Protein and nutrition access risk among Indian schoolchildren

Policy and findings report on 1,007 students screened with SNACC PARI, a free and open-source screening instrument, at partner schools in Maharashtra and Karnataka

20.0%	−1.15	63.7%	67.7%
CLINICALLY THIN BMI-for-age below −2	MEAN z-SCORE all respondents	REPORT COST AS a barrier to protein	CANNOT READILY buy protein locally

1. Methodology

Data were collected through a structured, self-administered questionnaire delivered on mobile devices and completed by students at partner schools in Maharashtra and Karnataka, together with participants recruited online, over the course of one year. The instrument comprises 23 items: 18 scored questions covering diet quality, economic access, nutritional awareness and physical access, and 5 measurements consisting of height, weight, age, sex and class. Completion takes approximately five minutes. Responses are written to a fixed schema under a self-generated identification code that records no name, roll number or contact detail.

The instrument operates two separate computational tracks, shown in Figure 1. The questionnaire items produce a risk score between 0 and 100, divided into low (33 and below), moderate (34 to 66) and high (67 and above) bands. Height, weight, age and sex produce a BMI-for-age z-score computed from the WHO 2007 growth reference using the published LMS parameters, $z = ((BMI/M)^{L} - 1)/(L \cdot S)$. No anthropometric value enters the risk score and no questionnaire response enters the z-score, so any association between the two is external to the construction of either.

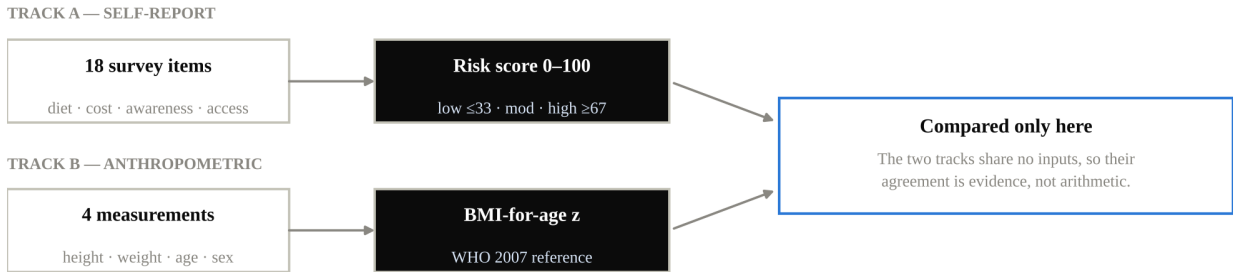


Figure 1. Instrument architecture. The two tracks are computed independently and are compared only after both are complete.

Analysis covered all 1,007 completed responses. Risk scores were recomputed from the raw item responses and reproduced the recorded scores for all 1,007 records. Thinness was defined as a BMI-for-age z-score below −2 and severe thinness as below −3, following WHO classification. Association between risk score and z-score was measured by Spearman rank correlation. Discrimination against clinical thinness was measured as area under the receiver operating characteristic curve. Trend across risk bands was tested by the Cochran-Armitage test for trend. The independent contribution of each domain was estimated by ordinary least squares regression of z-score on the four standardised domain scores entered simultaneously.

2. Findings

2.1 Anthropometric status of the cohort

Of 1,007 students screened, 201 (20.0%) recorded a BMI-for-age z-score below −2 and 11 (1.1%) below −3. Mean BMI-for-age was −1.15 with a standard deviation of 0.92, against a reference population mean of zero. The distribution is displaced across its full range rather than concentrated in a lower tail, as shown in Figure 2.

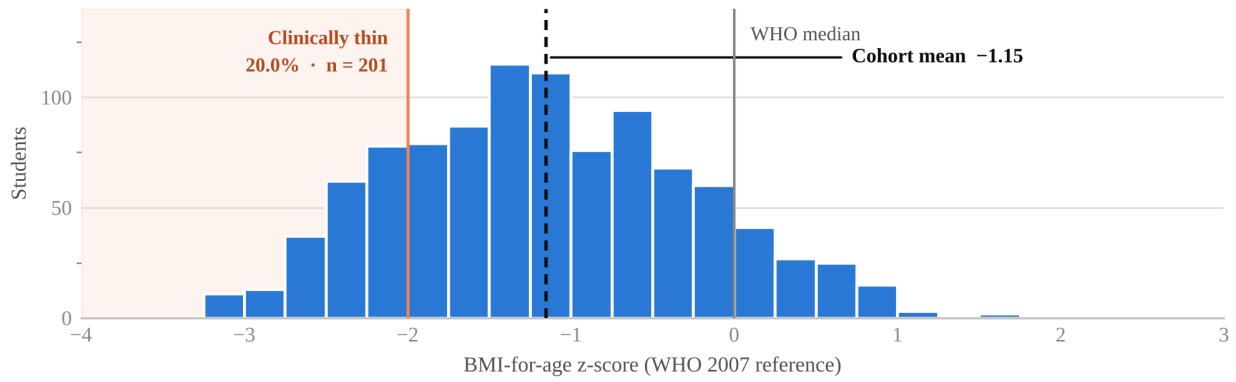


Figure 2. Distribution of BMI-for-age z-scores against the WHO 2007 reference (n = 1,007). The shaded region marks the clinical thinness threshold.

2.2 Reported barriers

Cost was reported as a barrier to obtaining protein by 63.7% of respondents, of whom 36.8% identified it as a major reason for going without. Protein foods were reported as unavailable or hard to obtain locally by 67.7%, with 46.0% reporting that such foods are not sold near them at all. A daily school meal was not received by 55.5%. On the awareness items, 57.6% reported having no idea what protein does and 65.4% did not know their own requirement. Full prevalence figures are given in Figure 3.

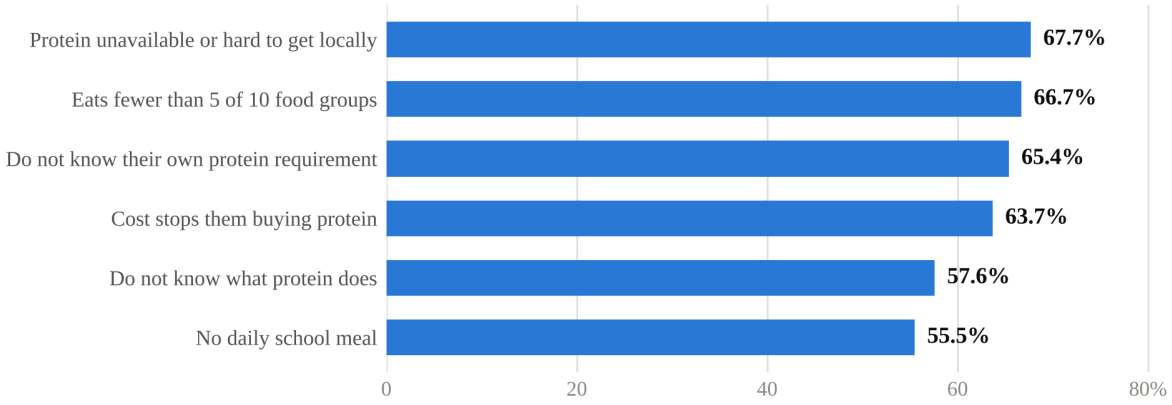


Figure 3. Prevalence of each reported barrier (n = 1,007). Dietary diversity is measured as the number of ten food groups consumed on at least three days per week.

2.3 Association between risk score and anthropometric status

Clinical thinness rose across the three risk bands from 7.4% in the low band to 16.0% in the moderate band and 30.3% in the high band, a relative risk of 4.09 between the high and low bands. Mean BMI-for-age fell across the same bands from −0.64 to −1.11 to −1.50. The trend tested at z = 7.64 ($p = 2.2 \times 10^{-14}$). Across the full range the risk score correlated with BMI-for-age at Spearman rho = −0.416 ($p = 1.7 \times 10^{-43}$) and discriminated clinical thinness with an area under the curve of 0.716. At the high-band threshold, sensitivity was 66.7% and specificity 61.8%.

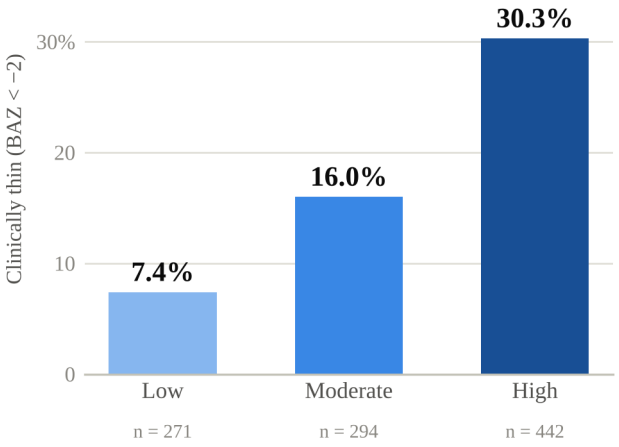


Figure 4. Clinical thinness by risk band, with band sizes.

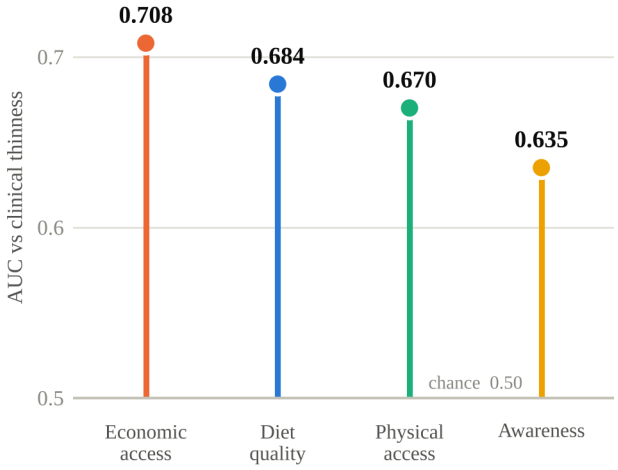


Figure 5. Discrimination of each domain against clinical thinness, as area under the ROC curve.

2.4 Independent contribution of each domain

Entered individually, all four domains discriminated clinical thinness above chance at p below 10^{-19}, as reported in Figure 5. Entered simultaneously in a single regression on BMI-for-age, economic access returned a coefficient of −0.192 standard deviations ($p < 0.001$) and physical access −0.113 ($p = 0.001$), both per standard deviation of domain score. Diet quality returned −0.095 ($p = 0.046$). The coefficient for awareness was −0.054 with a 95% confidence interval from −0.121 to 0.012 ($p = 0.111$), which includes zero.

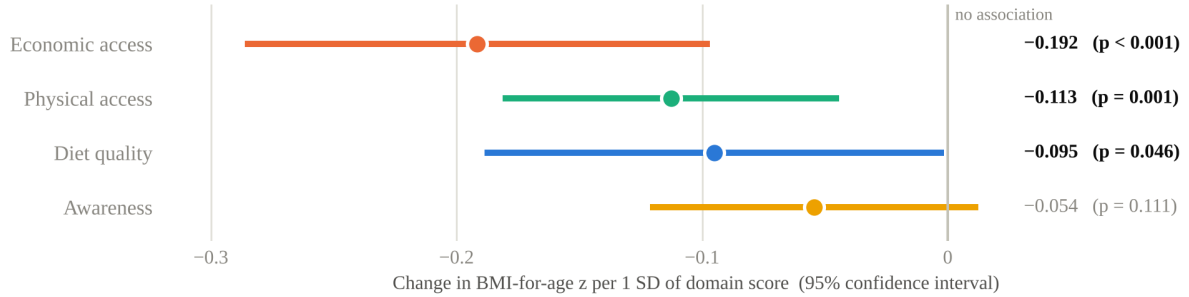


Figure 6. Independent association of each domain with BMI-for-age from a single model containing all four (n = 1,007). Bars show 95% confidence intervals.

3. Conclusions

1 Undernutrition in this cohort is a displacement of the whole distribution rather than a minority caseload. A mean BMI-for-age of −1.15 places the median respondent well below the reference median, so the deficit extends beyond the 20.0% meeting the clinical threshold.

2 Affordability and physical availability are the constraints associated with measured growth status. Awareness is deficient in most respondents but shows no association with BMI-for-age once the material constraints are accounted for.

3 The questionnaire identifies anthropometric risk without receiving any anthropometric input, which establishes that population screening can be conducted without weighing or measuring equipment.

4 A screening programme set at the clinical threshold alone would omit the group sitting immediately above it, which the displacement of the distribution shows to be substantial.

4. Recommendations

The following are ordered by the strength of the evidence supporting them. Each is tied to the conclusion from which it derives.

1 Where the objective is measurable improvement in growth status, intervention should be directed at the affordability and local availability of protein-dense foods rather than at nutrition information campaigns. Economic access and physical access were the only domains retaining an independent association with BMI-for-age when all four were entered together. Awareness is deficient in a majority of respondents, 57.6% reporting no idea what protein does, and is worth addressing on its own terms, but the evidence here does not support it as the primary instrument for anthropometric outcomes. This follows from Conclusion 2.

2 The protein content of meals provided under PM POSHAN should be reviewed, and daily provision extended where it is currently absent. A daily school meal was not received by 55.5% of respondents, and school meal provision is one of the two structural items retaining an independent association with measured growth status. Because the scheme is administered by the Ministry of Education, it is the most direct instrument available to this ministry for acting on the constraint the data identifies. This follows from Conclusion 2.

3 School health screening should record and report the continuous BMI-for-age z-score rather than category membership alone. Reporting only the count below the clinical threshold conceals movement within the distribution, which is where the change produced by any intervention would first appear. A district reporting mean BMI-for-age alongside case counts can detect improvement a year or more before it crosses a threshold. This follows from Conclusions 1 and 4.

4 A secondary observation threshold should be set at one standard deviation below the reference median. In this cohort 38.9% sit between −2 and −1, above the clinical threshold and therefore invisible to a categorical screen, while carrying measurably reduced growth status. Including them raises the group of interest from 20.0% to 58.9% of those screened. Identifying this group does not require clinical referral, only monitoring and inclusion in meal provision. This follows from Conclusions 1 and 4.

5 Screening should record which barrier is binding for each student, not risk alone. A school informed that a given proportion of its students are at risk cannot choose between a cost intervention, a supply intervention and an education intervention; a school informed which domain carries the largest share of that risk can. The domain breakdown is produced by the same five-minute questionnaire at no additional cost in time or equipment. This follows from Conclusions 2 and 3.

6 Screening should be repeated within the academic year so that change is measured rather than inferred. Each record carries a self-generated identification code that permits two rounds to be matched student by student without storing any identifying detail, which allows the effect of a meal or supply intervention to be estimated directly against a baseline. A single round establishes prevalence; two rounds establish whether a measure worked.

7 District-level deployment should be piloted before wider adoption. The instrument requires no licence fee, no equipment beyond a browser, and no measurement session in order to produce the risk score and the barrier breakdown, and it operates in English, Hindi, Marathi and Kannada. A single district pilot would establish whether the associations reported here hold in a larger and more representative population before any commitment of programme resources. This follows from Conclusion 3.

Sources

de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization* 2007;85(9):660–667. · Ministry of Health and Family Welfare, UNICEF and Population Council. *Comprehensive National Nutrition Survey 2016–2018*. New Delhi, 2019. · ICMR–National Institute of Nutrition Expert Group. *Nutrient Requirements for Indians: Recommended Dietary Allowances and Estimated Average Requirements*. Hyderabad, 2020. · The anonymised response set and the full source code are published at snaccpari.com.