**Child undernutrition and its association with household environmental conditions in Bangladesh**

**Supplementary table 1.** Operational definition of the variables of interest

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| --- | --- | --- |
| **Outcome variables** | **Definition** | **Categories** |
| Wasting | Wasted of children was assessed via weight-for-height, where children with height-for-age Z score less than median (M) – 2 standard deviations (SD) or M – 3 SD of the reference population are moderately and severely wasted | 0 = Not wasted  1 = Severely or moderately wasted |
| Stunting | Stunting of children was assessed via height-for-age, where children with height-for-age Z score less than median (M) – 2 standard deviations (SD) or M – 3 SD of the reference population are moderately and severely stunted. | 0 = Not stunted  1 = Severely or moderately stunted |
| Underweight | Underweight of children was assessed via weight-for-height, where children with height-for-age Z score less than median (M) – 2 standard deviations (SD) or M – 3 SD of the reference population are moderately and severely underweight. | 0 = Not underweight  1 = Severely or moderately underweight |
| Anthropometric failure | Anthropometric failure refers to composite index of anthropometric failure (CIAF) (1). It is a composite index that calculated the overall prevalence of under nutrition in children. This indicates the overall single, multiple or no burden of anthropometric measures of children (1). | 0 = Failure A: No failure  1 = Failure B: Wasted only  2 = Failure C: Stunted only  3 = Failure D: Underweight only  4 = Failure E: Wasted and underweight  5 = Failure F: Stunted and underweight  6 = Failure G: Stunted, wasted and underweight. |
| **Exposure variables** | | |
| **Household environment condition (HEC) indicators** | | |
| Housing materials | The household that built with finished roof, floor and wall materials are improved household. Finished floor materials are parquet or polished wood, ceramic tiles, cement, carpet; finished wall materials are cement, stone with lime/cement, and cement blocks; and finished roof materials are metal, calamine, cement fibre, ceramic tiles, cement and roofing shingles.  Unimproved material refers to the use of natural or rudimentary materials like earth/sand, dung, wood plunks, palm/bamboo, cardboard, rustic mat, etc. | 0 = Improved;  1 = Unimproved |
| **WASHplus indicators** |  |  |
| Household air pollution from cooking | It defined as the presence of fuel used for cooking included coal/lignite, charcoal, wood, straw, shrubs/grass, agricultural crop or animal dung; otherwise, clean fuels such as electricity, liquid propane gas (LPG), natural gas, and biogas. We also used the cooking location for determining the level of expose of household indoor air pollution. The respondents were categorized as unexposed if they used clean fuels for cooking, moderately exposed if they used solid fuels for cooking in a separate building or outdoors, and highly exposed if they used solid fuels for cooking inside their houses. This variable was derived following previous studies in LMICs. | 0 = Unexposed  1 = Moderately exposed  2 = Highly exposed |
| Water source | The sources of drinking water are collected from any unprotected well/borehole/tube well, river/dam/lake/ponds/stream/canal and cart with small tank are considered as the unimproved water source, otherwise the water collected from piped facility, tube well or borehole, protected well, rainwater, tanker truck or bottled water are considered as improved water source. | 0 = Improved water source  1 = Unimproved water source |
| Drinking water treatment | The drinking water was treated for making it safe-drinking water includes boiling, bleaching or mixing chlorine, using water filter are considered as appropriately treated. | 0 = Appropriately treated  1 = Inappropriately treated/not treated. |
| Sanitation facility | Basic sanitation is defined as use of improved facilities that are not shared with other households. Includes safely managed sanitation service, which is not shown separately. | 0 = Basic sanitation  1 = poor sanitation or open defecation |
| Handwashing facility | The household had observable handwashing place with available water and cleaning reagent are considered as the standard handwashing facility. | 0 = Standard handwashing facility  12 = Poor handwashing facility |
| Poor household environment quality score | Poor household environment quality scoring is an index of the quality of the house where the respective households have one or more poor household environment quality characteristics. The score is calculated based on poor household environment quality characteristics that includes unimproved housing materials, overcrowding, moderate or highly IAP exposure, unimproved water source, inappropriate or no treatment of drinking water, poor sanitation facility or open defecation, poor hand washing facilities. | 0 = no poor HEC characteristics,  1 = 1 poor HEC characteristics,  2 = 2 poor HEC characteristics,  3 = 3 poor HEC characteristics,  4 = 4 poor HEC characteristics; and  5 = 5 or more poor HEC characteristics |

**Supplementary table 2.** Background characteristics of the study participants: BDHS 2017/18

|  |  |
| --- | --- |
| **Characteristics** | **% (95% CI)** |
| **Child’s age** |  |
| 0 years | 21.24 (20.34-22.17) |
| 1 years | 19.93 (19.00-20.90) |
| 2 years | 20.01 (19.10-20.94) |
| 3 years | 19.22 (18.24-20.23) |
| 4 years | 19.60 (18.68-20.55) |
| **Child’s sex** |  |
| Male | 52.24 (51.10-53.38) |
| Female | 47.76 (46.62-48.90) |
| **Religion** |  |
| Muslim | 91.96 (90.20-93.42) |
| Non-Muslim | 8.04 (6.58-9.80) |
| **Sex of the household head** |  |
| Male | 86.63 (85.39-87.78) |
| Female | 13.37 (12.22-14.61) |
| **Education level of child’s mother** |  |
| No formal education | 7.36 (6.53-8.28) |
| Primary | 28.82 (27.20-30.49) |
| Secondary | 48.43 (46.81-50.06) |
| Higher | 15.40 (14.19-16.69) |
| **Education level of child’s father** |  |
| No formal education | 15.13 (13.81-16.54) |
| Primary | 34.43 (32.99-35.89) |
| Secondary | 32.88 (31.49-34.30) |
| Higher | 17.57 (16.30-18.91) |
| **Working status of child’s mother** |  |
| Unemployed | 59.34 (57.24-61.41) |
| Employed | 40.66 (38.59-42.76) |
| **Wealth quintile** |  |
| Poor | 41.77 (39.40-44.18) |
| Middle | 18.77 (17.49-20.13) |
| Rich | 39.46 (37.16-41.81) |
| **Household size** |  |
| 1-5 members | 53.39 (51.67-55.10) |
| 6-10 members | 40.05 (38.52-41.60) |
| 10+ members | 6.56 (5.65-7.61) |
| **Place of residence** |  |
| Urban | 27.51 (26.12-28.94) |
| Rural | 72.49 (71.06-73.88) |
| **Division** |  |
| Barisal | 5.54 (5.03-6.11) |
| Chattogram | 20.83 (19.46-22.27) |
| Dhaka | 25.80 (24.25-27.42) |
| Mymensingh | 8.35 (7.63-9.14) |
| Khulna | 9.13 (8.42-9.90) |
| Rajshahi | 11.63 (10.62-12.72) |
| Rangpur | 10.50 (9.73-11.32) |
| Sylhet | 8.21 (7.38-9.12) |

**Supplementary table 3.** Division-wise distribution of anthropometric failure and household environmental condition indicators

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Barishal** | **Chattogram** | **Dhaka** | **Khulna** | **Mymensingh** | **Rajshahi** | **Rangpur** | **Sylhet** | **Total** |
| **Anthropometric failure (having any form of undernutrition)** | **40.6** | **39.3** | **33.7** | **32.4** | **42.1** | **39.4** | **36.8** | **52.0** | **38.3** |
| Failure A: No anthropometric failure | 59.4 | 60.7 | 66.3 | 67.6 | 58.0 | 60.6 | 63.3 | 48.0 | 61.7 |
| Failure B: Wasted only | 2.8 | 3.1 | 2.7 | 2.1 | 2.0 | 2.1 | 1.7 | 2.7 | 2.5 |
| Failure C: Stunted only | 15.3 | 15.3 | 12.6 | 11.4 | 14.2 | 14.2 | 14.8 | 16.6 | 14.1 |
| Failure D: Underweight only | 2.6 | 2.5 | 2.4 | 2.2 | 3.3 | 5.5 | 2.6 | 3.6 | 3.0 |
| Failure E: Wasted with underweight | 3.0 | 2.5 | 3.9 | 3.1 | 2.8 | 2.0 | 2.7 | 4.1 | 3.1 |
| Failure F: Stunted with underweight | 14.1 | 13.8 | 10.0 | 11.1 | 15.7 | 12.2 | 12.4 | 21.6 | 13.1 |
| Failure G: Stunted, wasted and underweight | 2.9 | 2.2 | 2.1 | 2.6 | 4.1 | 3.3 | 2.6 | 3.4 | 2.7 |
| **Poor HEC score** |  |  |  |  |  |  |  |  |  |
| No poor HEC characteristics | 0.8 | 7.4 | 13.0 | 1.4 | 0.3 | 1.7 | 1.3 | 7.8 | 4.9 |
| 1 poor HEC characteristics | 4.8 | 9.9 | 15.4 | 8.3 | 5.7 | 5.8 | 6.1 | 8.6 | 8.5 |
| 2 poor HEC characteristics | 7.8 | 13.6 | 18.3 | 13.1 | 8.8 | 12.9 | 10.6 | 10.7 | 12.3 |
| 3 poor HEC characteristics | 11.2 | 19.9 | 22.0 | 17.3 | 12.4 | 16.4 | 16.3 | 16.1 | 16.9 |
| 4 poor HEC characteristics | 32.9 | 23.1 | 16.2 | 29.5 | 23.8 | 23.6 | 25.9 | 20.8 | 23.8 |
| 5 or more poor HEC characteristics | 42.5 | 26.1 | 15.3 | 30.4 | 49.1 | 39.5 | 39.8 | 36.0 | 33.6 |
| **Total** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** | **100.00** |

**Supplementary table 4.** Urban-rural differential effect of exposure variables on under-5 children stunting, wasting and underweight assessed using generalized linear model modified with the Poisson regression.

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| --- | --- | --- | --- | --- | --- | --- |
| **Characteristics** | **Adj. PR (95% CI)** | | | | | |
| **Stunting** | | **Wasting** | | **Underweight** | |
| **Urban** | **Rural** | **Urban** | **Rural** | **Urban** | **Rural** |
| **Child age** | 1.04 (0.98-1.09) | 1.05 (1.02-1.08)\*\*\* | 0.95 (0.85-1.07) | 1.08 (0.99-1.17) | 1.11 (1.04-1.17)\*\*\* | 1.16 (1.12-1.21)\*\*\* |
| **Sex of the child** |  |  |  |  |  |  |
| Male | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Female | 0.99 (0.83-1.17) | 1.01 (0.92-1.10) | 0.67 (0.5-0.9)\*\* | 0.86 (0.69-1.07) | 0.98 (0.82-1.22) | 1.04 (0.93-1.17) |
| **Religion** |  |  |  |  |  |  |
| Muslim | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Non-Muslim | 0.94 (0.71-1.26) | 0.96 (0.82-1.13) | 1.02 (0.61-1.7) | 0.89 (0.60-1.32) | 1.02 (0.75-1.38) | 0.93 (0.76-1.14) |
| **Sex of the household head** |  |  |  |  |  |  |
| Male | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Female | 0.99 (0.75-1.3) | 0.89 (0.77-1.02) | 0.94 (0.56-1.59) | 0.69 (0.48-1.01) | 0.95 (0.67-1.33) | 0.78 (0.63-0.97)\* |
| **Division** |  |  |  |  |  |  |
| Barishal | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Chattogram | 1.19 (0.88-1.6) | 1.03 (0.86-1.23) | 0.9 (0.46-1.75) | 0.85 (0.56-1.29) | 1.04 (0.71-1.51) | 1.00 (0.78-1.27) |
| Dhaka | 1.04 (0.78-1.4) | 0.83 (0.64-1.06) | 1.41 (0.76-2.61) | 0.75 (0.45-1.24) | 1 (0.69-1.46) | 0.84 (0.61-1.16) |
| Khulna | 0.97 (0.73-1.29) | 0.71 (0.57-0.89)\*\* | 0.77 (0.39-1.53) | 0.85 (0.55-1.34) | 0.69 (0.43-1.09) | 0.85 (0.65-1.12) |
| Mymensingh | 1.27 (0.87-1.84) | 0.96 (0.82-1.14) | 1.27 (0.71-2.27) | 0.96 (0.64-1.46) | 1.09 (0.7-1.71) | 1.13 (0.92-1.38) |
| Rajshahi | 0.96 (0.7-1.33) | 0.87 (0.71-1.07) | 1.23 (0.65-2.31) | 0.86 (0.56-1.36) | 1.06 (0.69-1.64) | 1.05 (0.81-1.35) |
| Rangpur | 1.00 (0.68-1.48) | 0.90 (0.76-1.07) | 1.05 (0.54-2.04) | 0.75 (0.48-1.20) | 0.96 (0.6-1.52) | 0.92 (0.73-1.15) |
| Sylhet | 1.49 (1.16-1.92)\*\* | 1.20 (1.02-1.41)\* | 0.75 (0.35-1.61) | 1.17 (0.78-1.74) | 0.97 (0.65-1.45) | 1.41 (1.14-1.75)\*\* |
| **Education level of child’s mother** |  |  |  |  |  |  |
| No education | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Primary | 1.07 (0.81-1.4) | 0.92 (0.79-1.07) | 0.82 (0.49-1.39) | 0.76 (0.51-1.14) | 0.93 (0.66-1.32) | 0.77 (0.64-0.93)\*\* |
| Secondary | 0.93 (0.68-1.27) | 0.86 (0.72-1.02) | 0.74 (0.43-1.26) | 0.80 (0.53-1.19) | 0.69 (0.48-1)\* | 0.74 (0.60-0.91)\*\* |
| Higher | 0.68 (0.42-1.1) | 0.67 (0.50-0.88)\*\* | 0.68 (0.33-1.39) | 0.55 (0.31-0.99)\* | 0.55 (0.34-0.88)\*\* | 0.46 (0.32-0.65)\*\*\* |
| **Education level of child’s father** |  |  |  |  |  |  |
| No education | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Primary | 0.9 (0.75-1.09) | 0.88 (0.78-0.99)\* | 1.03 (0.65-1.64) | 1.03 (0.73-1.46) | 0.87 (0.67-1.13) | 0.91 (0.78-1.06) |
| Secondary | 0.67 (0.52-0.86)\*\* | 0.77 (0.66-0.90)\*\*\* | 1.02 (0.58-1.78) | 1.23 (0.85-1.79) | 0.84 (0.62-1.12) | 0.88 (0.74-1.05) |
| Higher | 0.47 (0.31-0.7)\*\*\* | 0.67 (0.53-0.86)\*\* | 0.85 (0.41-1.75) | 1.17 (0.69-1.98) | 0.59 (0.36-0.95)\* | 0.79 (0.59-1.06) |
| **Working status of child’s mother** |  |  |  |  |  |  |
| Unemployed | 1.00 | 1.00 | 1.00 | 1.00 |  |  |
| Employed | 1.12 (0.93-1.33) | 1.04 (0.93-1.17) | 1.20 (0.89-1.61) | 0.90 (0.72-1.13) | 1.17 (0.96-1.42) | 0.96 (0.85-1.09) |
| **Household size** |  |  |  |  |  |  |
| 1-5 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 6-10 | 1.11 (0.92-1.33) | 1.00 (0.89-1.11) | 1.12 (0.79-1.61) | 0.85 (0.66-1.10) | 1.15 (0.92-1.43) | 1.02 (0.89-1.18) |
| 10+ | 1.21 (0.71-2.05) | 0.98 (0.78-1.25) | 1.49 (0.82-2.72) | 1.04 (0.64-1.61) | 0.99 (0.6-1.64) | 1.01 (0.77-1.28) |

**Note:** All the models were run separately for each type of household environment condition characteristics and was adjusted for child’s age, child’s sex, religion, sex of the household head, education level of child’s mother, education level of child’s father, working status of the child’s mother, household size, place of residence, division. Values with superscript asterisks \*, \*\*, and \*\*\* indicate p<0.05, p<0.01, and p<0.001, respectively. (ref): Reference category, RR: risk ratio, CI: confidence interval.

**References**

1. Bose K (2018) The concept of composite index of anthropometric failure (CIAF): revisited and revised. *Anthropology* 3, 32-35.