

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

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

| | |
|-------------------------------|--|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID | bmjopen-2019-032866 |
| Article Type: | Research |
| Date Submitted by the Author: | 11-Jul-2019 |
| Complete List of Authors: | Hossain, Fariha Binte; Independent Researcher , Shawon, Md Shajedur Rahman; Oxford University, Nuffield Department of Population Health Al-Abid, Md Shehab Uddin; National Heart Foundation Hospital and Research Institute Mahmood, Sultan; Independent Researcher Adhikary, Gourab ; Independent Researcher Bulbul, Md. M. Islam; Institute of Public Health Nutrition (IPHN), National Nutrition Services (NNS) |
| Keywords: | Double burden, underweight, overweight, under-five children, socioeconomic status, South Asia |
| | |

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 1 **TITLE:**
4

5 2 Double burden of malnutrition in children aged 24-59 months by socioeconomic
6
7 3 status in five South Asian countries: evidence from Demographic and Health
8
9
10 4 Surveys
11

12 5 **SUBTITLE:**
13

14 6 Double burden of malnutrition among under-five children in South Asia
15
16

17 7 **AUTHORS:**
18

19 8 Fariha Binte Hossain^{1†}, Md Shajedur Rahman Shawon^{2†}, Md Shehab Uddin Al-
20
21 9 Abid³, Sultan Mahmood¹, Gourab Adhikary⁴, Md M Islam Bulbul⁵
22

23
24 10 ¹ Independent Researcher
25

26 11 ² Nuffield Department of Population Health, University of Oxford, Richard Doll
27
28 12 Building, OX3 7LF, UK Email: md.shawon@ndph.ox.ac.uk
29

30 13 ³ National Heart Foundation Hospital and Research Institute, Dhaka, Bangladesh
31
32 14 Email: abid79@nhf.org.bd
33

34 15 ⁴ Health Systems and Population Studies Division, icddr,b, 68 Shaheed Tajuddin
35
36 16 Ahmed Sarani, Mohakhali, Dhaka 1212, Bangladesh Email: gourabdmc@gmail.com
37

38 17 ⁵ National Nutrition Services, Ministry of Health and Family Welfare, Bangladesh
39
40 18 Email: bulbul1022@yahoo.com
41
42

43
44 19 **CORRESPONDING AUTHOR:**
45

46 20 Fariha Binte Hossain
47

48
49 21 Independent Researcher, 368/3D Ahmednagar, Paikpara, Mirpur-1, Dhaka 1216,
50
51 22 Bangladesh
52

53 23 Email: fariha.binte.hossain@gmail.com
54
55

56 24
57

58 25
59

60 26 † These authors contributed equally

1 **ABSTRACT**

2 **Objectives:** The extent of double burden of malnutrition among children aged under
3 five years in South Asian countries is unknown. We aimed to explore the double
4 burden of malnutrition among young children by household's socioeconomic status
5 in South Asian countries.

6 **Design:** Nationally-representative cross-sectional surveys.

7 **Settings:** Latest Demographic and Health Surveys from Bangladesh, India,
8 Pakistan, Maldives, and Nepal.

9 **Participants:** Children aged 24-59 months with valid measured information on
10 height and weight (n=146,996).

11 **Primary exposure and outcome measures:** Information on household's
12 socioeconomic status (e.g. wealth index, highest level of education) was collected
13 using face-to-face interview. Underweight and overweight were defined according to
14 definitions of World Health Organisation and International Obesity Task Force,
15 respectively.

16 **Results:** The prevalence of underweight ranged from 19% in Maldives to 38% in
17 India. The prevalence of overweight was between 2% and 4% in Bangladesh, India,
18 and Nepal, whereas Pakistan (7%) and Maldives (9%) had slightly higher
19 prevalence. Higher household wealth was inversely associated with prevalence of
20 underweight. ORs (95% CI) for richest vs poorest households for Bangladesh, India,
21 Maldives, Nepal and Pakistan were 0.31 (0.25-0.37), 0.36 (0.34-0.37), 0.51 (0.20-
22 1.32), 0.38 (0.23-0.62), and 0.58 (0.41-0.82), respectively. When compared to
23 poorest households, richest households had higher odds of having children who
24 were overweight in Bangladesh (1.96 [1.27-3.02]) and India (1.53 [1.41-1.66]), but
25 lower odds in Pakistan (0.22 [0.14-0.34]). The likelihood of having underweight

1 children decreased with increasing household education level in all five countries.
2 Households with higher education were more likely to have overweight children only
3 in Bangladesh (2.97 [1.88-4.68]) and India (1.37 [1.25-1.50]).

4 **Conclusions:** While the associations for household's socioeconomic status with
5 underweight among under-five children were consistent in South Asian countries, the
6 associations with overweight seem heterogeneous. These differences warrant
7 different approaches for developing national nutrition programs and strategies to
8 tackle double burden of malnutrition in this region.

9 Keywords:

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

11

1 STRENGTHS AND LIMITATIONS OF THIS STUDY

- 2 • This is the first study to investigate the double burden of malnutrition among
3 children aged under five years in South Asian countries, using nationally-
4 representative samples.
- 5 • We used height and weight information which were measured by trained
6 research personnel.
- 7 • Use of International Obesity Task Force (IOTF) classification to define
8 overweight ensures cross-comparison of estimates with those from other
9 regions.
- 10 • Even though we adjusted for several factors to examine the associations of
11 socioeconomic status with underweight and overweight, we did not have
12 information on dietary and lifestyle factors that could modify those
13 associations.
- 14 • Due to smaller sample sizes in Maldives and Nepal, we could not reliably
15 estimate the associations of socioeconomic status with underweight and
16 overweight.

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
4 [1]. 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 Double burden of malnutrition is an emerging problem in the low and middle-income
10 countries (LMICs). Historically, these countries have huge burden of undernutrition in
11 children [3,4], but there is also a growing burden of overnutrition in recent times,
12 particularly due to economic growth, rapid urbanization, and adoption of western
13 lifestyles [5–7]. South Asia is comprised mostly of LMICs, and all of them are
14 experiencing similar trends in both childhood undernutrition and overnutrition. While
15 South Asian countries have highest numbers of underweight children due to higher
16 prevalence rates and large populations in younger age groups [8], the number of
17 overweight children is also increasing rapidly [5–7]. South Asians children living in
18 developed countries also have a much higher prevalence of overweight than any
19 other ethnic groups - a recent study suggests [9]. However, there is no study - to the
20 best of our knowledge - which looked at double burden of malnutrition among
21 children aged under five years in any South Asian countries. So, the extent of this
22 emerging public health problem in this age group in South Asian countries is still
23 unknown.

24 Ensuring optimum nutrition in early years of life is an important public health agenda,
25 particularly because both underweight and overweight in these years are associated

1
2
3 1 with wide range of morbidities in early life as well as in later life [5,10]. Health
4
5 2 systems in South Asian countries are still focusing mainly on prevention of childhood
6
7 3 undernutrition, but an increasing trend in overnutrition demands newer approach to
8
9
10 4 tackle double burden of malnutrition among children in this region. To have better
11
12 5 strategies to solve the problem of double burden of malnutrition among children
13
14 6 under the age of five years, we also need to understand the socioeconomic
15
16
17 7 inequalities in nutritional outcomes. While previous studies have suggested that
18
19 8 there can be substantial differences in the burden of underweight and overweight
20
21 9 among older children by household's wealth, education level, and area of residence
22
23
24 10 [11–14], such associations are not clear for children under five years in South Asian
25
26 11 countries. Given the nutrition status in early childhood can track into later childhood
27
28 12 and adulthood, identifying socioeconomic groups with higher burden of underweight
29
30 13 and overweight is crucial for tailoring public health prevention interventions.
31
32
33 14 In this study, we aimed to quantify the extent of underweight and overweight among
34
35 15 children aged 24-59 months in South Asian countries, and to estimate their
36
37 16 associations with household's socioeconomic status, using the latest nationally-
38
39
40 17 representative surveys.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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. Year of survey for each included country is given in Table 1.
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
2
3 1 freely available from the program website. We received authorization from the DHS
4
5 2 program for using the relevant datasets for this analysis. The data we received were
6
7 3 anonymized for protection of privacy, anonymity and confidentiality.

8
9
10 4 These surveys have very high response rate, usually 90% and above. Detailed
11
12 5 questionnaires of included surveys are available in the final report of each survey.

13
14 6 We used the children's record (coded as "KR" in DHS program) datasets which
15
16 7 contained information about children born in the last 5 years prior to the survey
17
18 8 (aged 0-59 months). The present analysis is based on children aged 24 – 59 months
19
20 9 who had valid measurement of their weight and height. We excluded children aged
21
22 10 less than 24 months because there is no available classification system for defining
23
24 11 overweight for them.
25
26
27
28
29
30

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

32
33 14 In DHS, height and weight of the children were measured by trained personnel using
34
35 15 standardized instruments and procedures. Lightweight SECA scales (Hamburg,
36
37 16 Germany) with digital screen, designed and manufactured by the United Nations
38
39 17 Children's Fund (UNICEF), were used to measure weight. The height/length was
40
41 18 measured by boards, produced by Shorr Productions (Maryland, USA). In children
42
43 19 with height less than 85 centimetres, recumbent length was measured, whereas
44
45 20 standing height was measured for those taller than this. Body mass index (BMI) was
46
47 21 calculated by dividing body weight (kg) by squared height (m²).
48
49

50
51 22 Childhood underweight is based on the indicator weight-for-age, which is an overall
52
53 23 indicator of population's nutritional status. A child with weight-for-age less than two
54
55 24 standard deviations (-2 SD) from the median of the reference population is
56
57 25 considered as underweight according to World Health Organization (WHO)
58
59
60

1 guidelines [17]. Underweight is a composite definition which can encompass
2 stunting, 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
5 to IOTF, a child aged between 2 years and 18 years is classified as overweight if
6 their BMI is larger than the age and sex-specific BMI cut-off corresponding to an
7 adult BMI of $>25 \text{ kg/m}^2$. Our definition of childhood overweight also included those
8 with obesity and it is referred to hereafter as “overweight” for simplicity.

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
20 then categorized into five groups (i.e. poorest, poorer, middle, richer, and richest)
21 based on the quintile distribution of the sample.

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
2
3 1 There were wide variations in the prevalence of undernutrition and overweight
4
5 2 according to household's wealth index (Figure 2) and household's highest education
6
7 3 (Figure 3) in all countries. Between the poorest and the richest households, the
8
9 4 burden of undernutrition decreased by more than half in all of these five countries.
10
11 5 The prevalence of overweight almost doubled between the poorest and the richest
12
13 6 households in Bangladesh and India, whereas such differences were not clearly
14
15 7 evident in Maldives and Nepal. In Pakistan, rich households were less likely to have
16
17 8 overweight children than poor households. The prevalence of undernutrition and
18
19 9 overweight according to household's highest education level followed similar country-
20
21 10 specific patterns observed for wealth index (Figure 3). Notably, children in
22
23 11 households with higher education had much higher rate of overweight in
24
25 12 Bangladesh, India, and Pakistan.
26
27 13 When adjusted for age, sex, area of residence, and education, there was reliable
28
29 14 evidence for inverse relationship between wealth index and prevalence of
30
31 15 underweight in Bangladesh, India, Nepal, and Pakistan; whereas such conclusion
32
33 16 could not be made for Maldives possibly due to smaller number of cases (Figure 4).
34
35 17 The adjusted ORs for richest vs. poorest households were 0.36 (95% CI 0.34-0.37)
36
37 18 and 0.31 (95% CI 0.25-0.37) in India and Bangladesh, respectively. Richest
38
39 19 households were more likely to have children who were overweight in compared to
40
41 20 the poorest households in India (OR 1.53, 95% CI 1.41-1.66) and in Bangladesh (OR
42
43 21 1.96, 95% CI 1.27-3.02). In contrary, richest households were less likely to have
44
45 22 overweight children in Pakistan when compared to poorest households (OR 0.22,
46
47 23 95% CI 0.14-0.34). The overall associations of wealth index with underweight and
48
49 24 overweight were not significant for Maldives and Nepal.
50
51
52
53
54
55
56
57
58
59
60

1
2
3 1 There were significant inverse associations between household's education level and
4
5 2 underweight in all countries except Maldives, after adjustment for age, sex, area of
6
7 3 residence, and wealth index (Figure 5). The ORs of underweight for higher education
8
9 4 vs. no education were 0.48 (95% CI 0.46-0.51), 0.63 (95% CI 0.49-0.81), and 0.38
10
11 5 (95% CI 0.24-0.59) in India, Bangladesh, and Pakistan, respectively. Households
12
13 6 with higher education were more likely to have overweight children when compared
14
15 7 to households with no education in Bangladesh (OR 2.97, 95% CI 1.88-4.68), and in
16
17 8 India (OR 1.37, 95% 1.25-1.50). Overweight in children was not associated with
18
19 9 education level in Maldives, Nepal, and Pakistan.
20
21
22
23
24 10 Additional analyses showed that there were no appreciable sex differences for
25
26 11 underweight and overweight prevalence (Supplementary Table S1). The prevalence
27
28 12 for underweight and overweight differed between rural and urban areas
29
30
31 13 (Supplementary Table 2), although adjusted models showed no significant
32
33 14 association for area of residence with underweight and overweight (Supplementary
34
35 15 Table 3). This illustrates that socioeconomic status can explain the rural-urban
36
37 16 differences in double burden of malnutrition.
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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–
24 27]. We also observed significant nutrition disparity by household socioeconomic
25 status. 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
16 higher 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
22 urban-rural gap in burden of overweight and obesity, but we found no significant
23 differences after adjustment for socioeconomic variables. This means that
24 socioeconomic distribution of households can largely explain the observed urban-
25 rural differences for the burden of childhood overweight. In our study, the

1 associations for socioeconomic status with childhood overweight were
2 heterogeneous among countries, but it could be due to small number of overweight
3 children in those countries. A previous study from Pakistan with a representative
4 multistage cluster sample also found that affluent urban population was facing a
5 rapid rise in overweight and obesity among primary school children [30].
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.

For peer review only

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

1 **ACKNOWLEDGEMENTS**

2 The authors thank the participants of Demographic and Health Surveys used in this
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.

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.

15 **COMPETING INTERESTS STATEMENT**

16 None declared

18 **FUNDING STATEMENT**

19 This research received no specific grant from any funding agency in the public,
20 commercial or not-for-profit sectors.

22 **DATA SHARING STATEMENT**

23 This study used data from Demographic and Health Surveys (DHS) for Bangladesh,
24 India, Maldives, Nepal, and Pakistan, which are available from the DHS programme
25 website.

1 PATIENT AND PUBLIC INVOLVEMENT

2 There was no patient and public involvement in the development of the research
3 question, design of this study, recruitment to and conduct of the study.

5 REFERENCES

- 6 1 World Health Organization. Double burden of malnutrition. Nutrition.
7 2019.<https://www.who.int/nutrition/double-burden-malnutrition/en/> (accessed 3
8 Apr 2019).
- 9 2 Shrimpton, Roger; Rokx C. The Double Burden of Malnutrition : A Review of
10 Global Evidence. Washington, DC: 2012.
11 <https://openknowledge.worldbank.org/handle/10986/27417>
- 12 3 Harding KL, Aguayo VM, Webb P. Factors associated with wasting among
13 children under five years old in South Asia: Implications for action. *PLoS One*
14 2018;**13**:e0198749.<https://doi.org/10.1371/journal.pone.0198749>
- 15 4 Stevens GA, Finucane MM, Paciorek CJ, *et al.* Trends in mild, moderate, and
16 severe stunting and underweight, and progress towards MDG 1 in 141
17 developing countries: a systematic analysis of population representative data.
18 *Lancet (London, England)* 2012;**380**:824–34. doi:10.1016/S0140-
19 6736(12)60647-3
- 20 5 GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in
21 195 Countries over 25 Years. *N Engl J Med* Published Online First: 2017.
22 doi:10.1056/NEJMoa1614362
- 23 6 de Onis M, Blázkovská M. Prevalence and trends of overweight among
24 preschool children in developing countries. *Am J Clin Nutr* 2000;**72**:1032–
25 9.<http://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=2001004>

- 1
2
3 1 608&lang=es&site=ehost-live
4
5 2 7 de Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight
6 and obesity among preschool children. *Am J Clin Nutr* 2010;**92**:1257–64.
7
8 3
9
10 4
11
12 5 8 Black RE, Victora CG, Walker SP, *et al*. Maternal and child undernutrition and
13
14
15 6
16
17 7
18
19 8 9 Hudda MT, Nightingale CM, Donin AS, *et al*. Patterns of childhood body mass
20
21
22 9
23
24 10
25
26 11
27
28 12
29
30
31 13 10 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass
32
33
34 14
35
36 15
37
38 16
39
40 17
41
42 18 11 Van de Poel E, Hosseinpoor AR, Speybroeck N, *et al*. Socioeconomic
43
44
45 19
46
47 20
48
49 21 12 Chowdhury TR, Chakrabarty S, Rakib M, *et al*. Socio-economic risk factors for
50
51
52 22
53
54 23
55
56 24 13 Hoque ME, Doi SAR, Mannan M, *et al*. Prevalence of overweight and obesity
57
58
59 25
60

- 1
2
3 1 *Nutr Rev* 2014;**72**:541–50. doi:10.1111/nure.12130
4
5 2 14 Khadilkar V V., Khadilkar A V., Cole TJ, *et al.* Overweight and obesity
6
7 prevalence and body mass index trends in Indian children. *Int J Pediatr Obes*
8 3
9 2011;**6**:e216–24. doi:10.3109/17477166.2010.541463
10 4
11
12 5 15 The DHS Program. DHS Overview. 2019.[https://dhsprogram.com/What-We-](https://dhsprogram.com/What-We-Do/Survey-Types/DHS.cfm)
13 6
14 Do/Survey-Types/DHS.cfm (accessed 3 Apr 2019).
15 7 16 DHS Program. Using datasets for analysis.
16 8
17 <https://dhsprogram.com/data/Using-Datasets-for-Analysis.cfm> (accessed 14
18 9
19 Nov 2017).
20 10 17 World Health Organization. WHO child growth standards : length/height-for-
21 11
22 age, weight-for-age, weight-for-length, weight-forheight and body mass index-
23 12
24 for-age : methods and development. Geneva: 2006.
25 13
26 https://www.who.int/childgrowth/standards/Technical_report.pdf
27 14 18 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs
28 15
29 for thinness, overweight and obesity. *Pediatr Obes* 2012;**7**:284–94.
30 16
31 doi:10.1111/j.2047-6310.2012.00064.x
32 17 19 Cole TJ, Bellizzi MC, Flegal KM, *et al.* Establishing a standard definition for
33 18
34 child overweight and obesity worldwide: international survey. *BMJ*
35 19
36 2000;**320**:1240–3.
37 20 20 StataCorp. svy estimation - Estimation commands for survey data.
38 21
39 <https://www.stata.com/manuals13/svysvyestimation.pdf> (accessed 3 Apr
40 22
41 2019).
42 23 21 Plummer M. Improved estimates of floating absolute risk. *Stat Med*
43 24
44 2004;**23**:93–104. doi:10.1002/sim.1485
45 25 22 United Nations. The Millennium Development Goals Report. New York: 2015.
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 1 [https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG 2015 rev](https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015_rev)
4
5 2 (July 1).pdf
6
7
8 3 23 Akseer N, Kamali M, Arifeen SE, *et al.* Progress in maternal and child health:
9
10 4 how has South Asia fared? *BMJ* 2017;**357**:j1608. doi:10.1136/bmj.j1608
11
12 5 24 The World Bank Group. World Bank Open Data: Free and open access to
13
14 6 global development data. 2019.<https://data.worldbank.org/> (accessed 1 Mar
15
16 7 2019).
17
18
19 8 25 Pravara NK, Piryani S, Chaurasiya SP, *et al.* Determinants of severe acute
20
21 9 malnutrition among children under 5 years of age in Nepal: a community-
22
23 10 based case-control study. *BMJ Open* 2017;**7**:e017084. doi:10.1136/bmjopen-
24
25 11 2017-017084
26
27
28 12 26 Ansuya, Nayak BS, Unnikrishnan B, *et al.* Risk factors for malnutrition among
29
30 13 preschool children in rural Karnataka: a case-control study. *BMC Public Health*
31
32 14 2018;**18**:283. doi:10.1186/s12889-018-5124-3
33
34
35 15 27 Chowdhury MRK, Rahman MS, Khan MMH, *et al.* Risk Factors for Child
36
37 16 Malnutrition in Bangladesh: A Multilevel Analysis of a Nationwide Population-
38
39 17 Based Survey. *J Pediatr* 2016;**172**:194-201.e1.
40
41 18 doi:10.1016/j.jpeds.2016.01.023
42
43
44 19 28 Perez-Escamilla R, Bermudez O, Buccini GS, *et al.* Nutrition disparities and
45
46 20 the global burden of malnutrition. *BMJ* 2018;**361**:k2252.
47
48 21 doi:10.1136/bmj.k2252
49
50
51 22 29 Ranjani H, Mehreen TS, Pradeepa R, *et al.* Epidemiology of childhood
52
53 23 overweight & obesity in India: A systematic review. *Indian J Med Res*
54
55 24 2016;**143**:160–74. doi:10.4103/0971-5916.180203
56
57
58 25 30 Mushtaq MU, Gull S, Abdullah HM, *et al.* Prevalence and socioeconomic
59
60

- 1
2
3 1 correlates of overweight and obesity among Pakistani primary school children.
4
5 2 *BMC Public Health* 2011;**11**:724. doi:10.1186/1471-2458-11-724
6
7
8 3 31 Bulbul T, Hoque M. Prevalence of childhood obesity and overweight in
9
10 4 Bangladesh: findings from a countrywide epidemiological study. *BMC Pediatr*
11
12 5 2014;**14**:86. doi:10.1186/1471-2431-14-86
13
14
15 6 32 Rahman S, Islam MT, Alam DS. Obesity and overweight in Bangladeshi
16
17 7 children and adolescents: a scoping review. *BMC Public Health* 2014;**14**:70.
18
19 8 doi:10.1186/1471-2458-14-70
20
21
22 9 33 Gupta N, Misra A, Goel K, *et al.* Childhood Obesity in Developing Countries:
23
24 10 Epidemiology, Determinants, and Prevention. *Endocr Rev* 2012;**33**:48–70.
25
26 11 doi:10.1210/er.2010-0028
27
28
29 12 34 Hemmingsson E. Early Childhood Obesity Risk Factors: Socioeconomic
30
31 13 Adversity, Family Dysfunction, Offspring Distress, and Junk Food Self-
32
33 14 Medication. *Curr Obes Rep* 2018;**7**:204–9. doi:10.1007/s13679-018-0310-2
34
35
36 15 35 Peter E, Mark R. *Leveraging Urbanization in South Asia : Managing Spatial*
37
38 16 *Transformation for Prosperity and Livability*. South Asia. Washington, DC: :
39
40 17 World Bank 2016. <https://openknowledge.worldbank.org/handle/10986/22549>
41
42
43 18 36 Jayawardena R, Byrne NM, Soares MJ, *et al.* Prevalence, Trends and
44
45 19 Associated Socio-Economic Factors of Obesity in South Asia. *Obes Facts*
46
47 20 2013;**6**:405–14. doi:10.1159/000355598
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 **1 FIGURE LEGENDS**
4

5 **2 Figure 1:** Prevalence of underweight and overweight, by country
6

7
8 Sampling weight provided by the Demographic and Health Survey (DHS)[16] was
9
10 used to estimate country-representative prevalence. Error bars represent 95%
11
12 confidence intervals
13

14 **6 Figure 2:** Prevalence of underweight and overweight, by household's wealth index
15

16
17 Error bars represent 95% confidence intervals
18

19 **8 Figure 3:** Prevalence of underweight and overweight, by household's highest
20
21 educational attainment
22

23
24 Error bars represent 95% confidence intervals
25

26 **11 Figure 4:** Odds ratios of underweight and overweight, by household's wealth index
27

28
29 Analyses were adjusted for age, sex, area of residence, and household's highest
30
31 educational attainment
32

33 **14 Figure 5:** Odds ratios of underweight and overweight, by household's highest
34

35
36 educational attainment
37

38
39 Analyses were adjusted for age, sex, area of residence, and household's wealth
40
41 index
42

43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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) |

5

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

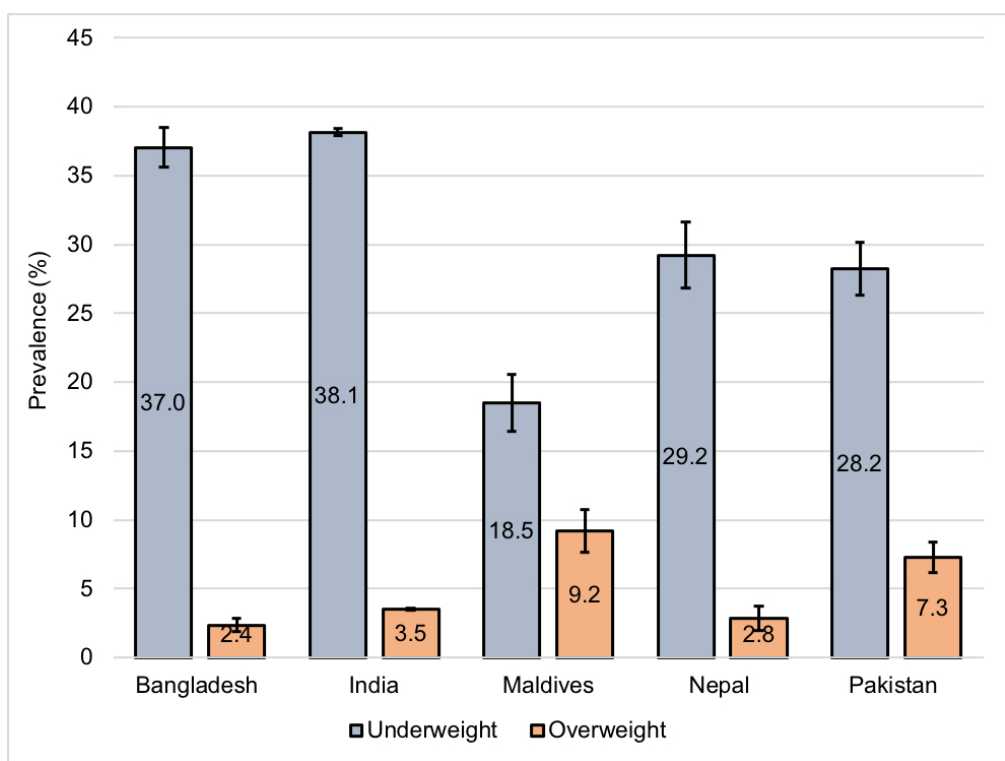


Figure 1: Prevalence of underweight and overweight, by country. Sampling weight provided by the Demographic and Health Survey (DHS)[16] was used to estimate country-representative prevalence. Error bars represent 95% confidence intervals

83x62mm (300 x 300 DPI)

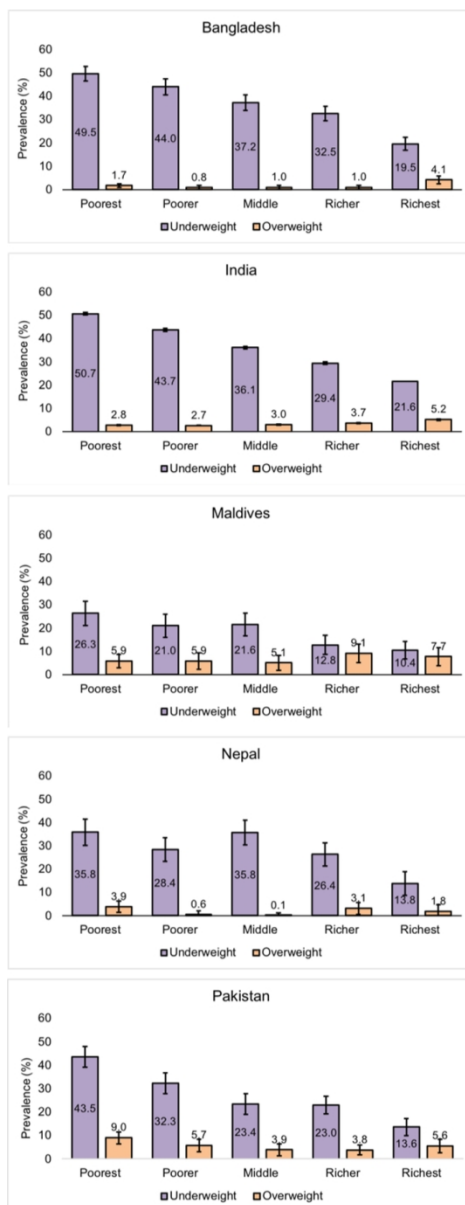


Figure 2: Prevalence of underweight and overweight, by household's wealth index
 Error bars represent 95% confidence intervals

30x78mm (600 x 600 DPI)

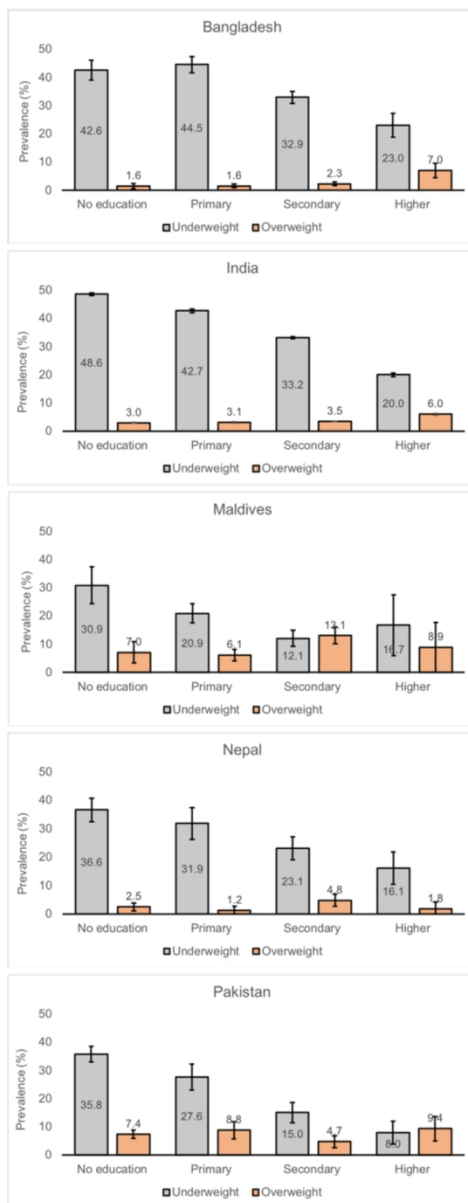


Figure 3: Prevalence of underweight and overweight, by household's highest educational attainment
Error bars represent 95% confidence intervals

30x77mm (600 x 600 DPI)

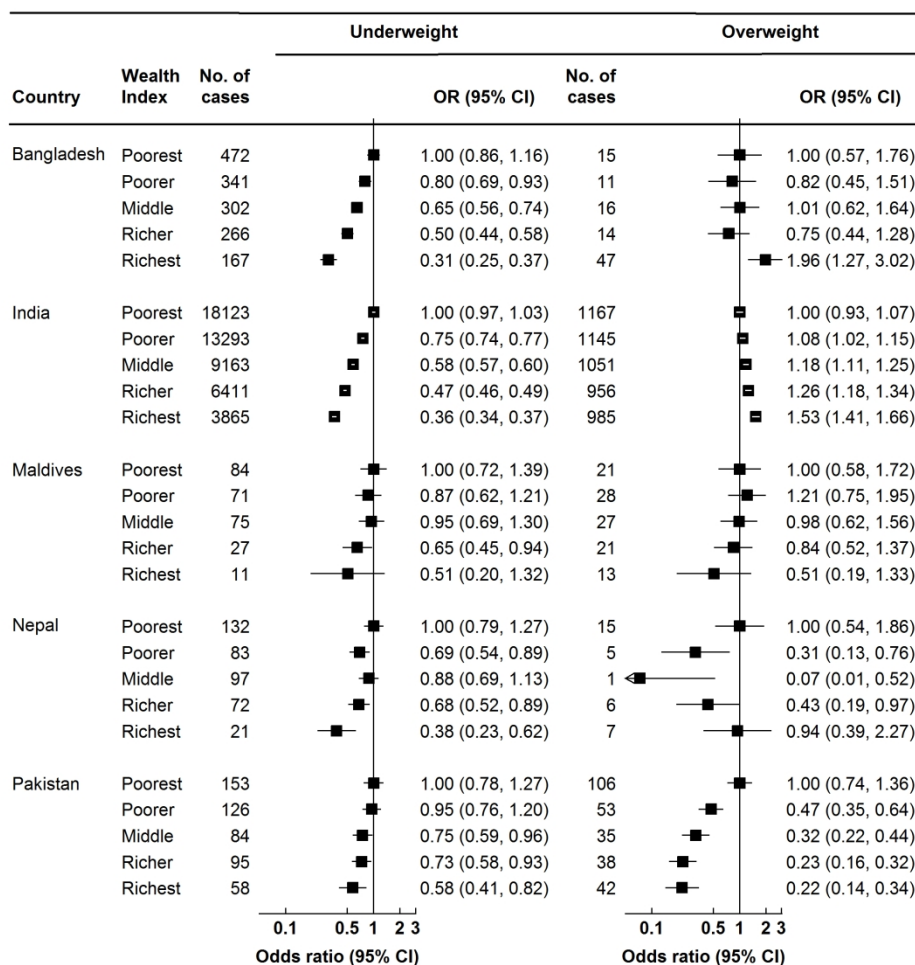


Figure 4: Odds ratios of underweight and overweight, by household's wealth index
Analyses were adjusted for age, sex, area of residence, and household's highest educational attainment

209x211mm (300 x 300 DPI)

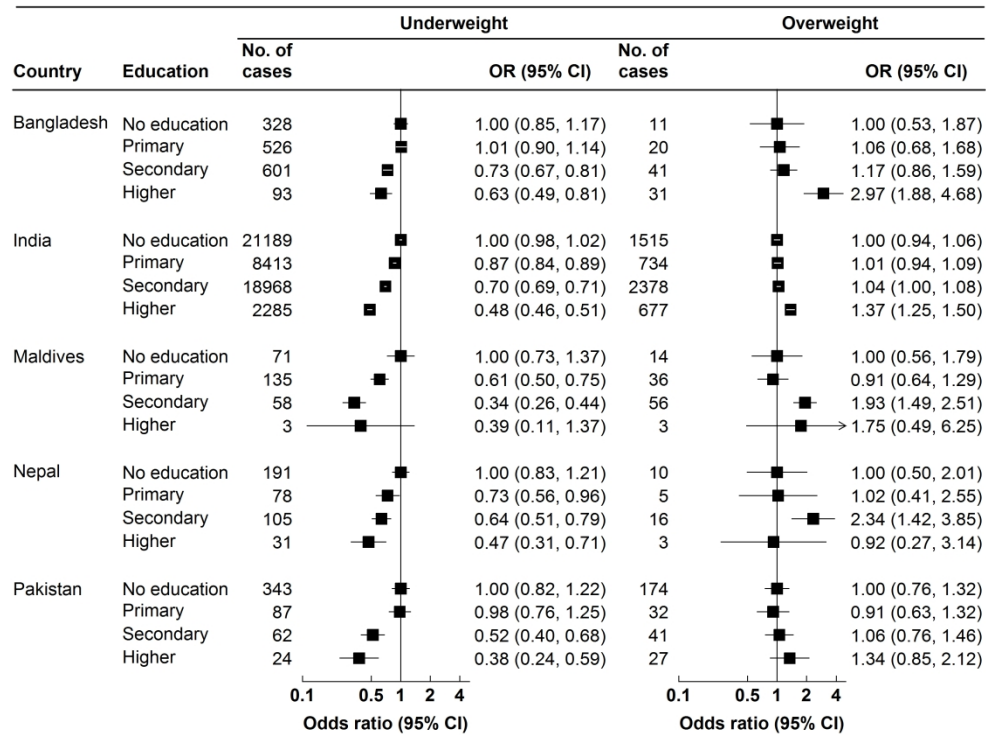


Figure 5: Odds ratios of underweight and overweight, by household's highest educational attainment
Analyses were adjusted for age, sex, area of residence, and household's wealth index

277x209mm (300 x 300 DPI)

1
2
3
4
5 **Double burden of malnutrition in children aged 24-59 months by**
6 **socioeconomic status in five south Asian countries: evidence from**
7
8
9
10 **Demographic and Health Surveys**
11

12 Fariha Binte Hossain, Md Shajedur Rahman Shawon, Md Shehab Uddin Al-Abid,
13
14 Sultan Mahmood, Gourab Adhikary, Md M Islam Bulbul
15
16

17
18
19 **Supplementary materials**
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table S1: Prevalence of underweight and overweight among children aged 24-59 months, by sex

| | Prevalence (95% CIs) | |
|--------------------|----------------------|------------------|
| | Boys | Girls |
| Underweight | | |
| Bangladesh | 35.2 (33.2-37.2) | 39.0 (36.9-41.1) |
| India | 37.4 (37.0-37.7) | 38.9 (38.6-39.3) |
| Maldives | 17.6 (14.9-20.7) | 19.4 (16.6-22.6) |
| Nepal | 29.3 (26.1-32.8) | 29.1 (25.8-32.6) |
| Pakistan | 30.6 (27.9-33.4) | 25.7 (23.1-28.4) |
| Overweight | | |
| Bangladesh | 2.0 (1.5-2.6) | 2.8 (2.1-3.6) |
| India | 3.4 (3.2-3.5) | 3.7 (3.5-3.8) |
| Maldives | 8.3 (6.5-10.7) | 10.0 (7.9-12.5) |
| Nepal | 1.7 (1.0-3.0) | 4.0 (2.7-5.7) |
| Pakistan | 7.2 (5.8-8.9) | 7.3 (5.9-9.1) |

Sampling weights provided by the Demographic and Health Survey (DHS) were used to estimate country-representative prevalence. 95% confidence intervals (CIs) for prevalence estimates were calculated using a logit transform of the estimate.

Table S2: Prevalence of underweight and overweight among children aged 24-59 months, by area of residence

| | Prevalence (95% CIs) | |
|--------------------|----------------------|------------------|
| | Urban | Rural |
| Underweight | | |
| Bangladesh | 30.0 (27.4-32.9) | 39.4 (37.7-41.1) |
| India | 30.9 (30.4-31.4) | 41.0 (40.7-41.3) |
| Maldives | 11.5 (8.8-15.0) | 21.7 (19.1-24.4) |
| Nepal | 25.4 (22.4-28.7) | 33.6 (30.1-37.4) |
| Pakistan | 23.3 (20.2-26.7) | 30.4 (28.1-32.8) |
| Overweight | | |
| Bangladesh | 3.9 (2.9-5.2) | 1.8 (1.4-2.4) |
| India | 4.4 (4.2-4.7) | 3.1 (3.0-3.2) |
| Maldives | 13.2 (10.2-16.8) | 7.4 (5.8-9.2) |
| Nepal | 3.1 (2.1-4.6) | 2.5 (1.5-4.0) |
| Pakistan | 6.6 (4.9-8.8) | 7.6 (6.3-9.1) |

Sampling weights provided by the Demographic and Health Survey (DHS) were used to estimate country-representative prevalence. 95% confidence intervals (CIs) for prevalence estimates were calculated using a logit transform of the estimate.

Table S3: Associations of area of residence with underweight and overweight among children aged 24-59 months

| | Area | No. of case | Adjusted OR (95% CIs) † |
|--------------------|-------|-------------|-------------------------|
| Underweight | | | |
| Bangladesh | Urban | 416 | 1.00 (Reference) |
| | Rural | 1132 | 0.94 (0.80-1.10) |
| India | Urban | 10075 | 1.00 (Reference) |
| | Rural | 40780 | 0.90 (0.87-0.92) |
| Maldives | Urban | 20 | 1.00 (Reference) |
| | Rural | 248 | 1.03 (0.46-2.31) |
| Nepal | Urban | 204 | 1.00 (Reference) |
| | Rural | 201 | 1.11 (0.87-1.43) |
| Pakistan | Urban | 185 | 1.00 (Reference) |
| | Rural | 331 | 1.01 (0.79-1.29) |
| Overweight | | | |
| Bangladesh | Urban | 52 | 1.00 (Reference) |
| | Rural | 51 | 0.69 (0.44-1.09) |
| India | Urban | 1420 | 1.00 (Reference) |
| | Rural | 3884 | 1.05 (0.98-1.13) |
| Maldives | Urban | 25 | 1.00 (Reference) |
| | Rural | 85 | 0.39 (0.16-0.96) |
| Nepal | Urban | 18 | 1.00 (Reference) |
| | Rural | 16 | 1.23 (0.57-2.66) |
| Pakistan | Urban | 118 | 1.00 (Reference) |
| | Rural | 156 | 0.57 (0.41-0.79) |

† Adjusted for age, sex, household's highest education and household's wealth index

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

| | | Reporting Item | Page Number |
|---------------------------|---------------------|---|-----------------------|
| Title and abstract | | | |
| Title | #1a | Indicate the study's design with a commonly used term in the title or the abstract | Page 1 |
| Abstract | #1b | Provide in the abstract an informative and balanced summary of what was done and what was found | Page 2-3 |
| Introduction | | | |
| Background / rationale | #2 | Explain the scientific background and rationale for the investigation being reported | Page 5 |
| Objectives | #3 | State specific objectives, including any prespecified hypotheses | Page 6 lines 14-16 |
| Methods | | | |

| | | | | |
|----|----------------------|----------------------|---|-----------|
| 1 | Study design | #4 | Present key elements of study design early in the paper | Page 7 |
| 2 | | | | |
| 3 | Setting | #5 | Describe the setting, locations, and relevant dates, including periods of | Page 7 |
| 4 | | | recruitment, exposure, follow-up, and data collection | |
| 5 | | | | |
| 6 | | | | |
| 7 | Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection | Page 7 |
| 8 | | | of participants. | |
| 9 | | | | |
| 10 | | | | |
| 11 | | #7 | Clearly define all outcomes, exposures, predictors, potential | Page 8-9 |
| 12 | | | confounders, and effect modifiers. Give diagnostic criteria, if | |
| 13 | | | applicable | |
| 14 | | | | |
| 15 | | | | |
| 16 | Data sources / | #8 | For each variable of interest give sources of data and details of | NA |
| 17 | measurement | | methods of assessment (measurement). Describe comparability of | |
| 18 | | | assessment methods if there is more than one group. Give information | |
| 19 | | | separately for for exposed and unexposed groups if applicable. | |
| 20 | | | | |
| 21 | | | | |
| 22 | | | | |
| 23 | Bias | #9 | Describe any efforts to address potential sources of bias | Page 10 |
| 24 | | | | lines 11- |
| 25 | | | | 15 |
| 26 | | | | |
| 27 | | | | |
| 28 | Study size | #10 | Explain how the study size was arrived at | NA |
| 29 | | | | |
| 30 | | | | |
| 31 | Quantitative | #11 | Explain how quantitative variables were handled in the analyses. If | Page 8-9 |
| 32 | variables | | applicable, describe which groupings were chosen, and why | |
| 33 | | | | |
| 34 | Statistical | #12a | Describe all statistical methods, including those used to control for | Page 10 |
| 35 | methods | | confounding | |
| 36 | | | | |
| 37 | | | | |
| 38 | Statistical | #12b | Describe any methods used to examine subgroups and interactions | NA |
| 39 | methods | | | |
| 40 | | | | |
| 41 | | | | |
| 42 | Statistical | #12c | Explain how missing data were addressed | NA |
| 43 | methods | | | |
| 44 | | | | |
| 45 | | | | |
| 46 | Statistical | #12d | If applicable, describe analytical methods taking account of sampling | NA |
| 47 | methods | | strategy | |
| 48 | | | | |
| 49 | | | | |
| 50 | Statistical | #12e | Describe any sensitivity analyses | Page 13 |
| 51 | methods | | | lines 10- |
| 52 | | | | 16 |
| 53 | | | | |
| 54 | | | | |
| 55 | Results | | | |
| 56 | | | | |
| 57 | Participants | #13a | Report numbers of individuals at each stage of study—eg numbers | Page 11 |
| 58 | | | | |
| 59 | | | | |
| 60 | | | | |

1 potentially eligible, examined for eligibility, confirmed eligible,
 2 included in the study, completing follow-up, and analysed. Give
 3 information separately for for exposed and unexposed groups if
 4 applicable.
 5

| | | | |
|----|-------------------|--|----------------------------------|
| 6 | | | |
| 7 | Participants | #13b Give reasons for non-participation at each stage | NA |
| 8 | | | |
| 9 | Participants | #13c Consider use of a flow diagram | Page 11 |
| 10 | | | |
| 11 | Descriptive data | #14a Give characteristics of study participants (eg demographic, clinical, 12 social) and information on exposures and potential confounders. Give 13 information separately for exposed and unexposed groups if 14 applicable. 15 | Page 11 |
| 16 | | | |
| 17 | Descriptive data | #14b Indicate number of participants with missing data for each variable of 18 interest | NA |
| 19 | | | |
| 20 | Outcome data | #15 Report numbers of outcome events or summary measures. Give 21 information separately for exposed and unexposed groups if 22 applicable. 23 | Page 11 |
| 24 | | | |
| 25 | Main results | #16a Give unadjusted estimates and, if applicable, confounder-adjusted 26 estimates and their precision (eg, 95% confidence interval). Make clear 27 which confounders were adjusted for and why they were included | Page 12 |
| 28 | | | |
| 29 | Main results | #16b Report category boundaries when continuous variables were 30 categorized | NA |
| 31 | | | |
| 32 | Main results | #16c If relevant, consider translating estimates of relative risk into absolute 33 risk for a meaningful time period | NA |
| 34 | | | |
| 35 | Other analyses | #17 Report other analyses done—e.g., analyses of subgroups and 36 interactions, and sensitivity analyses | Page 13 37 lines 10- 38 16 |
| 39 | | | |
| 40 | | | |
| 41 | | | |
| 42 | | | |
| 43 | | | |
| 44 | | | |
| 45 | Discussion | | |
| 46 | | | |
| 47 | Key results | #18 Summarise key results with reference to study objectives | Page 14 |
| 48 | | | |
| 49 | Limitations | #19 Discuss limitations of the study, taking into account sources of 50 potential bias or imprecision. Discuss both direction and magnitude of 51 any potential bias. | Page 16- 52 17 |
| 53 | | | |
| 54 | Interpretation | #20 Give a cautious overall interpretation considering objectives, 55 limitations, multiplicity of analyses, results from similar studies, and | Page 14- 56 16 |
| 57 | | | |
| 58 | | | |
| 59 | | | |
| 60 | | | |

other relevant evidence.

1
2
3 Generalisability [#21](#) Discuss the generalisability (external validity) of the study results Page 16

4
5 **Other**
6 **Information**

7
8
9 Funding [#22](#) Give the source of funding and the role of the funders for the present Page 18
10 study and, if applicable, for the original study on which the present
11 article is based
12

13
14 Notes:

- 15
16 • 3: Page 6 lines 14-16
17
18 • 9: Page 10 lines 11-15
19
20
21 • 12e: Page 13 lines 10-16
22
23 • 17: Page 13 lines 10-16 The STROBE checklist is distributed under the terms of the Creative Commons
24 Attribution License CC-BY. This checklist was completed on 09. July 2019 using
25 <https://www.goodreports.org/>, a tool made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

BMJ Open

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

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID | bmjopen-2019-032866.R1 |
| Article Type: | Original research |
| Date Submitted by the Author: | 07-Oct-2019 |
| Complete List of Authors: | Hossain, Fariha Binte; Independent Researcher , Shawon, Md Shajedur Rahman; Oxford University, Nuffield Department of Population Health Al-Abid, Md Shehab Uddin; National Heart Foundation Hospital and Research Institute Mahmood, Sultan; Independent Researcher Adhikary, Gourab ; ICDDR, Health Systems and Population Studies Division Bulbul, Md. M. Islam; Institute of Public Health Nutrition (IPHN), National Nutrition Services (NNS) |
| Primary Subject Heading: | Global health |
| Secondary Subject Heading: | Public health, Nutrition and metabolism, Global health, Epidemiology |
| Keywords: | Double burden, underweight, overweight, under-five children, socioeconomic status, South Asia |
| | |

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 1 **TITLE:**
4

5 2 Double burden of malnutrition in children aged 24-59 months by socioeconomic
6
7 3 status in five South Asian countries: evidence from Demographic and Health
8
9
10 4 Surveys
11

12 5 **SUBTITLE:**
13

14 6 Double burden of malnutrition among under-five children in South Asia
15
16

17 7 **AUTHORS:**
18

19 8 Fariha Binte Hossain^{1†}, Md Shajedur Rahman Shawon^{2†}, Md Shehab Uddin Al-Abid³,
20
21 9 Sultan Mahmood Sami¹, Gourab Adhikary⁴, Md M Islam Bulbul⁵
22

23
24 10 ¹ Independent Researcher
25

26 11 ² Nuffield Department of Population Health, University of Oxford, Richard Doll
27
28 12 Building, OX3 7LF, UK Email: md.shawon@ndph.ox.ac.uk
29

30 13 ³ National Heart Foundation Hospital and Research Institute, Dhaka, Bangladesh
31
32 14 Email: abid79@nhf.org.bd
33

34 15 ⁴ Health Systems and Population Studies Division, icddr,b, 68 Shaheed Tajuddin
35
36 16 Ahmed Sarani, Mohakhali, Dhaka 1212, Bangladesh Email: gourabdmc@gmail.com
37
38

39 17 ⁵ National Nutrition Services, Ministry of Health and Family Welfare, Bangladesh
40
41 18 Email: bulbul1022@yahoo.com
42
43

44 19 **CORRESPONDING AUTHOR:**
45

46 20 Fariha Binte Hossain
47

48
49 21 Independent Researcher, 368/3D Ahmednagar, Paikpara, Mirpur-1, Dhaka 1216,
50
51 22 Bangladesh
52

53 23 Email: fariha.binte.hossain@gmail.com
54
55

56 24
57

58 25
59

60 26 † These authors contributed equally

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60

1 **ABSTRACT**

2 **Objectives:** We aimed to investigate the socioeconomic inequalities in the burden of
3 underweight and overweight among children in South Asia. We also examined other
4 factors that were associated with these outcomes independently of household's
5 socioeconomic status.

6 **Design:** Nationally-representative surveys.

7 **Settings:** Demographic and Health Surveys from Bangladesh, India, Pakistan,
8 Maldives, and Nepal, which were conducted between 2009 and 2016.

9 **Participants:** Children aged 24-59 months with valid measurement for height and
10 weight (n=146,996).

11 **Primary exposure and outcome measures:** Primary exposures were household's
12 wealth index and level of education. Underweight and overweight were defined
13 according to the World Health Organization and International Obesity Task Force
14 definitions, respectively.

15 **Results:** Underweight prevalence was 37% in Bangladesh, 38% in India, 19% in
16 Maldives, 29% in Nepal, and 28% in Pakistan. Bangladesh, India, and Nepal had
17 similar overweight prevalence (between 2% and 4%) whereas Pakistan (7%) and
18 Maldives (9%) had higher prevalence. As expected, households with higher wealth
19 index or education had lower odds of having underweight children. Adjusted-odds
20 ratios (ORs) of underweight for richest vs poorest households were 0.4 [95% CI:0.3-
21 0.5], 0.5 [0.5-0.6], 0.5 [0.2-1.4], 0.5 [0.3-0.8], and 0.7 [0.5-1.1] for Bangladesh, India,
22 Maldives, Nepal and Pakistan, respectively. Compared to poorest households,
23 richest households were more likely to have overweight children in all countries
24 except Pakistan, but such associations were not significant after adjustment for other
25 factors. There were higher odds of having overweight children in households with

1
2
3 1 higher education in Bangladesh (OR 2.1 [95% CI:1.3-3.5]), India (1.2 [1.2-1.3]), and
4
5 2 Pakistan (1.8 [1.1-2.9]) when compared to households with no education. Maternal
6
7 3 nutritional status was consistently associated with children's nutritional outcomes
8
9 4 after adjustments for socioeconomic status.

10
11
12 5 **Conclusions:** Our study provides evidence for socioeconomic inequalities for
13
14 6 childhood underweight and overweight in South Asian countries, although the
15
16 7 directions of associations for underweight and overweight might be different.

17
18
19 8 **Keywords:**

20
21 9 Double burden, underweight, overweight, under-five children, South Asia,
22
23 10 Bangladesh, India, Pakistan, Nepal, Maldives
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 STRENGTHS AND LIMITATIONS OF THIS STUDY

- 2 • This is the first study to investigate the double burden of malnutrition among
3 children aged under five years in South Asian countries, using nationally-
4 representative samples.
- 5 • We used height and weight information which were measured by trained
6 research personnel.
- 7 • Use of International Obesity Task Force (IOTF) classification to define
8 overweight ensures cross-comparison of estimates with those from other
9 regions.
- 10 • Although we adjusted for several child, household and maternal factors when
11 examining the associations of socioeconomic status with underweight and
12 overweight, we did not have information on many dietary and lifestyle factors
13 that could modify those associations.
- 14 • We examined the effects of other factors on childhood underweight and
15 overweight after adjustment for household's socioeconomic status.

1 INTRODUCTION

2 Double burden of malnutrition implies the presence of both undernutrition and
3 overnutrition (overweight or obesity) either at the individual, household, or population
4 level [1]. At the individual level, an undernourished child can be overweight or obese
5 when they reach adulthood, whereas at household level coexistence of underweight
6 and overweight children or adults can be possible. At the population level, double
7 burden of malnutrition indicates the prevalence of both underweight and overweight
8 in the same community, country, or region. Double burden of malnutrition is an
9 emerging problem in the low and middle-income countries (LMICs) [1,2]. Historically,
10 these countries have a considerable burden of undernutrition in children [3,4], but
11 there is also a growing burden of overnutrition in recent times, particularly due to
12 economic growth, rapid urbanisation, and adoption of western lifestyles [5,6].
13 Ensuring optimum nutrition in early years of life is an important public health agenda,
14 mainly because both underweight and overweight in these years are associated with
15 a wide range of morbidities in early life as well as in later life [7,8].
16 According to the World Report on Nutrition 2018 [9], South Asia had the highest
17 burden of child undernutrition in the world - approximately 39% of all stunted children
18 were from this region. While the health systems in South Asian countries are still
19 focusing mainly on the prevention of childhood undernutrition, there has been
20 growing evidence that the number of children with overweight and obesity is also
21 increasing in recent years [5,10–12]. While these studies examined the burden of
22 undernutrition or overnutrition individually, studying both outcomes together in a
23 population will be more useful to the relevant stakeholders. So far, studies looking at
24 the issue of the double burden of malnutrition in countries from this region focused
25 mainly on the coexistence of overweight or obese mother and underweight or

1
2
3 1 stunted child within the same household [13–15]. To the best of our knowledge, no
4
5 2 study looked at the double burden of malnutrition among children aged under five
6
7 3 years in South Asian countries.
8
9
10 4 In high-income countries, overweight in children are associated with poorer
11
12 5 socioeconomic conditions [16–18]. In LMICs, it has been shown consistently that
13
14 6 children in poorer households are more likely to be underweight than those in richer
15
16 7 households [15,19]. However, it is not clear whether lower socioeconomic status can
17
18 8 also increase the likelihood of children with overweight in LMICs. While
19
20 9 understanding the socioeconomic inequalities in nutritional outcomes is very
21
22 10 important, identifying other factors that might influence these outcomes
23
24 11 independently of socioeconomic status help us to develop effective public health
25
26 12 interventions.
27
28 13 This study uses data from the Demographic and Health Surveys (DHS), which
29
30 14 provide nationally-representative estimates for a wide range of monitoring and
31
32 15 impact evaluation indicators in the areas of population, health, and nutrition [20].
33
34 16 While these surveys provide the prevalence of underweight and overweight among
35
36 17 children by socioeconomic status, it is essential to understand the associations
37
38 18 between them by taking account of other factors that might confound such
39
40 19 associations. In this study, we aimed to investigate the associations of household's
41
42 20 wealth index and highest education level with the prevalence of underweight and
43
44 21 overweight among children aged 24-59 months in five South Asian countries. Also,
45
46 22 we explored which other factors can influence childhood underweight and overweight
47
48 23 independently of household's socioeconomic status.
49
50
51
52
53
54
55
56 24

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. The included surveys were conducted in 2014, 2015-16, 2009,
8 2016, and 2012-13 for Bangladesh, India, Maldives, Nepal and Pakistan,
9 respectively.

10 DHS are nationally-representative household surveys which are usually conducted
11 about every five years. These surveys provide data for a wide range of monitoring
12 and impact evaluation indicators in the areas of population, health, and nutrition. A
13 DHS is conducted by a national implementing agency, which can be any bonafide
14 governmental, non-governmental, or private-sector organization and has enough
15 experience in the execution of surveys that are national in scope. Technical
16 assistance throughout the whole process is provided by the DHS program [20].

17 DHS is usually based on a two-stage stratified sampling of households. In the first
18 stage, sampling census enumeration areas are selected using probability
19 proportional to size (PPS) sampling technique through statistics provided by the
20 respective national statistical office. In the second stage, households are selected
21 through systematic random sampling from the complete listing of households within
22 a selected enumeration area [21].

23 Ethical approval for each DHS is taken from the ICF Institutional Review Board as
24 well as by a review board in the host country. More details of such ethical approval
25 can be found in the DHS program website [<https://dhsprogram.com/>]. Informed

1 consent to participate in the study is taken from the participant, or from the parent or
2 guardian if anthropometric measurements are taken from a child. The data files are
3 freely available from the program website. We received authorization from the DHS
4 program for using the relevant datasets for this analysis. The data we received were
5 anonymized for protection of privacy, anonymity and confidentiality.

6 These surveys have a very high response rate, usually 90% and above. Detailed
7 questionnaires of included surveys are available in the final report of each survey.

8 We used the children's record (coded as "KR" in DHS program) datasets which
9 contained information about children born in the last five years prior to the survey
10 (aged 0-59 months). The present analysis is based on children aged 24 – 59 months
11 who had a valid measurement of their weight and height. We excluded children aged
12 less than 24 months because most of the available classification system for defining
13 childhood overweight starts from 24 months [22,23].

14 Anthropometric measurement, and defining underweight and overweight

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

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

1 considered as underweight according to the World Health Organization (WHO)
2 guidelines [24]. Underweight is a composite definition which can encompass
3 stunting, wasting or both.

4 To define childhood overweight, we used the age and sex-specific BMI cut-offs from
5 the International Obesity Task Force (IOTF) classification system [23,25]. According
6 to IOTF, a child aged between 2 years and 18 years is classified as overweight if
7 their BMI is larger than the age and sex-specific BMI cut-off corresponding to an
8 adult BMI of $>25 \text{ kg/m}^2$. Our definition of childhood overweight also included those
9 with obesity and it is referred to hereafter as "overweight" for simplicity.

10

11 **Covariates**

12 DHS collected information on a wide range of variables from the selected
13 households using a face-to-face interview with the respondents conducted by trained
14 personnel. DHS collected information on socioeconomic factors like the area of
15 residence and household's wealth index. Place of residence (rural and urban) was
16 defined according to country-specific definitions. Household's highest education level
17 was based on the educational attainment of the child's mother and father. For
18 household's wealth index, each national implementing agency constructed a country-
19 specific index using principal components analysis from data on household assets
20 including durable goods (i.e. bicycles, televisions etc.) and dwelling characteristics
21 (i.e. sanitation, source of drinking water and construction material of house etc.) [26].
22 This wealth index was then categorized into five groups (i.e. poorest, poorer, middle,
23 richer, and richest) based on the quintile distribution of the sample.
24 We also included indicators of child's exposure to nutrition-sensitive interventions
25 (focusing on the underlying determinants of malnutrition) such as receiving vitamin A

1
2
3 1 in the last six months and receiving the deworming drug in last six months [27].
4
5 2 Households with flush toilet, ventilated improved pit latrine, traditional pit latrine with
6
7 3 a slab, or composting toilet were considered to have improved access to sanitation,
8
9
10 4 whereas households with improved access to drinking water were considered if they
11
12 5 had connection (piped), public standpipe, borehole, protected dug well or spring, or
13
14 6 rainwater collection.
15
16
17 7

18 19 8 **Statistical analysis**

20
21 9 We conducted all analysis following the instructions given in the DHS guide to
22
23 10 analysis [21]. Considering the two-stage stratified cluster sampling in DHS, we
24
25 11 applied Stata's survey estimation procedures ("svy" command) for the estimation of
26
27 12 proportions, means, and regression analysis [28].
28
29
30 13 The percent distributions for characteristics of included children are described as
31
32 14 proportions, for each DHS survey. To estimate the prevalence of childhood
33
34 15 underweight and overweight, we used sampling weights given in each DHS dataset
35
36 16 in order to get nationally-representative estimates. 95% confidence intervals (CIs) for
37
38 17 prevalence estimates were calculated using a logit transform of the estimate. We
39
40 18 also estimated the prevalence of childhood underweight and overweight by the levels
41
42 19 of socioeconomic factors to assess the inequalities by those factors.
43
44
45 20 To examine the associations of socioeconomic factors (i.e. household's wealth index
46
47 21 and household's highest level of education) with the prevalence of childhood
48
49 22 underweight and overweight, we used multiple logistic regression, separately for
50
51 23 each included country. At first, these analyses were minimally-adjusted for child's
52
53 24 age and sex; and then they were adjusted for the child's exposure to nutrition-
54
55 25 sensitive interventions, area of residence, access to improved sanitation and to
56
57
58
59
60

1 improved drinking water, number of household members, number of under-five
2 children in household, mother's age at first birth, and mother's BMI.
3 To explore which factors can influence the prevalence of childhood underweight and
4 overweight after accounting for household's socioeconomic status, we estimated the
5 odds ratios (ORs) for all child-, household- and maternal-level factors with
6 adjustment for household's wealth index and highest level of education.

7 All analyses were performed using Stata v15.1 (Statacorp, College Station, TX,
8 USA). All statistical analyses were two-sided and p-value <0.05 was considered as
9 statistically significant.

10

11 **Patient and public involvement**

12 Patients and the public were not involved in the development of research questions,
13 design of the study, recruitment and conduct of the study, or dissemination of the
14 study results.

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 characteristics of the study
4 population for each of these countries. There were almost equal distributions for both
5 sex and age in all country samples. At least half of the children in all countries
6 received vitamin A in the last six months. While Maldives and Nepal had excellent
7 coverage (80% or more) for deworming drugs, only about one in three children
8 received the deworming drug in India and Pakistan. Majority of the children were
9 from the rural area except in Nepal, and the proportions varied widely between 43%
10 and 86%. Overall, most of the households had access to improved sanitation and
11 drinking water supply, except the percentages of household with access to improved
12 sanitation are particularly low in Bangladesh and India. The proportions of household
13 with no formal education were particularly high in India, Nepal, and Pakistan. More
14 than half of the households in Bangladesh and India had members who completed
15 secondary or higher education. The samples from original surveys were divided into
16 quintiles based on the household's wealth index, and after relevant exclusions, the
17 distributions remained more or less similar for this study. India, Maldives, and
18 Pakistan had households with a median of two children aged under five years, while
19 Bangladesh and Nepal had a median of one child per household. Most mothers
20 were less than 25 years old at their first birth. The prevalence of mothers with
21 underweight was higher in Bangladesh (20%) and India (23%) than in other
22 countries, whereas the prevalence of mothers with overweight was higher in
23 Maldives (42%) and Pakistan (37%) than in other countries.

1
2
3 1 As expected, the prevalence of underweight was much higher than the prevalence of
4
5 2 overweight in all five countries (Figure 1). India had the highest (38%) prevalence of
6
7 3 underweight among children aged 24-59 months followed by Bangladesh (37%),
8
9 4 Nepal (29%), Pakistan (28%), and Maldives had the lowest prevalence (19%). For
10
11 5 overweight among these children, Bangladesh, India, and Nepal had similar
12
13 6 prevalence (between 2% and 4%) whereas Pakistan and Maldives higher
14
15 7 prevalence, 7% and 9% respectively. When we looked at the combined prevalence
16
17 8 of both forms of malnutrition, India (42%) and Bangladesh (39%) had a much higher
18
19 9 burden compared to other countries (Maldives [28%], Nepal [32%], Pakistan [36%]).
20
21
22
23
24 10 The prevalence of underweight was particularly low in Maldives and Pakistan, but
25
26 11 they had a higher prevalence of overweight.
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

13 The prevalence of underweight and overweight varied widely according to both the
14 household's wealth index in all countries (Figure 2). Between the poorest and the
15 richest households, the burden of undernutrition decreased by more than half. On
16 the other hand, the richest households in Bangladesh and India had almost two
17 times higher prevalence of overweight than the poorest households. Such clear
18 differences were not evident in Maldives and Nepal, while the richest households
19 were less likely to have overweight children compared to poorest households in
20 Pakistan. The prevalence of underweight and overweight according to the
21 household's highest education level followed similar country-specific patterns
22 observed for wealth index (Figure 3). Notably, children in households with higher
23 education had a much higher rate of overweight in Bangladesh, India, and Pakistan.
24

1
2
3 1 Table 2 shows the minimally-adjusted and fully-adjusted associations of household's
4
5 2 wealth index and highest education level with the prevalence of underweight and
6
7 3 overweight. There was strong evidence of an inverse relationship between the
8
9 4 household's wealth index and the prevalence of underweight in children, which was
10
11 5 not attenuated even after adjustment for a wide range of covariates except for
12
13 6 Maldives and Pakistan. Compared to the poorest households, the richest households
14
15 7 were less likely to have children with underweight (adjusted-OR for Bangladesh 0.4
16
17 8 [95% CI: 0.3-0.5], India 0.5 [0.5-0.6], Maldives 0.5 [0.2-1.4], Nepal 0.5 [0.3-0.8], and
18
19 9 Pakistan 0.7 [0.5-1.1]. For the household's highest education level, we also observed
20
21 10 that households with secondary or higher education were less likely to have children
22
23 11 with underweight when compared to households with no education. The adjusted-
24
25 12 OR for higher education vs no education was 0.7 (0.6-1.0) for Bangladesh, 0.6 (0.5-
26
27 13 0.6) for India, 0.5 (0.1-1.7) for Maldives, 0.6 (0.4-0.9) for Nepal and 0.4 (0.3-0.7) for
28
29 14 Pakistan.
30
31
32
33
34
35
36
37

38 16 Table 2 also shows that the richest households were more likely to have children
39
40 17 with overweight than the poorest households in all countries except Pakistan.
41
42 18 However, the positive associations between household's wealth index and
43
44 19 overweight prevalence in children were not significant after adjustment for other
45
46 20 variables. The adjusted ORs were 1.3 (0.8-2.2) for Bangladesh, 1.1 (1.0-1.2) for
47
48 21 India, 0.5 (0.2-1.4) for Maldives, and 1.2 (0.5-2.9) for Nepal. In Pakistan, the richest
49
50 22 households less likely to have overweight children, which remained significant after
51
52 23 adjustment for other variables (adjusted-OR 0.1 [0.1-0.2]). Household's education
53
54 24 level was also positively associated with the prevalence of overweight in children.
55
56 25 When compared with households with no formal education, households with higher
57
58
59
60

1 education had higher odds of having overweight children in Bangladesh (OR 2.1
2 [1.3-3.5]), India (OR 1.2 [1.2-1.3]), and Pakistan (OR 1.8 [1.1-2.9]). Maldives and
3 Nepal had fewer households with higher education, but the adjusted ORs for
4 secondary vs no education were 2.3 (1.7-3.1) and 1.8 (1.1-3.1), respectively.
5 We then explored the associations of other factors with underweight and overweight
6 among children after accounting for household socioeconomic status (Table 3).
7 Factors like living in rural, improved access to sanitation and to drinking water, older
8 maternal age at first birth, and maternal underweight were significantly associated
9 with childhood underweight in some but not all countries. Maternal underweight was
10 consistently found to be associated with increased odds of childhood underweight
11 (adjusted-OR vs normal weight in Bangladesh 1.9 [1.6-2.3], in India 1.7 [1.7-1.8], in
12 Nepal 2.1 [1.6-2.9] and in Pakistan 2.0 [1.4-2.7]). For childhood overweight,
13 maternal overweight was found to be associated with increased odds in Bangladesh
14 (OR 1.9 [1.2-3.0]), India (OR 1.3 [1.2-1.4]) and Pakistan (OR 1.8 [1.4-2.5]), but not in
15 Maldives (OR 1.3 [0.9-2.0]) and Nepal (OR 0.9 [0.3-2.2]). In Pakistan, those children
16 who received vitamin A or deworming drug in the last six months were less likely to
17 be overweight than those who did not receive those interventions. For India and
18 Pakistan, improved access to sanitation and drinking water were significantly
19 associated with childhood overweight, although the directions of such associations
20 were not consistent.

21

1 DISCUSSION

2 This study involving nationally-representative surveys conducted in recent times in
3 five South Asian countries provided empirical evidence on the burden of underweight
4 and overweight among children aged 24-59 months, and their associations with
5 socioeconomic status factors. We found that there was a substantial burden of
6 undernutrition among younger children in South Asian countries, while a differential
7 burden of overnutrition was also seen. Households with higher socioeconomic status
8 (as measured by wealth index and the highest level of education) were associated
9 with lower odds of underweight children, although some of those associations did not
10 reach statistical significance after adjustment for related factors. Household's
11 socioeconomic status and childhood overweight were positively associated in all
12 countries except Pakistan, but results from fully-adjusted models indicated that such
13 associations could be explained by other factors. Households with higher wealth or
14 education were less likely to have children with overweight only in Pakistan. After
15 taking household's socioeconomic status into account, maternal nutritional status
16 was found to be strongly associated with the child's nutritional status, whereas
17 evidence for associations with other factors was inconsistent across countries.
18 South Asian countries have experienced a striking economic growth in the last few
19 decades, which triggered unprecedented improvements in maternal mortality, infant
20 mortality, under-five mortality, and child undernutrition [29,30]. Trends in the
21 prevalence of childhood underweight have been declining in these countries, with
22 almost 25-30% reduction between 2004 and 2014 in Bangladesh, India, Pakistan,
23 and Nepal [31]. However, the existing burden of undernutrition is still high – our
24 study found that around one-third of under-five children in this region are still
25 underweight. Previous studies conducted in the region have found that poor

1 socioeconomic status, lower level of parental education, younger age of mother at
2 birth, short birth interval, and initiation of complementary feeding are important
3 determinants of undernutrition among under-five children [32–34]. We observed
4 large inequalities in the prevalence of underweight in each of the included countries,
5 which could not be explained by other factors studied here. Our study also showed
6 that factors like maternal underweight could significantly increase the likelihood of
7 underweight in children, while other factors like older age of mother at birth, and
8 access to improved sanitation were also associated with lower odds of childhood
9 underweight. These associations were statistically significant, mostly in India
10 because of a relatively large sample size. DHS data have information on feeding
11 practices for children aged up to two years, so we could not adjust for variables
12 related to feeding practices [26].

13 There has been evidence on increasing trends of overweight in younger children in
14 many South Asian countries, although the prevalence is still quite low compared to
15 the prevalence of underweight. Recent reports [12,35–37] from South Asian
16 countries highlighted the rise of overweight burden in children, but mainly in older
17 groups. Overweight among under-five children is still overlooked in current literature.
18 In our study, we provided evidence for an increasing burden of overweight in this age
19 group, which clustered mainly in households with higher socioeconomic status. We
20 found that the associations between socioeconomic status and the prevalence of
21 childhood overweight can be heterogeneous between countries, with positive
22 associations in most countries and inverse association in Pakistan. This highlights
23 the need for cross-country comparisons for better understanding of double burden of
24 malnutrition. Frequent intake of energy-dense foods and physical inactivity have
25 been shown to be associated with overweight and obesity both in children and adults

1 [38,39]. These lifestyle behaviours are common in the higher socioeconomic group in
2 LMICs, and therefore, both childhood and adulthood overweight are clustered in
3 affluent households in urban areas [35,37]. Our study showed that mothers who
4 were overweight had higher odds of having children with overweight when compared
5 with mothers who were of normal weight - suggesting that public health nutrition
6 programmes should prioritise children whose mothers are overweight. Our findings
7 on having lower odds of overweight among children exposed to nutrition-sensitive
8 programmes (receiving vitamin A and deworming drug) in Pakistan can be studied
9 further to examine the efficacy of such programmes to reduce double burden of
10 malnutrition in LMICs.

11 The findings from our study highlight the importance of considering not only
12 socioeconomic inequalities but also other maternal and household level factors while
13 developing public health interventions and policies to tackle both childhood
14 undernutrition and overnutrition. Also, the opposite directions for associations of
15 socioeconomic status and nutritional outcomes suggest that the concept of “one size
16 fits all” is not applicable to tackle the emerging problem of the double burden of
17 malnutrition. Previous studies suggested that a multi-sectoral approach is needed to
18 alleviate poverty and other social inequalities related to the double burden of
19 malnutrition in South Asia and beyond [40].

20 Our study is the first study to look at the coexistence of underweight and overweight
21 among under-five children in South Asian countries by socioeconomic status. One of
22 the major strengths of our study is the use of nationally-representative samples with
23 objectively measured height and weight data from five different countries, which
24 allowed cross-country comparisons of the results. We were also able to adjust for
25 several factors in the multivariable models, but there are possibilities of residual

1
2
3 1 confounding due to unmeasured factors and/or imperfect assessment of measured
4
5 2 factors. Due to smaller sample sizes in Maldives and Nepal, we could not reliably
6
7 3 estimate the associations. Problems of reverse causation could also arise in the
8
9 4 observed estimates due to the cross-sectional nature of the study. We used the
10
11 5 IOTF reference to define childhood overweight instead of the WHO or Centers for
12
13 6 Disease Control (CDC) references [22,23,25]. The IOTF classification system is
14
15 7 based on large datasets from six regions covering different ethnicities, therefore
16
17 8 more suitable for international comparisons [23,25]. When compared with other
18
19 9 references, the IOTF reference yielded similar estimates for overall overweight
20
21 10 prevalence but different estimates for obesity [41,42]. It was also found to be more
22
23 11 specific in identifying children with overweight and obesity than other references [43].
24
25 12 We assessed childhood undernutrition by assessing only underweight, which is a
26
27 13 composite measure of wasting and stunting. Previous studies have found that
28
29 14 stunting and overweight can occur concurrently in an individual [44], therefore there
30
31 15 may be double counting of children while studying double burden of malnutrition.
32
33 16 Looking at children who are stunted and overweight can offer more insights into the
34
35 17 topic, but we did not look into this issue in our study.
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

19 In conclusion, our study provides evidence for socioeconomic disparities for the
20 coexistence of under- and over-nutrition among children aged 24-59 months in South
21 Asian countries. It also showed that factors like maternal nutritional status was
22 strongly associated with nutritional outcomes in children. These unmet inequalities
23 for both underweight and overweight should be considered while developing national
24 public health nutrition programmes and strategies.

25

1
2
3 1
4
5
6 2 **ACKNOWLEDGEMENTS**
7
8 3 The authors thank the participants of Demographic and Health Surveys used in this
9
10 4 study from Bangladesh, India, Maldives, Nepal, and Pakistan. We would also like to
11
12 5 thank the DHS Program to authorize us to use the data.
13
14 6
15
16
17 7 **AUTHOR CONTRIBUTIONS**
18
19 8 Conception and design: FH, MS, SA and MB
20
21 9 Data collection and management: FH, SS, and GA
22
23
24 10 Data analysis: FH, MS, SS
25
26 11 Interpretation of the results: All authors
27
28 12 Drafting of the article: FH and MS
29
30 13 Critical revision of the article for important intellectual content: All authors
31
32 14 Final approval of the article: All authors.
33
34
35 15
36
37 16 **COMPETING INTERESTS STATEMENT**
38
39 17 None declared
40
41
42 18
43
44 19 **FUNDING STATEMENT**
45
46 20 This research received no specific grant from any funding agency in the public,
47
48 21 commercial or not-for-profit sectors.
49
50
51 22
52
53 23 **DATA SHARING STATEMENT**
54
55
56
57
58
59
60

1
2
3 1 This study used data from Demographic and Health Surveys (DHS) for Bangladesh,
4
5 2 India, Maldives, Nepal, and Pakistan, which are available from the DHS programme
6
7 3 website.
8
9

10 4 REFERENCES

- 11
12 5 1 World Health Organization. Double burden of malnutrition. Nutrition.
13
14 2019.<https://www.who.int/nutrition/double-burden-malnutrition/en/> (accessed 3
15
16 7 Apr 2019).
17
18 8 2 Shrimpton, Roger; Rokx C. The Double Burden of Malnutrition : A Review of
19
20 9 Global Evidence. Washington, DC: 2012.
21
22 <https://openknowledge.worldbank.org/handle/10986/27417>
23
24 10
25 11 3 Stevens GA, Finucane MM, Paciorek CJ, *et al*. Trends in mild, moderate, and
26
27 12 severe stunting and underweight, and progress towards MDG 1 in 141
28
29 13 developing countries: a systematic analysis of population representative data.
30
31 14 *Lancet (London, England)* 2012;**380**:824–34. doi:10.1016/S0140-
32
33 15 6736(12)60647-3
34
35 16 4 Harding KL, Aguayo VM, Webb P. Factors associated with wasting among
36
37 17 children under five years old in South Asia: Implications for action. *PLoS One*
38
39 18 2018;**13**:e0198749.<https://doi.org/10.1371/journal.pone.0198749>
40
41 19 5 de Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight
42
43 20 and obesity among preschool children. *Am J Clin Nutr* 2010;**92**:1257–64.
44
45 21 doi:10.3945/ajcn.2010.29786.1
46
47 22 6 de Onis M, Blössner M. Prevalence and trends of overweight among
48
49 23 preschool children in developing countries. *Am J Clin Nutr* 2000;**72**:1032–
50
51 24 9.<http://search.ebscohost.com/login.aspx?direct=true&db=cin20&AN=2001004>
52
53 25 608&lang=es&site=ehost-live
54
55
56
57
58
59
60

- 1
2
3 1 7 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass
4 index, underweight, overweight, and obesity from 1975 to 2016: a pooled
5 2
6 index, underweight, overweight, and obesity from 1975 to 2016: a pooled
7 analysis of 2416 population-based measurement studies in 128.9 million
8 3
9 children, adolescents, and adults. *Lancet (London, England)* 2017;**390**:2627–
10 4
11 42. doi:10.1016/S0140-6736(17)32129-3
12 5
13 42. doi:10.1016/S0140-6736(17)32129-3
14 6 8 GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in
15 6 8 GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in
16 195 Countries over 25 Years. *N Engl J Med* Published Online First: 2017.
17 7
18 195 Countries over 25 Years. *N Engl J Med* Published Online First: 2017.
19 8
20 doi:10.1056/NEJMoa1614362
21 9 9 Development Initiatives. 2018 Global Nutrition Report: Shining a light to spur
22 9 9 Development Initiatives. 2018 Global Nutrition Report: Shining a light to spur
23 action on nutrition. Bristol, UK: 2018. <https://globalnutritionreport.org/>
24 10
25 action on nutrition. Bristol, UK: 2018. <https://globalnutritionreport.org/>
26 11 10 Hoque ME, Doi SAR, Mannan M, *et al*. Prevalence of overweight and obesity
27 11 10 Hoque ME, Doi SAR, Mannan M, *et al*. Prevalence of overweight and obesity
28 among children and adolescents of the indian subcontinent: A meta-analysis.
29 12
30 among children and adolescents of the indian subcontinent: A meta-analysis.
31 13
32 *Nutr Rev* 2014;**72**:541–50. doi:10.1111/nure.12130
33 14 11 Khadilkar V V., Khadilkar A V., Cole TJ, *et al*. Overweight and obesity
34 14 11 Khadilkar V V., Khadilkar A V., Cole TJ, *et al*. Overweight and obesity
35 prevalence and body mass index trends in Indian children. *Int J Pediatr Obes*
36 15
37 prevalence and body mass index trends in Indian children. *Int J Pediatr Obes*
38 2011;**6**:e216–24. doi:10.3109/17477166.2010.541463
39 16
40 17 12 Bulbul T, Hoque M. Prevalence of childhood obesity and overweight in
41 17 12 Bulbul T, Hoque M. Prevalence of childhood obesity and overweight in
42 Bangladesh: findings from a countrywide epidemiological study. *BMC Pediatr*
43 18
44 Bangladesh: findings from a countrywide epidemiological study. *BMC Pediatr*
45 2014;**14**:86. doi:10.1186/1471-2431-14-86
46 19
47 20 13 Das S, Fahim SM, Islam MS, *et al*. Prevalence and sociodemographic
48 20 13 Das S, Fahim SM, Islam MS, *et al*. Prevalence and sociodemographic
49 determinants of household-level double burden of malnutrition in Bangladesh.
50 21
51 determinants of household-level double burden of malnutrition in Bangladesh.
52 22
53 *Public Health Nutr* 2019;**22**:1425–32. doi:10.1017/S1368980018003580
54 23 14 Oddo VM, Rah JH, Semba RD, *et al*. Predictors of maternal and child double
55 23 14 Oddo VM, Rah JH, Semba RD, *et al*. Predictors of maternal and child double
56 burden of malnutrition in rural Indonesia and Bangladesh. *Am J Clin Nutr*
57 24
58 burden of malnutrition in rural Indonesia and Bangladesh. *Am J Clin Nutr*
59 2012;**95**:951–8. doi:10.3945/ajcn.111.026070
60 25
60 2012;**95**:951–8. doi:10.3945/ajcn.111.026070

- 1
2
3 1 15 Black RE, Victora CG, Walker SP, *et al.* Maternal and child undernutrition and
4
5 2 overweight in low-income and middle-income countries. *Lancet (London,*
6
7 3 *England)* 2013;**382**:427–51. doi:10.1016/S0140-6736(13)60937-X
8
9
10 4 16 Bann D, Johnson W, Li L, *et al.* Socioeconomic inequalities in childhood and
11
12 5 adolescent body-mass index, weight, and height from 1953 to 2015: an
13
14 6 analysis of four longitudinal, observational, British birth cohort studies. *Lancet*
15
16 7 *Public Heal* 2018;**3**:e194–203. doi:10.1016/S2468-2667(18)30045-8
17
18
19 8 17 Barriuso L, Miqueleiz E, Albaladejo R, *et al.* Socioeconomic position and
20
21 9 childhood-adolescent weight status in rich countries: a systematic review,
22
23 10 1990–2013. *BMC Pediatr* 2015;**15**:129. doi:10.1186/s12887-015-0443-3
24
25
26 11 18 Shrewsbury V, Wardle J. Socioeconomic status and adiposity in childhood: a
27
28 12 systematic review of cross-sectional studies 1990--2005. *Obes (Silver Spring)*
29
30 13 2008;**16**.
31
32
33 14 19 Van de Poel E, Hosseinpoor AR, Speybroeck N, *et al.* Socioeconomic
34
35 15 inequality in malnutrition in developing countries. *Bull World Health Organ*
36
37 16 2008;**86**:282–91. doi:10.2471/BLT.07.044800
38
39
40 17 20 The DHS Program: Demographic and Health Surveys.
41
42 18 2019.<https://dhsprogram.com/> (accessed 21 May 2019).
43
44
45 19 21 DHS Program. Using datasets for analysis.
46
47 20 <https://dhsprogram.com/data/Using-Datasets-for-Analysis.cfm> (accessed 14
48
49 21 Nov 2017).
50
51
52 22 22 Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, *et al.* CDC growth charts:
53
54 23 United States. *Adv Data* 2000;:1–27.
55
56
57 24 23 Cole TJ, Bellizzi MC, Flegal KM, *et al.* Establishing a standard definition for
58
59 25 child overweight and obesity worldwide: international survey. *BMJ*
60

- 1
2
3 1 2000;**320**:1240–3.
4
5 2 24 World Health Organization. WHO child growth standards : length/height-for-
6
7 age, weight-for-age, weight-for-length, weight-forheight and body mass index-
8 3
9 for-age : methods and development. Geneva: 2006.
10 4
11 https://www.who.int/childgrowth/standards/Technical_report.pdf
12 5
13
14 6 25 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs
15
16 for thinness, overweight and obesity. *Pediatr Obes* 2012;**7**:284–94.
17 7
18 doi:10.1111/j.2047-6310.2012.00064.x
19 8
20
21 9 26 The DHS Program. DHS Overview. 2019.[https://dhsprogram.com/What-We-](https://dhsprogram.com/What-We-Do/Survey-Types/DHS.cfm)
22
23 Do/Survey-Types/DHS.cfm (accessed 3 Apr 2019).
24 10
25
26 11 27 Ruel MT, Alderman H, Group M and CNS. Nutrition-sensitive interventions and
27
28 programmes: how can they help to accelerate progress in improving maternal
29 12
30 and child nutrition? *Lancet* 2013;**382**:536–51.
31 13
32
33 14 28 StataCorp. svy estimation - Estimation commands for survey data.
34
35 <https://www.stata.com/manuals13/svysvyestimation.pdf> (accessed 3 Apr
36 15
37 2019).
38 16
39
40 17 29 Akseer N, Kamali M, Arifeen SE, *et al.* Progress in maternal and child health:
41
42 how has South Asia fared? *BMJ* 2017;**357**:j1608. doi:10.1136/bmj.j1608
43 18
44
45 19 30 United Nations. The Millennium Development Goals Report. New York: 2015.
46
47 [https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG 2015 rev](https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf)
48 20
49 (July 1).pdf
50 21
51
52 22 31 The World Bank Group. World Bank Open Data: Free and open access to
53
54 global development data. 2019.<https://data.worldbank.org/> (accessed 1 Mar
55 23
56 2019).
57 24
58
59 25 32 Pravana NK, Piryani S, Chaurasiya SP, *et al.* Determinants of severe acute
60

- 1
2
3 1 malnutrition among children under 5 years of age in Nepal: a community-
4 based case-control study. *BMJ Open* 2017;**7**:e017084. doi:10.1136/bmjopen-
5 2017-017084
6
7
8
9
10 4 33 Ansuya, Nayak BS, Unnikrishnan B, *et al.* Risk factors for malnutrition among
11 preschool children in rural Karnataka: a case-control study. *BMC Public Health*
12 2018;**18**:283. doi:10.1186/s12889-018-5124-3
13
14
15
16
17 7 34 Chowdhury MRK, Rahman MS, Khan MMH, *et al.* Risk Factors for Child
18 Malnutrition in Bangladesh: A Multilevel Analysis of a Nationwide Population-
19 Based Survey. *J Pediatr* 2016;**172**:194-201.e1.
20
21
22
23
24 10 doi:10.1016/j.jpeds.2016.01.023
25
26 11 35 Ranjani H, Mehreen TS, Pradeepa R, *et al.* Epidemiology of childhood
27 overweight & obesity in India: A systematic review. *Indian J Med Res*
28 2016;**143**:160–74. doi:10.4103/0971-5916.180203
29
30
31
32
33 14 36 Mushtaq MU, Gull S, Abdullah HM, *et al.* Prevalence and socioeconomic
34 correlates of overweight and obesity among Pakistani primary school children.
35
36
37
38 16 *BMC Public Health* 2011;**11**:724. doi:10.1186/1471-2458-11-724
39
40 17 37 Rahman S, Islam MT, Alam DS. Obesity and overweight in Bangladeshi
41 children and adolescents: a scoping review. *BMC Public Health* 2014;**14**:70.
42
43
44
45 19 doi:10.1186/1471-2458-14-70
46
47 20 38 Hemmingsson E. Early Childhood Obesity Risk Factors: Socioeconomic
48 Adversity, Family Dysfunction, Offspring Distress, and Junk Food Self-
49 Medication. *Curr Obes Rep* 2018;**7**:204–9. doi:10.1007/s13679-018-0310-2
50
51
52
53 23 39 Gupta N, Misra A, Goel K, *et al.* Childhood Obesity in Developing Countries:
54 Epidemiology, Determinants, and Prevention. *Endocr Rev* 2012;**33**:48–70.
55
56
57
58 25 doi:10.1210/er.2010-0028
59
60

- 1
2
3 1 40 Perez-Escamilla R, Bermudez O, Buccini GS, *et al.* Nutrition disparities and
4 the global burden of malnutrition. *BMJ* 2018;**361**:k2252.
5
6 2
7 doi:10.1136/bmj.k2252
8 3
9
10 4 41 Tuan NT, Nicklas TA. Age, sex and ethnic differences in the prevalence of
11 underweight and overweight, defined by using the CDC and IOTF cut points in
12 Asian children. *Eur J Clin Nutr* 2009;**63**:1305.
13 5
14 6
15
16 7 42 Moselakgomo K V, Van Staden M. Diagnostic comparison of Centers for
17 Disease Control and Prevention and International Obesity Task Force criteria
18 for obesity classification in South African children. *African J Prim Heal care*
19 *Fam Med* 2017;**9**:e1–7. doi:10.4102/phcfm.v9i1.1383
20 8
21 9
22 10
23
24 11 43 Valerio G, Balsamo A, Baroni MG, *et al.* Childhood obesity classification
25 systems and cardiometabolic risk factors: a comparison of the Italian, World
26 Health Organization and International Obesity Task Force references. *Ital J*
27 *Pediatr* 2017;**43**:19. doi:10.1186/s13052-017-0338-z
28 12
29 13
30 14
31 15 44 Bates K, Gjonça A, Leone T. Double burden or double counting of child
32 malnutrition? The methodological and theoretical implications of
33 stuntingoverweight in low and middle income countries. *J Epidemiol*
34 *Community Health* 2017;**71**:779 LP – 785. doi:10.1136/jech-2017-209008
35 16
36 17
37 18
38 19
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 **1 FIGURE LEGENDS**
4

5 **2 Figure 1: Prevalence of underweight and overweight, by country**
6

7
8 Sampling weight provided by the Demographic and Health Survey (DHS) and Stata's
9
10 survey estimation procedures were used to estimate country-representative
11
12 prevalence. Error bars represent 95% confidence intervals.
13
14
15
16

17 **7 Figure 2: Prevalence of underweight and overweight, by household's wealth**
18
19 **8 index**
20

21
22 Sampling weight provided by the Demographic and Health Survey (DHS) and Stata's
23
24 survey estimation procedures were used to estimate country-representative
25
26 prevalence. Error bars represent 95% confidence intervals.
27
28
29
30

31 **13 Figure 3: Prevalence of underweight and overweight, by household's highest**
32
33 **14 level of education**
34

35
36 Sampling weight provided by the Demographic and Health Survey (DHS) and Stata's
37
38 survey estimation procedures were used to estimate country-representative
39
40 prevalence. Error bars represent 95% confidence intervals.
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 Table 1: Sample characteristics in five demographic and health survey data, by
2 country

| | 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 variables | | | | | |
| Sex, n (%) | | | | | |
| 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) |
| Age in year, n (%) | | | | | |
| 2-3 | 1406 (33.7) | 45298 (32.8) | 452 (33.8) | 460 (33.1) | 668 (34.0) |
| 3-4 | 1377 (33.0) | 47506 (34.4) | 464 (34.7) | 479 (34.5) | 641 (32.6) |
| 4-5 | 1387 (33.3) | 45329 (32.8) | 423 (31.6) | 449 (32.3) | 655 (33.4) |
| Received vitamin A in last 6 months, n (%) | 2735 (66.0) | 73678 (54.1) | 695 (81.8) | 1232 (88.8) | 1252 (64.6) |
| Received deworming drug in last 6 months, n (%) | 2153 (51.7) | 43319 (31.6) | 1104 (82.8) | 1105 (79.8) | 593 (30.3) |
| Household variables | | | | | |
| Area of residence, n (%) | | | | | |
| 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) |
| Access to improved sanitation, n (%) | 2741 (65.7) | 67441 (48.8) | 1278 (95.4) | 1047 (75.4) | 1455 (74.1) |
| Access to improved drinking water, n (%) | 3791 (90.9) | 114018 (82.5) | 1210 (90.4) | 1206 (86.8) | 1564 (79.6) |
| Wealth index, n (%) | | | | | |
| 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) |
| Highest education level, n (%) | | | | | |
| 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) |
| No. of household member, median (IQR) | 5.0 (4.0, 7.0) | 6.0 (5.0, 8.0) | 8.0 (6.0, 11.0) | 5.0 (4.0, 7.0) | 8.0 (6.0, 11.0) |
| No. of under-five children, median (IQR) | 1.0 (1.0, 2.0) | 2.0 (1.0, 2.0) | 2.0 (1.0, 2.0) | 1.0 (1.0, 2.0) | 2.0 (2.0, 3.0) |
| Maternal variables | | | | | |
| Mother's age at first birth, n (%) | | | | | |
| Less than 250 years | 3056 (73.3) | 50969 (36.9) | 499 (37.3) | 759 (54.6) | 812 (41.3) |
| 20-24 years | 927 (22.2) | 66287 (48.0) | 649 (48.5) | 531 (38.2) | 812 (41.3) |
| 25 years or above | 187 (4.5) | 20878 (15.1) | 191 (14.3) | 99 (7.1) | 340 (17.3) |
| Mother's BMI (kg/m ²) category, n (%) | | | | | |
| Underweight | 835 (20.1) | 31127 (22.6) | 94 (7.4) | 228 (16.4) | 224 (11.5) |
| Normal weight | 2439 (58.6) | 85490 (62.0) | 639 (50.3) | 937 (67.5) | 1006 (51.5) |
| Overweight | 885 (21.3) | 21172 (15.4) | 538 (42.3) | 224 (16.1) | 723 (37.0) |

1 **Table 2: Associations of household's wealth index and highest education with childhood underweight and overweight**

| | ORs (95% CI) * | | | | | | | | | |
|-------------------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
| | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted |
| Underweight | | | | | | | | | | |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (0.9-1.1) | 1.0 (0.8-1.2) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (0.8-1.3) | 1.0 (0.7-1.4) | 1.0 (0.8-1.2) | 1.0 (0.8-1.3) | 1.0 (0.8-1.2) | 1.0 (0.7-1.3) |
| Poorer | 0.8 (0.7-0.9) | 0.8 (0.7-1.0) | 0.7 (0.7-0.7) | 0.8 (0.8-0.8) | 0.8 (0.6-1.0) | 0.9 (0.6-1.3) | 0.6 (0.5-0.8) | 0.6 (0.5-0.8) | 0.9 (0.7-1.1) | 1.0 (0.8-1.3) |
| Middle | 0.6 (0.5-0.7) | 0.7 (0.6-0.8) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.8 (0.6-1.0) | 1.0 (0.7-1.4) | 0.8 (0.6-1.0) | 0.8 (0.6-1.0) | 0.7 (0.5-0.9) | 0.8 (0.6-1.1) |
| Richer | 0.4 (0.4-0.5) | 0.6 (0.5-0.7) | 0.4 (0.4-0.4) | 0.6 (0.6-0.6) | 0.5 (0.3-0.7) | 0.7 (0.5-1.0) | 0.6 (0.4-0.8) | 0.7 (0.5-0.9) | 0.6 (0.4-0.7) | 0.9 (0.7-1.1) |
| Richest | 0.3 (0.2-0.3) | 0.4 (0.3-0.5) | 0.3 (0.3-0.3) | 0.5 (0.5-0.5) | 0.3 (0.2-0.6) | 0.5 (0.2-1.5) | 0.3 (0.2-0.4) | 0.4 (0.3-0.7) | 0.3 (0.3-0.4) | 0.7 (0.5-1.1) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (0.9-1.2) | 1.0 (0.9-1.2) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (0.7-1.3) | 1.0 (0.7-1.4) | 1.0 (0.8-1.2) | 1.0 (0.8-1.2) | 1.0 (0.9-1.1) | 1.0 (0.8-1.2) |
| Primary | 1.0 (0.9-1.1) | 1.1 (0.9-1.2) | 0.8 (0.7-0.8) | 0.9 (0.9-0.9) | 0.6 (0.5-0.7) | 0.6 (0.5-0.7) | 0.7 (0.6-0.9) | 0.8 (0.6-1.1) | 0.8 (0.7-1.1) | 1.0 (0.8-1.3) |
| Secondary | 0.6 (0.5-0.6) | 0.8 (0.7-0.9) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.3 (0.2-0.4) | 0.3 (0.2-0.4) | 0.5 (0.4-0.7) | 0.8 (0.6-1.0) | 0.4 (0.3-0.5) | 0.5 (0.4-0.7) |
| Higher | 0.3 (0.3-0.4) | 0.7 (0.6-1.0) | 0.3 (0.3-0.3) | 0.6 (0.5-0.6) | 0.2 (0.1-0.8) | 0.5 (0.1-1.9) | 0.3 (0.2-0.5) | 0.5 (0.4-0.8) | 0.3 (0.2-0.4) | 0.4 (0.2-0.6) |
| Overweight | | | | | | | | | | |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (0.6-1.7) | 1.0 (0.5-1.9) | 1.0 (0.9-1.1) | 1.0 (0.9-1.1) | 1.0 (0.6-1.6) | 1.0 (0.6-1.8) | 1.0 (0.6-1.7) | 1.0 (0.5-1.9) | 1.0 (0.8-1.2) | 1.0 (0.7-1.5) |
| Poorer | 0.9 (0.5-1.6) | 0.8 (0.4-1.5) | 1.1 (1.0-1.2) | 1.0 (1.0-1.1) | 1.3 (0.9-2.0) | 1.4 (0.8-2.2) | 0.4 (0.2-0.9) | 0.4 (0.1-0.9) | 0.5 (0.4-0.7) | 0.4 (0.3-0.6) |
| Middle | 1.2 (0.7-2.0) | 1.0 (0.6-1.6) | 1.2 (1.1-1.3) | 1.0 (1.0-1.1) | 1.2 (0.8-1.8) | 1.1 (0.7-1.7) | 0.1 (0.0-0.6) | 0.1 (0.0-0.6) | 0.4 (0.3-0.5) | 0.3 (0.2-0.4) |
| Richer | 1.0 (0.6-1.7) | 0.7 (0.4-1.2) | 1.3 (1.2-1.4) | 1.0 (1.0-1.1) | 1.7 (1.1-2.7) | 0.9 (0.5-1.4) | 0.5 (0.2-1.1) | 0.5 (0.2-1.1) | 0.3 (0.2-0.4) | 0.2 (0.1-0.2) |
| Richest | 3.8 (2.8-5.0) | 1.4 (0.8-2.3) | 1.7 (1.6-1.8) | 1.2 (1.1-1.3) | 1.9 (1.1-3.4) | 0.5 (0.2-1.4) | 1.1 (0.5-2.3) | 1.0 (0.4-2.4) | 0.4 (0.3-0.5) | 0.1 (0.1-0.2) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (0.6-1.8) | 1.0 (0.5-1.9) | 1.0 (1.0-1.1) | 1.0 (0.9-1.1) | 1.0 (0.6-1.7) | 1.0 (0.5-1.9) | 1.0 (0.5-1.9) | 1.0 (0.5-2.1) | 1.0 (0.9-1.2) | 1.0 (0.7-1.3) |
| Primary | 1.1 (0.7-1.7) | 1.1 (0.7-1.7) | 1.1 (1.0-1.1) | 1.0 (0.9-1.1) | 0.9 (0.7-1.3) | 1.1 (0.7-1.5) | 1.0 (0.4-2.4) | 1.1 (0.4-2.7) | 0.6 (0.4-0.9) | 0.9 (0.6-1.4) |
| Secondary | 1.4 (1.0-1.9) | 1.1 (0.8-1.5) | 1.2 (1.1-1.2) | 1.0 (0.9-1.0) | 2.1 (1.6-2.7) | 2.1 (1.6-2.7) | 2.0 (1.2-3.3) | 1.9 (1.1-3.1) | 0.6 (0.4-0.8) | 1.3 (0.9-1.8) |
| Higher | 5.2 (3.6-7.5) | 2.0 (1.2-3.3) | 1.7 (1.6-1.9) | 1.2 (1.1-1.3) | 2.0 (0.6-6.8) | 0.6 (0.1-5.0) | 0.9 (0.3-2.8) | 0.6 (0.2-2.2) | 0.8 (0.5-1.1) | 1.6 (1.0-2.5) |

2 * Minimally adjusted models were adjusted for child's age and sex; and fully-adjusted models were additionally adjusted for area of residence, receiving vitamin A and
3 deworming drug, access to improved sanitation and drinking water, number of household member, number of under-five children, mother's age at first birth, and mother's BMI.

1 **Table 3: Socioeconomic status-adjusted odds ratios (ORs) of underweight and overweight by various child, household**
2 **and maternal factors**

| | ORs (95% CI) | | | | | | | | | |
|--|---------------|---------------|----------------------|----------------------|---------------|---------------|----------------------|---------------|---------------|----------------------|
| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
| | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight |
| Child's variables | | | | | | | | | | |
| Sex | | | | | | | | | | |
| Male | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Female | 1.2 (1.0-1.4) | 1.2 (0.8-1.8) | 1.0 (1.0-1.1) | 1.0 (1.0-1.1) | 1.1 (0.9-1.5) | 1.1 (0.7-1.7) | 1.1 (0.9-1.4) | 1.5 (0.7-2.9) | 0.9 (0.7-1.1) | 1.0 (0.8-1.3) |
| Age | | | | | | | | | | |
| 2-3 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 3-4 years | 1.0 (0.8-1.2) | 1.0 (0.6-1.6) | 1.0 (1.0-1.0) | 1.0 (0.9-1.0) | 1.0 (0.7-1.3) | 1.4 (0.9-2.3) | 0.8 (0.6-1.0) | 2.6 (1.1-6.5) | 0.9 (0.7-1.1) | 1.4 (1.0-1.9) |
| 4-5 years | 1.0 (0.9-1.2) | 0.8 (0.5-1.4) | 1.0 (1.0-1.0) | 0.9 (0.9-1.0) | 0.7 (0.5-1.0) | 1.3 (0.8-2.1) | 0.9 (0.7-1.2) | 1.5 (0.6-4.1) | 0.9 (0.7-1.2) | 1.2 (0.9-1.7) |
| Received vitamin A in last 6 months | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.1) | 1.2 (0.7-1.8) | 1.1 (1.0-1.1) | 1.1 (1.0-1.1) | 1.2 (0.8-2.0) | 1.0 (0.5-1.9) | 0.8 (0.5-1.1) | 1.1 (0.3-3.8) | 1.2 (1.0-1.6) | 0.5 (0.4-0.6) |
| Received deworming drug in last 6 months | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.9 (0.8-1.1) | 0.9 (0.6-1.4) | 1.0 (0.9-1.0) | 1.1 (1.0-1.2) | 1.5 (1.0-2.3) | 0.8 (0.5-1.3) | 1.0 (0.7-1.3) | 1.4 (0.5-3.6) | 0.8 (0.6-1.0) | 0.6 (0.4-0.8) |
| Household variables | | | | | | | | | | |
| Area of residence | | | | | | | | | | |
| Urban | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Rural | 0.9 (0.8-1.1) | 0.7 (0.4-1.1) | 0.9 (0.9-0.9) | 1.1 (1.0-1.1) | 1.0 (0.4-2.2) | 0.4 (0.2-1.0) | 1.1 (0.9-1.4) | 1.2 (0.6-2.6) | 1.0 (0.8-1.3) | 0.6 (0.4-0.8) |
| Improved access to sanitation | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.1) | 1.1 (0.7-1.9) | 0.8 (0.8-0.8) | 1.2 (1.1-1.3) | 0.7 (0.4-1.3) | 1.5 (0.4-4.8) | 0.7 (0.5-0.9) | 1.0 (0.4-2.5) | 0.8 (0.6-1.1) | 1.6 (1.1-2.2) |
| Improved access to drinking water | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.2) | 1.6 (0.7-3.7) | 0.9 (0.9-1.0) | 1.2 (1.1-1.2) | 1.5 (0.8-2.7) | 0.9 (0.4-1.7) | 1.0 (0.7-1.5) | 0.9 (0.4-2.2) | 1.2 (0.9-1.6) | 0.7 (0.5-0.9) |
| No. of household member | 1.0 (1.0-1.0) | 1.0 (0.9-1.1) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (1.0-1.1) | 1.0 (0.9-1.0) | 1.1 (1.0-1.1) | 0.9 (0.8-1.1) | 1.0 (1.0-1.0) | 1.1 (1.0-1.1) |
| No. of children under five | 1.1 (1.0-1.2) | 1.0 (0.8-1.3) | 1.1 (1.1-1.1) | 0.9 (0.9-1.0) | 1.1 (1.0-1.2) | 1.0 (0.8-1.2) | 1.1 (0.9-1.2) | 0.7 (0.4-1.1) | 1.0 (1.0-1.1) | 1.0 (0.9-1.1) |
| Maternal variables | | | | | | | | | | |
| Mother's age at first birth | | | | | | | | | | |
| Less than 20 years | 1.1 (0.9-1.3) | 0.6 (0.4-1.0) | 1.1 (1.0-1.1) | 1.0 (0.9-1.0) | 1.1 (0.8-1.5) | 0.7 (0.4-1.1) | 0.9 (0.7-1.2) | 0.5 (0.2-1.0) | 1.0 (0.8-1.2) | 0.8 (0.6-1.1) |

| | | | | | | | | | | | |
|-----------------------|----------------------|----------------------|----------------------|----------------------|---------------|---------------|----------------------|---------------|----------------------|----------------------|-----------|
| 20-24 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 25 years or more | 0.8 (0.5-1.1) | 1.7 (0.9-3.3) | 0.8 (0.8-0.8) | 1.3 (1.2-1.4) | 0.8 (0.5-1.3) | 1.1 (0.6-1.9) | 0.8 (0.5-1.4) | 0.5 (0.1-2.3) | 0.9 (0.7-1.3) | 0.8 (0.5-1.1) | |
| Mother's BMI category | | | | | | | | | | | |
| Normal weight | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | |
| Underweight | 1.9 (1.6-2.3) | 0.5 (0.2-1.1) | 1.7 (1.7-1.8) | 0.5 (0.5-0.6) | 1.3 (0.7-2.1) | 0.2 (0.1-1.0) | 2.1 (1.6-2.9) | 0.4 (0.1-1.5) | 2.0 (1.4-2.7) | 0.4 (0.3-0.8) | |
| Overweight | 0.7 (0.5-0.8) | 1.9 (1.2-3.0) | 0.6 (0.6-0.7) | 1.3 (1.2-1.4) | 0.7 (0.5-1.0) | 1.3 (0.9-2.0) | 0.5 (0.3-0.7) | 0.9 (0.3-2.2) | 0.6 (0.5-0.8) | 1.8 (1.4-2.5) | |

1 *Bold cells indicate statistically significant estimates (p<0.05)

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

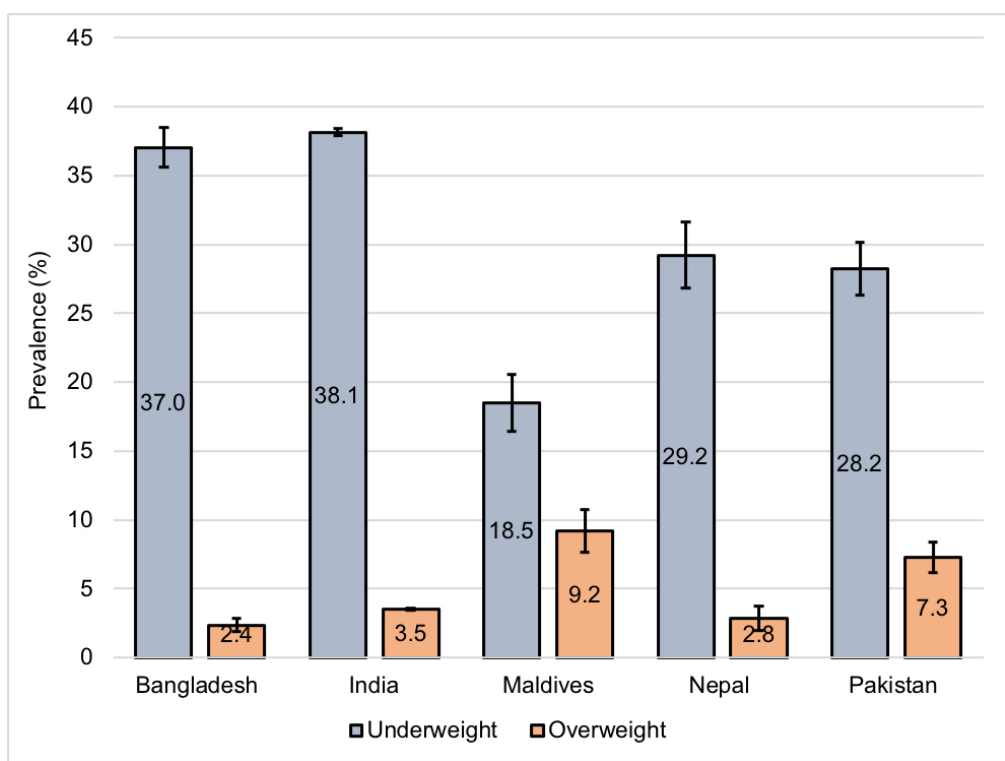
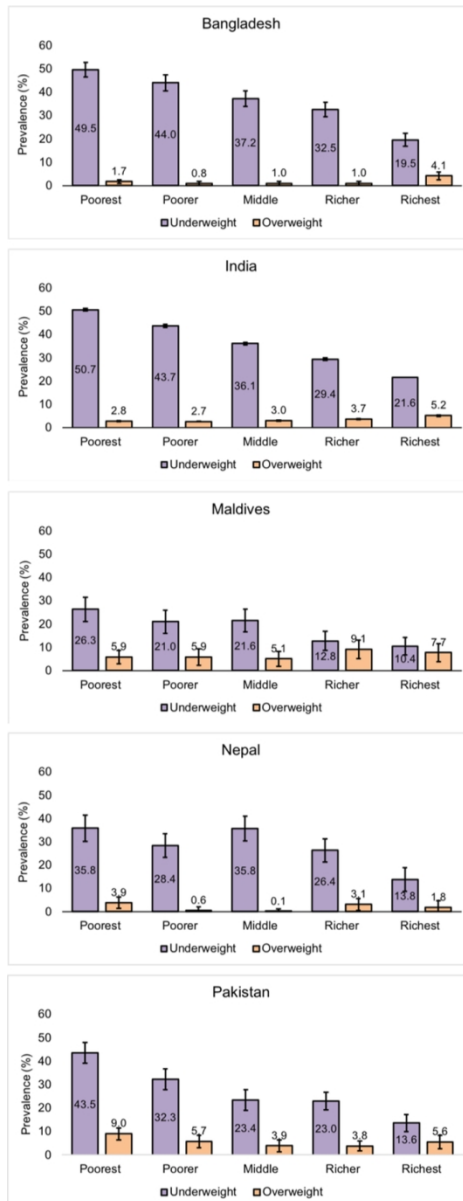


Figure 1: Prevalence of underweight and overweight, by country
Sampling weight provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence. Error bars represent 95% confidence intervals.

83x62mm (300 x 300 DPI)



Prevalence of underweight and overweight, by household’s wealth index
 Sampling weight provided by the Demographic and Health Survey (DHS) and Stata’s survey estimation procedures were used to estimate country-representative prevalence. Error bars represent 95% confidence intervals.

30x78mm (600 x 600 DPI)

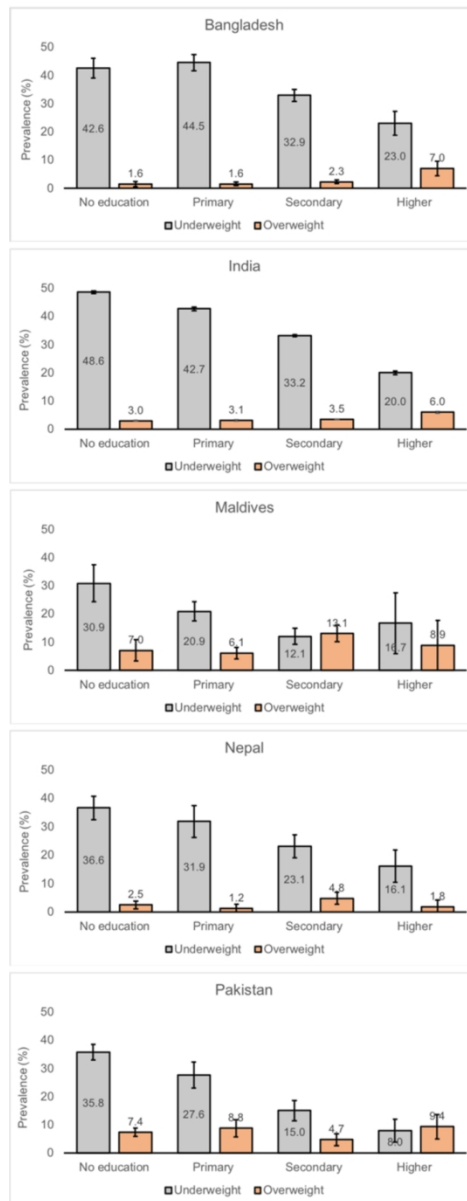


Figure 3: Prevalence of underweight and overweight, by household's highest level of education. Sampling weight provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence. Error bars represent 95% confidence intervals.

30x77mm (600 x 600 DPI)

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

| | | Reporting Item | Page Number |
|---------------------------|---------------------|---|-----------------------|
| Title and abstract | | | |
| Title | #1a | Indicate the study's design with a commonly used term in the title or the abstract | Page 1 |
| Abstract | #1b | Provide in the abstract an informative and balanced summary of what was done and what was found | Page 2-3 |
| Introduction | | | |
| Background / rationale | #2 | Explain the scientific background and rationale for the investigation being reported | Page 5 |
| Objectives | #3 | State specific objectives, including any prespecified hypotheses | Page 6 lines 14-16 |
| Methods | | | |

| | | | | |
|----|----------------------|----------------------|---|-----------|
| 1 | Study design | #4 | Present key elements of study design early in the paper | Page 7 |
| 2 | | | | |
| 3 | Setting | #5 | Describe the setting, locations, and relevant dates, including periods of | Page 7 |
| 4 | | | recruitment, exposure, follow-up, and data collection | |
| 5 | | | | |
| 6 | | | | |
| 7 | Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection | Page 7 |
| 8 | | | of participants. | |
| 9 | | | | |
| 10 | | | | |
| 11 | | #7 | Clearly define all outcomes, exposures, predictors, potential | Page 8-9 |
| 12 | | | confounders, and effect modifiers. Give diagnostic criteria, if | |
| 13 | | | applicable | |
| 14 | | | | |
| 15 | | | | |
| 16 | Data sources / | #8 | For each variable of interest give sources of data and details of | NA |
| 17 | measurement | | methods of assessment (measurement). Describe comparability of | |
| 18 | | | assessment methods if there is more than one group. Give information | |
| 19 | | | separately for for exposed and unexposed groups if applicable. | |
| 20 | | | | |
| 21 | | | | |
| 22 | | | | |
| 23 | Bias | #9 | Describe any efforts to address potential sources of bias | Page 10 |
| 24 | | | | lines 11- |
| 25 | | | | 15 |
| 26 | | | | |
| 27 | | | | |
| 28 | Study size | #10 | Explain how the study size was arrived at | NA |
| 29 | | | | |
| 30 | | | | |
| 31 | Quantitative | #11 | Explain how quantitative variables were handled in the analyses. If | Page 8-9 |
| 32 | variables | | applicable, describe which groupings were chosen, and why | |
| 33 | | | | |
| 34 | Statistical | #12a | Describe all statistical methods, including those used to control for | Page 10 |
| 35 | methods | | confounding | |
| 36 | | | | |
| 37 | | | | |
| 38 | Statistical | #12b | Describe any methods used to examine subgroups and interactions | NA |
| 39 | methods | | | |
| 40 | | | | |
| 41 | | | | |
| 42 | Statistical | #12c | Explain how missing data were addressed | NA |
| 43 | methods | | | |
| 44 | | | | |
| 45 | | | | |
| 46 | Statistical | #12d | If applicable, describe analytical methods taking account of sampling | NA |
| 47 | methods | | strategy | |
| 48 | | | | |
| 49 | | | | |
| 50 | Statistical | #12e | Describe any sensitivity analyses | Page 13 |
| 51 | methods | | | lines 10- |
| 52 | | | | 16 |
| 53 | | | | |
| 54 | | | | |
| 55 | Results | | | |
| 56 | | | | |
| 57 | Participants | #13a | Report numbers of individuals at each stage of study—eg numbers | Page 11 |
| 58 | | | | |
| 59 | | | | |
| 60 | | | | |

potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.

| | | | |
|----|-------------------|--|----------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | Participants | #13b Give reasons for non-participation at each stage | NA |
| 8 | | | |
| 9 | Participants | #13c Consider use of a flow diagram | Page 11 |
| 10 | | | |
| 11 | Descriptive data | #14a Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable. | Page 11 |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | Descriptive data | #14b Indicate number of participants with missing data for each variable of interest | NA |
| 19 | | | |
| 20 | | | |
| 21 | | | |
| 22 | Outcome data | #15 Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. | Page 11 |
| 23 | | | |
| 24 | | | |
| 25 | | | |
| 26 | | | |
| 27 | Main results | #16a Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | Page 12 |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| 31 | | | |
| 32 | | | |
| 33 | Main results | #16b Report category boundaries when continuous variables were categorized | NA |
| 34 | | | |
| 35 | | | |
| 36 | | | |
| 37 | Main results | #16c If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | NA |
| 38 | | | |
| 39 | | | |
| 40 | Other analyses | #17 Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | Page 13 lines 10- 16 |
| 41 | | | |
| 42 | | | |
| 43 | | | |
| 44 | | | |
| 45 | | | |
| 46 | Discussion | | |
| 47 | | | |
| 48 | Key results | #18 Summarise key results with reference to study objectives | Page 14 |
| 49 | | | |
| 50 | Limitations | #19 Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. | Page 16- 17 |
| 51 | | | |
| 52 | | | |
| 53 | | | |
| 54 | | | |
| 55 | | | |
| 56 | Interpretation | #20 Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and | Page 14- 16 |
| 57 | | | |
| 58 | | | |
| 59 | | | |
| 60 | | | |

other relevant evidence.

1
2
3 Generalisability [#21](#) Discuss the generalisability (external validity) of the study results Page 16

4
5 **Other**
6 **Information**

7
8
9 Funding [#22](#) Give the source of funding and the role of the funders for the present Page 18
10 study and, if applicable, for the original study on which the present
11 article is based
12

13
14 Notes:

- 15
16 • 3: Page 6 lines 14-16
17
18 • 9: Page 10 lines 11-15
19
20
21 • 12e: Page 13 lines 10-16
22
23 • 17: Page 13 lines 10-16 The STROBE checklist is distributed under the terms of the Creative Commons
24 Attribution License CC-BY. This checklist was completed on 09. July 2019 using
25 <https://www.goodreports.org/>, a tool made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

BMJ Open

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

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID | bmjopen-2019-032866.R2 |
| Article Type: | Original research |
| Date Submitted by the Author: | 20-Dec-2019 |
| Complete List of Authors: | Hossain, Fariha Binte; Independent Researcher , Shawon, Md Shajedur Rahman; Oxford University, Nuffield Department of Population Health Al-Abid, Md Shehab Uddin; National Heart Foundation Hospital and Research Institute Mahmood, Sultan; Independent Researcher Adhikary, Gourab ; ICDDR, Health Systems and Population Studies Division Bulbul, Md. M. Islam; Institute of Public Health Nutrition (IPHN), National Nutrition Services (NNS) |
| Primary Subject Heading: | Global health |
| Secondary Subject Heading: | Public health, Nutrition and metabolism, Global health, Epidemiology |
| Keywords: | Double burden, underweight, overweight, under-five children, socioeconomic status, South Asia |
| | |

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 1 **TITLE:**
4

5 2 Double burden of malnutrition in children aged 24-59 months by socioeconomic
6
7 3 status in five South Asian countries: evidence from Demographic and Health
8
9
10 4 Surveys
11

12 5 **SUBTITLE:**
13

14 6 Double burden of malnutrition among under-five children in South Asia
15

16
17 7 **AUTHORS:**
18

19 8 Fariha Binte Hossain^{1†}, Md Shajedur Rahman Shawon^{2†}, Md Shehab Uddin Al-Abid³,
20
21 9 Sultan Mahmood Sami¹, Gourab Adhikary⁴, Md M Islam Bulbul⁵
22

23
24 10 ¹ Independent Researcher
25

26 11 ² Nuffield Department of Population Health, University of Oxford, Richard Doll
27
28 12 Building, OX3 7LF, UK Email: md.shawon@ndph.ox.ac.uk
29

30 13 ³ National Heart Foundation Hospital and Research Institute, Dhaka, Bangladesh
31
32 14 Email: abid79@nhf.org.bd
33

34 15 ⁴ Health Systems and Population Studies Division, icddr,b, 68 Shaheed Tajuddin
35
36 16 Ahmed Sarani, Mohakhali, Dhaka 1212, Bangladesh Email: gourabdmc@gmail.com
37

38 17 ⁵ National Nutrition Services, Ministry of Health and Family Welfare, Bangladesh
39
40 18 Email: bulbul1022@yahoo.com
41
42

43
44 19 **CORRESPONDING AUTHOR:**
45

46 20 Fariha Binte Hossain
47

48
49 21 Independent Researcher, 368/3D Ahmednagar, Paikpara, Mirpur-1, Dhaka 1216,
50
51 22 Bangladesh
52

53 23 Email: fariha.binte.hossain@gmail.com
54

55
56 24
57

58 25
59

60 26 † These authors contributed equally

1 **ABSTRACT**

2 **Objectives:** We aimed to investigate the socioeconomic inequalities in the burden of
3 underweight and overweight among children in South Asia. We also examined other
4 factors that were associated with these outcomes independently of household's
5 socioeconomic status.

6 **Design:** Nationally-representative surveys.

7 **Settings:** Demographic and Health Surveys from Bangladesh, India, Pakistan,
8 Maldives, and Nepal, which were conducted between 2009 and 2016.

9 **Participants:** Children aged 24-59 months with valid measurement for height and
10 weight (n=146,996).

11 **Primary exposure and outcome measures:** Primary exposures were household's
12 wealth index and level of education. Underweight and overweight were defined
13 according to the World Health Organization and International Obesity Task Force
14 definitions, respectively.

15 **Results:** Underweight prevalence was 37% in Bangladesh, 38% in India, 19% in
16 Maldives, 29% in Nepal, and 28% in Pakistan. Bangladesh, India, and Nepal had
17 similar overweight prevalence (between 2% and 4%) whereas Pakistan (7%) and
18 Maldives (9%) had higher prevalence. As expected, households with higher wealth
19 index or education had lower odds of having underweight children. Adjusted-odds
20 ratios (ORs) of underweight for richest vs poorest households were 0.4 [95% CI:0.3-
21 0.5], 0.5 [0.5-0.6], 0.5 [0.2-1.4], 0.5 [0.3-0.8], and 0.7 [0.5-1.1] for Bangladesh, India,
22 Maldives, Nepal and Pakistan, respectively. Compared to poorest households,
23 richest households were more likely to have overweight children in all countries
24 except Pakistan, but such associations were not significant after adjustment for other
25 factors. There were higher odds of having overweight children in households with

1
2
3 1 higher education in Bangladesh (OR 2.1 [95% CI:1.3-3.5]), India (1.2 [1.2-1.3]), and
4
5 2 Pakistan (1.8 [1.1-2.9]) when compared to households with no education. Maternal
6
7 3 nutritional status was consistently associated with children's nutritional outcomes
8
9 4 after adjustments for socioeconomic status.

10
11
12 5 **Conclusions:** Our study provides evidence for socioeconomic inequalities for
13
14 6 childhood underweight and overweight in South Asian countries, although the
15
16 7 directions of associations for underweight and overweight might be different.

17
18
19 8 **Keywords:**

20
21 9 Double burden, underweight, overweight, under-five children, South Asia,
22
23 10 Bangladesh, India, Pakistan, Nepal, Maldives
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 STRENGTHS AND LIMITATIONS OF THIS STUDY

- 2 • This is the first study to investigate the double burden of malnutrition among
3 children aged under five years in South Asian countries, using nationally-
4 representative samples.
- 5 • We used height and weight information which were measured by trained
6 research personnel.
- 7 • Use of International Obesity Task Force (IOTF) classification to define
8 overweight ensures cross-comparison of estimates with those from other
9 regions.
- 10 • Although we adjusted for several child, household and maternal factors when
11 examining the associations of socioeconomic status with underweight and
12 overweight, we did not have information on many dietary and lifestyle factors
13 that could modify those associations.
- 14 • We examined the effects of other factors on childhood underweight and
15 overweight after adjustment for household's socioeconomic status.

1 INTRODUCTION

2 Double burden of malnutrition implies the presence of both undernutrition and
3 overnutrition (overweight or obesity) either at the individual, household, or population
4 level [1]. At the individual level, an undernourished child can be overweight or obese
5 when they reach adulthood, whereas at household level coexistence of
6 undernourished and overweight children or adults can be possible. At the population
7 level, double burden of malnutrition indicates the presence of both undernutrition and
8 overnutrition in the same community, country, or region. Undernutrition can be
9 assessed by underweight (low weight-for-age), wasting (low weight-for-height), and
10 stunting (low height-for-age) [2]. Wasting and stunting reflect acute weight loss and
11 long-term growth restriction, respectively; whereas underweight indicates wasting,
12 stunting, or both.

13 Double burden of malnutrition is an emerging problem in the low and middle-income
14 countries (LMICs), including South Asian countries [1,3]. Historically, these countries
15 have a considerable burden of undernutrition in children [4,5], for example, according
16 to the World Report on Nutrition 2018 [6], approximately 39% of all stunted children
17 were from this region. But there has been growing evidence that the number of
18 children with overweight and obesity is also increasing in recent years in South Asian
19 countries, particularly due to economic growth, rapid urbanisation, and adoption of
20 western lifestyles [7–10]. Ensuring optimum nutrition in early years of life is an
21 important public health agenda, mainly because both undernutrition and overnutrition
22 in these years are associated with a wide range of morbidities in early life as well as
23 in later life [11,12].

24 Understanding the socioeconomic inequalities in nutritional outcomes is essential.

25 The associations of socioeconomic status with undernutrition and overnutrition might

1
2
3 1 be different in LMICs to those in high-income countries. In high-income countries,
4
5 2 overweight in children is associated with poorer socioeconomic conditions [13–15],
6
7 3 but it is not clear whether lower socioeconomic status can increase the likelihood of
8
9 4 children with overweight in LMICs too. It has been consistently shown that children in
10
11 5 poorer households are more likely to be underweight than those in richer households
12
13 6 [16,17]. Moreover, identifying other factors that might influence nutritional outcomes
14
15 7 independently of socioeconomic status will help to develop effective public health
16
17 8 interventions.

18
19 9 While many studies separately examined the burden of undernutrition or
20
21 10 overnutrition, studying both outcomes together in a population will be more useful to
22
23 11 the relevant stakeholders. So far, studies looking at the issue of the double burden of
24
25 12 malnutrition in South Asian countries focused mainly on the coexistence of
26
27 13 overweight or obese mother and underweight or stunted child within the same
28
29 14 household [16,18,19]. While studying double burden of malnutrition, it is also
30
31 15 essential to study the burden and underlying factors of childhood underweight,
32
33 16 stunting and wasting because they are very different constructs of undernutrition. To
34
35 17 the best of our knowledge, no study looked at the double burden of malnutrition
36
37 18 among children aged under five years in South Asian countries.

38
39 19 This study uses data from the Demographic and Health Surveys (DHS), which
40
41 20 provide nationally-representative estimates for a wide range of monitoring and
42
43 21 impact evaluation indicators in the areas of population, health, and nutrition [20].

44
45 22 While these surveys provide the prevalence of underweight and overweight among
46
47 23 children by socioeconomic status, it is essential to understand the associations
48
49 24 between them by taking account of other factors that might confound such
50
51 25 associations. In this study, we aimed to investigate the associations of household's
52
53
54
55
56
57
58
59
60

1
2
3 1 wealth index and highest education level with the prevalence of underweight and
4
5 2 overweight among children aged 24-59 months in five South Asian countries. Also,
6
7 3 we explored which other factors can influence childhood underweight and overweight
8
9 4 independently of household's socioeconomic status.
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1 1 **METHODS**

2 2 **Study design and data sources**

3 3 This study is based on the latest DHS data from five South Asian countries, namely
4 4 Bangladesh, India, Pakistan, Maldives, and Nepal. Other countries in the South
5 5 Asian regions (e.g. Afghanistan, Bhutan, and Sri Lanka) were not included in this
6 6 study because of either DHS was not conducted, or anthropometric data for children
7 7 were not available. The included surveys were conducted in 2014, 2015-16, 2009,
8 8 2016, and 2012-13 for Bangladesh, India, Maldives, Nepal and Pakistan,
9 9 respectively.

10 10 DHS are nationally-representative household surveys which are usually conducted
11 11 about every five years. These surveys provide data for a wide range of monitoring
12 12 and impact evaluation indicators in the areas of population, health, and nutrition. A
13 13 DHS is conducted by a national implementing agency, which can be any bonafide
14 14 governmental, non-governmental, or private-sector organization and has enough
15 15 experience in the execution of surveys that are national in scope. Technical
16 16 assistance throughout the whole process is provided by the DHS program [20].

17 17 DHS is usually based on a two-stage stratified sampling of households. In the first
18 18 stage, sampling census enumeration areas are selected using probability
19 19 proportional to size (PPS) sampling technique through statistics provided by the
20 20 respective national statistical office. In the second stage, households are selected
21 21 through systematic random sampling from the complete listing of households within
22 22 a selected enumeration area [21].

23 23 Ethical approval for each DHS is taken from the ICF Institutional Review Board as
24 24 well as by a review board in the host country. More details of such ethical approval
25 25 can be found in the DHS program website [<https://dhsprogram.com/>]. Informed

1 consent to participate in the study is taken from the participant, or from the parent or
2 guardian if anthropometric measurements are taken from a child. The data files are
3 freely available from the program website. We received authorization from the DHS
4 program for using the relevant datasets for this analysis. The data we received were
5 anonymized for protection of privacy, anonymity and confidentiality.

6 These surveys have a very high response rate, usually 90% and above. Detailed
7 questionnaires of included surveys are available in the final report of each survey.

8 We used the children's record (coded as "KR" in DHS program) datasets which
9 contained information about children born in the last five years prior to the survey
10 (aged 0-59 months). The present analysis is based on children aged 24 – 59 months
11 who had a valid measurement of their weight and height. We excluded children aged
12 less than 24 months because most of the available classification system for defining
13 childhood overweight starts from 24 months [22,23]. Flowchart of study participants
14 included in this analysis is given in Supplementary Figure S1.

16 **Anthropometric measurement, and defining undernutrition and overnutrition**

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

1
2
3 1 While each indicator of child undernutrition reflects distinct aspects undernutrition,
4
5 2 we assessed undernutrition mainly by underweight in this study. Childhood
6
7 3 underweight indicates the overall population's nutritional status, and is a composite
8
9 4 indicator which can encompass stunting, wasting, or both. According to the World
10
11 5 Health Organization (WHO) guidelines [2], a child with weight-for-age less than two
12
13 6 standard deviations (-2 SD) from the median of the reference population was
14
15 7 considered as underweight.

16
17
18
19 8 To define childhood overweight, we used the age and sex-specific BMI cut-offs from
20
21 9 the International Obesity Task Force (IOTF) classification system [23,24]. According
22
23 10 to IOTF, a child aged between 2 years and 18 years is classified as overweight if
24
25 11 their BMI is larger than the age and sex-specific BMI cut-off corresponding to an
26
27 12 adult BMI of $>25 \text{ kg/m}^2$. Our definition of childhood overweight also included those
28
29 13 with obesity and it is referred to hereafter as "overweight" for simplicity.
30
31
32
33
34

35 **Covariates**

36
37 16 DHS collected information on a wide range of variables from the selected
38
39 17 households using a face-to-face interview with the respondents conducted by trained
40
41 18 personnel. DHS collected information on socioeconomic factors like the area of
42
43 19 residence and household's wealth index. Place of residence (rural and urban) was
44
45 20 defined according to country-specific definitions. Household's highest education level
46
47 21 was based on the educational attainment of the child's mother and father. For
48
49 22 household's wealth index, each national implementing agency constructed a country-
50
51 23 specific index using principal components analysis from data on household assets
52
53 24 including durable goods (i.e. bicycles, televisions etc.) and dwelling characteristics
54
55 25 (i.e. sanitation, source of drinking water and construction material of house etc.) [25].
56
57
58
59
60

1
2
3 1 This wealth index was then categorized into five groups (i.e. poorest, poorer, middle,
4
5 2 richer, and richest) based on the quintile distribution of the sample.
6

7
8 3 We also included indicators of child's exposure to nutrition-sensitive interventions
9
10 4 (focusing on the underlying determinants of malnutrition) such as receiving vitamin A
11
12 5 in the last six months and receiving the deworming drug in last six months [26].
13

14 6 Households with flush toilet, ventilated improved pit latrine, traditional pit latrine with
15
16 7 a slab, or composting toilet were considered to have improved access to sanitation,
17
18 8 whereas households with improved access to drinking water were considered if they
19
20 9 had connection (piped), public standpipe, borehole, protected dug well or spring, or
21
22 10 rainwater collection.
23
24
25

26 11

27 28 12 **Statistical analysis**

29
30 13 We conducted all analysis following the instructions given in the DHS guide to
31
32 14 analysis [21]. Considering the two-stage stratified cluster sampling in DHS, we
33
34 15 applied Stata's survey estimation procedures ("svy" command) for the estimation of
35
36 16 proportions, means, and regression analysis [27].
37
38

39
40 17 The percent distributions for characteristics of included children are described as
41
42 18 proportions, for each DHS survey. To estimate the prevalence of childhood
43
44 19 underweight and overweight, we used sampling weights given in each DHS dataset
45
46 20 in order to get nationally-representative estimates. 95% confidence intervals (CIs) for
47
48 21 prevalence estimates were calculated using a logit transform of the estimate. We
49
50 22 also estimated the prevalence of childhood underweight and overweight by the levels
51
52 23 of socioeconomic factors to assess the inequalities by those factors.
53
54

55
56 24 To examine the associations of socioeconomic factors (i.e. household's wealth index
57
58 25 and household's highest level of education) with the prevalence of childhood
59
60

1
2
3 1 underweight and overweight, we used multiple logistic regression, separately for
4
5 2 each included country. At first, these analyses were minimally-adjusted for child's
6
7 3 age and sex; and then they were adjusted for the child's exposure to nutrition-
8
9 4 sensitive interventions, area of residence, access to improved sanitation and to
10
11 5 improved drinking water, number of under-five children in household, mother's age at
12
13 6 first birth, mother's height, and mother's BMI. Missing data in the adjustment
14
15 7 variables (usually less than 5%) were considered as separate categories so that the
16
17 8 same children were compared in all analyses. To explore which factors can influence
18
19 9 the prevalence of childhood underweight and overweight after accounting for
20
21 10 household's socioeconomic status, we estimated the odds ratios (ORs) for all child-,
22
23 11 household- and maternal-level factors with adjustment for household's wealth index
24
25 12 and highest level of education.

26
27 13 All analyses were additionally conducted for childhood stunting and wasting. Stunting
28
29 14 and wasting were defined respectively as height-for-age less than two standard
30
31 15 deviations (-2 SD) and weight-for-height less than two standard deviations (-2 SD)
32
33 16 from the median of the reference population [2].

34
35 17 All analyses were performed using Stata v15.1 (Statacorp, College Station, TX,
36
37 18 USA). All statistical analyses were two-sided and p-value <0.05 was considered as
38
39 19 statistically significant.

20 21 **Patient and public involvement**

22 Patients and the public were not involved in the development of research questions,
23 design of the study, recruitment and conduct of the study, or dissemination of the
24 study results.

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 characteristics of the study
4 population for each of these countries. There were almost equal distributions for both
5 sex and age in all country samples. At least half of the children in all countries
6 received vitamin A in the last six months. While Maldives and Nepal had excellent
7 coverage (80% or more) for deworming drugs, only about one in three children
8 received the deworming drug in India and Pakistan. Majority of the children were
9 from the rural area except in Nepal, and the proportions varied widely between 43%
10 and 86%. Overall, most of the households had access to improved sanitation and
11 drinking water supply, except the percentages of household with access to improved
12 sanitation are particularly low in Bangladesh and India. The proportions of household
13 with no formal education were particularly high in India, Nepal, and Pakistan. More
14 than half of the households in Bangladesh and India had members who completed
15 secondary or higher education. The samples from original surveys were divided into
16 quintiles based on the household's wealth index, and after relevant exclusions, the
17 distributions remained more or less similar for this study. India, Maldives, and
18 Pakistan had households with a median of two children aged under five years, while
19 Bangladesh and Nepal had a median of one child per household. Most mothers
20 were less than 25 years old at their first birth. The prevalence of mothers with
21 underweight was higher in Bangladesh (20%) and India (23%) than in other
22 countries, whereas the prevalence of mothers with overweight was higher in
23 Maldives (42%) and Pakistan (37%) than in other countries.

24

1
2
3 1 As expected, the prevalence of underweight was much higher than the prevalence of
4
5 2 overweight in all five countries (Figure 1 and Supplementary Table S1). India had the
6
7 3 highest (38%) prevalence of underweight among children aged 24-59 months
8
9 4 followed by Bangladesh (37%), Nepal (29%), Pakistan (28%), and Maldives had the
10
11 5 lowest prevalence (19%). For overweight among these children, Bangladesh, India,
12
13 6 and Nepal had similar prevalence (between 2% and 4%) whereas Pakistan and
14
15 7 Maldives higher prevalence, 7% and 9% respectively. When we looked at the
16
17 8 combined prevalence of both forms of malnutrition, India (42%) and Bangladesh
18
19 9 (39%) had a much higher burden compared to other countries (Maldives [28%],
20
21 10 Nepal [32%], Pakistan [36%]) (Figure 1). The prevalence of underweight was
22
23 11 particularly low in Maldives and Pakistan, but they had a higher prevalence of
24
25 12 overweight. Bangladesh, India, Nepal and Pakistan had high prevalence of childhood
26
27 13 stunting (between 42% and 48%), whereas only 17% of children in Maldives were
28
29 14 stunted (Supplementary Table S2). The prevalence of children with wasting was
30
31 15 highest in India (18%) and lowest in Nepal (6%) (Supplementary Table S3).
32
33 16 The prevalence of underweight and overweight varied widely according to both the
34
35 17 household's wealth index in all countries (Figure 2). Between the poorest and the
36
37 18 richest households, the burden of undernutrition decreased by more than half. On
38
39 19 the other hand, the richest households in Bangladesh and India had almost two
40
41 20 times higher prevalence of overweight than the poorest households. Such clear
42
43 21 differences were not evident in Maldives and Nepal, while the richest households
44
45 22 were less likely to have overweight children compared to poorest households in
46
47 23 Pakistan. The prevalence of underweight and overweight according to the
48
49 24 household's highest education level followed similar country-specific patterns
50
51 25 observed for wealth index (Figure 3). Notably, children in households with higher
52
53
54
55
56
57
58
59
60

1
2
3 1 education had higher burden of overweight in Bangladesh, India, and Pakistan than
4
5 2 children in no or little education. Similar trends were observed for stunting and
6
7 3 wasting prevalence by household's socioeconomic status (Supplementary Table S2
8
9 4 and S3).

10
11
12 5 Table 2 shows the minimally-adjusted and fully-adjusted associations of household's
13
14 6 wealth index and highest education level with the prevalence of underweight and
15
16 7 overweight. There was strong evidence of an inverse relationship between the
17
18 8 household's wealth index and the prevalence of underweight in children, which was
19
20 9 not attenuated even after adjustment for a wide range of covariates except for
21
22 10 Maldives and Pakistan. Compared to the poorest households, the richest households
23
24 11 were less likely to have children with underweight (adjusted-OR for Bangladesh 0.4
25
26 12 [95% CI: 0.3-0.5], India 0.5 [0.5-0.6], Maldives 0.5 [0.2-1.4], Nepal 0.5 [0.3-0.8], and
27
28 13 Pakistan 0.7 [0.5-1.1]. For the household's highest education level, we also observed
29
30 14 that households with secondary or higher education were less likely to have children
31
32 15 with underweight when compared to households with no education. The adjusted-
33
34 16 OR for higher education vs no education was 0.7 (0.6-1.0) for Bangladesh, 0.6 (0.5-
35
36 17 0.6) for India, 0.5 (0.1-1.7) for Maldives, 0.6 (0.4-0.9) for Nepal and 0.4 (0.3-0.7) for
37
38 18 Pakistan. Additional analyses for childhood stunting and wasting yielded similar
39
40 19 associations with household's wealth index and highest level of education
41
42 20 (Supplementary Table S4 and S5).

43
44 21 Table 2 also shows that the richest households were more likely to have children
45
46 22 with overweight than the poorest households in all countries except Pakistan.
47
48 23 However, the positive associations between household's wealth index and
49
50 24 overweight prevalence in children were not significant after adjustment for other
51
52 25 variables. The adjusted ORs were 1.3 (0.8-2.2) for Bangladesh, 1.1 (1.0-1.2) for
53
54
55
56
57
58
59
60

1
2
3 1 India, 0.5 (0.2-1.4) for Maldives, and 1.2 (0.5-2.9) for Nepal. In Pakistan, the richest
4
5 2 households less likely to have overweight children, which remained significant after
6
7 3 adjustment for other variables (adjusted-OR 0.1 [0.1-0.2]). Household's education
8
9 4 level was also positively associated with the prevalence of overweight in children.
10
11 5 When compared with households with no formal education, households with higher
12
13 6 education had higher odds of having overweight children in Bangladesh (OR 2.1
14
15 7 [1.3-3.5]), India (OR 1.2 [1.2-1.3]), and Pakistan (OR 1.8 [1.1-2.9]). Maldives and
16
17 8 Nepal had fewer households with higher education, but the adjusted ORs for
18
19 9 secondary vs no education were 2.3 (1.7-3.1) and 1.8 (1.1-3.1), respectively.
20
21 10 We then explored the associations of other factors with underweight and overweight
22
23 11 among children after accounting for household socioeconomic status (Table 3).
24
25 12 Factors like living in rural, improved access to sanitation and to drinking water, older
26
27 13 maternal age at first birth, low maternal height, and maternal underweight were
28
29 14 significantly associated with childhood underweight in some but not all countries.
30
31 15 Maternal underweight was consistently found to be associated with increased odds
32
33 16 of childhood underweight (adjusted-OR vs normal weight in Bangladesh 1.9 [1.6-
34
35 17 2.3], in India 1.7 [1.7-1.8], in Nepal 2.1 [1.6-2.9] and in Pakistan 2.0 [1.4-2.7]). Low
36
37 18 maternal height was also strongly associated with childhood underweight, stunting
38
39 19 and wasting, although the strength of associations varied by the definitions of
40
41 20 undernutrition (Table 3 and Supplementary Table S6 and S7).
42
43 21 For childhood overweight, maternal overweight was found to be associated with
44
45 22 increased odds in Bangladesh (OR 1.9 [1.2-3.0]), India (OR 1.3 [1.2-1.4]) and
46
47 23 Pakistan (OR 1.8 [1.4-2.5]), but not in Maldives (OR 1.3 [0.9-2.0]) and Nepal (OR 0.9
48
49 24 [0.3-2.2]). In Pakistan, those children who received vitamin A or deworming drug in
50
51 25 the last six months were less likely to be overweight than those who did not receive
52
53
54
55
56
57
58
59
60

1
2
3 1 those interventions. For India and Pakistan, improved access to sanitation and
4
5 2 drinking water were significantly associated with childhood overweight, although the
6
7 3 directions of such associations were not consistent.
8
9
10 4
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1 DISCUSSION

2 This study involving nationally-representative surveys conducted in recent times in
3 five South Asian countries provided empirical evidence on the burden of underweight
4 and overweight among children aged 24-59 months, and their associations with
5 socioeconomic status factors. We found that there was a substantial burden of
6 undernutrition among younger children in South Asian countries, while a differential
7 burden of overnutrition was also seen. Households with higher socioeconomic status
8 (as measured by wealth index and the highest level of education) were associated
9 with lower odds of underweight children, although some of those associations did not
10 reach statistical significance after adjustment for related factors. Household's
11 socioeconomic status and childhood overweight were positively associated in all
12 countries except Pakistan, but results from fully-adjusted models indicated that such
13 associations could be explained by other factors. Households with higher wealth or
14 education were less likely to have children with overweight only in Pakistan. After
15 taking household's socioeconomic status into account, maternal nutritional status
16 was found to be strongly associated with the child's nutritional status, whereas
17 evidence for associations with other factors was inconsistent across countries.

18
19 South Asian countries have experienced a striking economic growth in the last few
20 decades, which triggered unprecedented improvements in maternal mortality, infant
21 mortality, under-five mortality, and child undernutrition [28,29]. Trends in the
22 prevalence of childhood underweight have been declining in these countries, with
23 almost 25-30% reduction between 2004 and 2014 in Bangladesh, India, Pakistan,
24 and Nepal [30]. However, the existing burden of undernutrition is still high – our
25 study found that around one-third of under-five children in this region are still

1
2
3 1 underweight. Previous studies conducted in the region have found that poor
4
5 2 socioeconomic status, lower level of parental education, younger age of mother at
6
7 3 birth, short birth interval, and initiation of complementary feeding are important
8
9 4 determinants of undernutrition among under-five children [31–33]. We observed
10
11 5 large inequalities in the prevalence of underweight in each of the included countries,
12
13 6 which could not be explained by other factors studied here. Our study also showed
14
15 7 that factors like low maternal height and maternal underweight could significantly
16
17 8 increase the likelihood of undernutrition in children, while other factors like older age
18
19 9 of mother at birth, and access to improved sanitation were also associated with lower
20
21 10 odds of childhood underweight. These associations were statistically significant,
22
23 11 mostly in India because of a relatively large sample size. DHS data have information
24
25 12 on feeding practices for children aged up to two years, so we could not adjust for
26
27 13 variables related to feeding practices [25]. To have better insights on the assessment
28
29 14 of childhood undernutrition, we additionally explored the burden and the underlying
30
31 15 factors of childhood stunting and wasting.
32
33 16 There has been evidence on increasing trends of overweight in younger children in
34
35 17 many South Asian countries, although the prevalence is still quite low compared to
36
37 18 the prevalence of underweight. Recent reports [9,34–36] from South Asian countries
38
39 19 highlighted the rise of overweight burden in children, but mainly in older groups.
40
41 20 Overweight among under-five children is still overlooked in current literature. In our
42
43 21 study, we provided evidence for an increasing burden of overweight in this age
44
45 22 group, which clustered mainly in households with higher socioeconomic status. We
46
47 23 found that the associations between socioeconomic status and the prevalence of
48
49 24 childhood overweight can be heterogeneous between countries, with positive
50
51 25 associations in most countries and inverse association in Pakistan. This highlights
52
53
54
55
56
57
58
59
60

1
2
3 1 the need for cross-country comparisons for better understanding of double burden of
4
5 2 malnutrition. Frequent intake of energy-dense foods and physical inactivity have
6
7 3 been shown to be associated with overweight and obesity both in children and adults
8
9 4 [37,38]. These lifestyle behaviours are common in the higher socioeconomic group in
10
11 5 LMICs, and therefore, both childhood and adulthood overweight are clustered in
12
13 6 affluent households in urban areas [34,36]. Our study showed that mothers who
14
15 7 were overweight had higher odds of having children with overweight when compared
16
17 8 with mothers who were of normal weight - suggesting that public health nutrition
18
19 9 programmes should prioritise children whose mothers are overweight. Our findings
20
21 10 on having lower odds of overweight among children exposed to nutrition-sensitive
22
23 11 programmes (receiving vitamin A and deworming drug) in Pakistan can be studied
24
25 12 further to examine the efficacy of such programmes to reduce double burden of
26
27 13 malnutrition in LMICs.

28
29 14 The findings from our study highlight the importance of considering not only
30
31 15 socioeconomic inequalities but also other maternal and household level factors while
32
33 16 developing public health interventions and policies to tackle both childhood
34
35 17 undernutrition and overnutrition. Also, the opposite directions for associations of
36
37 18 socioeconomic status and nutritional outcomes suggest that the concept of “one size
38
39 19 fits all” is not applicable to tackle the emerging problem of the double burden of
40
41 20 malnutrition. Previous studies suggested that a multi-sectoral approach is needed to
42
43 21 alleviate poverty and other social inequalities related to the double burden of
44
45 22 malnutrition in South Asia and beyond [39].

46
47 23 Our study is the first study to look at the coexistence of underweight and overweight
48
49 24 among under-five children in South Asian countries by socioeconomic status. One of
50
51 25 the major strengths of our study is the use of nationally-representative samples with
52
53
54
55
56
57
58
59
60

1
2
3 1 objectively measured height and weight data from five different countries, which
4
5 2 allowed cross-country comparisons of the results. We were also able to adjust for
6
7 3 several factors in the multivariable models, but there are possibilities of residual
8
9 4 confounding due to unmeasured factors and/or imperfect assessment of measured
10
11 5 factors. Due to smaller sample sizes in Maldives and Nepal, we could not reliably
12
13 6 estimate the associations. Problems of reverse causation could also arise in the
14
15 7 observed estimates due to the cross-sectional nature of the study. We used the
16
17 8 IOTF reference to define childhood overweight instead of the WHO or Centers for
18
19 9 Disease Control (CDC) references [22–24]. The IOTF classification system is based
20
21 10 on large datasets from six regions covering different ethnicities, therefore more
22
23 11 suitable for international comparisons [23,24]. When compared with other
24
25 12 references, the IOTF reference yielded similar estimates for overall overweight
26
27 13 prevalence but different estimates for obesity [40,41]. It was also found to be more
28
29 14 specific in identifying children with overweight and obesity than other references [42].
30
31 15 We assessed childhood undernutrition by assessing underweight, wasting and
32
33 16 stunting. Previous studies have found that stunting and overweight can occur
34
35 17 concurrently in an individual [43], therefore there may be double counting of children
36
37 18 while studying double burden of malnutrition using stunting and overweight. Looking
38
39 19 at children who are stunted and overweight can offer more insights into the topic, but
40
41 20 we did not look into this issue in our study.
42
43
44
45
46
47
48
49
50

51 21
52 22 In conclusion, our study provides evidence for socioeconomic disparities for the
53
54 23 coexistence of under- and over-nutrition among children aged 24-59 months in South
55
56 24 Asian countries. It also showed that factors like maternal nutritional status was
57
58 25 strongly associated with nutritional outcomes in children. These unmet inequalities
59
60

1
2
3 1 for both underweight and overweight should be considered while developing national
4
5 2 public health nutrition programmes and strategies.
6
7
8 3
9
10 4

11 5 **ACKNOWLEDGEMENTS**

12
13
14 6 The authors thank the participants of Demographic and Health Surveys used in this
15
16
17 7 study from Bangladesh, India, Maldives, Nepal, and Pakistan. We would also like to
18
19 8 thank the DHS Program to authorize us to use the data.
20
21
22 9

23 10 **AUTHOR CONTRIBUTIONS**

24
25
26 11 Conception and design: FH, MS, SA and MB
27
28 12 Data collection and management: FH, SS, and GA
29
30
31 13 Data analysis: FH, MS, SS
32
33 14 Interpretation of the results: All authors
34
35 15 Drafting of the article: FH and MS
36
37 16 Critical revision of the article for important intellectual content: All authors
38
39 17 Final approval of the article: All authors.
40
41
42 18

43 19 **COMPETING INTERESTS STATEMENT**

44
45
46 20 None declared
47
48
49 21

50 22 **FUNDING STATEMENT**

51
52
53 23 This research received no specific grant from any funding agency in the public,
54
55
56 24 commercial or not-for-profit sectors.
57
58
59 25
60

1 DATA SHARING STATEMENT

2 This study used data from Demographic and Health Surveys (DHS) for Bangladesh,
3 India, Maldives, Nepal, and Pakistan, which are available from the DHS programme
4 website.

5 REFERENCES

- 6 1 World Health Organization. Double burden of malnutrition. Nutrition.
7 2019. <https://www.who.int/nutrition/double-burden-malnutrition/en/> (accessed 3
8 Apr 2019).
- 9 2 World Health Organization. WHO child growth standards : length/height-for-
10 age, weight-for-age, weight-for-length, weight-forheight and body mass index-
11 for-age : methods and development. Geneva: 2006.
12 https://www.who.int/childgrowth/standards/Technical_report.pdf
- 13 3 Shrimpton, Roger; Rokx C. The Double Burden of Malnutrition : A Review of
14 Global Evidence. Washington, DC: 2012.
15 <https://openknowledge.worldbank.org/handle/10986/27417>
- 16 4 Stevens GA, Finucane MM, Paciorek CJ, *et al.* Trends in mild, moderate, and
17 severe stunting and underweight, and progress towards MDG 1 in 141
18 developing countries: a systematic analysis of population representative data.
19 *Lancet (London, England)* 2012;**380**:824–34. doi:10.1016/S0140-
20 6736(12)60647-3
- 21 5 Harding KL, Aguayo VM, Webb P. Factors associated with wasting among
22 children under five years old in South Asia: Implications for action. *PLoS One*
23 2018;**13**:e0198749. <https://doi.org/10.1371/journal.pone.0198749>
- 24 6 Development Initiatives. 2018 Global Nutrition Report: Shining a light to spur
25 action on nutrition. Bristol, UK: 2018. <https://globalnutritionreport.org/>

- 1
2
3 1 7 Hoque ME, Doi SAR, Mannan M, *et al.* Prevalence of overweight and obesity
4 among children and adolescents of the indian subcontinent: A meta-analysis.
5
6 2
7
8 3
9
10 4 8 Khadilkar V V., Khadilkar A V., Cole TJ, *et al.* Overweight and obesity
11 prevalence and body mass index trends in Indian children. *Int J Pediatr Obes*
12 2011;**6**:e216–24. doi:10.3109/17477166.2010.541463
13
14 6
15
16
17 7 9 Bulbul T, Hoque M. Prevalence of childhood obesity and overweight in
18 Bangladesh: findings from a countrywide epidemiological study. *BMC Pediatr*
19 2014;**14**:86. doi:10.1186/1471-2431-14-86
20
21 9
22
23
24 10 10 de Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight
25 and obesity among preschool children. *Am J Clin Nutr* 2010;**92**:1257–64.
26
27 11
28
29 12
30
31 13 11 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass
32 index, underweight, overweight, and obesity from 1975 to 2016: a pooled
33 analysis of 2416 population-based measurement studies in 128.9 million
34 children, adolescents, and adults. *Lancet (London, England)* 2017;**390**:2627–
35
36 15
37
38 16
39
40 17
41
42 18 12 GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in
43 195 Countries over 25 Years. *N Engl J Med* Published Online First: 2017.
44
45 19
46
47 20
48
49 21 13 Bann D, Johnson W, Li L, *et al.* Socioeconomic inequalities in childhood and
50 adolescent body-mass index, weight, and height from 1953 to 2015: an
51
52 22
53
54 23
55
56 24
57
58 25 14 Barriuso L, Miqueleiz E, Albaladejo R, *et al.* Socioeconomic position and
59
60

- 1
2
3 1 childhood-adolescent weight status in rich countries: a systematic review,
4
5 2 1990–2013. *BMC Pediatr* 2015;**15**:129. doi:10.1186/s12887-015-0443-3
6
7
8 3 15 Shrewsbury V, Wardle J. Socioeconomic status and adiposity in childhood: a
9
10 4 systematic review of cross-sectional studies 1990–2005. *Obes (Silver Spring)*
11
12 5 2008;**16**.
13
14 6 16 Black RE, Victora CG, Walker SP, *et al*. Maternal and child undernutrition and
15
16 7 overweight in low-income and middle-income countries. *Lancet (London,*
17
18 8 *England)* 2013;**382**:427–51. doi:10.1016/S0140-6736(13)60937-X
19
20
21 9 17 Van de Poel E, Hosseinpoor AR, Speybroeck N, *et al*. Socioeconomic
22
23 10 inequality in malnutrition in developing countries. *Bull World Health Organ*
24
25 11 2008;**86**:282–91. doi:10.2471/BLT.07.044800
26
27
28 12 18 Das S, Fahim SM, Islam MS, *et al*. Prevalence and sociodemographic
29
30 13 determinants of household-level double burden of malnutrition in Bangladesh.
31
32 14 *Public Health Nutr* 2019;**22**:1425–32. doi:10.1017/S1368980018003580
33
34
35 15 19 Oddo VM, Rah JH, Semba RD, *et al*. Predictors of maternal and child double
36
37 16 burden of malnutrition in rural Indonesia and Bangladesh. *Am J Clin Nutr*
38
39 17 2012;**95**:951–8. doi:10.3945/ajcn.111.026070
40
41
42 18 20 The DHS Program: Demographic and Health Surveys.
43
44 19 2019.<https://dhsprogram.com/> (accessed 21 May 2019).
45
46
47 20 21 DHS Program. Using datasets for analysis.
48
49 21 <https://dhsprogram.com/data/Using-Datasets-for-Analysis.cfm> (accessed 14
50
51 22 Nov 2017).
52
53
54 23 22 Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, *et al*. CDC growth charts:
55
56 24 United States. *Adv Data* 2000;:1–27.
57
58
59 25 23 Cole TJ, Bellizzi MC, Flegal KM, *et al*. Establishing a standard definition for
60

- 1
2
3 1 child overweight and obesity worldwide: international survey. *BMJ*
4
5 2 2000;**320**:1240–3.
6
7
8 3 24 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs
9
10 4 for thinness, overweight and obesity. *Pediatr Obes* 2012;**7**:284–94.
11
12 5 doi:10.1111/j.2047-6310.2012.00064.x
13
14 6 25 The DHS Program. DHS Overview. 2019.[https://dhsprogram.com/What-We-](https://dhsprogram.com/What-We-Do/Survey-Types/DHS.cfm)
15
16 Do/Survey-Types/DHS.cfm (accessed 3 Apr 2019).
17
18 7
19 8 26 Ruel MT, Alderman H, Group M and CNS. Nutrition-sensitive interventions and
20
21 9 programmes: how can they help to accelerate progress in improving maternal
22
23 10 and child nutrition? *Lancet* 2013;**382**:536–51.
24
25
26 11 27 StataCorp. svy estimation - Estimation commands for survey data.
27
28 12 <https://www.stata.com/manuals13/svysvyestimation.pdf> (accessed 3 Apr
29
30 13 2019).
31
32
33 14 28 Akseer N, Kamali M, Arifeen SE, *et al.* Progress in maternal and child health:
34
35 15 how has South Asia fared? *BMJ* 2017;**357**:j1608. doi:10.1136/bmj.j1608
36
37 16 29 United Nations. The Millennium Development Goals Report. New York: 2015.
38
39 17 [https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG 2015 rev](https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf)
40
41 18 (July 1).pdf
42
43
44 19 30 The World Bank Group. World Bank Open Data: Free and open access to
45
46 20 global development data. 2019.<https://data.worldbank.org/> (accessed 1 Mar
47
48 21 2019).
49
50
51 22 31 Pravana NK, Piryani S, Chaurasiya SP, *et al.* Determinants of severe acute
52
53 23 malnutrition among children under 5 years of age in Nepal: a community-
54
55 24 based case–control study. *BMJ Open* 2017;**7**:e017084. doi:10.1136/bmjopen-
56
57 25 2017-017084
58
59
60

- 1
2
3 1 32 Ansuya, Nayak BS, Unnikrishnan B, *et al.* Risk factors for malnutrition among
4 preschool children in rural Karnataka: a case-control study. *BMC Public Health*
5 2
6 3
7 2018;**18**:283. doi:10.1186/s12889-018-5124-3
8
9
10 4 33 Chowdhury MRK, Rahman MS, Khan MMH, *et al.* Risk Factors for Child
11 Malnutrition in Bangladesh: A Multilevel Analysis of a Nationwide Population-
12 Based Survey. *J Pediatr* 2016;**172**:194-201.e1.
13 5
14 6
15 2016;**172**:194-201.e1.
16 7
17 doi:10.1016/j.jpeds.2016.01.023
18
19 8 34 Ranjani H, Mehreen TS, Pradeepa R, *et al.* Epidemiology of childhood
20 overweight & obesity in India: A systematic review. *Indian J Med Res*
21 9
22 2016;**143**:160–74. doi:10.4103/0971-5916.180203
23 10
24
25 11 35 Mushtaq MU, Gull S, Abdullah HM, *et al.* Prevalence and socioeconomic
26 correlates of overweight and obesity among Pakistani primary school children.
27 12
28 *BMC Public Health* 2011;**11**:724. doi:10.1186/1471-2458-11-724
29 13
30
31 14 36 Rahman S, Islam MT, Alam DS. Obesity and overweight in Bangladeshi
32 children and adolescents: a scoping review. *BMC Public Health* 2014;**14**:70.
33 15
34 doi:10.1186/1471-2458-14-70
35 16
36
37 17 37 Hemmingsson E. Early Childhood Obesity Risk Factors: Socioeconomic
38 Adversity, Family Dysfunction, Offspring Distress, and Junk Food Self-
39 Medication. *Curr Obes Rep* 2018;**7**:204–9. doi:10.1007/s13679-018-0310-2
40 18
41
42 20 38 Gupta N, Misra A, Goel K, *et al.* Childhood Obesity in Developing Countries:
43 Epidemiology, Determinants, and Prevention. *Endocr Rev* 2012;**33**:48–70.
44 21
45 2012;**33**:48–70.
46 22
47 doi:10.1210/er.2010-0028
48
49 23 39 Perez-Escamilla R, Bermudez O, Buccini GS, *et al.* Nutrition disparities and
50 the global burden of malnutrition. *BMJ* 2018;**361**:k2252.
51 24
52
53 25 2018;**361**:k2252.
54
55 doi:10.1136/bmj.k2252
56
57
58
59
60

- 1
2
3 1 40 Tuan NT, Nicklas TA. Age, sex and ethnic differences in the prevalence of
4
5 2 underweight and overweight, defined by using the CDC and IOTF cut points in
6
7 3 Asian children. *Eur J Clin Nutr* 2009;**63**:1305.
8
9
10 4 41 Moselakgomo K V, Van Staden M. Diagnostic comparison of Centers for
11
12 5 Disease Control and Prevention and International Obesity Task Force criteria
13
14 6 for obesity classification in South African children. *African J Prim Heal care*
15
16 7 *Fam Med* 2017;**9**:e1–7. doi:10.4102/phcfm.v9i1.1383
17
18
19 8 42 Valerio G, Balsamo A, Baroni MG, *et al*. Childhood obesity classification
20
21 9 systems and cardiometabolic risk factors: a comparison of the Italian, World
22
23 10 Health Organization and International Obesity Task Force references. *Ital J*
24
25 11 *Pediatr* 2017;**43**:19. doi:10.1186/s13052-017-0338-z
26
27
28 12 43 Bates K, Gjonça A, Leone T. Double burden or double counting of child
29
30 13 malnutrition? The methodological and theoretical implications of
31
32 14 stuntingoverweight in low and middle income countries. *J Epidemiol*
33
34 15 *Community Health* 2017;**71**:779 LP – 785. doi:10.1136/jech-2017-209008
35
36
37
38 16
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 **1 FIGURE LEGENDS**
4

5 **2 Figure 1: Prevalence of underweight and overweight, by country**
6

7
8 3 Sampling weights provided by the Demographic and Health Survey (DHS) and
9
10 4 Stata's survey estimation procedures were used to estimate country-representative
11
12 5 prevalence. Corresponding 95% confidence intervals of prevalence estimates are
13
14 6 given in Supplementary Table S2.
15
16

17 7
18
19 **8 Figure 2: Prevalence of underweight and overweight, by household's wealth**
20
21 **9 index**
22

23
24 10 Sampling weights provided by the Demographic and Health Survey (DHS) and
25
26 11 Stata's survey estimation procedures were used to estimate country-representative
27
28 12 prevalence. Corresponding 95% confidence intervals of prevalence estimates are
29
30 13 given in Supplementary Table S2.
31
32

33 14
34
35 **15 Figure 3: Prevalence of underweight and overweight, by household's highest**
36
37 **16 level of education**
38

39
40 17 Sampling weights provided by the Demographic and Health Survey (DHS) and
41
42 18 Stata's survey estimation procedures were used to estimate country-representative
43
44 19 prevalence. Corresponding 95% confidence intervals of prevalence estimates are
45
46 20 given in Supplementary Table S2.
47
48

49 21
50
51
52
53
54
55
56
57
58
59
60

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

| | 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 variables | | | | | |
| Sex, n (%) | | | | | |
| 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) |
| Age in year, n (%) | | | | | |
| 2-3 | 1406 (33.7) | 45298 (32.8) | 452 (33.8) | 460 (33.1) | 668 (34.0) |
| 3-4 | 1377 (33.0) | 47506 (34.4) | 464 (34.7) | 479 (34.5) | 641 (32.6) |
| 4-5 | 1387 (33.3) | 45329 (32.8) | 423 (31.6) | 449 (32.3) | 655 (33.4) |
| Received vitamin A in last 6 months, n (%) | 2735 (66.0) | 73678 (54.1) | 695 (81.8) | 1232 (88.8) | 1252 (64.6) |
| Received deworming drug in last 6 months, n (%) | 2153 (51.7) | 43319 (31.6) | 1104 (82.8) | 1105 (79.8) | 593 (30.3) |
| Household variables | | | | | |
| Area of residence, n (%) | | | | | |
| 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) |
| Access to improved sanitation, n (%) | 2741 (65.7) | 67441 (48.8) | 1278 (95.4) | 1047 (75.4) | 1455 (74.1) |
| Access to improved drinking water, n (%) | 3791 (90.9) | 114018 (82.5) | 1210 (90.4) | 1206 (86.8) | 1564 (79.6) |
| Wealth index, n (%) | | | | | |
| 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) |
| Highest education level, n (%) | | | | | |
| 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) |
| No. of household member, median (IQR) | 5.0 (4.0, 7.0) | 6.0 (5.0, 8.0) | 8.0 (6.0, 11.0) | 5.0 (4.0, 7.0) | 8.0 (6.0, 11.0) |
| No. of under-five children, median (IQR) | 1.0 (1.0, 2.0) | 2.0 (1.0, 2.0) | 2.0 (1.0, 2.0) | 1.0 (1.0, 2.0) | 2.0 (2.0, 3.0) |
| Maternal variables | | | | | |
| Mother's age at first birth, n (%) | | | | | |
| Less than 250 years | 3056 (73.3) | 50969 (36.9) | 499 (37.3) | 759 (54.6) | 812 (41.3) |
| 20-24 years | 927 (22.2) | 66287 (48.0) | 649 (48.5) | 531 (38.2) | 812 (41.3) |
| 25 years or above | 187 (4.5) | 20878 (15.1) | 191 (14.3) | 99 (7.1) | 340 (17.3) |
| Mother's BMI (kg/m ²) category, n (%) | | | | | |
| Underweight | 835 (20.1) | 31127 (22.6) | 94 (7.4) | 228 (16.4) | 224 (11.5) |
| Normal weight | 2439 (58.6) | 85490 (62.0) | 639 (50.3) | 937 (67.5) | 1006 (51.5) |
| Overweight | 885 (21.3) | 21172 (15.4) | 538 (42.3) | 224 (16.1) | 723 (37.0) |
| Mother's height (cm) category, n (%) | | | | | |
| <145 | 518 (12.4) | 15474 (11.2) | 134 (10.5) | 165 (11.9) | 90 (4.6) |
| 145-149.9 | 1228 (29.4) | 36721 (26.6) | 333 (26.1) | 367 (26.4) | 281 (14.3) |
| 150-154.9 | 1432 (34.3) | 47088 (34.1) | 446 (34.9) | 490 (35.3) | 636 (32.4) |
| 155+ | 992 (23.8) | 38685 (28.0) | 364 (28.5) | 367 (26.4) | 957 (48.7) |

There was less than 1% missing value for variables: received vitamin A in last 6 months, received deworming drug in last 6 months, mother's height, and mother's BMI in all countries except Maldives. For Maldives, there were around 5% missing values in mother's height and mother's BMI. There was no missing value in other variables listed in this table.

1 **Table 2: Associations of household’s wealth index and highest education with childhood underweight and overweight**

| | ORs (95% CI) * | | | | | | | | | |
|-------------------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
| | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted |
| Underweight | | | | | | | | | | |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Poorer | 0.8 (0.7-0.9) | 0.8 (0.7-1.0) | 0.7 (0.7-0.7) | 0.8 (0.8-0.8) | 0.8 (0.6-1.0) | 0.9 (0.6-1.3) | 0.6 (0.5-0.8) | 0.6 (0.5-0.8) | 0.9 (0.7-1.1) | 1.0 (0.8-1.3) |
| Middle | 0.6 (0.5-0.7) | 0.7 (0.6-0.8) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.8 (0.6-1.0) | 1.0 (0.7-1.4) | 0.8 (0.6-1.0) | 0.8 (0.6-1.0) | 0.7 (0.5-0.9) | 0.8 (0.6-1.1) |
| Richer | 0.4 (0.4-0.5) | 0.6 (0.5-0.7) | 0.4 (0.4-0.4) | 0.6 (0.6-0.6) | 0.5 (0.3-0.7) | 0.7 (0.5-1.0) | 0.6 (0.4-0.8) | 0.7 (0.5-0.9) | 0.6 (0.4-0.7) | 0.9 (0.7-1.1) |
| Richest | 0.3 (0.2-0.3) | 0.4 (0.3-0.5) | 0.3 (0.3-0.3) | 0.5 (0.5-0.5) | 0.3 (0.2-0.6) | 0.5 (0.2-1.5) | 0.3 (0.2-0.4) | 0.4 (0.3-0.7) | 0.3 (0.3-0.4) | 0.7 (0.5-1.1) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Primary | 1.0 (0.9-1.1) | 1.1 (0.9-1.2) | 0.8 (0.7-0.8) | 0.9 (0.9-0.9) | 0.6 (0.5-0.7) | 0.6 (0.5-0.7) | 0.7 (0.6-0.9) | 0.8 (0.6-1.1) | 0.8 (0.7-1.1) | 1.0 (0.8-1.3) |
| Secondary | 0.6 (0.5-0.6) | 0.8 (0.7-0.9) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.3 (0.2-0.4) | 0.3 (0.2-0.4) | 0.5 (0.4-0.7) | 0.8 (0.6-1.0) | 0.4 (0.3-0.5) | 0.5 (0.4-0.7) |
| Higher | 0.3 (0.3-0.4) | 0.7 (0.6-1.0) | 0.3 (0.3-0.3) | 0.6 (0.5-0.6) | 0.2 (0.1-0.8) | 0.5 (0.1-1.9) | 0.3 (0.2-0.5) | 0.5 (0.4-0.8) | 0.3 (0.2-0.4) | 0.4 (0.2-0.6) |
| Overweight | | | | | | | | | | |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Poorer | 0.9 (0.5-1.6) | 0.8 (0.4-1.5) | 1.1 (1.0-1.2) | 1.0 (1.0-1.1) | 1.3 (0.9-2.0) | 1.4 (0.8-2.2) | 0.4 (0.2-0.9) | 0.4 (0.1-0.9) | 0.5 (0.4-0.7) | 0.4 (0.3-0.6) |
| Middle | 1.2 (0.7-2.0) | 1.0 (0.6-1.6) | 1.2 (1.1-1.3) | 1.0 (1.0-1.1) | 1.2 (0.8-1.8) | 1.1 (0.7-1.7) | 0.1 (0.0-0.6) | 0.1 (0.0-0.6) | 0.4 (0.3-0.5) | 0.3 (0.2-0.4) |
| Richer | 1.0 (0.6-1.7) | 0.7 (0.4-1.2) | 1.3 (1.2-1.4) | 1.0 (1.0-1.1) | 1.7 (1.1-2.7) | 0.9 (0.5-1.4) | 0.5 (0.2-1.1) | 0.5 (0.2-1.1) | 0.3 (0.2-0.4) | 0.2 (0.1-0.2) |
| Richest | 3.8 (2.8-5.0) | 1.4 (0.8-2.3) | 1.7 (1.6-1.8) | 1.2 (1.1-1.3) | 1.9 (1.1-3.4) | 0.5 (0.2-1.4) | 1.1 (0.5-2.3) | 1.0 (0.4-2.4) | 0.4 (0.3-0.5) | 0.1 (0.1-0.2) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Primary | 1.1 (0.7-1.7) | 1.1 (0.7-1.7) | 1.1 (1.0-1.1) | 1.0 (0.9-1.1) | 0.9 (0.7-1.3) | 1.1 (0.7-1.5) | 1.0 (0.4-2.4) | 1.1 (0.4-2.7) | 0.6 (0.4-0.9) | 0.9 (0.6-1.4) |
| Secondary | 1.4 (1.0-1.9) | 1.1 (0.8-1.5) | 1.2 (1.1-1.2) | 1.0 (0.9-1.0) | 2.1 (1.6-2.7) | 2.1 (1.6-2.7) | 2.0 (1.2-3.3) | 1.9 (1.1-3.1) | 0.6 (0.4-0.8) | 1.3 (0.9-1.8) |
| Higher | 5.2 (3.6-7.5) | 2.0 (1.2-3.3) | 1.7 (1.6-1.9) | 1.2 (1.1-1.3) | 2.0 (0.6-6.8) | 0.6 (0.1-5.0) | 0.9 (0.3-2.8) | 0.6 (0.2-2.2) | 0.8 (0.5-1.1) | 1.6 (1.0-2.5) |

2 * Minimally adjusted models were adjusted for child’s age and sex; and fully-adjusted models were additionally adjusted for area of residence, receiving vitamin A and
3 deworming drug, access to improved sanitation and drinking water, number of under-five children, mother’s age at first birth, mother’s height, and mother’s BMI. Analyses were
4 conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata’s survey estimation procedures.

1 **Table 3: Socioeconomic status-adjusted odds ratios (ORs) of underweight and overweight for various child, household**
 2 **and maternal factors**
 3

| | ORs (95% CI)* | | | | | | | | | |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
| | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight |
| Child's variables | | | | | | | | | | |
| Sex | | | | | | | | | | |
| Male | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Female | 1.2 (1.0-1.4) | 1.2 (0.8-1.8) | 1.0 (1.0-1.1) | 1.0 (1.0-1.1) | 1.1 (0.9-1.5) | 1.1 (0.7-1.7) | 1.1 (0.9-1.4) | 1.5 (0.7-2.9) | 0.9 (0.7-1.1) | 1.0 (0.8-1.3) |
| Age | | | | | | | | | | |
| 2-3 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 3-4 years | 1.0 (0.8-1.2) | 1.0 (0.6-1.6) | 1.0 (1.0-1.0) | 1.0 (0.9-1.0) | 1.0 (0.7-1.3) | 1.4 (0.9-2.3) | 0.8 (0.6-1.0) | 2.6 (1.1-6.5) | 0.9 (0.7-1.1) | 1.4 (1.0-1.9) |
| 4-5 years | 1.0 (0.9-1.2) | 0.8 (0.5-1.4) | 1.0 (1.0-1.0) | 0.9 (0.9-1.0) | 0.7 (0.5-1.0) | 1.3 (0.8-2.1) | 0.9 (0.7-1.2) | 1.5 (0.6-4.1) | 0.9 (0.7-1.2) | 1.2 (0.9-1.7) |
| Received vitamin A in last 6 months | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.1) | 1.2 (0.7-1.8) | 1.1 (1.0-1.1) | 1.1 (1.0-1.1) | 1.2 (0.8-2.0) | 1.0 (0.5-1.9) | 0.8 (0.5-1.1) | 1.1 (0.3-3.8) | 1.2 (1.0-1.6) | 0.5 (0.4-0.6) |
| Received deworming drug in last 6 months | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.9 (0.8-1.1) | 0.9 (0.6-1.4) | 1.0 (0.9-1.0) | 1.1 (1.0-1.2) | 1.5 (1.0-2.3) | 0.8 (0.5-1.3) | 1.0 (0.7-1.3) | 1.4 (0.5-3.6) | 0.8 (0.6-1.0) | 0.6 (0.4-0.8) |
| Household variables | | | | | | | | | | |
| Area of residence | | | | | | | | | | |
| Urban | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Rural | 0.9 (0.8-1.1) | 0.7 (0.4-1.1) | 0.9 (0.9-0.9) | 1.1 (1.0-1.1) | 1.0 (0.4-2.2) | 0.4 (0.2-1.0) | 1.1 (0.9-1.4) | 1.2 (0.6-2.6) | 1.0 (0.8-1.3) | 0.6 (0.4-0.8) |
| Improved access to sanitation | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.1) | 1.1 (0.7-1.9) | 0.8 (0.8-0.8) | 1.2 (1.1-1.3) | 0.7 (0.4-1.3) | 1.5 (0.4-4.8) | 0.7 (0.5-0.9) | 1.0 (0.4-2.5) | 0.8 (0.6-1.1) | 1.6 (1.1-2.2) |
| Improved access to drinking water | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.2) | 1.6 (0.7-3.7) | 1.2 (1.1-1.2) | 0.9 (0.9-1.0) | 1.5 (0.8-2.7) | 0.9 (0.4-1.7) | 1.0 (0.7-1.5) | 0.9 (0.4-2.2) | 1.2 (0.9-1.6) | 0.7 (0.5-0.9) |
| No. of children under five | 1.1 (1.0-1.2) | 1.0 (0.8-1.3) | 1.1 (1.1-1.1) | 0.9 (0.9-1.0) | 1.1 (1.0-1.2) | 1.0 (0.8-1.2) | 1.1 (0.9-1.2) | 0.7 (0.4-1.1) | 1.0 (1.0-1.1) | 1.0 (0.9-1.1) |

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

Maternal variables

Mother's age at first birth

| | | | | | | | | | | |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Less than 20 years | 1.1 (0.9-1.3) | 0.6 (0.4-1.0) | 1.1 (1.0-1.1) | 1.0 (0.9-1.0) | 1.1 (0.8-1.5) | 0.7 (0.4-1.1) | 0.9 (0.7-1.2) | 0.5 (0.2-1.0) | 1.0 (0.8-1.2) | 0.8 (0.6-1.1) |
| 20-24 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 25 years or more | 0.8 (0.5-1.1) | 1.7 (0.9-3.3) | 0.8 (0.8-0.8) | 1.3 (1.2-1.4) | 0.8 (0.5-1.3) | 1.1 (0.6-1.9) | 0.8 (0.5-1.4) | 0.5 (0.1-2.3) | 0.9 (0.7-1.3) | 0.8 (0.5-1.1) |

Mother's BMI category

| | | | | | | | | | | |
|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Normal weight | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Underweight | 1.9 (1.6-2.3) | 0.5 (0.2-1.1) | 1.7 (1.7-1.8) | 0.5 (0.5-0.6) | 1.3 (0.7-2.1) | 0.2 (0.1-1.0) | 2.1 (1.6-2.9) | 0.4 (0.1-1.5) | 2.0 (1.4-2.7) | 0.4 (0.3-0.8) |
| Overweight | 0.7 (0.5-0.8) | 1.9 (1.2-3.0) | 0.6 (0.6-0.7) | 1.3 (1.2-1.4) | 0.7 (0.5-1.0) | 1.3 (0.9-2.0) | 0.5 (0.3-0.7) | 0.9 (0.3-2.2) | 0.6 (0.5-0.8) | 1.8 (1.4-2.5) |

Mother's height category

| | | | | | | | | | | |
|----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <145 cm | 3.2 (2.5-4.0) | 1.2 (0.6-2.4) | 2.7 (2.5-2.8) | 0.9 (0.8-1.0) | 4.6 (2.8-7.4) | 0.7 (0.3-1.6) | 3.5 (2.3-5.3) | 1.5 (0.5-4.7) | 2.6 (1.6-4.0) | 1.2 (0.7-2.1) |
| 145-149 cm | 2.1 (1.7-2.5) | 1.0 (0.6-1.7) | 1.9 (1.8-2.0) | 0.9 (0.8-1.0) | 2.1 (1.4-3.3) | 1.0 (0.6-1.7) | 2.0 (1.4-2.9) | 1.1 (0.4-3.0) | 1.7 (1.3-2.3) | 1.6 (1.1-2.2) |
| 150-154 cm | 1.5 (1.2-1.8) | 1.0 (0.6-1.7) | 1.4 (1.4-1.4) | 1.0 (0.9-1.1) | 1.9 (1.3-2.9) | 0.6 (0.4-1.0) | 1.5 (1.1-2.1) | 1.1 (0.5-2.8) | 1.3 (1.1-1.7) | 0.8 (0.6-1.1) |
| 155 cm or more | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |

* Logistic regression models were adjusted for household's wealth index and highest education. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

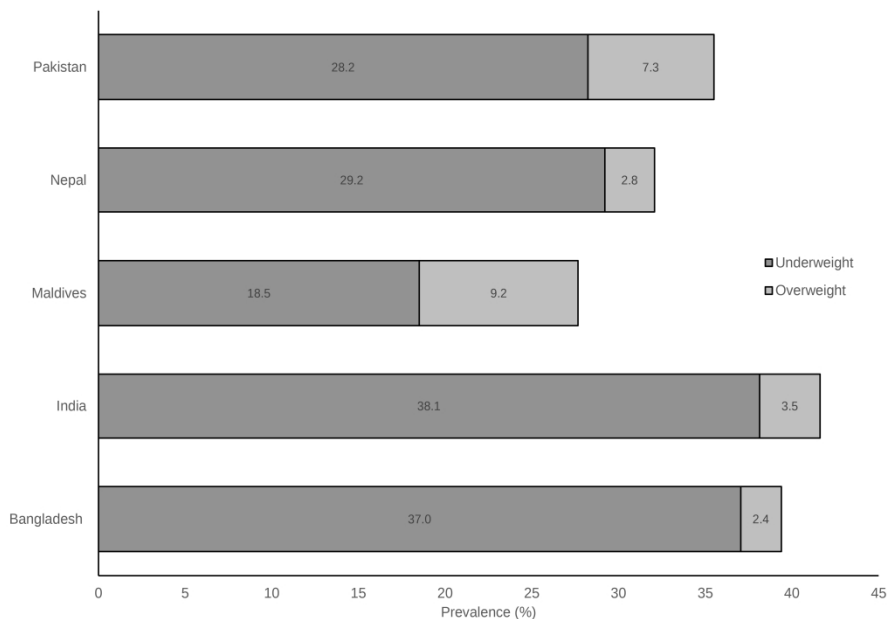


Figure 1: Prevalence of underweight and overweight, by country

Sampling weights provided by the Demographic and Health Survey (DHS) and Stata’s survey estimation procedures were used to estimate country-representative prevalence. Corresponding 95% confidence intervals of prevalence estimates are given in Supplementary Table S2.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

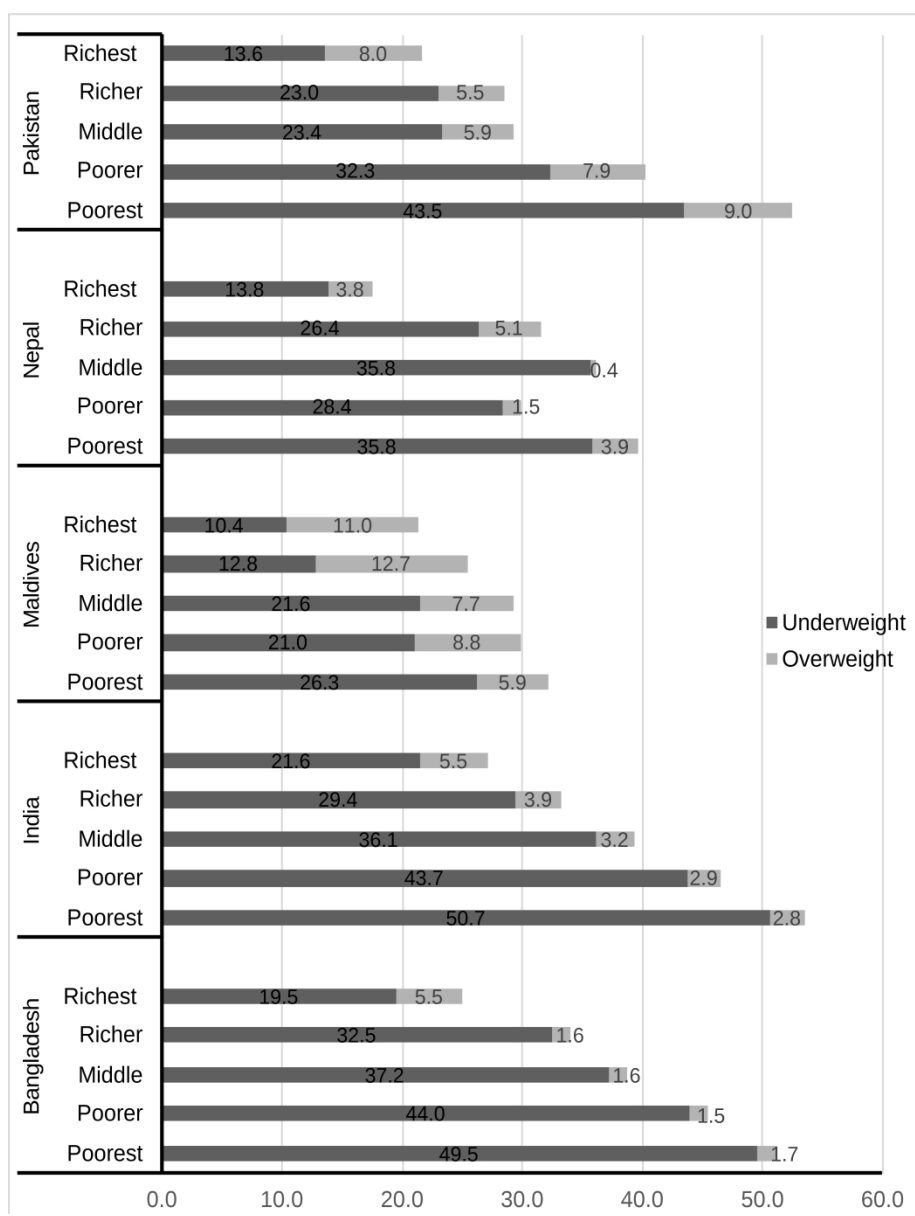


Figure 2: Prevalence of underweight and overweight, by household's wealth index
 Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence. Corresponding 95% confidence intervals of prevalence estimates are given in Supplementary Table S2.

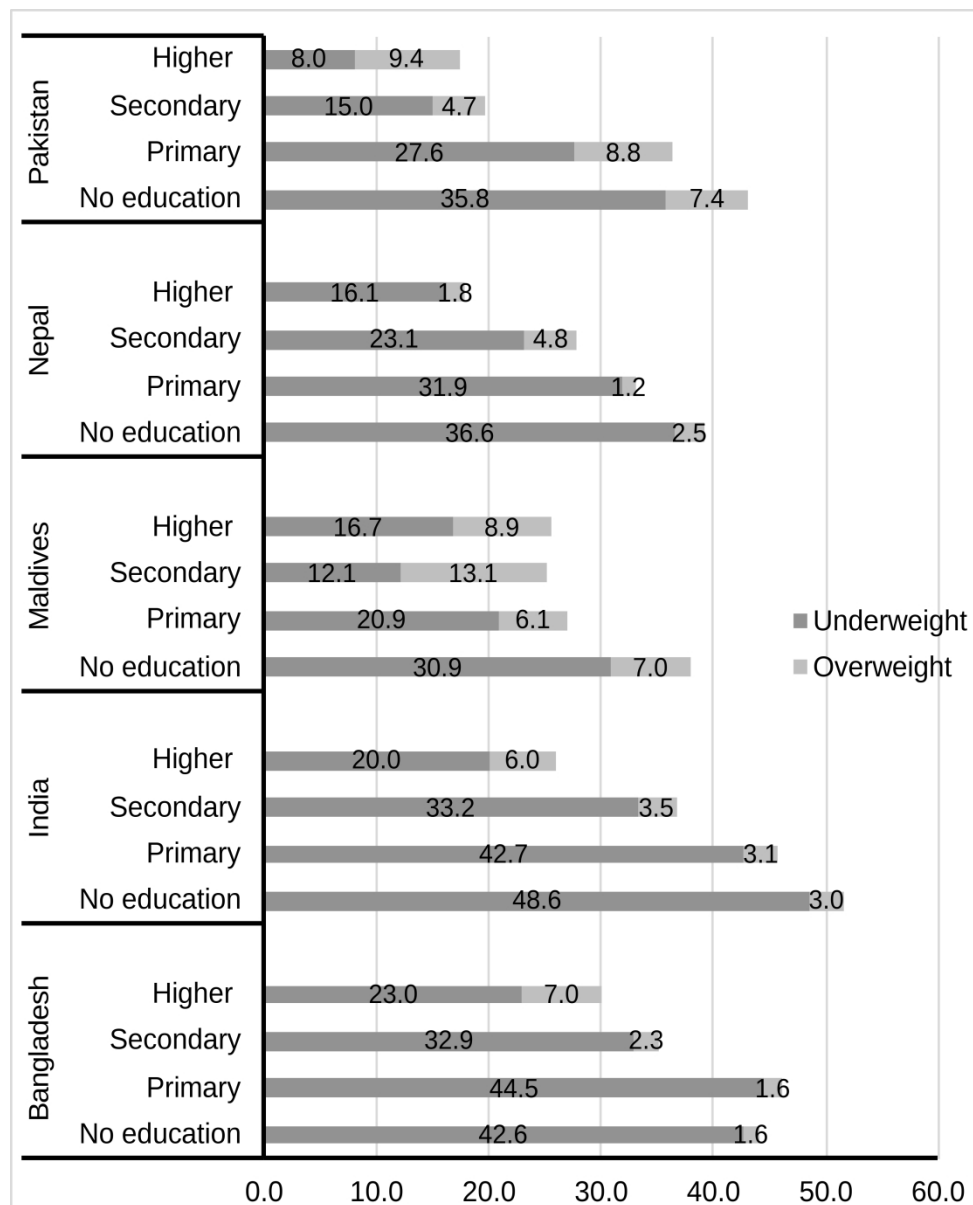


Figure 3: Prevalence of underweight and overweight, by household's highest level of education

Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence. Corresponding 95% confidence intervals of prevalence estimates are given in Supplementary Table S2.

1
2
3
4
5 **Double burden of malnutrition in children aged 24-59 months by**
6 **socioeconomic status in five south Asian countries: evidence from**
7
8
9
10 **Demographic and Health Surveys**
11

12 Fariha Binte Hossain, Md Shajedur Rahman Shawon, Md Shehab Uddin Al-Abid,
13
14 Sultan Mahmood, Gourab Adhikary, Md M Islam Bulbul
15
16

17
18
19 **Supplementary materials**
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

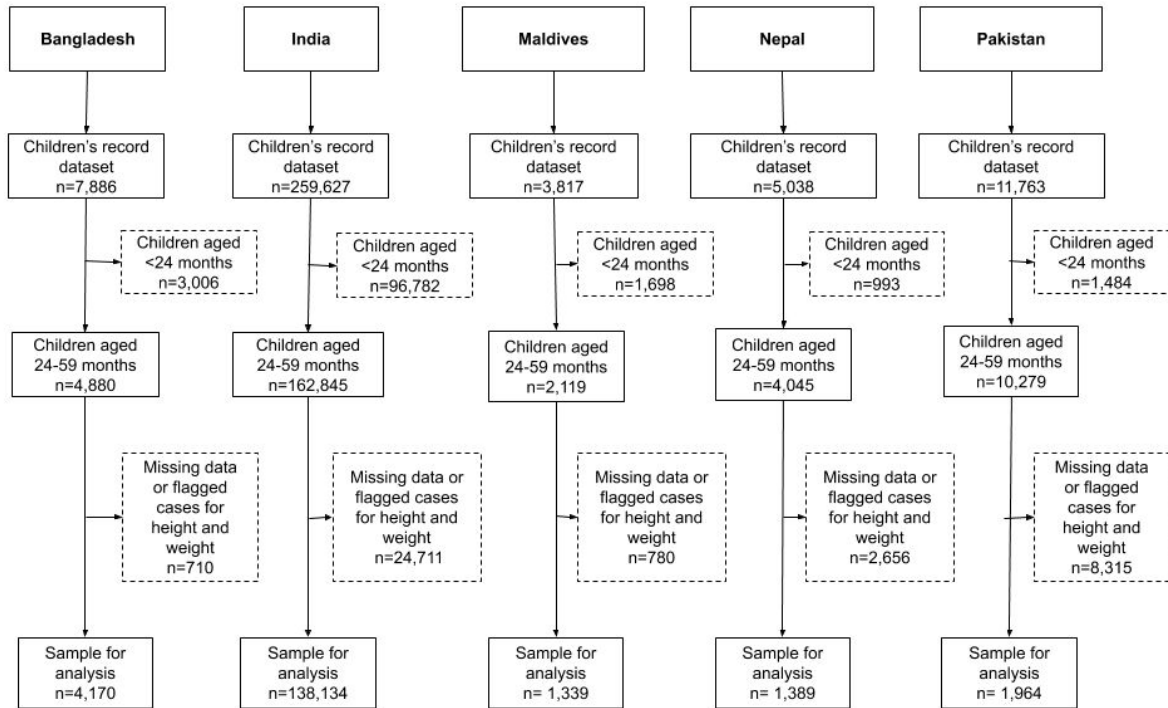


Figure S1: Flowchart of study participants included in this analysis

Table S1: Prevalence of underweight and overweight with 95% confidence intervals (95% CIs) in five South Asian countries, overall and by household's wealth index and highest education level

| | Bangladesh | India | Maldives | Nepal | Pakistan |
|--|------------------|------------------|------------------|------------------|------------------|
| Prevalence of underweight*, % (95% CIs) | | | | | |
| Overall | 37.0 (35.6-38.5) | 38.1 (37.9-38.4) | 18.5 (16.5-20.7) | 29.2 (26.9-31.7) | 28.2 (26.3-30.2) |
| Wealth index | | | | | |
| Poorest | 49.5 (46.4-52.7) | 50.7 (50.1-51.2) | 26.3 (21.4-31.9) | 35.8 (30.4-41.6) | 43.5 (39.2-47.9) |
| Poorer | 44.0 (40.5-47.5) | 43.7 (43.2-44.3) | 21.0 (16.5-26.5) | 28.4 (23.6-33.8) | 32.3 (28.0-36.9) |
| Middle | 37.2 (33.9-40.6) | 36.1 (35.6-36.7) | 21.6 (17.1-26.8) | 35.8 (30.6-41.3) | 23.4 (19.3-28.1) |
| Richer | 32.5 (29.4-35.7) | 29.4 (28.8-30.0) | 12.8 (9.3-17.4) | 26.4 (21.7-31.7) | 23.0 (19.5-26.9) |
| Richest | 19.5 (16.9-22.4) | 21.6 (21.0-22.1) | 10.4 (7.2-14.8) | 13.8 (9.5-19.7) | 13.6 (10.4-17.7) |
| Household's highest education | | | | | |
| No education | 42.6 (39.1-46.1) | 48.6 (48.1-49.1) | 30.9 (24.7-37.9) | 36.6 (32.6-40.8) | 35.8 (33.1-38.5) |
| Primary | 44.5 (41.7-47.4) | 42.7 (42.0-43.4) | 20.9 (17.7-24.5) | 31.9 (26.6-37.7) | 27.6 (23.2-32.5) |
| Secondary | 32.9 (30.8-35.1) | 33.2 (32.8-33.6) | 12.1 (9.5-15.2) | 23.1 (19.3-27.5) | 15.0 (11.8-19.0) |
| Higher | 23.0 (19.0-27.6) | 20.0 (19.3-20.7) | 16.7 (8.5-30.2) | 16.1 (11.3-22.6) | 8.0 (4.8-12.9) |
| Prevalence of overweight, % (95% CIs) | | | | | |
| Overall | 2.4 (1.9-2.9) | 3.5 (3.4-3.6) | 9.2 (7.7-10.8) | 2.8 (2.1-3.8) | 7.3 (6.3-8.5) |
| Wealth index | | | | | |
| Poorest | 1.7 (1.1-2.8) | 2.8 (2.7-3.0) | 5.9 (3.6-9.4) | 3.9 (2.2-6.9) | 9.0 (6.8-11.9) |
| Poorer | 1.5 (0.8-2.6) | 2.9 (2.7-3.1) | 8.8 (5.9-12.9) | 1.5 (0.6-3.7) | 7.9 (5.7-10.9) |
| Middle | 1.6 (1.0-2.8) | 3.2 (3.0-3.4) | 7.7 (5.1-11.5) | 0.4 (0.1-2.3) | 5.9 (3.9-8.8) |
| Richer | 1.6 (1.0-2.7) | 3.9 (3.7-4.2) | 12.7 (9.1-17.3) | 5.1 (3.1-8.3) | 5.5 (3.8-7.9) |
| Richest | 5.5 (4.1-7.3) | 5.5 (5.2-5.9) | 11.0 (7.7-15.4) | 3.8 (1.8-7.8) | 8.0 (5.6-11.3) |
| Education level | | | | | |
| No education | 1.6 (0.9-2.7) | 3.0 (2.8-3.1) | 7.0 (4.2-11.7) | 2.5 (1.5-4.2) | 7.4 (6.0-9.0) |
| Primary | 1.6 (1.0-2.5) | 3.1 (2.9-3.4) | 6.1 (4.4-8.4) | 1.2 (0.4-3.5) | 8.8 (6.2-12.2) |
| Secondary | 2.3 (1.7-3.0) | 3.5 (3.3-3.6) | 13.1 (10.5-16.3) | 4.8 (3.1-7.3) | 4.7 (3.0-7.3) |
| Higher | 7.0 (4.8-10.0) | 6.0 (5.6-6.4) | 8.9 (3.5-21.1) | 1.8 (0.6-5.4) | 9.4 (5.9-14.6) |

*Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence.

Table S2: Prevalence of stunting with 95% confidence intervals (95% CIs) in five South Asian countries, overall and by household's wealth index and highest education level

| | Prevalence of stunting*, % (95% CI) | | | | |
|-------------------------------|-------------------------------------|------------------|------------------|------------------|------------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Overall | 41.6 (40.2-43.1) | 41.8 (41.5-42.1) | 16.5 (14.6-18.6) | 41.6 (39.0-44.2) | 48.2 (46.1-50.3) |
| Wealth index | | | | | |
| Poorest | 58.8 (55.7-61.9) | 56.9 (56.4-57.4) | 19.6 (15.2-24.7) | 58.2 (52.3-63.8) | 62.3 (57.9-66.4) |
| Poorer | 49.9 (46.4-53.4) | 48.0 (47.4-48.5) | 20.8 (16.3-26.2) | 42.8 (37.3-48.4) | 61.0 (56.3-65.5) |
| Middle | 41.3 (38.0-44.8) | 39.9 (39.3-40.5) | 16.9 (12.9-21.7) | 42.4 (37.0-48.0) | 47.3 (42.1-52.4) |
| Richer | 35.4 (32.3-38.7) | 30.7 (30.1-31.3) | 13.5 (9.9-18.2) | 37.2 (31.9-42.8) | 41.3 (37.0-45.7) |
| Richest | 19.4 (16.7-22.3) | 22.8 (22.2-23.4) | 11.9 (8.5-16.4) | 19.9 (14.7-26.4) | 22.8 (18.7-27.6) |
| Household's highest education | | | | | |
| No education | 51.3 (47.7-54.8) | 55.0 (54.6-55.5) | 21.0 (15.8-27.5) | 51.6 (47.4-55.8) | 58.8 (56.0-61.6) |
| Primary | 52.5 (49.7-55.4) | 47.0 (46.3-47.7) | 18.5 (15.5-22.0) | 41.1 (35.3-47.1) | 50.3 (45.1-55.5) |
| Secondary | 34.4 (32.3-36.6) | 35.2 (34.8-35.6) | 14.1 (11.3-17.3) | 35.3 (30.8-40.0) | 26.6 (22.5-31.2) |
| Higher | 24.4 (20.3-29.1) | 21.3 (20.5-22.0) | 6.8 (2.3-18.5) | 26.1 (20.0-33.4) | 20.5 (15.2-27.0) |

*Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence.

Table S3: Prevalence of wasting with 95% confidence intervals (95% CIs) in five South Asian countries, overall and by household's wealth index and highest education level

| | Prevalence of wasting*, % (95% CI) | | | | |
|-------------------------------|------------------------------------|------------------|------------------|----------------|-----------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Overall | 12.5 (11.6-13.6) | 17.9 (17.7-18.1) | 11.1 (9.5-12.9) | 6.4 (5.2-7.8) | 6.9 (5.9-8.1) |
| Wealth index | | | | | |
| Poorest | 13.3 (11.3-15.6) | 20.0 (19.5-20.4) | 14.8 (11.0-19.5) | 5.9 (3.7-9.4) | 11.9 (9.4-15.1) |
| Poorer | 15.0 (12.6-17.6) | 18.6 (18.1-19.0) | 13.7 (10.0-18.5) | 7.4 (5.0-11.0) | 5.5 (3.7-8.1) |
| Middle | 11.8 (9.8-14.3) | 17.3 (16.8-17.7) | 12.5 (9.1-16.9) | 6.7 (4.4-10.1) | 5.4 (3.4-8.2) |
| Richer | 12.2 (10.2-14.5) | 16.8 (16.3-17.2) | 6.6 (4.1-10.3) | 6.4 (4.1-9.8) | 4.7 (3.1-7.0) |
| Richest | 10.3 (8.4-12.6) | 15.6 (15.1-16.1) | 7.8 (5.1-11.8) | 4.9 (2.6-9.2) | 6.1 (4.0-9.2) |
| Household's highest education | | | | | |
| No education | 9.1 (7.2-11.3) | 19.1 (18.8-19.5) | 16.8 (12.1-22.8) | 8.0 (6.0-10.7) | 7.6 (6.2-9.3) |
| Primary | 14.0 (12.2-16.1) | 18.3 (17.8-18.9) | 12.1 (9.6-15.1) | 7.4 (4.8-11.2) | 7.3 (5.0-10.5) |
| Secondary | 13.0 (11.6-14.6) | 17.7 (17.4-18.0) | 8.1 (6.0-10.8) | 4.6 (3.0-7.2) | 5.2 (3.4-7.9) |
| Higher | 12.5 (9.5-16.3) | 14.2 (13.6-14.8) | 13.2 (6.1-26.2) | 3.9 (1.8-8.2) | 5.1 (2.7-9.4) |

*Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence.

Table S4: Associations of household's wealth index and highest education with childhood stunting

| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
|-------------------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
| | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Poorer | 0.7 (0.6-0.8) | 0.8 (0.7-0.9) | 0.7 (0.7-0.7) | 0.8 (0.8-0.9) | 1.2 (0.9-1.5) | 1.3 (0.9-1.8) | 0.5 (0.4-0.6) | 0.5 (0.4-0.6) | 0.9 (0.7-1.1) | 0.9 (0.7-1.1) |
| Middle | 0.5 (0.5-0.6) | 0.7 (0.6-0.8) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.9 (0.6-1.1) | 1.1 (0.8-1.5) | 0.4 (0.4-0.6) | 0.4 (0.3-0.5) | 0.6 (0.5-0.8) | 0.6 (0.5-0.7) |
| Richer | 0.4 (0.3-0.5) | 0.5 (0.5-0.6) | 0.4 (0.3-0.4) | 0.5 (0.5-0.6) | 0.8 (0.5-1.1) | 1.0 (0.7-1.4) | 0.4 (0.3-0.5) | 0.4 (0.3-0.5) | 0.5 (0.4-0.6) | 0.4 (0.3-0.5) |
| Richest | 0.2 (0.2-0.2) | 0.3 (0.3-0.4) | 0.2 (0.2-0.3) | 0.4 (0.4-0.5) | 0.6 (0.3-1.1) | 0.8 (0.3-2.1) | 0.2 (0.1-0.2) | 0.2 (0.1-0.3) | 0.2 (0.2-0.3) | 0.2 (0.2-0.3) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Primary | 0.9 (0.8-1.0) | 0.9 (0.8-1.1) | 0.8 (0.8-0.8) | 0.9 (0.9-0.9) | 0.9 (0.7-1.1) | 0.9 (0.7-1.1) | 0.6 (0.5-0.8) | 0.7 (0.5-0.9) | 0.8 (0.6-1.0) | 1.1 (0.9-1.4) |
| Secondary | 0.4 (0.4-0.5) | 0.6 (0.6-0.7) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.6 (0.4-0.7) | 0.5 (0.4-0.7) | 0.5 (0.4-0.7) | 0.8 (0.7-1.0) | 0.3 (0.3-0.4) | 0.6 (0.5-0.8) |
| Higher | 0.3 (0.2-0.3) | 0.6 (0.5-0.8) | 0.2 (0.2-0.2) | 0.5 (0.5-0.5) | 0.3 (0.1-1.1) | 0.3 (0.1-1.4) | 0.4 (0.3-0.5) | 0.6 (0.4-0.9) | 0.3 (0.2-0.4) | 0.6 (0.4-0.8) |

* Minimally adjusted models were adjusted for child's age and sex; and fully-adjusted models were additionally adjusted for area of residence, receiving vitamin A and deworming drug, access to improved sanitation and drinking water, number of under-five children, mother's age at first birth, mother's height, and mother's BMI. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

Table S5: Associations of household’s wealth index and highest education with childhood wasting

| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
|-------------------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
| | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (0.8-1.2) | 1.0 (0.8-1.3) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (0.7-1.4) | 1.0 (0.7-1.5) | 1.0 (0.6-1.5) | 1.0 (0.6-1.6) | 1.0 (0.7-1.4) | 1.0 (0.6-1.6) |
| Poorer | 1.1 (0.9-1.3) | 1.1 (0.9-1.3) | 0.8 (0.8-0.8) | 0.9 (0.9-0.9) | 0.9 (0.6-1.2) | 0.9 (0.6-1.3) | 1.1 (0.7-1.8) | 1.0 (0.6-1.5) | 0.6 (0.4-1.0) | 0.7 (0.5-1.2) |
| Middle | 0.9 (0.7-1.1) | 0.9 (0.7-1.1) | 0.7 (0.7-0.8) | 0.9 (0.9-0.9) | 0.9 (0.6-1.2) | 1.0 (0.7-1.5) | 1.2 (0.8-1.8) | 1.0 (0.6-1.5) | 0.7 (0.5-1.1) | 0.9 (0.6-1.4) |
| Richer | 0.7 (0.6-0.9) | 0.8 (0.6-0.9) | 0.7 (0.7-0.7) | 0.9 (0.9-0.9) | 0.6 (0.4-1.0) | 1.1 (0.7-1.7) | 1.1 (0.7-1.8) | 1.2 (0.7-1.8) | 0.6 (0.4-0.9) | 0.9 (0.6-1.4) |
| Richest | 0.7 (0.5-0.9) | 0.8 (0.6-1.1) | 0.6 (0.6-0.7) | 0.9 (0.8-0.9) | 0.4 (0.2-0.8) | 1.3 (0.3-5.0) | 0.8 (0.4-1.6) | 1.1 (0.5-2.5) | 0.7 (0.5-1.1) | 1.0 (0.6-1.8) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (0.8-1.3) | 1.0 (0.8-1.3) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (0.7-1.4) | 1.0 (0.6-1.6) | 1.0 (0.7-1.4) | 1.0 (0.7-1.4) | 1.0 (0.8-1.3) | 1.0 (0.7-1.5) |
| Primary | 1.4 (1.2-1.6) | 1.5 (1.2-1.7) | 0.9 (0.9-0.9) | 0.9 (0.9-1.0) | 0.8 (0.6-1.0) | 0.8 (0.6-1.0) | 0.9 (0.5-1.4) | 1.0 (0.6-1.6) | 0.8 (0.5-1.3) | 1.0 (0.6-1.5) |
| Secondary | 1.2 (1.0-1.4) | 1.4 (1.2-1.6) | 0.8 (0.8-0.8) | 0.9 (0.9-0.9) | 0.5 (0.4-0.7) | 0.6 (0.4-0.8) | 0.6 (0.4-1.0) | 0.7 (0.5-1.0) | 0.9 (0.6-1.3) | 1.0 (0.6-1.5) |
| Higher | 1.1 (0.8-1.5) | 1.6 (1.1-2.3) | 0.7 (0.6-0.7) | 0.8 (0.8-0.9) | 0.7 (0.2-2.3) | 1.8 (0.5-6.9) | 0.4 (0.2-0.9) | 0.4 (0.2-1.0) | 0.9 (0.5-1.5) | 0.9 (0.5-1.6) |

* Minimally adjusted models were adjusted for child’s age and sex; and fully-adjusted models were additionally adjusted for area of residence, receiving vitamin A and deworming drug, access to improved sanitation and drinking water, number of under-five children, mother’s age at first birth, mother’s height, and mother’s BMI. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata’s survey estimation procedures.

Table S6: Socioeconomic status-adjusted odds ratios (ORs) of stunting for various child, household and maternal factors

| | OR (95% CI)* | | | | |
|--|---------------|---------------|----------------|---------------|---------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Child's variables | | | | | |
| Sex | | | | | |
| Male | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Female | 1.0 (0.9-1.1) | 1.0 (1.0-1.0) | 1.3 (1.0-1.8) | 1.0 (0.8-1.2) | 0.9 (0.8-1.1) |
| Age | | | | | |
| 2-3 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 3-4 years | 1.1 (1.0-1.3) | 1.0 (1.0-1.1) | 0.9 (0.6-1.2) | 0.7 (0.5-0.9) | 0.9 (0.7-1.1) |
| 4-5 years | 0.8 (0.7-0.9) | 0.9 (0.8-0.9) | 0.5 (0.4-0.8) | 0.7 (0.5-0.9) | 0.8 (0.6-1.0) |
| Received vitamin A in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.9-1.2) | 1.0 (1.0-1.0) | 1.1 (0.7-1.7) | 0.8 (0.5-1.1) | 1.1 (0.9-1.3) |
| Received deworming drug in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.9-1.1) | 0.9 (0.9-1.0) | 1.1 (0.7-1.6) | 1.0 (0.8-1.3) | 0.8 (0.6-1.0) |
| Household variables | | | | | |
| Area of residence | | | | | |
| Urban | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Rural | 0.9 (0.8-1.1) | 0.9 (0.9-1.0) | 0.9 (0.4-2.0) | 1.0 (0.8-1.3) | 0.7 (0.6-0.9) |
| Improved access to sanitation | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.8 (0.7-1.0) | 0.9 (0.9-0.9) | 0.7 (0.4-1.2) | 0.6 (0.5-0.8) | 1.3 (1.0-1.7) |
| Improved access to drinking water | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.9 (0.8-1.2) | 1.2 (1.1-1.2) | 1.0 (0.5-1.7) | 1.1 (0.8-1.5) | 1.2 (1.0-1.6) |
| No. of children under five | 1.2 (1.1-1.3) | 1.1 (1.1-1.1) | 1.0 (0.9-1.2) | 1.1 (1.0-1.3) | 1.1 (1.0-1.2) |
| Maternal variables | | | | | |
| Mother's age at first birth | | | | | |
| Less than 20 years | 1.1 (0.9-1.3) | 1.1 (1.1-1.1) | 0.8 (0.6-1.2) | 0.8 (0.7-1.1) | 0.9 (0.7-1.1) |
| 20-24 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 25 years or more | 0.6 (0.4-0.9) | 0.8 (0.8-0.8) | 1.0 (0.7-1.6) | 0.5 (0.3-0.9) | 0.8 (0.6-1.0) |
| Mother's BMI category | | | | | |
| Normal weight | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Underweight | 1.3 (1.1-1.5) | 1.3 (1.2-1.3) | 0.9 (0.5-1.6) | 1.4 (1.1-1.9) | 1.7 (1.2-2.3) |
| Overweight | 0.7 (0.6-0.8) | 0.8 (0.7-0.8) | 0.9 (0.7-1.2) | 0.6 (0.4-0.8) | 1.0 (0.8-1.2) |
| Mother's height category | | | | | |
| <145 cm | 4.9 (3.9-6.3) | 3.5 (3.4-3.7) | 6.2 (3.6-10.7) | 4.1 (2.7-6.1) | 3.7 (2.2-6.2) |
| 145-149 cm | 2.5 (2.1-3.0) | 2.2 (2.1-2.3) | 3.3 (2.1-5.4) | 2.7 (2.0-3.8) | 2.3 (1.7-3.0) |
| 150-154 cm | 1.9 (1.5-2.2) | 1.5 (1.5-1.6) | 2.5 (1.6-4.0) | 1.6 (1.2-2.2) | 1.4 (1.1-1.7) |
| 155 cm or more | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |

* Logistic regression models were adjusted for household's wealth index and highest education. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

Table S7: Socioeconomic status-adjusted odds ratios (ORs) of wasting for various child, household and maternal factors

| | OR (95% CI)* | | | | |
|--|---------------|---------------|---------------|---------------|---------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Child's variables | | | | | |
| Sex | | | | | |
| Male | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Female | 1.0 (0.8-1.2) | 0.9 (0.8-0.9) | 0.8 (0.6-1.1) | 0.9 (0.6-1.4) | 0.7 (0.5-1.0) |
| Age | | | | | |
| 2-3 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 3-4 years | 1.0 (0.8-1.2) | 0.9 (0.9-0.9) | 1.1 (0.7-1.7) | 0.8 (0.5-1.4) | 0.9 (0.6-1.4) |
| 4-5 years | 1.2 (0.9-1.5) | 0.9 (0.8-0.9) | 1.3 (0.9-2.0) | 0.9 (0.6-1.6) | 0.7 (0.5-1.1) |
| Received vitamin A in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.1 (0.9-1.3) | 1.1 (1.1-1.1) | 1.6 (0.9-2.9) | 0.6 (0.3-1.0) | 1.0 (0.7-1.4) |
| Received deworming drug in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.9 (0.7-1.1) | 1.0 (1.0-1.1) | 1.8 (1.0-2.9) | 1.1 (0.6-1.8) | 0.7 (0.5-1.1) |
| Household variables | | | | | |
| Area of residence | | | | | |
| Urban | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Rural | 1.1 (0.9-1.4) | 0.9 (0.9-1.0) | 2.7 (0.9-7.8) | 0.6 (0.4-0.9) | 1.0 (0.6-1.5) |
| Improved access to sanitation | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.2 (0.9-1.4) | 0.9 (0.8-0.9) | 0.7 (0.4-1.4) | 0.6 (0.4-1.0) | 0.7 (0.5-1.1) |
| Improved access to drinking water | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.2 (0.9-1.6) | 1.0 (1.0-1.1) | 1.5 (0.7-3.2) | 1.5 (0.7-3.3) | 0.6 (0.4-0.9) |
| No. of children under five | 0.9 (0.8-1.0) | 0.9 (0.9-1.0) | 1.1 (0.9-1.3) | 0.8 (0.6-1.0) | 1.0 (0.9-1.1) |
| Maternal variables | | | | | |
| Mother's age at first birth | | | | | |
| Less than 20 years | 1.0 (0.8-1.3) | 1.0 (1.0-1.0) | 1.1 (0.8-1.6) | 1.1 (0.7-1.7) | 0.9 (0.6-1.4) |
| 20-24 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 25 years or more | 0.9 (0.6-1.5) | 0.9 (0.9-1.0) | 0.6 (0.4-1.2) | 1.1 (0.4-2.6) | 1.1 (0.7-1.8) |
| Mother's BMI category | | | | | |
| Normal weight | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Underweight | 1.5 (1.2-1.9) | 1.4 (1.4-1.5) | 1.7 (1.0-3.0) | 1.7 (1.0-2.8) | 1.3 (0.8-2.1) |
| Overweight | 0.6 (0.4-0.8) | 0.6 (0.6-0.6) | 0.7 (0.5-1.0) | 0.5 (0.2-1.1) | 0.6 (0.4-0.9) |
| Mother's height category | | | | | |
| <145 cm | 1.3 (1.0-1.8) | 1.0 (1.0-1.1) | 1.0 (0.6-1.8) | 1.1 (0.6-2.2) | 1.4 (0.6-3.0) |
| 145-149 cm | 1.1 (0.9-1.5) | 1.1 (1.0-1.1) | 0.6 (0.4-1.0) | 1.0 (0.6-1.7) | 0.9 (0.5-1.5) |
| 150-154 cm | 1.0 (0.8-1.3) | 1.0 (1.0-1.1) | 1.1 (0.7-1.7) | 0.7 (0.4-1.2) | 1.2 (0.8-1.8) |
| 155 cm or more | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |

* Logistic regression models were adjusted for household's wealth index and highest education. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

| | | Reporting Item | Page Number |
|---------------------------|---------------------|---|-----------------------|
| Title and abstract | | | |
| Title | #1a | Indicate the study's design with a commonly used term in the title or the abstract | Page 1 |
| Abstract | #1b | Provide in the abstract an informative and balanced summary of what was done and what was found | Page 2-3 |
| Introduction | | | |
| Background / rationale | #2 | Explain the scientific background and rationale for the investigation being reported | Page 5 |
| Objectives | #3 | State specific objectives, including any prespecified hypotheses | Page 6 lines 14-16 |
| Methods | | | |

| | | | | |
|----|----------------------|----------------------|---|-----------|
| 1 | Study design | #4 | Present key elements of study design early in the paper | Page 7 |
| 2 | | | | |
| 3 | Setting | #5 | Describe the setting, locations, and relevant dates, including periods of | Page 7 |
| 4 | | | recruitment, exposure, follow-up, and data collection | |
| 5 | | | | |
| 6 | | | | |
| 7 | Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection | Page 7 |
| 8 | | | of participants. | |
| 9 | | | | |
| 10 | | | | |
| 11 | | #7 | Clearly define all outcomes, exposures, predictors, potential | Page 8-9 |
| 12 | | | confounders, and effect modifiers. Give diagnostic criteria, if | |
| 13 | | | applicable | |
| 14 | | | | |
| 15 | | | | |
| 16 | Data sources / | #8 | For each variable of interest give sources of data and details of | NA |
| 17 | measurement | | methods of assessment (measurement). Describe comparability of | |
| 18 | | | assessment methods if there is more than one group. Give information | |
| 19 | | | separately for for exposed and unexposed groups if applicable. | |
| 20 | | | | |
| 21 | | | | |
| 22 | | | | |
| 23 | Bias | #9 | Describe any efforts to address potential sources of bias | Page 10 |
| 24 | | | | lines 11- |
| 25 | | | | 15 |
| 26 | | | | |
| 27 | | | | |
| 28 | Study size | #10 | Explain how the study size was arrived at | NA |
| 29 | | | | |
| 30 | | | | |
| 31 | Quantitative | #11 | Explain how quantitative variables were handled in the analyses. If | Page 8-9 |
| 32 | variables | | applicable, describe which groupings were chosen, and why | |
| 33 | | | | |
| 34 | Statistical | #12a | Describe all statistical methods, including those used to control for | Page 10 |
| 35 | methods | | confounding | |
| 36 | | | | |
| 37 | | | | |
| 38 | Statistical | #12b | Describe any methods used to examine subgroups and interactions | NA |
| 39 | methods | | | |
| 40 | | | | |
| 41 | | | | |
| 42 | Statistical | #12c | Explain how missing data were addressed | NA |
| 43 | methods | | | |
| 44 | | | | |
| 45 | | | | |
| 46 | Statistical | #12d | If applicable, describe analytical methods taking account of sampling | NA |
| 47 | methods | | strategy | |
| 48 | | | | |
| 49 | | | | |
| 50 | Statistical | #12e | Describe any sensitivity analyses | Page 13 |
| 51 | methods | | | lines 10- |
| 52 | | | | 16 |
| 53 | | | | |
| 54 | | | | |
| 55 | Results | | | |
| 56 | | | | |
| 57 | Participants | #13a | Report numbers of individuals at each stage of study—eg numbers | Page 11 |
| 58 | | | | |
| 59 | | | | |
| 60 | | | | |

potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for exposed and unexposed groups if applicable.

| | | | |
|----|-------------------|--|----------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | Participants | #13b Give reasons for non-participation at each stage | NA |
| 8 | | | |
| 9 | Participants | #13c Consider use of a flow diagram | Page 11 |
| 10 | | | |
| 11 | Descriptive data | #14a Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable. | Page 11 |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | Descriptive data | #14b Indicate number of participants with missing data for each variable of interest | NA |
| 19 | | | |
| 20 | | | |
| 21 | | | |
| 22 | Outcome data | #15 Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. | Page 11 |
| 23 | | | |
| 24 | | | |
| 25 | | | |
| 26 | | | |
| 27 | Main results | #16a Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | Page 12 |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| 31 | | | |
| 32 | | | |
| 33 | Main results | #16b Report category boundaries when continuous variables were categorized | NA |
| 34 | | | |
| 35 | | | |
| 36 | | | |
| 37 | Main results | #16c If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | NA |
| 38 | | | |
| 39 | | | |
| 40 | Other analyses | #17 Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | Page 13 lines 10- 16 |
| 41 | | | |
| 42 | | | |
| 43 | | | |
| 44 | | | |
| 45 | | | |
| 46 | Discussion | | |
| 47 | | | |
| 48 | Key results | #18 Summarise key results with reference to study objectives | Page 14 |
| 49 | | | |
| 50 | Limitations | #19 Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. | Page 16- 17 |
| 51 | | | |
| 52 | | | |
| 53 | | | |
| 54 | | | |
| 55 | | | |
| 56 | Interpretation | #20 Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and | Page 14- 16 |
| 57 | | | |
| 58 | | | |
| 59 | | | |
| 60 | | | |

other relevant evidence.

1
2
3 Generalisability [#21](#) Discuss the generalisability (external validity) of the study results Page 16

4
5 **Other**
6 **Information**

7
8
9 Funding [#22](#) Give the source of funding and the role of the funders for the present Page 18
10 study and, if applicable, for the original study on which the present
11 article is based
12

13
14 Notes:

- 15
16 • 3: Page 6 lines 14-16
17
18 • 9: Page 10 lines 11-15
19
20
21 • 12e: Page 13 lines 10-16
22
23 • 17: Page 13 lines 10-16 The STROBE checklist is distributed under the terms of the Creative Commons
24 Attribution License CC-BY. This checklist was completed on 09. July 2019 using
25 <https://www.goodreports.org/>, a tool made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

BMJ Open

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

| | |
|---------------------------------|---|
| Journal: | <i>BMJ Open</i> |
| Manuscript ID | bmjopen-2019-032866.R3 |
| Article Type: | Original research |
| Date Submitted by the Author: | 26-Feb-2020 |
| Complete List of Authors: | Hossain, Fariha Binte; Independent Researcher , Shawon, Md Shajedur Rahman; Oxford University, Nuffield Department of Population Health Al-Abid, Md Shehab Uddin; National Heart Foundation Hospital and Research Institute Mahmood, Sultan; Independent Researcher Adhikary, Gourab ; ICDDR, Health Systems and Population Studies Division Bulbul, Md. M. Islam; Institute of Public Health Nutrition (IPHN), National Nutrition Services (NNS) |
| Primary Subject Heading: | Global health |
| Secondary Subject Heading: | Public health, Nutrition and metabolism, Global health, Epidemiology |
| Keywords: | Double burden, underweight, overweight, under-five children, socioeconomic status, South Asia |
| | |

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 1 **TITLE:**
4

5 2 Double burden of malnutrition in children aged 24-59 months by socioeconomic
6
7 3 status in five South Asian countries: evidence from Demographic and Health
8
9
10 4 Surveys
11

12 5 **SUBTITLE:**
13

14 6 Double burden of malnutrition among under-five children in South Asia
15

16
17 7 **AUTHORS:**
18

19 8 Fariha Binte Hossain^{1†}, Md Shajedur Rahman Shawon^{2†}, Md Shehab Uddin Al-Abid³,
20
21 9 Sultan Mahmood Sami¹, Gourab Adhikary⁴, Md M Islam Bulbul⁵
22

23
24 10 ¹ Independent Researcher
25

26 11 ² Nuffield Department of Population Health, University of Oxford, Richard Doll
27
28 12 Building, OX3 7LF, UK Email: md.shawon@ndph.ox.ac.uk
29

30 13 ³ National Heart Foundation Hospital and Research Institute, Dhaka, Bangladesh
31
32 14 Email: abid79@nhf.org.bd
33

34 15 ⁴ Health Systems and Population Studies Division, icddr,b, 68 Shaheed Tajuddin
35
36 16 Ahmed Sarani, Mohakhali, Dhaka 1212, Bangladesh Email: gourabdmc@gmail.com
37

38 17 ⁵ National Nutrition Services, Ministry of Health and Family Welfare, Bangladesh
39
40 18 Email: bulbul1022@yahoo.com
41
42

43
44 19 **CORRESPONDING AUTHOR:**
45

46 20 Fariha Binte Hossain
47

48
49 21 Independent Researcher, 368/3D Ahmednagar, Paikpara, Mirpur-1, Dhaka 1216,
50
51 22 Bangladesh
52

53 23 Email: fariha.binte.hossain@gmail.com
54

55
56 24
57

58 25
59

60 26 † These authors contributed equally

1
2
3 **1 ABSTRACT**
4

5 **2 Objectives:** We aimed to investigate the socioeconomic inequalities in the burden of
6
7
8 **3** underweight and overweight among children in South Asia. We also examined other
9
10 **4** factors that were associated with these outcomes independently of household's
11
12 **5** socioeconomic status.

13
14 **6 Design:** Nationally-representative surveys.

15
16
17 **7 Settings:** Demographic and Health Surveys from Bangladesh, India, Pakistan,
18
19 **8** Maldives, and Nepal, which were conducted between 2009 and 2016.

20
21 **9 Participants:** Children aged 24-59 months with valid measurement for height and
22
23
24 **10** weight (n=146,996).

25
26 **11 Primary exposure and outcome measures:** Primary exposures were household's
27
28 **12** wealth index and level of education. Underweight and overweight were defined
29
30 **13** according to the World Health Organization and International Obesity Task Force
31
32 **14** definitions, respectively.

33
34
35 **15 Results:** Underweight prevalence was 37% in Bangladesh, 38% in India, 19% in
36
37 **16** Maldives, 29% in Nepal, and 28% in Pakistan. Bangladesh, India, and Nepal had
38
39 **17** similar overweight prevalence (between 2% and 4%) whereas Pakistan (7%) and
40
41 **18** Maldives (9%) had higher prevalence. Households with higher wealth index or
42
43 **19** education had lower odds of having underweight children. Adjusted-odds ratios
44
45 **20** (ORs) of underweight for richest vs poorest households were 0.4 [95% CI:0.3-0.5],
46
47 **21** 0.5 [0.5-0.6], 0.5 [0.2-1.4], 0.5 [0.3-0.8], and 0.7 [0.5-1.1] for Bangladesh, India,
48
49 **22** Maldives, Nepal and Pakistan, respectively. Compared to poorest households,
50
51 **23** richest households were more likely to have overweight children in all countries
52
53 **24** except Pakistan, but such associations were not significant after adjustment for other
54
55 **25** factors. There were higher odds of having overweight children in households with
56
57
58
59
60

1
2
3 1 higher education in Bangladesh (OR 2.1 [95% CI:1.3-3.5]), India (1.2 [1.2-1.3]), and
4
5 2 Pakistan (1.8 [1.1-2.9]) when compared to households with no education. Maternal
6
7 3 nutritional status was consistently associated with children's nutritional outcomes
8
9 4 after adjustments for socioeconomic status.

10
11
12 5 **Conclusions:** Our study provides evidence for socioeconomic inequalities for
13
14 6 childhood underweight and overweight in South Asian countries, although the
15
16 7 directions of associations for underweight and overweight might be different.

17
18
19 8 **Keywords:**

20
21 9 Double burden, underweight, overweight, under-five children, South Asia,
22
23 10 Bangladesh, India, Pakistan, Nepal, Maldives
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 STRENGTHS AND LIMITATIONS OF THIS STUDY

- 2 • This is the first study to investigate the double burden of malnutrition among
3 children aged under five years in South Asian countries, using nationally-
4 representative samples.
- 5 • We used height and weight information which were measured by trained
6 research personnel.
- 7 • Use of International Obesity Task Force (IOTF) classification to define
8 overweight ensures cross-comparison of estimates with those from other
9 regions.
- 10 • Although we adjusted for several child, household and maternal factors when
11 examining the associations of socioeconomic status with underweight and
12 overweight, we did not have information on many dietary and lifestyle factors
13 that could modify those associations.
- 14 • We examined the effects of other factors on childhood underweight and
15 overweight after adjustment for household's socioeconomic status.

1 INTRODUCTION

2 Double burden of malnutrition implies the presence of both undernutrition and
3 overnutrition (overweight or obesity) either at the individual, household, or population
4 level [1]. At the individual level, an undernourished child can be overweight or obese
5 when they reach adulthood, whereas at household level coexistence of
6 undernourished and overweight children or adults can be possible. At the population
7 level, double burden of malnutrition indicates the presence of both undernutrition and
8 overnutrition in the same community, country, or region. Undernutrition can be
9 assessed by underweight (low weight-for-age), wasting (low weight-for-height), and
10 stunting (low height-for-age) [2]. Wasting and stunting reflect acute weight loss and
11 long-term growth restriction, respectively; whereas underweight indicates wasting,
12 stunting, or both.

13 Double burden of malnutrition is an emerging problem in the low and middle-income
14 countries (LMICs), including South Asian countries [1,3]. Historically, these countries
15 have a considerable burden of undernutrition in children [4,5], for example, according
16 to the World Report on Nutrition 2018 [6], approximately 39% of all stunted children
17 were from this region. But there has been growing evidence that the number of
18 children with overweight and obesity is also increasing in recent years in South Asian
19 countries, particularly due to economic growth, rapid urbanisation, and adoption of
20 western lifestyles [7–10]. Ensuring optimum nutrition in early years of life is an
21 important public health agenda, mainly because both undernutrition and overnutrition
22 in these years are associated with a wide range of morbidities in early life as well as
23 in later life [11,12].

24 Understanding the socioeconomic inequalities in nutritional outcomes in LMICs is
25 essential to seize programme and policy opportunities to address malnutrition in both

1 forms. The associations of socioeconomic status with undernutrition and
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 forms. The associations of socioeconomic status with undernutrition and
2 overnutrition might be different in LMICs to those in high-income countries. In high-
3 income countries, overweight in children is associated with poorer socioeconomic
4 conditions [13–15], but it is not clear whether lower socioeconomic status can
5 increase the likelihood of children with overweight in LMICs too. It has been
6 consistently shown that children in poorer households are more likely to be
7 underweight than those in richer households [16,17]. Moreover, identifying other
8 factors that might influence nutritional outcomes independently of socioeconomic
9 status will help to develop effective public health interventions.

10 While many studies separately examined the burden of undernutrition or
11 overnutrition, studying both outcomes together in a population can inform the
12 relevant stakeholders on seizing intervention and policy opportunities to tackle
13 childhood malnutrition in more holistic ways. So far, studies looking at the issue of
14 the double burden of malnutrition in South Asian countries focused mainly on the
15 coexistence of overweight or obese mother and underweight or stunted child within
16 the same household [16,18,19]. While studying double burden of malnutrition, it is
17 also essential to study the burden and underlying factors of childhood underweight,
18 stunting and wasting because they are very different constructs of undernutrition. To
19 the best of our knowledge, no study looked at the double burden of malnutrition
20 among children aged under five years in South Asian countries.

21 This study uses data from the Demographic and Health Surveys (DHS), which
22 provide nationally-representative estimates for a wide range of monitoring and
23 impact evaluation indicators in the areas of population, health, and nutrition [20].
24 While these surveys provide the prevalence of underweight and overweight among
25 children by socioeconomic status, it is essential to understand the associations

1
2
3 1 between them taking account of other factors that might confound such associations.
4
5 2 In this study, we aimed to investigate the associations of household's wealth index
6
7 3 and highest education level with the prevalence of underweight and overweight
8
9 4 among children aged 24-59 months in five South Asian countries. Also, we explored
10
11 5 which other factors can influence childhood underweight and overweight
12
13 6 independently of household's socioeconomic status.
14
15
16
17 7
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1 1 **METHODS**

2 2 **Study design and data sources**

3 3 This study is based on the latest DHS data from five South Asian countries, namely
4 4 Bangladesh, India, Pakistan, Maldives, and Nepal. Other countries in the South
5 5 Asian regions (e.g. Afghanistan, Bhutan, and Sri Lanka) were not included in this
6 6 study because of either DHS was not conducted, or anthropometric data for children
7 7 were not available. The included surveys were conducted in 2014, 2015-16, 2009,
8 8 2016, and 2012-13 for Bangladesh, India, Maldives, Nepal and Pakistan,
9 9 respectively.

10 10 DHS are nationally-representative household surveys which are usually conducted
11 11 about every five years. These surveys provide data for a wide range of monitoring
12 12 and impact evaluation indicators in the areas of population, health, and nutrition. A
13 13 DHS is conducted by a national implementing agency, which can be any bonafide
14 14 governmental, non-governmental, or private-sector organization and has enough
15 15 experience in the execution of surveys that are national in scope. Technical
16 16 assistance throughout the whole process is provided by the DHS program [20].

17 17 DHS is usually based on a two-stage stratified sampling of households. In the first
18 18 stage, sampling census enumeration areas are selected using probability
19 19 proportional to size (PPS) sampling technique through statistics provided by the
20 20 respective national statistical office. In the second stage, households are selected
21 21 through systematic random sampling from the complete listing of households within
22 22 a selected enumeration area [21].

23 23 Ethical approval for each DHS is taken from the ICF Institutional Review Board as
24 24 well as by a review board in the host country. More details of such ethical approval
25 25 can be found in the DHS program website [<https://dhsprogram.com/>]. Informed

1 consent to participate in the study is taken from the participant, or from the parent or
2 guardian if anthropometric measurements are taken from a child. The data files are
3 freely available from the program website. We received authorization from the DHS
4 program for using the relevant datasets for this analysis. The data we received were
5 anonymized for protection of privacy, anonymity and confidentiality.

6 These surveys have a very high response rate, usually 90% and above. Detailed
7 questionnaires of included surveys are available in the final report of each survey.
8 We used the children's record (coded as "KR" in DHS program) datasets which
9 contained information about children born in the last five years prior to the survey
10 (aged 0-59 months). The present analysis is based on children aged 24 – 59 months
11 who had a valid measurement of their weight and height. We excluded children aged
12 less than 24 months because most of the available classification system for defining
13 childhood overweight starts from 24 months [22,23]. Flowchart of study participants
14 included in this analysis is given in Supplementary Figure S1.

16 **Anthropometric measurement, and defining undernutrition and overnutrition**

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

1
2
3 1 While each indicator of child undernutrition reflects distinct aspects undernutrition,
4
5 2 we assessed undernutrition mainly by underweight in this study. Childhood
6
7 3 underweight indicates the overall population's nutritional status, and is a composite
8
9 4 indicator which can encompass stunting, wasting, or both. According to the World
10
11 5 Health Organization (WHO) guidelines [2], a child with weight-for-age less than two
12
13 6 standard deviations (-2 SD) from the median of the reference population was
14
15 7 considered as underweight.

16
17
18
19 8 To define childhood overweight, we used the age and sex-specific BMI cut-offs from
20
21 9 the International Obesity Task Force (IOTF) classification system [23,24]. According
22
23 10 to IOTF, a child aged between 2 years and 18 years is classified as overweight if
24
25 11 their BMI is larger than the age and sex-specific BMI cut-off corresponding to an
26
27 12 adult BMI of $>25 \text{ kg/m}^2$. Our definition of childhood overweight also included those
28
29 13 with obesity and it is referred to hereafter as "overweight" for simplicity.
30
31
32
33
34

35 **Covariates**

36
37 16 DHS collected information on a wide range of variables from the selected
38
39 17 households using a face-to-face interview with the respondents conducted by trained
40
41 18 personnel. DHS collected information on socioeconomic factors like the area of
42
43 19 residence and household's wealth index. Place of residence (rural and urban) was
44
45 20 defined according to country-specific definitions. Household's highest education level
46
47 21 was based on the educational attainment of the child's mother and father. For
48
49 22 household's wealth index, each national implementing agency constructed a country-
50
51 23 specific index using principal components analysis from data on household assets
52
53 24 including durable goods (i.e. bicycles, televisions etc.) and dwelling characteristics
54
55 25 (i.e. sanitation, source of drinking water and construction material of house etc.) [25].
56
57
58
59
60

1
2
3 1 This wealth index was then categorized into five groups (i.e. poorest, poorer, middle,
4
5 2 richer, and richest) based on the quintile distribution of the sample.
6

7
8 3 We also included indicators of child's exposure to nutrition-sensitive interventions
9
10 4 (focusing on the underlying determinants of malnutrition) such as receiving vitamin A
11
12 5 in the last six months and receiving the deworming drug in last six months [26].
13

14 6 Households with flush toilet, ventilated improved pit latrine, traditional pit latrine with
15
16 7 a slab, or composting toilet were considered to have improved access to sanitation,
17
18 8 whereas households with improved access to drinking water were considered if they
19
20 9 had connection (piped), public standpipe, borehole, protected dug well or spring, or
21
22 10 rainwater collection.
23
24
25

26 11

27 28 12 **Statistical analysis**

29
30 13 We conducted all analysis following the instructions given in the DHS guide to
31
32 14 analysis [21]. Considering the two-stage stratified cluster sampling in DHS, we
33
34 15 applied Stata's survey estimation procedures ("svy" command) for the estimation of
35
36 16 proportions, means, and regression analysis [27].
37
38

39
40 17 The percent distributions for characteristics of included children are described as
41
42 18 proportions, for each DHS survey. To estimate the prevalence of childhood
43
44 19 underweight and overweight, we used sampling weights given in each DHS dataset
45
46 20 in order to get nationally-representative estimates. 95% confidence intervals (CIs) for
47
48 21 prevalence estimates were calculated using a logit transform of the estimate. We
49
50 22 also estimated the prevalence of childhood underweight and overweight by the levels
51
52 23 of socioeconomic factors to assess the inequalities by those factors.
53
54

55
56 24 To examine the associations of socioeconomic factors (i.e. household's wealth index
57
58 25 and household's highest level of education) with the prevalence of childhood
59
60

1
2
3 1 underweight and overweight, we used multiple logistic regression, separately for
4
5 2 each included country. At first, these analyses were minimally-adjusted for child's
6
7 3 age and sex; and then they were adjusted for the child's exposure to nutrition-
8
9 4 sensitive interventions, area of residence, access to improved sanitation and to
10
11 5 improved drinking water, number of under-five children in household, mother's age at
12
13 6 first birth, mother's height, and mother's BMI. Missing data in the adjustment
14
15 7 variables (usually less than 5%) were considered as separate categories so that the
16
17 8 same children were compared in all analyses. To explore which factors can influence
18
19 9 the prevalence of childhood underweight and overweight after accounting for
20
21 10 household's socioeconomic status, we estimated the odds ratios (ORs) for all child-,
22
23 11 household- and maternal-level factors with adjustment for household's wealth index
24
25 12 and highest level of education.

26
27 13 All analyses were additionally conducted for childhood stunting and wasting. Stunting
28
29 14 and wasting were defined respectively as height-for-age less than two standard
30
31 15 deviations (-2 SD) and weight-for-height less than two standard deviations (-2 SD)
32
33 16 from the median of the reference population [2].

34
35 17 All analyses were performed using Stata v15.1 (Statacorp, College Station, TX,
36
37 18 USA). All statistical analyses were two-sided and p-value <0.05 was considered as
38
39 19 statistically significant.

20 21 **Patient and public involvement**

22 Patients and the public were not involved in the development of research questions,
23 design of the study, recruitment and conduct of the study, or dissemination of the
24 study results.

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 characteristics of the study
4 population for each of these countries. There were almost equal distributions for both
5 sex and age in all country samples. At least half of the children in all countries
6 received vitamin A in the last six months. While Maldives and Nepal had excellent
7 coverage (80% or more) for deworming drugs, only about one in three children
8 received the deworming drug in India and Pakistan. Majority of the children were
9 from the rural area except in Nepal, and the proportions varied widely between 43%
10 and 86%. Overall, most of the households had access to improved sanitation and
11 drinking water supply, except the percentages of household with access to improved
12 sanitation are particularly low in Bangladesh and India. The proportions of household
13 with no formal education were particularly high in India, Nepal, and Pakistan. More
14 than half of the households in Bangladesh and India had members who completed
15 secondary or higher education. The samples from original surveys were divided into
16 quintiles based on the household's wealth index, and after relevant exclusions, the
17 distributions remained more or less similar for this study. India, Maldives, and
18 Pakistan had households with a median of two children aged under five years, while
19 Bangladesh and Nepal had a median of one child per household. Most mothers
20 were less than 25 years old at their first birth. The prevalence of mothers with
21 underweight was higher in Bangladesh (20%) and India (23%) than in other
22 countries, whereas the prevalence of mothers with overweight was higher in
23 Maldives (42%) and Pakistan (37%) than in other countries.

24

1
2
3 1 As expected, the prevalence of underweight was much higher than the prevalence of
4
5 2 overweight in all five countries (Figure 1 and Supplementary Table S1). India had the
6
7 3 highest (38%) prevalence of underweight among children aged 24-59 months
8
9 4 followed by Bangladesh (37%), Nepal (29%), Pakistan (28%), and Maldives had the
10
11 5 lowest prevalence (19%). For overweight among these children, Bangladesh, India,
12
13 6 and Nepal had similar prevalence (between 2% and 4%) whereas Pakistan and
14
15 7 Maldives higher prevalence, 7% and 9% respectively. When we looked at the
16
17 8 combined prevalence of both forms of malnutrition, India (42%) and Bangladesh
18
19 9 (39%) had a much higher burden compared to other countries (Maldives [28%],
20
21 10 Nepal [32%], Pakistan [36%]) (Figure 1). The prevalence of underweight was
22
23 11 particularly low in Maldives and Pakistan, but they had a higher prevalence of
24
25 12 overweight. Bangladesh, India, Nepal and Pakistan had high prevalence of childhood
26
27 13 stunting (between 42% and 48%), whereas only 17% of children in Maldives were
28
29 14 stunted (Supplementary Table S2). The prevalence of children with wasting was
30
31 15 highest in India (18%) and lowest in Nepal (6%) (Supplementary Table S3).
32
33 16 The prevalence of underweight and overweight varied widely according to both the
34
35 17 household's wealth index in all countries (Figure 2). Between the poorest and the
36
37 18 richest households, the burden of undernutrition decreased by more than half. On
38
39 19 the other hand, the richest households in Bangladesh and India had almost two
40
41 20 times higher prevalence of overweight than the poorest households. Such clear
42
43 21 differences were not evident in Maldives and Nepal, while the richest households
44
45 22 were less likely to have overweight children compared to poorest households in
46
47 23 Pakistan. The prevalence of underweight and overweight according to the
48
49 24 household's highest education level followed similar country-specific patterns
50
51 25 observed for wealth index (Figure 3). Notably, children in households with higher
52
53
54
55
56
57
58
59
60

1 education had higher burden of overweight in Bangladesh, India, and Pakistan than
2 children in no or little education. Similar trends were observed for stunting and
3 wasting prevalence by household's socioeconomic status (Supplementary Table S2
4 and S3).

5 Table 2 shows the minimally-adjusted and fully-adjusted associations of household's
6 wealth index and highest education level with the prevalence of underweight and
7 overweight. There was strong evidence of an inverse relationship between the
8 household's wealth index and the prevalence of underweight in children, which was
9 not attenuated even after adjustment for a wide range of covariates except for
10 Maldives and Pakistan. Compared to the poorest households, the richest households
11 were less likely to have children with underweight (adjusted-OR for Bangladesh 0.4
12 [95% CI: 0.3-0.5], India 0.5 [0.5-0.6], Maldives 0.5 [0.2-1.4], Nepal 0.5 [0.3-0.8], and
13 Pakistan 0.7 [0.5-1.1]). For the household's highest education level, we also observed
14 that households with secondary or higher education were less likely to have children
15 with underweight when compared to households with no education. The adjusted-
16 OR for higher education vs no education was 0.7 (0.6-1.0) for Bangladesh, 0.6 (0.5-
17 0.6) for India, 0.5 (0.1-1.7) for Maldives, 0.6 (0.4-0.9) for Nepal and 0.4 (0.3-0.7) for
18 Pakistan. Additional analyses for childhood stunting and wasting yielded similar
19 associations with household's wealth index and highest level of education
20 (Supplementary Table S4 and S5).

21 Table 2 also shows that the richest households were more likely to have children
22 with overweight than the poorest households in all countries except Pakistan.
23 However, the positive associations between household's wealth index and
24 overweight prevalence in children were not significant after adjustment for other
25 variables. The adjusted ORs were 1.3 (0.8-2.2) for Bangladesh, 1.1 (1.0-1.2) for

1
2
3 1 India, 0.5 (0.2-1.4) for Maldives, and 1.2 (0.5-2.9) for Nepal. In Pakistan, the richest
4
5 2 households are less likely to have overweight children, which remained significant
6
7 3 after adjustment for other variables (adjusted-OR 0.1 [0.1-0.2]). Household's
8
9 4 education level was also positively associated with the prevalence of overweight in
10
11 5 children. When compared with households with no formal education, households
12
13 6 with higher education had higher odds of having overweight children in Bangladesh
14
15 7 (OR 2.1 [1.3-3.5]), India (OR 1.2 [1.2-1.3]), and Pakistan (OR 1.8 [1.1-2.9]). Maldives
16
17 8 and Nepal had fewer households with higher education, but the adjusted ORs for
18
19 9 secondary vs no education were 2.3 (1.7-3.1) and 1.8 (1.1-3.1), respectively.
20
21 10 We then explored the associations of other factors with underweight and overweight
22
23 11 among children after accounting for household socioeconomic status (Table 3).
24
25 12 Factors like living in rural, improved access to sanitation and to drinking water, older
26
27 13 maternal age at first birth, low maternal height, and maternal underweight were
28
29 14 significantly associated with childhood underweight in some but not all countries.
30
31 15 Maternal underweight was consistently found to be associated with increased odds
32
33 16 of childhood underweight (adjusted-OR vs normal weight in Bangladesh 1.9 [1.6-
34
35 17 2.3], in India 1.7 [1.7-1.8], in Nepal 2.1 [1.6-2.9] and in Pakistan 2.0 [1.4-2.7]). Low
36
37 18 maternal height was also strongly associated with childhood underweight, stunting
38
39 19 and wasting, although the strength of associations varied by the definitions of
40
41 20 undernutrition (Table 3 and Supplementary Table S6 and S7).
42
43 21 For childhood overweight, maternal overweight was found to be associated with
44
45 22 increased odds in Bangladesh (OR 1.9 [1.2-3.0]), India (OR 1.3 [1.2-1.4]) and
46
47 23 Pakistan (OR 1.8 [1.4-2.5]), but not in Maldives (OR 1.3 [0.9-2.0]) and Nepal (OR 0.9
48
49 24 [0.3-2.2]). In Pakistan, those children who received vitamin A or deworming drug in
50
51 25 the last six months were less likely to be overweight than those who did not receive
52
53
54
55
56
57
58
59
60

1
2
3 1 those interventions. For India and Pakistan, improved access to sanitation and
4
5 2 drinking water were significantly associated with childhood overweight, although the
6
7 3 directions of such associations were not consistent.
8
9
10 4
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1 DISCUSSION

2 This study involving nationally-representative surveys conducted in recent times in
3 five South Asian countries provided empirical evidence on the burden of underweight
4 and overweight among children aged 24-59 months, and their associations with
5 socioeconomic status factors. We found that there was a substantial burden of
6 undernutrition among younger children in South Asian countries, while a differential
7 burden of overnutrition was also seen. Households with higher socioeconomic status
8 (as measured by wealth index and the highest level of education) were associated
9 with lower odds of underweight children, although some of those associations did not
10 reach statistical significance after adjustment for related factors. Household's
11 socioeconomic status and childhood overweight were positively associated in all
12 countries except Pakistan, but results from fully-adjusted models indicated that such
13 associations could be explained by other factors. Households with higher wealth or
14 education were less likely to have children with overweight only in Pakistan. After
15 taking household's socioeconomic status into account, maternal nutritional status
16 was found to be strongly associated with the child's nutritional status, whereas
17 evidence for associations with other factors was inconsistent across countries.

18
19 South Asian countries have experienced a striking economic growth in the last few
20 decades, which triggered unprecedented improvements in maternal mortality, infant
21 mortality, under-five mortality, and child undernutrition [28,29]. Trends in the
22 prevalence of childhood underweight have been declining in these countries, with
23 almost 25-30% reduction between 2004 and 2014 in Bangladesh, India, Pakistan,
24 and Nepal [30]. However, the existing burden of undernutrition is still high – our
25 study found that around one-third of under-five children in this region are still

1
2
3 1 underweight. Previous studies conducted in the region have found that poor
4
5 2 socioeconomic status, lower level of parental education, younger age of mother at
6
7 3 birth, short birth interval, and initiation of complementary feeding are important
8
9 4 determinants of undernutrition among under-five children [31–33]. We observed
10
11 5 large inequalities in the prevalence of underweight in each of the included countries,
12
13 6 which could not be explained by other factors studied here. In line with previous
14
15 7 studies, our study also showed that factors like low maternal height and maternal
16
17 8 underweight could significantly increase the likelihood of undernutrition in children,
18
19 9 while other factors like older age of mother at birth, and access to improved
20
21 10 sanitation were also associated with lower odds of childhood underweight. These
22
23 11 associations were statistically significant, mostly in India because of a relatively large
24
25 12 sample size. DHS data have information on feeding practices for children aged up to
26
27 13 two years, so we could not adjust for variables related to feeding practices [25]. To
28
29 14 have better insights on the assessment of childhood undernutrition, we additionally
30
31 15 explored the burden and the underlying factors of childhood stunting and wasting.
32
33 16 These additional analyses showed that although the burden of childhood
34
35 17 undernutrition varied widely by the indicator of interest, the determinants of childhood
36
37 18 undernutrition were similar.
38
39 19 There has been evidence on increasing trends of overweight in younger children in
40
41 20 many South Asian countries, although the prevalence is still quite low compared to
42
43 21 the prevalence of underweight. Recent reports [9,34–36] from South Asian countries
44
45 22 highlighted the rise of overweight burden in children, but mainly in older groups.
46
47 23 Overweight among under-five children is still overlooked in current literature. In our
48
49 24 study, we provided evidence for an increasing burden of overweight in this age
50
51 25 group, which clustered mainly in households with higher socioeconomic status. We
52
53
54
55
56
57
58
59
60

1 found that the associations between socioeconomic status and the prevalence of
2 childhood overweight can be heterogeneous between countries, with positive
3 associations in most countries and inverse association in Pakistan. This highlights
4 the need for cross-country comparisons for better understanding of double burden of
5 malnutrition. Frequent intake of energy-dense foods and physical inactivity have
6 been shown to be associated with overweight and obesity both in children and adults
7 [37,38]. These lifestyle behaviours are common in the higher socioeconomic group in
8 LMICs, and therefore, both childhood and adulthood overweight are clustered in
9 affluent households in urban areas [34,36]. Our study showed that mothers who
10 were overweight had higher odds of having children with overweight when compared
11 with mothers who were of normal weight - suggesting that public health nutrition
12 programmes should prioritise children whose mothers are overweight. Our findings
13 on having lower odds of overweight among children exposed to nutrition-sensitive
14 programmes (receiving vitamin A and deworming drug) in Pakistan can be studied
15 further to examine the efficacy of such programmes to reduce double burden of
16 malnutrition in LMICs.

17 The findings from our study highlight the importance of considering not only
18 socioeconomic inequalities but also other maternal and household level factors while
19 developing public health interventions and policies to tackle both childhood
20 undernutrition and overnutrition. Also, the opposite directions for associations of
21 socioeconomic status and nutritional outcomes suggest that the concept of “one size
22 fits all” is not applicable to tackle the emerging problem of the double burden of
23 malnutrition. Previous studies suggested that a multi-sectoral approach is needed to
24 alleviate poverty and other social inequalities related to the double burden of
25 malnutrition in South Asia and beyond [39].

1
2
3 1 Our study is the first study to look at the coexistence of underweight and overweight
4
5 2 among under-five children in South Asian countries by socioeconomic status. One of
6
7 3 the major strengths of our study is the use of nationally-representative samples with
8
9 4 objectively measured height and weight data from five different countries, which
10
11 5 allowed cross-country comparisons of the results. We were also able to adjust for
12
13 6 several factors in the multivariable models, but there are possibilities of residual
14
15 7 confounding due to unmeasured factors and/or imperfect assessment of measured
16
17 8 factors. Due to smaller sample sizes in Maldives and Nepal, we could not reliably
18
19 9 estimate the associations. Problems of reverse causation could also arise in the
20
21 10 observed estimates due to the cross-sectional nature of the study. We used the
22
23 11 IOTF reference to define childhood overweight instead of the WHO or Centers for
24
25 12 Disease Control (CDC) references [22–24]. The IOTF classification system is based
26
27 13 on large datasets from six regions covering different ethnicities, therefore more
28
29 14 suitable for international comparisons [23,24]. When compared with other
30
31 15 references, the IOTF reference yielded similar estimates for overall overweight
32
33 16 prevalence but different estimates for obesity [40,41]. It was also found to be more
34
35 17 specific in identifying children with overweight and obesity than other references [42].
36
37 18 We assessed childhood undernutrition by assessing underweight, wasting and
38
39 19 stunting. Previous studies have found that stunting and overweight can occur
40
41 20 concurrently in an individual [43], therefore there may be double counting of children
42
43 21 while studying double burden of malnutrition using stunting and overweight. Looking
44
45 22 at children who are stunted and overweight can offer more insights into the topic, but
46
47 23 we did not look into this issue in our study.
48
49
50
51
52
53
54
55
56 24
57
58
59
60

1
2
3 1 In conclusion, our study provides evidence for socioeconomic disparities for the
4
5 2 coexistence of under- and over-nutrition among children aged 24-59 months in South
6
7 3 Asian countries. It also showed that factors like maternal nutritional status was
8
9 4 strongly associated with nutritional outcomes in children. These unmet inequalities
10
11 5 for both underweight and overweight should be considered while developing national
12
13 6 public health nutrition programmes and strategies.
14
15
16
17 7
18
19 8

9 **ACKNOWLEDGEMENTS**

10 The authors thank the participants of Demographic and Health Surveys used in this
11 study from Bangladesh, India, Maldives, Nepal, and Pakistan. We would also like to
12 thank the DHS Program to authorize us to use the data.
13

14 **AUTHOR CONTRIBUTIONS**

15 Conception and design: FH, MS, SA and MB
16 Data collection and management: FH, SS, and GA
17 Data analysis: FH, MS, SS
18 Interpretation of the results: All authors
19 Drafting of the article: FH and MS
20 Critical revision of the article for important intellectual content: All authors
21 Final approval of the article: All authors.
22

23 **COMPETING INTERESTS STATEMENT**

24 None declared
25

1 **FUNDING STATEMENT**

2 This research received no specific grant from any funding agency in the public,
3 commercial or not-for-profit sectors.

4 **DATA SHARING STATEMENT**

5 This study used data from Demographic and Health Surveys (DHS) for Bangladesh,
6 India, Maldives, Nepal, and Pakistan, which are available from the DHS programme
7 website.

8 **REFERENCES**

- 9
10 1 World Health Organization. Double burden of malnutrition. Nutrition.
11 2019.<https://www.who.int/nutrition/double-burden-malnutrition/en/> (accessed 3
12 Apr 2019).
- 13 2 World Health Organization. WHO child growth standards : length/height-for-
14 age, weight-for-age, weight-for-length, weight-forheight and body mass index-
15 for-age : methods and development. Geneva: 2006.
16 https://www.who.int/childgrowth/standards/Technical_report.pdf
- 17 3 Shrimpton, Roger; Rokx C. The Double Burden of Malnutrition : A Review of
18 Global Evidence. Washington, DC: 2012.
19 <https://openknowledge.worldbank.org/handle/10986/27417>
- 20 4 Stevens GA, Finucane MM, Paciorek CJ, *et al.* Trends in mild, moderate, and
21 severe stunting and underweight, and progress towards MDG 1 in 141
22 developing countries: a systematic analysis of population representative data.
23 *Lancet (London, England)* 2012;**380**:824–34. doi:10.1016/S0140-
24 6736(12)60647-3
- 25 5 Harding KL, Aguayo VM, Webb P. Factors associated with wasting among

- 1
2
3 1 children under five years old in South Asia: Implications for action. *PLoS One*
4
5 2018;**13**:e0198749. <https://doi.org/10.1371/journal.pone.0198749>
6
7
8 3 6 Development Initiatives. 2018 Global Nutrition Report: Shining a light to spur
9
10 4 action on nutrition. Bristol, UK: 2018. <https://globalnutritionreport.org/>
11
12 5 7 Hoque ME, Doi SAR, Mannan M, *et al*. Prevalence of overweight and obesity
13
14 6 among children and adolescents of the indian subcontinent: A meta-analysis.
15
16
17 7 *Nutr Rev* 2014;**72**:541–50. doi:10.1111/nure.12130
18
19 8 8 Khadilkar V V., Khadilkar A V., Cole TJ, *et al*. Overweight and obesity
20
21 9 prevalence and body mass index trends in Indian children. *Int J Pediatr Obes*
22
23 2011;**6**:e216–24. doi:10.3109/17477166.2010.541463
24
25
26 11 9 Bulbul T, Hoque M. Prevalence of childhood obesity and overweight in
27
28 12 Bangladesh: findings from a countrywide epidemiological study. *BMC Pediatr*
29
30 2014;**14**:86. doi:10.1186/1471-2431-14-86
31
32
33 14 10 de Onis M, Blössner M, Borghi E. Global prevalence and trends of overweight
34
35 15 and obesity among preschool children. *Am J Clin Nutr* 2010;**92**:1257–64.
36
37 16 doi:10.3945/ajcn.2010.29786.1
38
39
40 17 11 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass
41
42 18 index, underweight, overweight, and obesity from 1975 to 2016: a pooled
43
44 19 analysis of 2416 population-based measurement studies in 128.9 million
45
46 20 children, adolescents, and adults. *Lancet (London, England)* 2017;**390**:2627–
47
48 21 42. doi:10.1016/S0140-6736(17)32129-3
49
50
51 22 12 GBD 2015 Obesity Collaborators. Health Effects of Overweight and Obesity in
52
53 23 195 Countries over 25 Years. *N Engl J Med* Published Online First: 2017.
54
55 24 doi:10.1056/NEJMoa1614362
56
57
58 25 13 Bann D, Johnson W, Li L, *et al*. Socioeconomic inequalities in childhood and
59
60

- 1
2
3 1 adolescent body-mass index, weight, and height from 1953 to 2015: an
4
5 2 analysis of four longitudinal, observational, British birth cohort studies. *Lancet*
6
7 3 *Public Heal* 2018;**3**:e194–203. doi:10.1016/S2468-2667(18)30045-8
8
9
10 4 14 Barriuso L, Miqueleiz E, Albaladejo R, *et al*. Socioeconomic position and
11
12 5 childhood-adolescent weight status in rich countries: a systematic review,
13
14 6 1990–2013. *BMC Pediatr* 2015;**15**:129. doi:10.1186/s12887-015-0443-3
15
16
17 7 15 Shrewsbury V, Wardle J. Socioeconomic status and adiposity in childhood: a
18
19 8 systematic review of cross-sectional studies 1990–2005. *Obes (Silver Spring)*
20
21 9 2008;**16**.
22
23
24 10 16 Black RE, Victora CG, Walker SP, *et al*. Maternal and child undernutrition and
25
26 11 overweight in low-income and middle-income countries. *Lancet (London,*
27
28 12 *England)* 2013;**382**:427–51. doi:10.1016/S0140-6736(13)60937-X
29
30
31 13 17 Van de Poel E, Hosseinpoor AR, Speybroeck N, *et al*. Socioeconomic
32
33 14 inequality in malnutrition in developing countries. *Bull World Health Organ*
34
35 15 2008;**86**:282–91. doi:10.2471/BLT.07.044800
36
37
38 16 18 Das S, Fahim SM, Islam MS, *et al*. Prevalence and sociodemographic
39
40 17 determinants of household-level double burden of malnutrition in Bangladesh.
41
42 18 *Public Health Nutr* 2019;**22**:1425–32. doi:10.1017/S1368980018003580
43
44
45 19 19 Oddo VM, Rah JH, Semba RD, *et al*. Predictors of maternal and child double
46
47 20 burden of malnutrition in rural Indonesia and Bangladesh. *Am J Clin Nutr*
48
49 21 2012;**95**:951–8. doi:10.3945/ajcn.111.026070
50
51
52 22 20 The DHS Program: Demographic and Health Surveys.
53
54 23 2019.<https://dhsprogram.com/> (accessed 21 May 2019).
55
56 24 21 DHS Program. Using datasets for analysis.
57
58 25 <https://dhsprogram.com/data/Using-Datasets-for-Analysis.cfm> (accessed 14
59
60

- 1
2
3 1 Nov 2017).
- 4
5 2 22 Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, *et al.* CDC growth charts:
6
7 United States. *Adv Data* 2000;:1–27.
8 3
9
- 10 4 23 Cole TJ, Bellizzi MC, Flegal KM, *et al.* Establishing a standard definition for
11
12 child overweight and obesity worldwide: international survey. *BMJ*
13 5
14 2000;**320**:1240–3.
15 6
16
- 17 7 24 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs
18
19 for thinness, overweight and obesity. *Pediatr Obes* 2012;**7**:284–94.
20 8
21 doi:10.1111/j.2047-6310.2012.00064.x
22 9
23
- 24 10 25 The DHS Program. DHS Overview. 2019.[https://dhsprogram.com/What-We-](https://dhsprogram.com/What-We-Do/Survey-Types/DHS.cfm)
25
26 Do/Survey-Types/DHS.cfm (accessed 3 Apr 2019).
27 11
28
- 29 12 26 Ruel MT, Alderman H, Group M and CNS. Nutrition-sensitive interventions and
30
31 programmes: how can they help to accelerate progress in improving maternal
32
33 and child nutrition? *Lancet* 2013;**382**:536–51.
34 14
35
- 36 15 27 StataCorp. svy estimation - Estimation commands for survey data.
37
38 <https://www.stata.com/manuals13/svysvyestimation.pdf> (accessed 3 Apr
39
40 2019).
41 17
42
- 43 18 28 Akseer N, Kamali M, Arifeen SE, *et al.* Progress in maternal and child health:
44
45 how has South Asia fared? *BMJ* 2017;**357**:j1608. doi:10.1136/bmj.j1608
46 19
47
- 48 20 29 United Nations. The Millennium Development Goals Report. New York: 2015.
49
50 [https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG 2015 rev](https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf)
51
52 (July 1).pdf
53 22
54
- 55 23 30 The World Bank Group. World Bank Open Data: Free and open access to
56
57 global development data. 2019.<https://data.worldbank.org/> (accessed 1 Mar
58
59 2019).
60 25

- 1
2
3 1 31 Pravana NK, Piryani S, Chaurasiya SP, *et al.* Determinants of severe acute
4
5
6 2 malnutrition among children under 5 years of age in Nepal: a community-
7
8 3 based case–control study. *BMJ Open* 2017;**7**:e017084. doi:10.1136/bmjopen-
9
10 4 2017-017084
11
12 5 32 Ansuya, Nayak BS, Unnikrishnan B, *et al.* Risk factors for malnutrition among
13
14 6 preschool children in rural Karnataka: a case-control study. *BMC Public Health*
15
16 7 2018;**18**:283. doi:10.1186/s12889-018-5124-3
17
18
19 8 33 Chowdhury MRK, Rahman MS, Khan MMH, *et al.* Risk Factors for Child
20
21 9 Malnutrition in Bangladesh: A Multilevel Analysis of a Nationwide Population-
22
23 10 Based Survey. *J Pediatr* 2016;**172**:194-201.e1.
24
25
26 11 doi:10.1016/j.jpeds.2016.01.023
27
28 12 34 Ranjani H, Mehreen TS, Pradeepa R, *et al.* Epidemiology of childhood
29
30 13 overweight & obesity in India: A systematic review. *Indian J Med Res*
31
32 14 2016;**143**:160–74. doi:10.4103/0971-5916.180203
33
34
35 15 35 Mushtaq MU, Gull S, Abdullah HM, *et al.* Prevalence and socioeconomic
36
37 16 correlates of overweight and obesity among Pakistani primary school children.
38
39 17 *BMC Public Health* 2011;**11**:724. doi:10.1186/1471-2458-11-724
40
41
42 18 36 Rahman S, Islam MT, Alam DS. Obesity and overweight in Bangladeshi
43
44 19 children and adolescents: a scoping review. *BMC Public Health* 2014;**14**:70.
45
46 20 doi:10.1186/1471-2458-14-70
47
48
49 21 37 Hemmingsson E. Early Childhood Obesity Risk Factors: Socioeconomic
50
51 22 Adversity, Family Dysfunction, Offspring Distress, and Junk Food Self-
52
53 23 Medication. *Curr Obes Rep* 2018;**7**:204–9. doi:10.1007/s13679-018-0310-2
54
55
56 24 38 Gupta N, Misra A, Goel K, *et al.* Childhood Obesity in Developing Countries:
57
58 25 Epidemiology, Determinants, and Prevention. *Endocr Rev* 2012;**33**:48–70.
59
60

- 1
2
3 1 doi:10.1210/er.2010-0028
4
5 2 39 Perez-Escamilla R, Bermudez O, Buccini GS, *et al.* Nutrition disparities and
6
7 the global burden of malnutrition. *BMJ* 2018;**361**:k2252.
8
9 doi:10.1136/bmj.k2252
10
11 4
12 5 40 Tuan NT, Nicklas TA. Age, sex and ethnic differences in the prevalence of
13
14 underweight and overweight, defined by using the CDC and IOTF cut points in
15
16 Asian children. *Eur J Clin Nutr* 2009;**63**:1305.
17
18
19 8 41 Moselakgomo K V, Van Staden M. Diagnostic comparison of Centers for
20
21 Disease Control and Prevention and International Obesity Task Force criteria
22
23 for obesity classification in South African children. *African J Prim Heal care*
24
25 *Fam Med* 2017;**9**:e1–7. doi:10.4102/phcfm.v9i1.1383
26
27
28 12 42 Valerio G, Balsamo A, Baroni MG, *et al.* Childhood obesity classification
29
30 systems and cardiometabolic risk factors: a comparison of the Italian, World
31
32 Health Organization and International Obesity Task Force references. *Ital J*
33
34 *Pediatr* 2017;**43**:19. doi:10.1186/s13052-017-0338-z
35
36
37 16 43 Bates K, Gjonça A, Leone T. Double burden or double counting of child
38
39 malnutrition? The methodological and theoretical implications of
40
41 stuntingoverweight in low and middle income countries. *J Epidemiol*
42
43 *Community Health* 2017;**71**:779 LP – 785. doi:10.1136/jech-2017-209008
44
45
46
47 20
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 **1 FIGURE LEGENDS**
4

5 **2 Figure 1: Prevalence of underweight and overweight, by country**
6

7
8 3 Sampling weights provided by the Demographic and Health Survey (DHS) and
9
10 4 Stata's survey estimation procedures were used to estimate country-representative
11
12 5 prevalence. Corresponding 95% confidence intervals of prevalence estimates are
13
14 6 given in Supplementary Table S2.
15
16

17 7
18
19 **8 Figure 2: Prevalence of underweight and overweight, by household's wealth**
20
21 **9 index**
22

23
24 10 Sampling weights provided by the Demographic and Health Survey (DHS) and
25
26 11 Stata's survey estimation procedures were used to estimate country-representative
27
28 12 prevalence. Corresponding 95% confidence intervals of prevalence estimates are
29
30 13 given in Supplementary Table S2.
31
32

33 14
34
35 **15 Figure 3: Prevalence of underweight and overweight, by household's highest**
36
37 **16 level of education**
38

39
40 17 Sampling weights provided by the Demographic and Health Survey (DHS) and
41
42 18 Stata's survey estimation procedures were used to estimate country-representative
43
44 19 prevalence. Corresponding 95% confidence intervals of prevalence estimates are
45
46 20 given in Supplementary Table S2.
47
48

49 21
50
51
52
53
54
55
56
57
58
59
60

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

| | 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 variables | | | | | |
| Sex, n (%) | | | | | |
| 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) |
| Age in year, n (%) | | | | | |
| 2-3 | 1406 (33.7) | 45298 (32.8) | 452 (33.8) | 460 (33.1) | 668 (34.0) |
| 3-4 | 1377 (33.0) | 47506 (34.4) | 464 (34.7) | 479 (34.5) | 641 (32.6) |
| 4-5 | 1387 (33.3) | 45329 (32.8) | 423 (31.6) | 449 (32.3) | 655 (33.4) |
| Received vitamin A in last 6 months, n (%) | 2735 (66.0) | 73678 (54.1) | 695 (81.8) | 1232 (88.8) | 1252 (64.6) |
| Received deworming drug in last 6 months, n (%) | 2153 (51.7) | 43319 (31.6) | 1104 (82.8) | 1105 (79.8) | 593 (30.3) |
| Household variables | | | | | |
| Area of residence, n (%) | | | | | |
| 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) |
| Access to improved sanitation, n (%) | 2741 (65.7) | 67441 (48.8) | 1278 (95.4) | 1047 (75.4) | 1455 (74.1) |
| Access to improved drinking water, n (%) | 3791 (90.9) | 114018 (82.5) | 1210 (90.4) | 1206 (86.8) | 1564 (79.6) |
| Wealth index, n (%) | | | | | |
| 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) |
| Highest education level, n (%) | | | | | |
| 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) |
| No. of household member, median (IQR) | 5.0 (4.0, 7.0) | 6.0 (5.0, 8.0) | 8.0 (6.0, 11.0) | 5.0 (4.0, 7.0) | 8.0 (6.0, 11.0) |
| No. of under-five children, median (IQR) | 1.0 (1.0, 2.0) | 2.0 (1.0, 2.0) | 2.0 (1.0, 2.0) | 1.0 (1.0, 2.0) | 2.0 (2.0, 3.0) |
| Maternal variables | | | | | |
| Mother's age at first birth, n (%) | | | | | |
| Less than 25 years | 3056 (73.3) | 50969 (36.9) | 499 (37.3) | 759 (54.6) | 812 (41.3) |
| 20-24 years | 927 (22.2) | 66287 (48.0) | 649 (48.5) | 531 (38.2) | 812 (41.3) |
| 25 years or above | 187 (4.5) | 20878 (15.1) | 191 (14.3) | 99 (7.1) | 340 (17.3) |
| Mother's BMI (kg/m ²) category, n (%) | | | | | |
| Underweight | 835 (20.1) | 31127 (22.6) | 94 (7.4) | 228 (16.4) | 224 (11.5) |
| Normal weight | 2439 (58.6) | 85490 (62.0) | 639 (50.3) | 937 (67.5) | 1006 (51.5) |
| Overweight | 885 (21.3) | 21172 (15.4) | 538 (42.3) | 224 (16.1) | 723 (37.0) |
| Mother's height (cm) category, n (%) | | | | | |
| <145 | 518 (12.4) | 15474 (11.2) | 134 (10.5) | 165 (11.9) | 90 (4.6) |
| 145-149.9 | 1228 (29.4) | 36721 (26.6) | 333 (26.1) | 367 (26.4) | 281 (14.3) |
| 150-154.9 | 1432 (34.3) | 47088 (34.1) | 446 (34.9) | 490 (35.3) | 636 (32.4) |
| 155+ | 992 (23.8) | 38685 (28.0) | 364 (28.5) | 367 (26.4) | 957 (48.7) |

There was less than 1% missing value for variables: received vitamin A in last 6 months, received deworming drug in last 6 months, mother's height, and mother's BMI in all countries except Maldives. For Maldives, there were around 5% missing values in mother's height and mother's BMI. There was no missing value in other variables listed in this table.

1 **Table 2: Associations of household’s wealth index and highest education with childhood underweight and overweight**

| | ORs (95% CI) * | | | | | | | | | |
|-------------------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
| | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted |
| Underweight | | | | | | | | | | |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Poorer | 0.8 (0.7-0.9) | 0.8 (0.7-1.0) | 0.7 (0.7-0.7) | 0.8 (0.8-0.8) | 0.8 (0.6-1.0) | 0.9 (0.6-1.3) | 0.6 (0.5-0.8) | 0.6 (0.5-0.8) | 0.9 (0.7-1.1) | 1.0 (0.8-1.3) |
| Middle | 0.6 (0.5-0.7) | 0.7 (0.6-0.8) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.8 (0.6-1.0) | 1.0 (0.7-1.4) | 0.8 (0.6-1.0) | 0.8 (0.6-1.0) | 0.7 (0.5-0.9) | 0.8 (0.6-1.1) |
| Richer | 0.4 (0.4-0.5) | 0.6 (0.5-0.7) | 0.4 (0.4-0.4) | 0.6 (0.6-0.6) | 0.5 (0.3-0.7) | 0.7 (0.5-1.0) | 0.6 (0.4-0.8) | 0.7 (0.5-0.9) | 0.6 (0.4-0.7) | 0.9 (0.7-1.1) |
| Richest | 0.3 (0.2-0.3) | 0.4 (0.3-0.5) | 0.3 (0.3-0.3) | 0.5 (0.5-0.5) | 0.3 (0.2-0.6) | 0.5 (0.2-1.5) | 0.3 (0.2-0.4) | 0.4 (0.3-0.7) | 0.3 (0.3-0.4) | 0.7 (0.5-1.1) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Primary | 1.0 (0.9-1.1) | 1.1 (0.9-1.2) | 0.8 (0.7-0.8) | 0.9 (0.9-0.9) | 0.6 (0.5-0.7) | 0.6 (0.5-0.7) | 0.7 (0.6-0.9) | 0.8 (0.6-1.1) | 0.8 (0.7-1.1) | 1.0 (0.8-1.3) |
| Secondary | 0.6 (0.5-0.6) | 0.8 (0.7-0.9) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.3 (0.2-0.4) | 0.3 (0.2-0.4) | 0.5 (0.4-0.7) | 0.8 (0.6-1.0) | 0.4 (0.3-0.5) | 0.5 (0.4-0.7) |
| Higher | 0.3 (0.3-0.4) | 0.7 (0.6-1.0) | 0.3 (0.3-0.3) | 0.6 (0.5-0.6) | 0.2 (0.1-0.8) | 0.5 (0.1-1.9) | 0.3 (0.2-0.5) | 0.5 (0.4-0.8) | 0.3 (0.2-0.4) | 0.4 (0.2-0.6) |
| Overweight | | | | | | | | | | |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Poorer | 0.9 (0.5-1.6) | 0.8 (0.4-1.5) | 1.1 (1.0-1.2) | 1.0 (1.0-1.1) | 1.3 (0.9-2.0) | 1.4 (0.8-2.2) | 0.4 (0.2-0.9) | 0.4 (0.1-0.9) | 0.5 (0.4-0.7) | 0.4 (0.3-0.6) |
| Middle | 1.2 (0.7-2.0) | 1.0 (0.6-1.6) | 1.2 (1.1-1.3) | 1.0 (1.0-1.1) | 1.2 (0.8-1.8) | 1.1 (0.7-1.7) | 0.1 (0.0-0.6) | 0.1 (0.0-0.6) | 0.4 (0.3-0.5) | 0.3 (0.2-0.4) |
| Richer | 1.0 (0.6-1.7) | 0.7 (0.4-1.2) | 1.3 (1.2-1.4) | 1.0 (1.0-1.1) | 1.7 (1.1-2.7) | 0.9 (0.5-1.4) | 0.5 (0.2-1.1) | 0.5 (0.2-1.1) | 0.3 (0.2-0.4) | 0.2 (0.1-0.2) |
| Richest | 3.8 (2.8-5.0) | 1.4 (0.8-2.3) | 1.7 (1.6-1.8) | 1.2 (1.1-1.3) | 1.9 (1.1-3.4) | 0.5 (0.2-1.4) | 1.1 (0.5-2.3) | 1.0 (0.4-2.4) | 0.4 (0.3-0.5) | 0.1 (0.1-0.2) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Primary | 1.1 (0.7-1.7) | 1.1 (0.7-1.7) | 1.1 (1.0-1.1) | 1.0 (0.9-1.1) | 0.9 (0.7-1.3) | 1.1 (0.7-1.5) | 1.0 (0.4-2.4) | 1.1 (0.4-2.7) | 0.6 (0.4-0.9) | 0.9 (0.6-1.4) |
| Secondary | 1.4 (1.0-1.9) | 1.1 (0.8-1.5) | 1.2 (1.1-1.2) | 1.0 (0.9-1.0) | 2.1 (1.6-2.7) | 2.1 (1.6-2.7) | 2.0 (1.2-3.3) | 1.9 (1.1-3.1) | 0.6 (0.4-0.8) | 1.3 (0.9-1.8) |
| Higher | 5.2 (3.6-7.5) | 2.0 (1.2-3.3) | 1.7 (1.6-1.9) | 1.2 (1.1-1.3) | 2.0 (0.6-6.8) | 0.6 (0.1-5.0) | 0.9 (0.3-2.8) | 0.6 (0.2-2.2) | 0.8 (0.5-1.1) | 1.6 (1.0-2.5) |

2 * Minimally adjusted models were adjusted for child’s age and sex; and fully-adjusted models were additionally adjusted for area of residence, receiving vitamin A and
3 deworming drug, access to improved sanitation and drinking water, number of under-five children, mother’s age at first birth, mother’s height, and mother’s BMI. Analyses were
4 conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata’s survey estimation procedures.

1 **Table 3: Socioeconomic status-adjusted odds ratios (ORs) of underweight and overweight for various child, household**
 2 **and maternal factors**
 3

| | ORs (95% CI)* | | | | | | | | | |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
| | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight | Underweight | Overweight |
| Child's variables | | | | | | | | | | |
| Sex | | | | | | | | | | |
| Male | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Female | 1.2 (1.0-1.4) | 1.2 (0.8-1.8) | 1.0 (1.0-1.1) | 1.0 (1.0-1.1) | 1.1 (0.9-1.5) | 1.1 (0.7-1.7) | 1.1 (0.9-1.4) | 1.5 (0.7-2.9) | 0.9 (0.7-1.1) | 1.0 (0.8-1.3) |
| Age | | | | | | | | | | |
| 2-3 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 3-4 years | 1.0 (0.8-1.2) | 1.0 (0.6-1.6) | 1.0 (1.0-1.0) | 1.0 (0.9-1.0) | 1.0 (0.7-1.3) | 1.4 (0.9-2.3) | 0.8 (0.6-1.0) | 2.6 (1.1-6.5) | 0.9 (0.7-1.1) | 1.4 (1.0-1.9) |
| 4-5 years | 1.0 (0.9-1.2) | 0.8 (0.5-1.4) | 1.0 (1.0-1.0) | 0.9 (0.9-1.0) | 0.7 (0.5-1.0) | 1.3 (0.8-2.1) | 0.9 (0.7-1.2) | 1.5 (0.6-4.1) | 0.9 (0.7-1.2) | 1.2 (0.9-1.7) |
| Received vitamin A in last 6 months | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.1) | 1.2 (0.7-1.8) | 1.1 (1.0-1.1) | 1.1 (1.0-1.1) | 1.2 (0.8-2.0) | 1.0 (0.5-1.9) | 0.8 (0.5-1.1) | 1.1 (0.3-3.8) | 1.2 (1.0-1.6) | 0.5 (0.4-0.6) |
| Received deworming drug in last 6 months | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.9 (0.8-1.1) | 0.9 (0.6-1.4) | 1.0 (0.9-1.0) | 1.1 (1.0-1.2) | 1.5 (1.0-2.3) | 0.8 (0.5-1.3) | 1.0 (0.7-1.3) | 1.4 (0.5-3.6) | 0.8 (0.6-1.0) | 0.6 (0.4-0.8) |
| Household variables | | | | | | | | | | |
| Area of residence | | | | | | | | | | |
| Urban | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Rural | 0.9 (0.8-1.1) | 0.7 (0.4-1.1) | 0.9 (0.9-0.9) | 1.1 (1.0-1.1) | 1.0 (0.4-2.2) | 0.4 (0.2-1.0) | 1.1 (0.9-1.4) | 1.2 (0.6-2.6) | 1.0 (0.8-1.3) | 0.6 (0.4-0.8) |
| Improved access to sanitation | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.1) | 1.1 (0.7-1.9) | 0.8 (0.8-0.8) | 1.2 (1.1-1.3) | 0.7 (0.4-1.3) | 1.5 (0.4-4.8) | 0.7 (0.5-0.9) | 1.0 (0.4-2.5) | 0.8 (0.6-1.1) | 1.6 (1.1-2.2) |
| Improved access to drinking water | | | | | | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.8-1.2) | 1.6 (0.7-3.7) | 1.2 (1.1-1.2) | 0.9 (0.9-1.0) | 1.5 (0.8-2.7) | 0.9 (0.4-1.7) | 1.0 (0.7-1.5) | 0.9 (0.4-2.2) | 1.2 (0.9-1.6) | 0.7 (0.5-0.9) |
| No. of children under five | 1.1 (1.0-1.2) | 1.0 (0.8-1.3) | 1.1 (1.1-1.1) | 0.9 (0.9-1.0) | 1.1 (1.0-1.2) | 1.0 (0.8-1.2) | 1.1 (0.9-1.2) | 0.7 (0.4-1.1) | 1.0 (1.0-1.1) | 1.0 (0.9-1.1) |

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

Maternal variables

Mother's age at first birth

| | | | | | | | | | | |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Less than 20 years | 1.1 (0.9-1.3) | 0.6 (0.4-1.0) | 1.1 (1.0-1.1) | 1.0 (0.9-1.0) | 1.1 (0.8-1.5) | 0.7 (0.4-1.1) | 0.9 (0.7-1.2) | 0.5 (0.2-1.0) | 1.0 (0.8-1.2) | 0.8 (0.6-1.1) |
| 20-24 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 25 years or more | 0.8 (0.5-1.1) | 1.7 (0.9-3.3) | 0.8 (0.8-0.8) | 1.3 (1.2-1.4) | 0.8 (0.5-1.3) | 1.1 (0.6-1.9) | 0.8 (0.5-1.4) | 0.5 (0.1-2.3) | 0.9 (0.7-1.3) | 0.8 (0.5-1.1) |

Mother's BMI category

| | | | | | | | | | | |
|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Normal weight | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Underweight | 1.9 (1.6-2.3) | 0.5 (0.2-1.1) | 1.7 (1.7-1.8) | 0.5 (0.5-0.6) | 1.3 (0.7-2.1) | 0.2 (0.1-1.0) | 2.1 (1.6-2.9) | 0.4 (0.1-1.5) | 2.0 (1.4-2.7) | 0.4 (0.3-0.8) |
| Overweight | 0.7 (0.5-0.8) | 1.9 (1.2-3.0) | 0.6 (0.6-0.7) | 1.3 (1.2-1.4) | 0.7 (0.5-1.0) | 1.3 (0.9-2.0) | 0.5 (0.3-0.7) | 0.9 (0.3-2.2) | 0.6 (0.5-0.8) | 1.8 (1.4-2.5) |

Mother's height category

| | | | | | | | | | | |
|----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| <145 cm | 3.2 (2.5-4.0) | 1.2 (0.6-2.4) | 2.7 (2.5-2.8) | 0.9 (0.8-1.0) | 4.6 (2.8-7.4) | 0.7 (0.3-1.6) | 3.5 (2.3-5.3) | 1.5 (0.5-4.7) | 2.6 (1.6-4.0) | 1.2 (0.7-2.1) |
| 145-149 cm | 2.1 (1.7-2.5) | 1.0 (0.6-1.7) | 1.9 (1.8-2.0) | 0.9 (0.8-1.0) | 2.1 (1.4-3.3) | 1.0 (0.6-1.7) | 2.0 (1.4-2.9) | 1.1 (0.4-3.0) | 1.7 (1.3-2.3) | 1.6 (1.1-2.2) |
| 150-154 cm | 1.5 (1.2-1.8) | 1.0 (0.6-1.7) | 1.4 (1.4-1.4) | 1.0 (0.9-1.1) | 1.9 (1.3-2.9) | 0.6 (0.4-1.0) | 1.5 (1.1-2.1) | 1.1 (0.5-2.8) | 1.3 (1.1-1.7) | 0.8 (0.6-1.1) |
| 155 cm or more | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |

* Logistic regression models were adjusted for household's wealth index and highest education. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

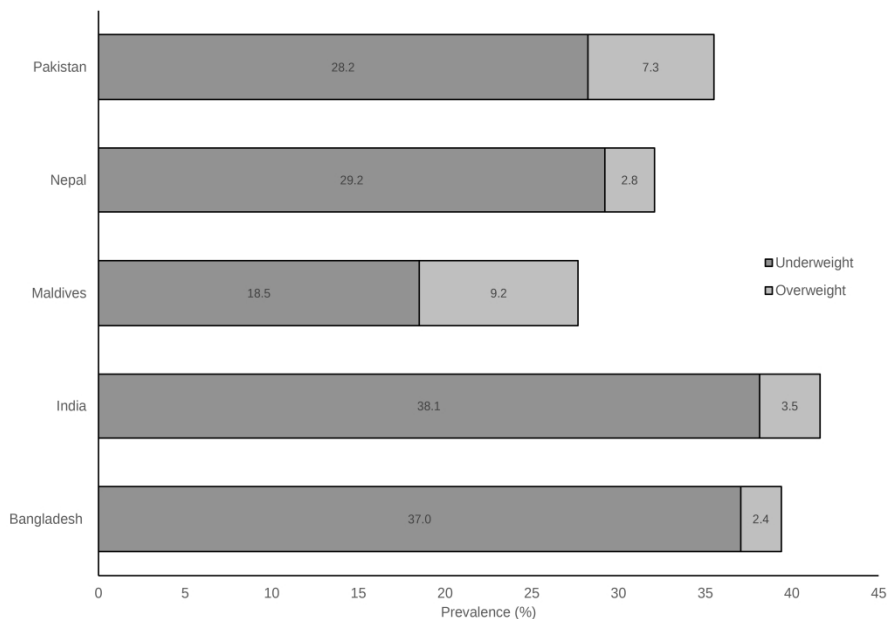


Figure 1: Prevalence of underweight and overweight, by country

Sampling weights provided by the Demographic and Health Survey (DHS) and Stata’s survey estimation procedures were used to estimate country-representative prevalence. Corresponding 95% confidence intervals of prevalence estimates are given in Supplementary Table S2.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

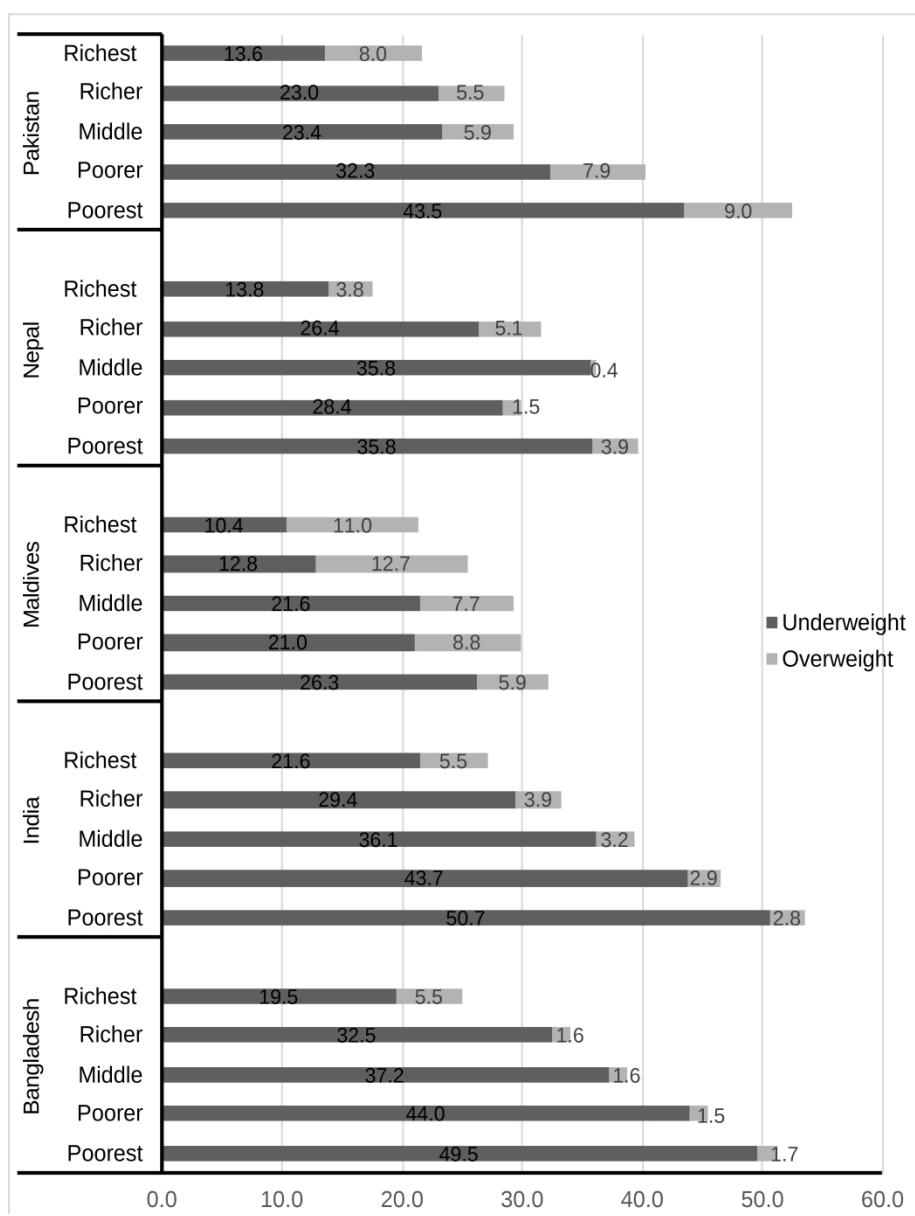


Figure 2: Prevalence of underweight and overweight, by household's wealth index
 Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence. Corresponding 95% confidence intervals of prevalence estimates are given in Supplementary Table S2.

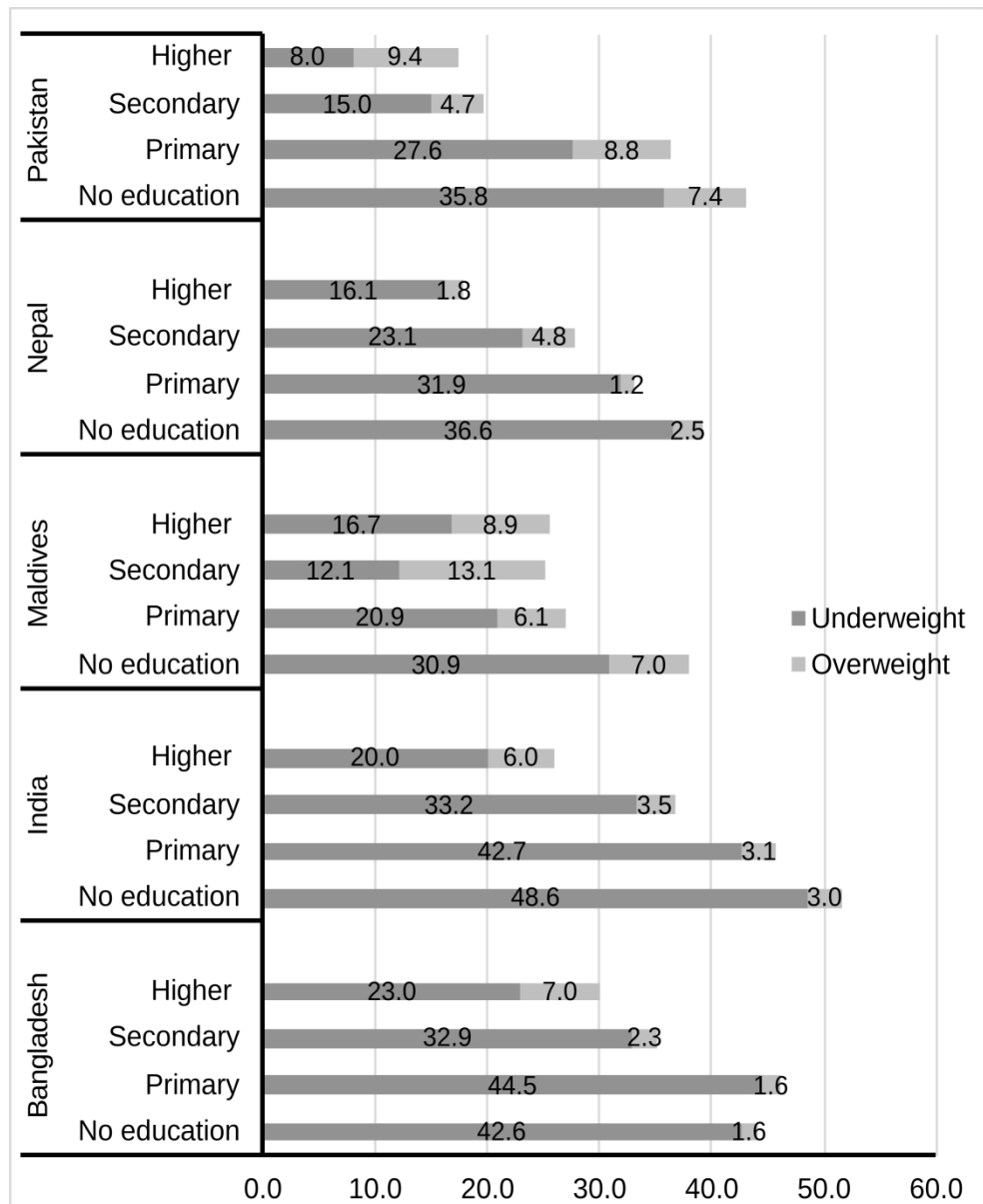


Figure 3: Prevalence of underweight and overweight, by household's highest level of education

Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence. Corresponding 95% confidence intervals of prevalence estimates are given in Supplementary Table S2.

1
2
3
4
5 **Double burden of malnutrition in children aged 24-59 months by**
6 **socioeconomic status in five south Asian countries: evidence from**
7
8
9
10 **Demographic and Health Surveys**
11

12 Fariha Binte Hossain, Md Shajedur Rahman Shawon, Md Shehab Uddin Al-Abid,
13
14 Sultan Mahmood, Gourab Adhikary, Md M Islam Bulbul
15
16

17
18
19 **Supplementary materials**
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

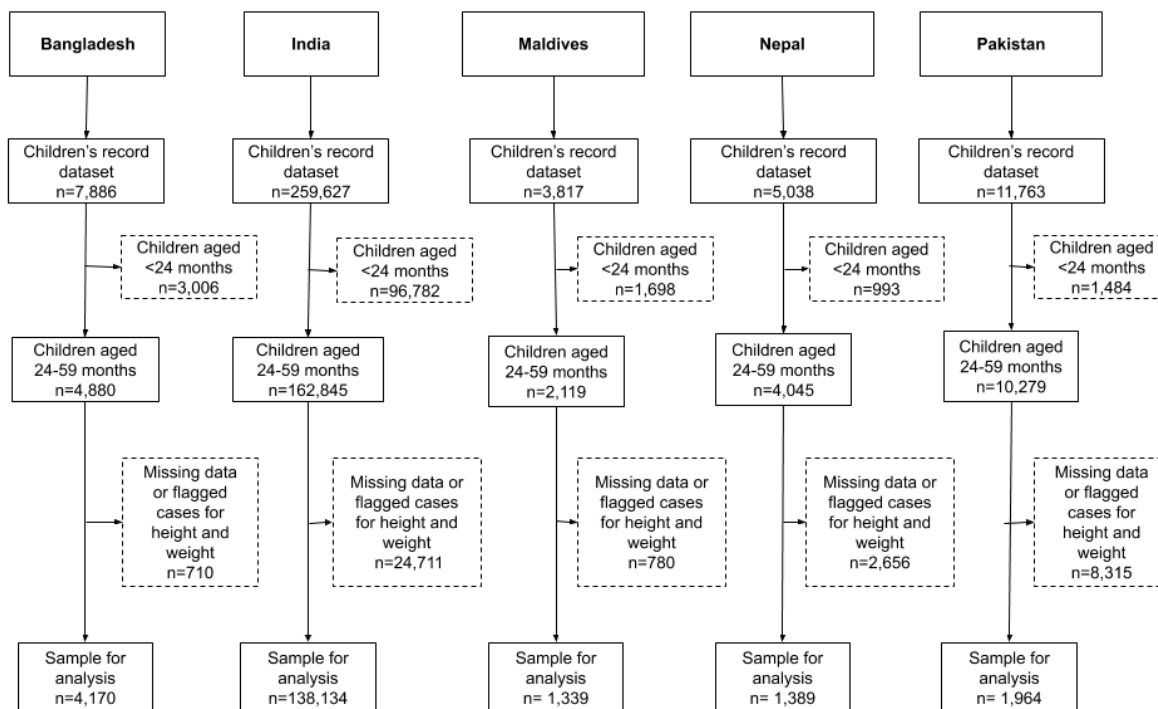


Figure S1: Flowchart of study participants included in this analysis

Table S1: Prevalence of underweight and overweight with 95% confidence intervals (95% CIs) in five South Asian countries, overall and by household's wealth index and highest education level

| | Bangladesh | India | Maldives | Nepal | Pakistan |
|--|------------------|------------------|------------------|------------------|------------------|
| Prevalence of underweight*, % (95% CIs) | | | | | |
| Overall | 37.0 (35.6-38.5) | 38.1 (37.9-38.4) | 18.5 (16.5-20.7) | 29.2 (26.9-31.7) | 28.2 (26.3-30.2) |
| Wealth index | | | | | |
| Poorest | 49.5 (46.4-52.7) | 50.7 (50.1-51.2) | 26.3 (21.4-31.9) | 35.8 (30.4-41.6) | 43.5 (39.2-47.9) |
| Poorer | 44.0 (40.5-47.5) | 43.7 (43.2-44.3) | 21.0 (16.5-26.5) | 28.4 (23.6-33.8) | 32.3 (28.0-36.9) |
| Middle | 37.2 (33.9-40.6) | 36.1 (35.6-36.7) | 21.6 (17.1-26.8) | 35.8 (30.6-41.3) | 23.4 (19.3-28.1) |
| Richer | 32.5 (29.4-35.7) | 29.4 (28.8-30.0) | 12.8 (9.3-17.4) | 26.4 (21.7-31.7) | 23.0 (19.5-26.9) |
| Richest | 19.5 (16.9-22.4) | 21.6 (21.0-22.1) | 10.4 (7.2-14.8) | 13.8 (9.5-19.7) | 13.6 (10.4-17.7) |
| Household's highest education | | | | | |
| No education | 42.6 (39.1-46.1) | 48.6 (48.1-49.1) | 30.9 (24.7-37.9) | 36.6 (32.6-40.8) | 35.8 (33.1-38.5) |
| Primary | 44.5 (41.7-47.4) | 42.7 (42.0-43.4) | 20.9 (17.7-24.5) | 31.9 (26.6-37.7) | 27.6 (23.2-32.5) |
| Secondary | 32.9 (30.8-35.1) | 33.2 (32.8-33.6) | 12.1 (9.5-15.2) | 23.1 (19.3-27.5) | 15.0 (11.8-19.0) |
| Higher | 23.0 (19.0-27.6) | 20.0 (19.3-20.7) | 16.7 (8.5-30.2) | 16.1 (11.3-22.6) | 8.0 (4.8-12.9) |
| Prevalence of overweight, % (95% CIs) | | | | | |
| Overall | 2.4 (1.9-2.9) | 3.5 (3.4-3.6) | 9.2 (7.7-10.8) | 2.8 (2.1-3.8) | 7.3 (6.3-8.5) |
| Wealth index | | | | | |
| Poorest | 1.7 (1.1-2.8) | 2.8 (2.7-3.0) | 5.9 (3.6-9.4) | 3.9 (2.2-6.9) | 9.0 (6.8-11.9) |
| Poorer | 1.5 (0.8-2.6) | 2.9 (2.7-3.1) | 8.8 (5.9-12.9) | 1.5 (0.6-3.7) | 7.9 (5.7-10.9) |
| Middle | 1.6 (1.0-2.8) | 3.2 (3.0-3.4) | 7.7 (5.1-11.5) | 0.4 (0.1-2.3) | 5.9 (3.9-8.8) |
| Richer | 1.6 (1.0-2.7) | 3.9 (3.7-4.2) | 12.7 (9.1-17.3) | 5.1 (3.1-8.3) | 5.5 (3.8-7.9) |
| Richest | 5.5 (4.1-7.3) | 5.5 (5.2-5.9) | 11.0 (7.7-15.4) | 3.8 (1.8-7.8) | 8.0 (5.6-11.3) |
| Education level | | | | | |
| No education | 1.6 (0.9-2.7) | 3.0 (2.8-3.1) | 7.0 (4.2-11.7) | 2.5 (1.5-4.2) | 7.4 (6.0-9.0) |
| Primary | 1.6 (1.0-2.5) | 3.1 (2.9-3.4) | 6.1 (4.4-8.4) | 1.2 (0.4-3.5) | 8.8 (6.2-12.2) |
| Secondary | 2.3 (1.7-3.0) | 3.5 (3.3-3.6) | 13.1 (10.5-16.3) | 4.8 (3.1-7.3) | 4.7 (3.0-7.3) |
| Higher | 7.0 (4.8-10.0) | 6.0 (5.6-6.4) | 8.9 (3.5-21.1) | 1.8 (0.6-5.4) | 9.4 (5.9-14.6) |

*Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence.

Table S2: Prevalence of stunting with 95% confidence intervals (95% CIs) in five South Asian countries, overall and by household's wealth index and highest education level

| | Prevalence of stunting*, % (95% CI) | | | | |
|-------------------------------|-------------------------------------|------------------|------------------|------------------|------------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Overall | 41.6 (40.2-43.1) | 41.8 (41.5-42.1) | 16.5 (14.6-18.6) | 41.6 (39.0-44.2) | 48.2 (46.1-50.3) |
| Wealth index | | | | | |
| Poorest | 58.8 (55.7-61.9) | 56.9 (56.4-57.4) | 19.6 (15.2-24.7) | 58.2 (52.3-63.8) | 62.3 (57.9-66.4) |
| Poorer | 49.9 (46.4-53.4) | 48.0 (47.4-48.5) | 20.8 (16.3-26.2) | 42.8 (37.3-48.4) | 61.0 (56.3-65.5) |
| Middle | 41.3 (38.0-44.8) | 39.9 (39.3-40.5) | 16.9 (12.9-21.7) | 42.4 (37.0-48.0) | 47.3 (42.1-52.4) |
| Richer | 35.4 (32.3-38.7) | 30.7 (30.1-31.3) | 13.5 (9.9-18.2) | 37.2 (31.9-42.8) | 41.3 (37.0-45.7) |
| Richest | 19.4 (16.7-22.3) | 22.8 (22.2-23.4) | 11.9 (8.5-16.4) | 19.9 (14.7-26.4) | 22.8 (18.7-27.6) |
| Household's highest education | | | | | |
| No education | 51.3 (47.7-54.8) | 55.0 (54.6-55.5) | 21.0 (15.8-27.5) | 51.6 (47.4-55.8) | 58.8 (56.0-61.6) |
| Primary | 52.5 (49.7-55.4) | 47.0 (46.3-47.7) | 18.5 (15.5-22.0) | 41.1 (35.3-47.1) | 50.3 (45.1-55.5) |
| Secondary | 34.4 (32.3-36.6) | 35.2 (34.8-35.6) | 14.1 (11.3-17.3) | 35.3 (30.8-40.0) | 26.6 (22.5-31.2) |
| Higher | 24.4 (20.3-29.1) | 21.3 (20.5-22.0) | 6.8 (2.3-18.5) | 26.1 (20.0-33.4) | 20.5 (15.2-27.0) |

*Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence.

Table S3: Prevalence of wasting with 95% confidence intervals (95% CIs) in five South Asian countries, overall and by household's wealth index and highest education level

| | Prevalence of wasting*, % (95% CI) | | | | |
|-------------------------------|------------------------------------|------------------|------------------|----------------|-----------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Overall | 12.5 (11.6-13.6) | 17.9 (17.7-18.1) | 11.1 (9.5-12.9) | 6.4 (5.2-7.8) | 6.9 (5.9-8.1) |
| Wealth index | | | | | |
| Poorest | 13.3 (11.3-15.6) | 20.0 (19.5-20.4) | 14.8 (11.0-19.5) | 5.9 (3.7-9.4) | 11.9 (9.4-15.1) |
| Poorer | 15.0 (12.6-17.6) | 18.6 (18.1-19.0) | 13.7 (10.0-18.5) | 7.4 (5.0-11.0) | 5.5 (3.7-8.1) |
| Middle | 11.8 (9.8-14.3) | 17.3 (16.8-17.7) | 12.5 (9.1-16.9) | 6.7 (4.4-10.1) | 5.4 (3.4-8.2) |
| Richer | 12.2 (10.2-14.5) | 16.8 (16.3-17.2) | 6.6 (4.1-10.3) | 6.4 (4.1-9.8) | 4.7 (3.1-7.0) |
| Richest | 10.3 (8.4-12.6) | 15.6 (15.1-16.1) | 7.8 (5.1-11.8) | 4.9 (2.6-9.2) | 6.1 (4.0-9.2) |
| Household's highest education | | | | | |
| No education | 9.1 (7.2-11.3) | 19.1 (18.8-19.5) | 16.8 (12.1-22.8) | 8.0 (6.0-10.7) | 7.6 (6.2-9.3) |
| Primary | 14.0 (12.2-16.1) | 18.3 (17.8-18.9) | 12.1 (9.6-15.1) | 7.4 (4.8-11.2) | 7.3 (5.0-10.5) |
| Secondary | 13.0 (11.6-14.6) | 17.7 (17.4-18.0) | 8.1 (6.0-10.8) | 4.6 (3.0-7.2) | 5.2 (3.4-7.9) |
| Higher | 12.5 (9.5-16.3) | 14.2 (13.6-14.8) | 13.2 (6.1-26.2) | 3.9 (1.8-8.2) | 5.1 (2.7-9.4) |

*Sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures were used to estimate country-representative prevalence.

Table S4: Associations of household's wealth index and highest education with childhood stunting

| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
|-------------------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
| | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Poorer | 0.7 (0.6-0.8) | 0.8 (0.7-0.9) | 0.7 (0.7-0.7) | 0.8 (0.8-0.9) | 1.2 (0.9-1.5) | 1.3 (0.9-1.8) | 0.5 (0.4-0.6) | 0.5 (0.4-0.6) | 0.9 (0.7-1.1) | 0.9 (0.7-1.1) |
| Middle | 0.5 (0.5-0.6) | 0.7 (0.6-0.8) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.9 (0.6-1.1) | 1.1 (0.8-1.5) | 0.4 (0.4-0.6) | 0.4 (0.3-0.5) | 0.6 (0.5-0.8) | 0.6 (0.5-0.7) |
| Richer | 0.4 (0.3-0.5) | 0.5 (0.5-0.6) | 0.4 (0.3-0.4) | 0.5 (0.5-0.6) | 0.8 (0.5-1.1) | 1.0 (0.7-1.4) | 0.4 (0.3-0.5) | 0.4 (0.3-0.5) | 0.5 (0.4-0.6) | 0.4 (0.3-0.5) |
| Richest | 0.2 (0.2-0.2) | 0.3 (0.3-0.4) | 0.2 (0.2-0.3) | 0.4 (0.4-0.5) | 0.6 (0.3-1.1) | 0.8 (0.3-2.1) | 0.2 (0.1-0.2) | 0.2 (0.1-0.3) | 0.2 (0.2-0.3) | 0.2 (0.2-0.3) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Primary | 0.9 (0.8-1.0) | 0.9 (0.8-1.1) | 0.8 (0.8-0.8) | 0.9 (0.9-0.9) | 0.9 (0.7-1.1) | 0.9 (0.7-1.1) | 0.6 (0.5-0.8) | 0.7 (0.5-0.9) | 0.8 (0.6-1.0) | 1.1 (0.9-1.4) |
| Secondary | 0.4 (0.4-0.5) | 0.6 (0.6-0.7) | 0.5 (0.5-0.5) | 0.7 (0.7-0.7) | 0.6 (0.4-0.7) | 0.5 (0.4-0.7) | 0.5 (0.4-0.7) | 0.8 (0.7-1.0) | 0.3 (0.3-0.4) | 0.6 (0.5-0.8) |
| Higher | 0.3 (0.2-0.3) | 0.6 (0.5-0.8) | 0.2 (0.2-0.2) | 0.5 (0.5-0.5) | 0.3 (0.1-1.1) | 0.3 (0.1-1.4) | 0.4 (0.3-0.5) | 0.6 (0.4-0.9) | 0.3 (0.2-0.4) | 0.6 (0.4-0.8) |

* Minimally adjusted models were adjusted for child's age and sex; and fully-adjusted models were additionally adjusted for area of residence, receiving vitamin A and deworming drug, access to improved sanitation and drinking water, number of under-five children, mother's age at first birth, mother's height, and mother's BMI. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46

Table S5: Associations of household’s wealth index and highest education with childhood wasting

| | Bangladesh | | India | | Maldives | | Nepal | | Pakistan | |
|-------------------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|
| | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted | Minimally-adjusted | Fully-adjusted |
| Household's wealth index | | | | | | | | | | |
| Poorest | 1.0 (0.8-1.2) | 1.0 (0.8-1.3) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (0.7-1.4) | 1.0 (0.7-1.5) | 1.0 (0.6-1.5) | 1.0 (0.6-1.6) | 1.0 (0.7-1.4) | 1.0 (0.6-1.6) |
| Poorer | 1.1 (0.9-1.3) | 1.1 (0.9-1.3) | 0.8 (0.8-0.8) | 0.9 (0.9-0.9) | 0.9 (0.6-1.2) | 0.9 (0.6-1.3) | 1.1 (0.7-1.8) | 1.0 (0.6-1.5) | 0.6 (0.4-1.0) | 0.7 (0.5-1.2) |
| Middle | 0.9 (0.7-1.1) | 0.9 (0.7-1.1) | 0.7 (0.7-0.8) | 0.9 (0.9-0.9) | 0.9 (0.6-1.2) | 1.0 (0.7-1.5) | 1.2 (0.8-1.8) | 1.0 (0.6-1.5) | 0.7 (0.5-1.1) | 0.9 (0.6-1.4) |
| Richer | 0.7 (0.6-0.9) | 0.8 (0.6-0.9) | 0.7 (0.7-0.7) | 0.9 (0.9-0.9) | 0.6 (0.4-1.0) | 1.1 (0.7-1.7) | 1.1 (0.7-1.8) | 1.2 (0.7-1.8) | 0.6 (0.4-0.9) | 0.9 (0.6-1.4) |
| Richest | 0.7 (0.5-0.9) | 0.8 (0.6-1.1) | 0.6 (0.6-0.7) | 0.9 (0.8-0.9) | 0.4 (0.2-0.8) | 1.3 (0.3-5.0) | 0.8 (0.4-1.6) | 1.1 (0.5-2.5) | 0.7 (0.5-1.1) | 1.0 (0.6-1.8) |
| Household's highest education | | | | | | | | | | |
| No education | 1.0 (0.8-1.3) | 1.0 (0.8-1.3) | 1.0 (1.0-1.0) | 1.0 (1.0-1.0) | 1.0 (0.7-1.4) | 1.0 (0.6-1.6) | 1.0 (0.7-1.4) | 1.0 (0.7-1.4) | 1.0 (0.8-1.3) | 1.0 (0.7-1.5) |
| Primary | 1.4 (1.2-1.6) | 1.5 (1.2-1.7) | 0.9 (0.9-0.9) | 0.9 (0.9-1.0) | 0.8 (0.6-1.0) | 0.8 (0.6-1.0) | 0.9 (0.5-1.4) | 1.0 (0.6-1.6) | 0.8 (0.5-1.3) | 1.0 (0.6-1.5) |
| Secondary | 1.2 (1.0-1.4) | 1.4 (1.2-1.6) | 0.8 (0.8-0.8) | 0.9 (0.9-0.9) | 0.5 (0.4-0.7) | 0.6 (0.4-0.8) | 0.6 (0.4-1.0) | 0.7 (0.5-1.0) | 0.9 (0.6-1.3) | 1.0 (0.6-1.5) |
| Higher | 1.1 (0.8-1.5) | 1.6 (1.1-2.3) | 0.7 (0.6-0.7) | 0.8 (0.8-0.9) | 0.7 (0.2-2.3) | 1.8 (0.5-6.9) | 0.4 (0.2-0.9) | 0.4 (0.2-1.0) | 0.9 (0.5-1.5) | 0.9 (0.5-1.6) |

* Minimally adjusted models were adjusted for child’s age and sex; and fully-adjusted models were additionally adjusted for area of residence, receiving vitamin A and deworming drug, access to improved sanitation and drinking water, number of under-five children, mother’s age at first birth, mother’s height, and mother’s BMI. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata’s survey estimation procedures.

Table S6: Socioeconomic status-adjusted odds ratios (ORs) of stunting for various child, household and maternal factors

| | OR (95% CI)* | | | | |
|--|---------------|---------------|----------------|---------------|---------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Child's variables | | | | | |
| Sex | | | | | |
| Male | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Female | 1.0 (0.9-1.1) | 1.0 (1.0-1.0) | 1.3 (1.0-1.8) | 1.0 (0.8-1.2) | 0.9 (0.8-1.1) |
| Age | | | | | |
| 2-3 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 3-4 years | 1.1 (1.0-1.3) | 1.0 (1.0-1.1) | 0.9 (0.6-1.2) | 0.7 (0.5-0.9) | 0.9 (0.7-1.1) |
| 4-5 years | 0.8 (0.7-0.9) | 0.9 (0.8-0.9) | 0.5 (0.4-0.8) | 0.7 (0.5-0.9) | 0.8 (0.6-1.0) |
| Received vitamin A in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.9-1.2) | 1.0 (1.0-1.0) | 1.1 (0.7-1.7) | 0.8 (0.5-1.1) | 1.1 (0.9-1.3) |
| Received deworming drug in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.0 (0.9-1.1) | 0.9 (0.9-1.0) | 1.1 (0.7-1.6) | 1.0 (0.8-1.3) | 0.8 (0.6-1.0) |
| Household variables | | | | | |
| Area of residence | | | | | |
| Urban | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Rural | 0.9 (0.8-1.1) | 0.9 (0.9-1.0) | 0.9 (0.4-2.0) | 1.0 (0.8-1.3) | 0.7 (0.6-0.9) |
| Improved access to sanitation | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.8 (0.7-1.0) | 0.9 (0.9-0.9) | 0.7 (0.4-1.2) | 0.6 (0.5-0.8) | 1.3 (1.0-1.7) |
| Improved access to drinking water | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.9 (0.8-1.2) | 1.2 (1.1-1.2) | 1.0 (0.5-1.7) | 1.1 (0.8-1.5) | 1.2 (1.0-1.6) |
| No. of children under five | 1.2 (1.1-1.3) | 1.1 (1.1-1.1) | 1.0 (0.9-1.2) | 1.1 (1.0-1.3) | 1.1 (1.0-1.2) |
| Maternal variables | | | | | |
| Mother's age at first birth | | | | | |
| Less than 20 years | 1.1 (0.9-1.3) | 1.1 (1.1-1.1) | 0.8 (0.6-1.2) | 0.8 (0.7-1.1) | 0.9 (0.7-1.1) |
| 20-24 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 25 years or more | 0.6 (0.4-0.9) | 0.8 (0.8-0.8) | 1.0 (0.7-1.6) | 0.5 (0.3-0.9) | 0.8 (0.6-1.0) |
| Mother's BMI category | | | | | |
| Normal weight | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Underweight | 1.3 (1.1-1.5) | 1.3 (1.2-1.3) | 0.9 (0.5-1.6) | 1.4 (1.1-1.9) | 1.7 (1.2-2.3) |
| Overweight | 0.7 (0.6-0.8) | 0.8 (0.7-0.8) | 0.9 (0.7-1.2) | 0.6 (0.4-0.8) | 1.0 (0.8-1.2) |
| Mother's height category | | | | | |
| <145 cm | 4.9 (3.9-6.3) | 3.5 (3.4-3.7) | 6.2 (3.6-10.7) | 4.1 (2.7-6.1) | 3.7 (2.2-6.2) |
| 145-149 cm | 2.5 (2.1-3.0) | 2.2 (2.1-2.3) | 3.3 (2.1-5.4) | 2.7 (2.0-3.8) | 2.3 (1.7-3.0) |
| 150-154 cm | 1.9 (1.5-2.2) | 1.5 (1.5-1.6) | 2.5 (1.6-4.0) | 1.6 (1.2-2.2) | 1.4 (1.1-1.7) |
| 155 cm or more | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |

* Logistic regression models were adjusted for household's wealth index and highest education. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

Table S7: Socioeconomic status-adjusted odds ratios (ORs) of wasting for various child, household and maternal factors

| | OR (95% CI)* | | | | |
|--|---------------|---------------|---------------|---------------|---------------|
| | Bangladesh | India | Maldives | Nepal | Pakistan |
| Child's variables | | | | | |
| Sex | | | | | |
| Male | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Female | 1.0 (0.8-1.2) | 0.9 (0.8-0.9) | 0.8 (0.6-1.1) | 0.9 (0.6-1.4) | 0.7 (0.5-1.0) |
| Age | | | | | |
| 2-3 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 3-4 years | 1.0 (0.8-1.2) | 0.9 (0.9-0.9) | 1.1 (0.7-1.7) | 0.8 (0.5-1.4) | 0.9 (0.6-1.4) |
| 4-5 years | 1.2 (0.9-1.5) | 0.9 (0.8-0.9) | 1.3 (0.9-2.0) | 0.9 (0.6-1.6) | 0.7 (0.5-1.1) |
| Received vitamin A in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.1 (0.9-1.3) | 1.1 (1.1-1.1) | 1.6 (0.9-2.9) | 0.6 (0.3-1.0) | 1.0 (0.7-1.4) |
| Received deworming drug in last 6 months | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 0.9 (0.7-1.1) | 1.0 (1.0-1.1) | 1.8 (1.0-2.9) | 1.1 (0.6-1.8) | 0.7 (0.5-1.1) |
| Household variables | | | | | |
| Area of residence | | | | | |
| Urban | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Rural | 1.1 (0.9-1.4) | 0.9 (0.9-1.0) | 2.7 (0.9-7.8) | 0.6 (0.4-0.9) | 1.0 (0.6-1.5) |
| Improved access to sanitation | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.2 (0.9-1.4) | 0.9 (0.8-0.9) | 0.7 (0.4-1.4) | 0.6 (0.4-1.0) | 0.7 (0.5-1.1) |
| Improved access to drinking water | | | | | |
| No | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Yes | 1.2 (0.9-1.6) | 1.0 (1.0-1.1) | 1.5 (0.7-3.2) | 1.5 (0.7-3.3) | 0.6 (0.4-0.9) |
| No. of children under five | 0.9 (0.8-1.0) | 0.9 (0.9-1.0) | 1.1 (0.9-1.3) | 0.8 (0.6-1.0) | 1.0 (0.9-1.1) |
| Maternal variables | | | | | |
| Mother's age at first birth | | | | | |
| Less than 20 years | 1.0 (0.8-1.3) | 1.0 (1.0-1.0) | 1.1 (0.8-1.6) | 1.1 (0.7-1.7) | 0.9 (0.6-1.4) |
| 20-24 years | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| 25 years or more | 0.9 (0.6-1.5) | 0.9 (0.9-1.0) | 0.6 (0.4-1.2) | 1.1 (0.4-2.6) | 1.1 (0.7-1.8) |
| Mother's BMI category | | | | | |
| Normal weight | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |
| Underweight | 1.5 (1.2-1.9) | 1.4 (1.4-1.5) | 1.7 (1.0-3.0) | 1.7 (1.0-2.8) | 1.3 (0.8-2.1) |
| Overweight | 0.6 (0.4-0.8) | 0.6 (0.6-0.6) | 0.7 (0.5-1.0) | 0.5 (0.2-1.1) | 0.6 (0.4-0.9) |
| Mother's height category | | | | | |
| <145 cm | 1.3 (1.0-1.8) | 1.0 (1.0-1.1) | 1.0 (0.6-1.8) | 1.1 (0.6-2.2) | 1.4 (0.6-3.0) |
| 145-149 cm | 1.1 (0.9-1.5) | 1.1 (1.0-1.1) | 0.6 (0.4-1.0) | 1.0 (0.6-1.7) | 0.9 (0.5-1.5) |
| 150-154 cm | 1.0 (0.8-1.3) | 1.0 (1.0-1.1) | 1.1 (0.7-1.7) | 0.7 (0.4-1.2) | 1.2 (0.8-1.8) |
| 155 cm or more | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) | 1.0 (Ref) |

* Logistic regression models were adjusted for household's wealth index and highest education. Analyses were conducted using sampling weights provided by the Demographic and Health Survey (DHS) and Stata's survey estimation procedures.

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectional reporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

| | | Reporting Item | Page Number |
|---------------------------|---------------------|---|-----------------------|
| Title and abstract | | | |
| Title | #1a | Indicate the study's design with a commonly used term in the title or the abstract | Page 1 |
| Abstract | #1b | Provide in the abstract an informative and balanced summary of what was done and what was found | Page 2-3 |
| Introduction | | | |
| Background / rationale | #2 | Explain the scientific background and rationale for the investigation being reported | Page 5 |
| Objectives | #3 | State specific objectives, including any prespecified hypotheses | Page 6 lines 14-16 |
| Methods | | | |

| | | | | |
|----|----------------------|----------------------|---|-----------|
| 1 | Study design | #4 | Present key elements of study design early in the paper | Page 7 |
| 2 | | | | |
| 3 | Setting | #5 | Describe the setting, locations, and relevant dates, including periods of | Page 7 |
| 4 | | | recruitment, exposure, follow-up, and data collection | |
| 5 | | | | |
| 6 | | | | |
| 7 | Eligibility criteria | #6a | Give the eligibility criteria, and the sources and methods of selection | Page 7 |
| 8 | | | of participants. | |
| 9 | | | | |
| 10 | | | | |
| 11 | | #7 | Clearly define all outcomes, exposures, predictors, potential | Page 8-9 |
| 12 | | | confounders, and effect modifiers. Give diagnostic criteria, if | |
| 13 | | | applicable | |
| 14 | | | | |
| 15 | | | | |
| 16 | Data sources / | #8 | For each variable of interest give sources of data and details of | NA |
| 17 | measurement | | methods of assessment (measurement). Describe comparability of | |
| 18 | | | assessment methods if there is more than one group. Give information | |
| 19 | | | separately for for exposed and unexposed groups if applicable. | |
| 20 | | | | |
| 21 | | | | |
| 22 | | | | |
| 23 | Bias | #9 | Describe any efforts to address potential sources of bias | Page 10 |
| 24 | | | | lines 11- |
| 25 | | | | 15 |
| 26 | | | | |
| 27 | | | | |
| 28 | Study size | #10 | Explain how the study size was arrived at | NA |
| 29 | | | | |
| 30 | | | | |
| 31 | Quantitative | #11 | Explain how quantitative variables were handled in the analyses. If | Page 8-9 |
| 32 | variables | | applicable, describe which groupings were chosen, and why | |
| 33 | | | | |
| 34 | Statistical | #12a | Describe all statistical methods, including those used to control for | Page 10 |
| 35 | methods | | confounding | |
| 36 | | | | |
| 37 | | | | |
| 38 | Statistical | #12b | Describe any methods used to examine subgroups and interactions | NA |
| 39 | methods | | | |
| 40 | | | | |
| 41 | | | | |
| 42 | Statistical | #12c | Explain how missing data were addressed | NA |
| 43 | methods | | | |
| 44 | | | | |
| 45 | | | | |
| 46 | Statistical | #12d | If applicable, describe analytical methods taking account of sampling | NA |
| 47 | methods | | strategy | |
| 48 | | | | |
| 49 | | | | |
| 50 | Statistical | #12e | Describe any sensitivity analyses | Page 13 |
| 51 | methods | | | lines 10- |
| 52 | | | | 16 |
| 53 | | | | |
| 54 | | | | |
| 55 | Results | | | |
| 56 | | | | |
| 57 | Participants | #13a | Report numbers of individuals at each stage of study—eg numbers | Page 11 |
| 58 | | | | |
| 59 | | | | |
| 60 | | | | |

potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for exposed and unexposed groups if applicable.

| | | | |
|----|-------------------|--|----------------------------|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | Participants | #13b Give reasons for non-participation at each stage | NA |
| 8 | | | |
| 9 | Participants | #13c Consider use of a flow diagram | Page 11 |
| 10 | | | |
| 11 | Descriptive data | #14a Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable. | Page 11 |
| 12 | | | |
| 13 | | | |
| 14 | | | |
| 15 | | | |
| 16 | | | |
| 17 | | | |
| 18 | Descriptive data | #14b Indicate number of participants with missing data for each variable of interest | NA |
| 19 | | | |
| 20 | | | |
| 21 | | | |
| 22 | Outcome data | #15 Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable. | Page 11 |
| 23 | | | |
| 24 | | | |
| 25 | | | |
| 26 | | | |
| 27 | Main results | #16a Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included | Page 12 |
| 28 | | | |
| 29 | | | |
| 30 | | | |
| 31 | | | |
| 32 | | | |
| 33 | Main results | #16b Report category boundaries when continuous variables were categorized | NA |
| 34 | | | |
| 35 | | | |
| 36 | | | |
| 37 | Main results | #16c If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | NA |
| 38 | | | |
| 39 | | | |
| 40 | Other analyses | #17 Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses | Page 13 lines 10- 16 |
| 41 | | | |
| 42 | | | |
| 43 | | | |
| 44 | | | |
| 45 | | | |
| 46 | Discussion | | |
| 47 | | | |
| 48 | Key results | #18 Summarise key results with reference to study objectives | Page 14 |
| 49 | | | |
| 50 | Limitations | #19 Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias. | Page 16- 17 |
| 51 | | | |
| 52 | | | |
| 53 | | | |
| 54 | | | |
| 55 | | | |
| 56 | Interpretation | #20 Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and | Page 14- 16 |
| 57 | | | |
| 58 | | | |
| 59 | | | |
| 60 | | | |

other relevant evidence.

1
2
3 Generalisability [#21](#) Discuss the generalisability (external validity) of the study results Page 16

4
5 **Other**
6 **Information**
7

8
9 Funding [#22](#) Give the source of funding and the role of the funders for the present Page 18
10 study and, if applicable, for the original study on which the present
11 article is based
12

13
14 Notes:

- 15
16 • 3: Page 6 lines 14-16
17
18 • 9: Page 10 lines 11-15
19
20
21 • 12e: Page 13 lines 10-16
22
23 • 17: Page 13 lines 10-16 The STROBE checklist is distributed under the terms of the Creative Commons
24 Attribution License CC-BY. This checklist was completed on 09. July 2019 using
25 <https://www.goodreports.org/>, a tool made by the [EQUATOR Network](#) in collaboration with [Penelope.ai](#)
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60