyses were performed using Stata v15.1 (Statacorp, College
 22 Station, TX, USA).

23

1 RESULTS

2 A total of 146 996 children aged between 24 and 59 months from five south Asian
3 countries were included in this study. Table 1 shows the sample characteristics for
4 each of these countries' latest DHS data. Sample population for five countries had
5 almost equal distribution for both sex and age. In all countries except Nepal, the
6 majority of the children were from rural area (according to the definition of specific
7 country), and the proportions varied widely between 57% and 86%. On average less
8 than one in every 10 households had at least one member who completed higher
9 education. India, Nepal and Pakistan had significant number ($\geq 33\%$) of households
10 where none had formal education, whereas in Bangladesh and Maldives proportion
11 of such households was relatively lower ($< 20\%$). The samples from original surveys
12 were divided into quintiles based on household's wealth index, and after relevant
13 exclusions for this study the distributions remained more or less similar (Table 1).
14 As expected, the better part of burden for malnutrition in all countries was due to
15 undernutrition (Figure 1). India had the highest (38%) prevalence of undernutrition
16 among children aged 24-59 months followed by Bangladesh (37%), Nepal (29%),
17 Pakistan (28%), and Maldives had the lowest prevalence (19%). For overweight
18 among these children, Bangladesh, India, and Nepal had similar prevalences
19 (between 2% and 4%) whereas Pakistan and Maldives had much higher prevalence,
20 7% and 9% respectively. When we looked at the combined burden of both forms of
21 malnutrition, India and Bangladesh had much higher burden in compared to other
22 countries. However, the prevalences for both undernutrition and overnutrition were
23 slightly higher in India than those in Bangladesh. In Pakistan and Maldives where
24 overweight prevalence was high, the burden of undernutrition was decreased.

1 There were wide variations in the prevalence of undernutrition and overweight
2 according to household's wealth index (Figure 2) and household's highest education
3 (Figure 3) in all countries. Between the poorest and the richest households, the
4 burden of undernutrition decreased by more than half in all of these five countries.
5 The prevalence of overweight almost doubled between the poorest and the richest
6 households in Bangladesh and India, whereas such differences were not clearly
7 evident in Maldives and Nepal. In Pakistan, rich households were less likely to have
8 overweight children than poor households. The prevalence of undernutrition and
9 overweight according to household's highest education level followed similar country-
10 specific patterns observed for wealth index (Figure 3). Notably, children in
11 households with higher education had much higher rate of overweight in
12 Bangladesh, India, and Pakistan.

13 When adjusted for age, sex, area of residence, and education, there was reliable
14 evidence for inverse relationship between wealth index and prevalence of
15 underweight in Bangladesh, India, Nepal, and Pakistan; whereas such conclusion
16 could not be made for Maldives possibly due to smaller number of cases (Figure 4).
17 The adjusted ORs for richest vs. poorest households were 0.36 (95% CI 0.34-0.37)
18 and 0.31 (95% CI 0.25-0.37) in India and Bangladesh, respectively. Richest
19 households were more likely to have children who were overweight in compared to
20 the poorest households in India (OR 1.53, 95% CI 1.41-1.66) and in Bangladesh (OR
21 1.96, 95% CI 1.27-3.02). In contrary, richest households were less likely to have
22 overweight children in Pakistan when compared to poorest households (OR 0.22,
23 95% CI 0.14-0.34). The overall associations of wealth index with underweight and
24 overweight were not significant for Maldives and Nepal.

1 There were significant inverse associations between household's education level and
2 underweight in all countries except Maldives, after adjustment for age, sex, area of
3 residence, and wealth index (Figure 5). The ORs of underweight for higher education
4 vs. no education were 0.48 (95% CI 0.46-0.51), 0.63 (95% CI 0.49-0.81), and 0.38
5 (95% CI 0.24-0.59) in India, Bangladesh, and Pakistan, respectively. Households
6 with higher education were more likely to have overweight children when compared
7 to households with no education in Bangladesh (OR 2.97, 95% CI 1.88-4.68), and in
8 India (OR 1.37, 95% CI 1.25-1.50). Overweight in children was not associated with
9 education level in Maldives, Nepal, and Pakistan.

10 Additional analyses showed that there were no appreciable sex differences for
11 underweight and overweight prevalence (Supplementary Table S1). The prevalence
12 for underweight and overweight differed between rural and urban areas
13 (Supplementary Table 2), although adjusted models showed no significant
14 association for area of residence with underweight and overweight (Supplementary
15 Table 3). This illustrates that socioeconomic status can explain the rural-urban
16 differences in double burden of malnutrition.

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1 DISCUSSION

2 This study involving nationally-representative surveys conducted in recent times in
3 five South Asian countries provided empirical evidence on double burden of
4 malnutrition among children aged 24-59 months and its association with
5 socioeconomic status factors. In South Asian countries, there is a substantial burden
6 of undernutrition among younger children while a differential burden of overnutrition
7 is also seen. Households with higher socioeconomic status (as measured by wealth
8 index and education) were consistently associated with lower odds of underweight
9 children in all countries, though the association did not reach statistical significance
10 in Maldives. The associations between socioeconomic status and overweight were
11 heterogeneous: both households with richest wealth and households with higher
12 education were more likely to have overweight children in India and Bangladesh, but
13 the evidence for such associations in other countries was not consistent.

14 South Asian countries have experienced striking economic growth in the last few
15 decades which triggered unprecedented improvements in maternal mortality, infant
16 mortality, under-five mortality, and child undernutrition.^{22,23} The prevalence of
17 childhood underweight was declined by 25-30% between 2004 and 2014 in
18 Bangladesh, India, Pakistan, and Nepal.²⁴ However, the existing burden of
19 undernutrition is still high – our study found that around one-third of under-five
20 children in this region are underweight. Previous studies conducted in the region
21 have found that poor socioeconomic status, lower level of parental education,
22 younger age of mother at birth, short birth interval, and initiation of complimentary
23 feeding are important determinants of undernutrition among under-five children.^{25–27}
24 We also observed significant nutrition disparity by household socioeconomic status.
25 In populous countries like Bangladesh, India, and Pakistan, almost half of the

1 children in poorest households were underweight. In multivariable models, both
2 household's socioeconomic status and household's highest education level were
3 found to be strongly associated with childhood underweight in all countries. Multi-
4 sector approach is needed to alleviate poverty and other social inequalities related to
5 undernutrition disparity in South Asia and beyond.²⁸
6 Recent reports^{29–32} from South Asian countries highlighted the rise of overweight
7 burden in children, but mainly in older groups. Overweight among under-five children
8 is still overlooked in current literature. In our study, we provided evidence for an
9 increasing burden of overweight in this age group, which clustered in households
10 with higher socioeconomic status. We used two indicator variables for household's
11 socioeconomic status, namely wealth index and highest level of education, and
12 found that after simultaneous adjustment for each other wealth index had better
13 explanatory power than education level. Frequent intake of energy-dense foods and
14 physical inactivity have been shown to be associated with overweight and obesity
15 both in children and adults.^{33,34} These lifestyle behaviors are common in the higher
16 socioeconomic group in LMICs and therefore, both childhood and adulthood
17 overweight are clustered in affluent households in urban areas.^{29,32} Public health
18 nutrition programmes should therefore focus on educating parent of younger children
19 about proper feeding guidance and importance of physical activity.
20 South Asian countries have seen an unprecedented rise of urbanization and
21 economic growth in recent times.³⁵ Previous studies^{29,32,36} reported about urban-rural
22 gap in burden of overweight and obesity, but we found no significant differences after
23 adjustment for socioeconomic variables. This means that socioeconomic distribution
24 of households can explain the observed urban-rural differences for the burden of
25 childhood overweight. In our study, the associations for socioeconomic status with

1 childhood overweight were heterogeneous among countries, but it could be due to
2 small number of overweight children in those countries. A previous study from
3 Pakistan with a representative multistage cluster sample also found that affluent
4 urban population was facing a rapid rise in overweight and obesity among primary
5 school children.

6 The findings from our study highlight the importance of considering social
7 determinants of health while developing public health interventions and policies to
8 tackle both childhood undernutrition and overnutrition. So far the public health
9 interventions in South Asia focus almost completely on the prevention of
10 undernutrition, but identifying groups with more likelihood of developing childhood
11 overweight and obesity can help to shift the focus of intervention to those groups.

12 We suggest the policy makers to provide more resources to tackle underweight while
13 care should be taken for the affluent section of the society to prevent overweight.

14 To the best of our knowledge, no study looked at the coexistence of underweight and
15 overweight among under-five children in South Asian countries by socioeconomic
16 status. We used nationally-representative samples for five South Asian countries to
17 investigate the association of double burden of malnutrition with households'
18 socioeconomic status. Child's height and weight were measured objectively by
19 trained field researchers using calibrated scales. We also used IOTF classification
20 system to define overweight among these children, which helps to compare the
21 overweight prevalence internationally. We were also able to adjust for several factors
22 in the multivariable models. Our study lacks information on dietary and lifestyle
23 factors, so we could not adjust for their effects on the association between
24 socioeconomic status and double burden of malnutrition. Due to smaller sample
25 sizes in Maldives and Nepal, we could not reliably estimate the associations. We

1 excluded those children who did not have anthropometric data, but DHS reports
2 suggest that they should not vary significantly in terms of sociodemographic
3 characteristics.
4 In conclusion, our study provides evidence for socioeconomic disparities for the
5 coexistence of under and over nutrition among children aged 24-59 months in South
6 Asian settings. These unmet inequalities for both underweight and overweight should
7 be considered while developing national public health nutrition programmes and
8 strategies.
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3 study from Bangladesh, India, Maldives, Nepal, and Pakistan. We would also like to
4 thank the DHS Program to authorize us to use the data.

5

6 **AUTHOR CONTRIBUTIONS**

7 Conception and design: FH, MS, SA and MB
8 Data collection and management: FH, SS, and GA
9 Data analysis: FH, MS, SS
10 Interpretation of the results: All authors
11 Drafting of the article: FH and MS
12 Critical revision of the article for important intellectual content: All authors
13 Final approval of the article: All authors.

14

15 **CONFLICT OF INTEREST**

16 None declared

17

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20

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4

1 **FIGURE LEGENDS**

2

3 **Figure 1:** Prevalence of underweight and overweight, by country

4 Sampling weight provided by the Demographic and Health Survey (DHS)¹⁶ was used
5 to estimate country-representative prevalence. Error bars represent 95% confidence
6 intervals

7

8 **Figure 2:** Prevalence of underweight and overweight, by household's wealth index

9 Error bars represent 95% confidence intervals

10

11 **Figure 3:** Prevalence of underweight and overweight, by household's highest

12 educational attainment

13 Error bars represent 95% confidence intervals

14

15 **Figure 4:** Odds ratios of underweight and overweight, by household's wealth index

16 Analyses were adjusted for age, sex, area of residence, and household's highest
17 educational attainment

18

19 **Figure 5:** Odds ratios of underweight and overweight, by household's highest

20 educational attainment

21 Analyses were adjusted for age, sex, area of residence, and household's wealth
22 index

23

1 TABLES

2

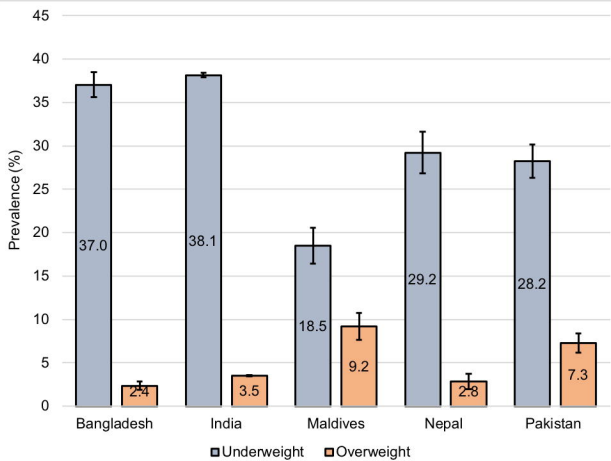
3 **Table 1: Sample characteristics in five demographic and health survey data, by**
4 **country**

| | Number (%) | | | | |
|-------------------------------------|-------------|---------------|-------------|------------|-------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Year of survey | 2014 | 2015-16 | 2009 | 2016 | 2012-13 |
| Number of children | 4170 | 138134 | 1339 | 1389 | 1964 |
| Child's sex | | | | | |
| Male | 2134 (51.2) | 71698 (51.9) | 672 (50.2) | 715 (51.5) | 1016 (51.7) |
| Female | 2036 (48.8) | 66436 (48.1) | 667 (49.8) | 674 (48.5) | 948 (48.3) |
| Child's age | | | | | |
| 2 year | 1406 (33.7) | 45298 (32.8) | 452 (33.8) | 460 (33.1) | 668 (34.0) |
| 3 year | 1377 (33.0) | 47506 (34.4) | 464 (34.7) | 479 (34.5) | 641 (32.6) |
| 4 year | 1387 (33.3) | 45329 (32.8) | 423 (31.6) | 449 (32.3) | 655 (33.4) |
| Area of residence | | | | | |
| Urban | 1316 (31.6) | 33245 (24.1) | 183 (13.7) | 788 (56.7) | 851 (43.3) |
| Rural | 2854 (68.4) | 104889 (75.9) | 1156 (86.3) | 601 (43.3) | 1113 (56.7) |
| Household's highest education level | | | | | |
| No education | 714 (17.1) | 44950 (32.5) | 221 (16.5) | 514 (37.0) | 1067 (54.3) |
| Primary | 1168 (28.0) | 20664 (15.0) | 615 (45.9) | 260 (18.7) | 303 (15.4) |
| Secondary | 1877 (45.0) | 60737 (44.0) | 462 (34.5) | 431 (31.0) | 385 (19.6) |
| Higher | 411 (9.9) | 11783 (8.5) | 26 (1.9) | 184 (13.2) | 209 (10.6) |
| Wealth index | | | | | |
| Poorest | 931 (22.3) | 36404 (26.4) | 330 (24.6) | 351 (25.3) | 443 (22.6) |
| Poorer | 781 (18.7) | 32673 (23.7) | 335 (25.0) | 308 (22.2) | 390 (19.9) |
| Middle | 808 (19.4) | 27462 (19.9) | 358 (26.7) | 296 (21.3) | 323 (16.4) |
| Richer | 843 (20.2) | 23044 (16.7) | 201 (15.0) | 276 (19.9) | 419 (21.3) |
| Richest | 807 (19.4) | 18551 (13.4) | 115 (8.6) | 158 (11.4) | 389 (19.8) |

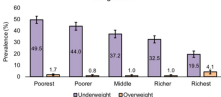
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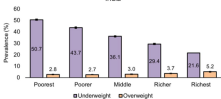
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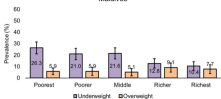
Bangladesh



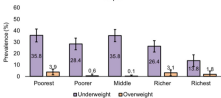
India



Maldives



Nepal



Pakistan

