

Supplementary Tables

Table S1. Hemoglobin Levels to Diagnose Anemia (g/L) [1]

<i>Age</i>	<i>Non-anemia</i>	<i>Mild anemia</i>	<i>Moderate Anemia</i>	<i>Severe Anemia</i>
5-11 years	115 or higher	110-114	80-109	Lower than 80
12-14 years	120 or higher	110-119	80-109	Lower than 80
Boys > 15 years	130 or higher	110-129	80-109	Lower than 80

Table S2. Serum Ferritin Levels To Diagnose Iron Stores [2]

	<i>Serum ferritin concentration (µg/l)</i>	
	>5 yr. male	>5 yr. female
Depleted iron stores	<15 µg/l	<15 µg/l
Elevated CRP /AGP concentration	< 30 µg/l	-
Severe risk of iron overload	>200 µg/l	>150 µg/l

Table S3. Serum 25-hydroxyvitamin D levels to diagnose Vitamin D Deficiency [3]

	<i>5(OH)D level (nmol/l)</i>
Deficient	< 30 nmol/l
Sufficient	>30 nmol/l

Table S4. Serum Retinol Levels To Diagnose VAD [4]

	<i>Serum Retinol (µg/dl)</i>
Normal	>30 µg/dl
Marginal Deficiency	>20 µg/dl and <30 µg/dl
Low deficiency	> 10 µg/dl and < 20µg/dl
Severe deficiency	< 10 µg/dl

Table S5. Plasma Zinc Levels To Diagnose Zinc Deficiency [5]

	<i>Plasma zinc concentration µg/dl</i>		
	Children <10yr	Females ≥10yr	Males ≥10yr
Morning fasting	-	70 µg/dl	74 µg/dl
Morning non-fasting	65 µg/dl	66 µg/dl	70 µg/dl
Afternoon	57 µg/dl	59 µg/dl	61 µg/dl

Table S6. Serum Calcium Levels [6]

<i>Age</i>	<i>Serum calcium (mg/dl)</i>
2-12 years	8.8-10.8 mg/dl
12-60 years	8.4-10.2 mg/dl

Table S7. Serum Folate Levels [7]

<i>Serum/plasma folate levels (ng/l)</i>	
Elevated	>20 ng/l
Normal	6–20 ng/l
Possible deficiency	3–5.9 ng/l
Deficient	< 3 ng/l

Table S8. Psychological Assessment Tools and Scoring

<i>Tool</i>	<i>Scoring</i>	<i>Reference no.</i>
SCARED	41 items comprise 5 scales. Responses range from ‘not true’ with a score of 0 to ‘very often true’ with a score of 2. Using the sum of each scale, cut-offs are: <ul style="list-style-type: none"> • Total Score ≥ 25 indicate an Anxiety Disorder • Panic Disorder Score of ≥ 7 • Generalized Anxiety Disorder ≥ 9 • Separation Anxiety Disorder ≥ 5 • Social Anxiety Disorder ≥ 8 • Significant school avoidance ≥ 3 	[8, 9]
SDQ	25 items comprise 5 scales of 5 items each. ‘Somewhat true’ is scored as 1, ‘not true’ as 0 and ‘certainly true’ as 2. Responses are summed for each scale. Normal cut-offs are:	[10]

Tool	Scoring	Reference no.
	<ul style="list-style-type: none"> • Total difficulties 0-13 • Emotional problems score 0-3 • Conduct problems score 0-2 • Hyperactivity score 0-5 • Peer problems score 0-2 • Prosocial score 6-10 	
WEMWBS	Total score obtained by summing each of the 14 items. Responses for each item ranges from 1 for 'None of the time' to 5 for 'all of the time'. The total possible score ranges from 14-70. Higher scores are associated with higher levels of mental well-being.	[11]
SRQ	The total score is obtained by summing each of the 20 items. There are two possible responses to each item. A score of 1 indicates the symptom was present and 0 indicates it was absent. A cut-off score of 8 generally indicates the existence of a probable mental disorder	[12, 13]
CTS2	There are 39 items that comprise 5 domains: negotiation; psychological aggression; physical assault; sexual coercion; and injury. Responses range from 'never' as 0 to '3 or more times' with a value of 3. Higher scores indicate more use of the tactic or of a domain of tactics.	[14, 15]
CTQ	There are 23 items that measure 5 types of maltreatment. Response for each item ranges from 1 for 'never true' to 5 for 'very often true'. Cut-offs for low, moderate and severe maltreatment are as follows: <ul style="list-style-type: none"> • Emotional Abuse: None=5-8; Low=9-12; Moderate=13-15; Severe ≥ 16 • Physical Abuse: None=5-7; Low=8-9; Moderate=10-12; Severe ≥ 13 • Sexual Abuse: None=5; Low=6-7; Moderate=8-12; Severe ≥ 13 • Emotional Neglect: None=5-9; Low=10-14; Moderate=15-17; Severe ≥ 18 • Physical Neglect: None=5-7; Low=8-9; Moderate=10-12; Severe ≥ 13 	[16]
MFQ	There are 33 items with a value of 0 for 'not true' to 2 for 'true'. The total score is a sum of all items. A score of ≥ 27 may indicate the presence of depression	[17-19]

Table S9. Study Variables

<i>Variable</i>	<i>Indicator</i>	<i>Questionnaire items (No.)</i>	<i>Potential Hypothesis Direction on Undernutrition & Poorer Mental Health</i>	<i>Source / Adapted from</i>	<i>Reference no. of tool</i>
DISTAL FACTORS					
Household Level Factors					
<i>Wealth Index</i>	Household construction material, the source of drinking water, sanitation facilities, cooking fuel, household utilities, household density, assets and livestock are used to compute a Wealth Index	17	Scale: greater household wealth, protective	DHS	[20, 21]
<i>Living Conditions</i>	Number of household members	1	greater, contributes	DHS	[20]
<i>Household Food Insecurity</i>	Household food insecurity experience scale (FIES)	8	Scale: moderate to severe, contributes	FIES – FAO	[22]
	No. of meals consumed by the household the day before the interview	4	greater, protective	FIES – FAO	[22]
<i>Household Dietary Diversity</i>	Number of food groups consumed on a weekly basis	15	Scale: greater, protective	FANTA	[23]
<i>WASH</i>					
Access to improved drinking water	Proportion of households with access to improved water sources.	2	greater, protective	DHS	[20]
Access to improved sanitation	Proportion of households with access to improved sanitation facilities.	3	greater, protective	DHS	[20]
	Proportion of mothers who wash	1	greater, protective	DHS	[20]

<i>Variable</i>	<i>Indicator</i>	<i>Questionnaire items (No.)</i>	<i>Potential Hypothesis Direction on Undernutrition & Poorer Mental Health</i>	<i>Source / Adapted from</i>	<i>Reference no. of tool</i>
	their hands after toilet use				
Parental Factors					
<i>Parental Occupation</i>	Proportion who are unemployed, unskilled/ skilled employment	2	Scale: more skilled employment, protective	DHS	[20]
<i>Parental Education</i>	Proportion of mothers/fathers who have completed some primary education, high school or above and those illiterate	2	Scale: greater education, protective	DHS	[20]
Peer Related Factors & Relationships					
	Proportion of participants with supportive friend/peer structure	4	greater, protective	HBSC	[24]
	Proportion of participants with supportive family structure	11	greater, protective	HBSC	[24]
	Proportion of participants using social media to communicate with peers	16	greater, protective	HBSC	[24]
PROXIMAL FACTORS					
Proximal Level 2					
Use of Services					
<i>Vaccination</i>	Proportion with vaccination record; Proportion with any vaccinations	7	greater, protective	DHS	[20]
<i>Education</i>					

<i>Variable</i>	<i>Indicator</i>	<i>Questionnaire items (No.)</i>	<i>Potential Hypothesis Direction on Undernutrition & Poorer Mental Health</i>	<i>Source / Adapted from</i>	<i>Reference no. of tool</i>
<i>Hygiene</i>	School attendance	10	greater, protective	DHS /HBSC	[20, 24]
	School support and attitudes	8	greater, protective	HBSC	[24]
	Proportion of participant who washes their hands after toilet use	1	greater, protective	GSHS	[25]
	Proportion of participants who brush their teeth	1	greater, protective	GSHS	[25]
<u>Nutrition and Health Practices</u>					
<i>Physical Activity</i>					
	Proportion of participants who were physically active in the past 7 days for a total of 60 minutes	3	greater, protective	GSHS	[25]
	Proportion of participants who spent > 4 hours sedentary outside of school time	1	greater, protective	GSHS	[25]
<i>Eating Practices and Diet</i>					
	Proportion of participants who were hungry	1	greater, contributes	GSHS	[25]
	Proportion of participants who ate breakfast	1	greater, protective	GSHS	[25]
	Proportion of participants with access to a school meal program;	3	greater, protective	GSHS	[25]
	Proportion of participants who eat at a fast food restaurant	1	no effect	GSHS	[25]
	Proportion of participants who	1	no effect	GSHS	[25]

Variable	Indicator	Questionnaire items (No.)	Potential Hypothesis Direction on Undernutrition & Poorer Mental Health	Source / Adapted from	Reference no. of tool
	drinking carbonated beverages				
	Proportion of participants who eating fruit or vegetables	2	greater, protective	GSHS	[25]
Maternal Factors					
<i>Mental Health</i>					
	WEMWBS: Score range from 14-70.	14	Five response categories	WEMWBS	[11]
	Prevalence of an SRQ score >8 (score maximum, 20)	20	Scale: greater, contributes	SRQ	[26]
	CTS2 score: prevalence of conflict	7	Scale: greater, contributes	CTS2	[14]
<i>Maternal Physical Health</i>					
Age	Proportion in age groupings of mother and fathers	2	Scale: older, protective	DHS	[20]
BMI level	Proportion with BMI>18.5	NA	greater, protective	Maternal anthropometric measurement	[27, 28]
Height	Proportion < 145cm	NA	greater, contribute-	Maternal anthropometric measurement	[27, 28]
Hygiene	Proportion of mothers who wash their hands prior to preparing food	4	greater, protective	DHS	[20]
	Proportion of mothers who wash their hands before eating	1	greater, protective	DHS	[20]
<i>Fetal/Infant Growth</i>					
Parity	Number of siblings	7	Scale: greater parity, contributes	DHS	[20]
Birth characteristics	Proportion of small size at birth	3	greater, contribute	DHS	[20]

Variable	Indicator	Questionnaire items (No.)	Potential Hypothesis Direction on Undernutrition & Poorer Mental Health	Source / Adapted from	Reference no. of tool
Infant feeding practices	Proportion ever breastfed and duration	2	greater, contribute	DHS	[20]
Risk behaviour					
Smoking	Proportion of participants that used tobacco products	4	greater, contribute	GSHS	[25]
Injury	Proportion of participants that were seriously injured in the last 12 months	4	greater, contribute	GSHS	[25]
Bullying	Proportion of participants that were bullied in the last 30 days	2	greater, contribute	GSHS	[25]
Proximal Level 1					
Physical Health					
<i>Anthropometry</i>					
Thinness	Proportion of participants with BAZ < -2SD	NA	greater, contribute	Anthropometric measurement	[27, 28]
Stunting	Proportion of participants with HAZ < -2SD	NA	greater, contribute	Anthropometric measurement	[27, 28]
	Proportion of participants with MUAC < 16.0 cm	NA	greater, contribute	Anthropometric measurement	[29]
<i>Puberty</i>					
	Proportion of participants <i>pre-puberty</i>		confounding variable	Puberty Phase Assessment	[30, 31]
	Proportion of participants <i>in puberty</i>		confounding variable	Puberty Phase Assessment	[30, 31]
	Proportion of participants <i>completing puberty</i>		confounding variable	Puberty Phase Assessment	[30, 31]
<i>Anemia and Nutrient Deficiencies</i>					

Variable	Indicator	Questionnaire items (No.)	Potential Hypothesis Direction on Undernutrition & Poorer Mental Health	Source / Adapted from	Reference no. of tool
Anemia	Proportion of anemic participants	NA	greater, contribute	Biomarker Analysis	[1]
IDA	Proportion of participants with IDA	NA	greater, contribute	Biomarker Analysis	[2, 32]
VAD	Proportion of participants with VAD	NA	greater, contribute	Biomarker Analysis	[4, 32]
Vitamin D	Proportion of Vitamin D deficient participants	NA	greater, contribute	Biomarker Analysis	[3]
Calcium	Proportion of calcium deficient participants	NA	greater, contribute	Biomarker Analysis	[6]
Folate	Proportion of folate deficient participants	NA	greater, contribute	Biomarker Analysis	[7]
Zinc	Proportion of zinc deficient participants	NA	greater, contribute	Biomarker Analysis	[5]
<u>Participant Mental Health</u>					
Anxiety Disorder	Prevalence of participant SCARED total Score ≥ 25	39	greater, contributes	SCARED	[8]
	Prevalence of a parental SCARED score >25	41	greater, contributes	SCARED	[8]
Depression	Prevalence of a participant score of ≥ 27	32	greater, contributes	MFQ	[33]
Maltreatment	Prevalence of score > 13 may indicate Emotional Abuse	22	greater, contributes	CTQ	[34]
	Prevalence of score > 10 may indicate Physical Abuse:	22	greater, contributes	CTQ	[34]
	Prevalence of score >8 may indicate Sexual Abuse	22	greater, contributes	CTQ	[34]
	Prevalence of score > 15 may indicate Emotional Neglect	22	greater, contributes	CTQ	[34]

<i>Variable</i>	<i>Indicator</i>	<i>Questionnaire items (No.)</i>	<i>Potential Hypothesis Direction on Undernutrition & Poorer Mental Health</i>	<i>Source / Adapted from</i>	<i>Reference no. of tool</i>
	Prevalence of score >10 may indicate Physical Neglect	22	greater, contributes	CTQ	[34]
Emotional and behavioural problems	Prevalence of a parental SDQ Score > 17	34	greater, contributes	SDQ	[35]
	Self –reported general health	10	Scale: better self-reported health, protective	HBSC	[24]

References

1. **Hemoglobin concentrations for the diagnosis of anemia and assessment of severity.** [www.who.int/vmnis/indicators/haemoglobin.pdf]
2. **Serum ferritin concentrations for the assessment of iron status and iron deficiency in populations** [http://www.who.int/vmnis/indicators/serum_ferritin.pdf]
3. Institute of Medicine Committee to Review Dietary Reference Intakes for Vitamin D, Calcium: **The National Academies Collection: Reports funded by National Institutes of Health.** In: *Dietary Reference Intakes for Calcium and Vitamin D.* edn. Edited by Ross AC, Taylor CL, Yaktine AL, Del Valle HB. Washington (DC): National Academies Press (US) National Academy of Sciences.; 2011.
4. **Serum retinol concentrations for determining the prevalence of vitamin A deficiency in populations** [<http://www.who.int/vmnis/indicators/retinol/en/>]
5. King JC, Brown KH, Gibson RS, Krebs NF, Lowe NM, Siekmann JH, Raiten DJ: **Biomarkers of Nutrition for Development (BOND)-Zinc Review.** *J Nutr* 2016.
6. Maier H, Bossert-Reuther S, Junge W, Nagel R, Klein G: **Calcium reference intervals re-established on Roche/hitachi and Cobas Integra® systems: P207.** *Clinical Chemistry and Laboratory Medicine* 2006, **44**(9):A191.
7. WHO: **Serum and red blood cell folate concentrations for assessing folate status in populations.** In: *Vitamin and Mineral Nutrition Information System.* Geneva: World Health Organization; 2012.
8. **Screen for Child Anxiety Related Disorders (SCARED) Tool** [www.wpic.pitt.edu/research]
9. Birmaher B, Khetarpal S, Brent D, Cully M, Balach L, Kaufman J, Neer SM: **The screen for child anxiety related emotional disorders (SCARED): Scale construction and psychometric characteristics.** *Journal of the American Academy of Child & Adolescent Psychiatry* 1997, **36**(4):545-553.
10. Goodman A, Lamping DL, Ploubidis GB: **When to use broader internalising and externalising subscales instead of the hypothesised five subscales on the Strengths and Difficulties Questionnaire (SDQ): data from British parents, teachers and children.** *Journal of abnormal child psychology* 2010, **38**(8):1179-1191.
11. Stewart-Brown S, Janmohamed K: **Warwick-Edinburgh mental well-being scale.** *User guide Version 2008*, **1.**
12. Ventevogel P, De Vries G, Scholte WF, Shinwari NR, Faiz H, Nassery R, van den Brink W, Olf M: **Properties of the Hopkins Symptom Checklist-25 (HSCL-25) and the Self-Reporting Questionnaire (SRQ-20) as screening instruments used in primary care in Afghanistan.** *Social psychiatry and psychiatric epidemiology* 2007, **42**(4):328-335.

13. Scholte WF, Verduin F, van Lammeren A, Rutayisire T, Kamperman AM: **Psychometric properties and longitudinal validation of the self-reporting questionnaire (SRQ-20) in a Rwandan community setting: a validation study.** *BMC Med Res Methodol* 2011, **11**:116.
14. Straus MA, Hamby SL, Boney-McCoy S, Sugarman DB: **The revised conflict tactics scales (CTS2) development and preliminary psychometric data.** *Journal of family issues* 1996, **17**(3):283-316.
15. Straus M: **Manual for scoring the CTS2 and CTSPC.** *Durham, NH: University of New Hampshire Family Research Laboratory Retrieved February 2004*, **12**:2005.
16. Bernstein DP, Fink L: **Childhood Trauma Questionnaire: A retrospective self-report manual.** San Antonio, TX: The Psychological Corporation; 1998.
17. Kent L, Vostanis P, Feehan C: **Detection of major and minor depression in children and adolescents: evaluation of the Mood and Feelings Questionnaire.** *Journal of child psychology and psychiatry, and allied disciplines* 1997, **38**(5):565-573.
18. Daviss WB, Birmaher B, Melhem NA, Axelson DA, Michaels SM, Brent DA: **Criterion validity of the Mood and Feelings Questionnaire for depressive episodes in clinic and non-clinic subjects.** *Journal of child psychology and psychiatry, and allied disciplines* 2006, **47**(9):927-934.
19. Wood A, Kroll L, Moore A, Harrington R: **Properties of the mood and feelings questionnaire in adolescent psychiatric outpatients: a research note.** *Journal of child psychology and psychiatry, and allied disciplines* 1995, **36**(2):327-334.
20. **Pakistan Demographic and Health Survey.** In. Edited by (NIPS) NIOPS, Services MoNH, (NHSRC) RaC, Pakistan Go. Pakistan: United States Agency for International Development (USAID); 2012-2013.
21. Rutstein S: **The DHS wealth index: Approaches for rural and urban areas.** In: *DHS Working Papers.* vol. 60. Calverton, Maryland, USA; 2008.
22. Calferio C, Nord M, Viviani S: **Technical Report. Methods for estimating comparable prevalence rates of food insecurity experienced by adults throughout the world.** In: *Voices of the Hungry.* vol. 1. Rome: FAO; 2016.
23. Kennedy G, Ballard T, Dop M: **Guidelines for Measuring Household and Individual Dietary Diversity.** Rome, Italy: Nutrition and Consumer Protection Division, Food and Agriculture Organization of the United Nations; 2011.
24. **Health Behaviour in School-aged Children (HBSC)**
[<http://www.hbsc.org/about/index.html>]
25. WHO: **Pakistan Global School-Based Student Health Survey 2008.** In. Geneva: WHO; 2009.
26. WHO: **A user's Guide to the Self-Reporting Questionnaire (SRQ).** In. Geneva: WHO; 1994.

27. Cogill B: **Anthropometric Indicators Measurement Guide**. In: *Project, FHI 360*. Washington, DC: Food and Nutrition Technical Assistance (FANTA) 2003.
28. de Onis M, Onyango AW, Van den Broeck J, Chumlea WC, Martorell R: **Measurement and standardization protocols for anthropometry used in the construction of a new international growth reference**. *Food Nutr Bull* 2004, **25**(1 Suppl):S27-36.
29. Centers for Disease Control and Prevention: **National Health and Nutrition Examination Survey (NHANES) Anthropometry Procedures Manual**. In. Atlanta: Centers for Disease Control; 2009.
30. Tanner JM, Whitehouse RH: **Clinical longitudinal standards for height, weight, height velocity, weight velocity, and stages of puberty**. *Arch Dis Child* 1976, **51**(3):170-179.
31. Royal College of Paediatrics and Child Health: **Fact Sheet:UK 2-18 years Growth Chart**. In. Edited by RCPCH. UK; 2012.
32. Namaste SM, Aaron GJ, Varadhan R, Peerson JM, Suchdev PS, Group BW: **Methodologic approach for the Biomarkers Reflecting Inflammation and Nutritional Determinants of Anemia (BRINDA) project**. *Am J Clin Nutr* 2017, **106**(Suppl 1):333S-347S.
33. Costello EJ, Angold A: **Scales to assess child and adolescent depression: checklists, screens, and nets**. *Journal of the American Academy of Child and Adolescent Psychiatry* 1988, **27**(6):726-737.
34. Bernstein DP, Stein JA, Newcomb MD, Walker E, Pogge D, Ahluvalia T, Stokes J, Handelsman L, Medrano M, Desmond D *et al*: **Development and validation of a brief screening version of the Childhood Trauma Questionnaire**. *Child Abuse Negl* 2003, **27**(2):169-190.
35. Goodman R: **The Strengths and Difficulties Questionnaire: a research note**. *Journal of child psychology and psychiatry, and allied disciplines* 1997, **38**(5):581-586.