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Original Research Paper

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OBESITY MISCONCEPTIONS AND DIABETES KNOWLEDGE GAPS IN NORTHERN INDIAN ADOLESCENTS: A K-MEANS SEGMENTATION STUDY

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ABSTRACT

Background: Obesity is the leading modifiable risk factor for type 2 diabetes mellitus (T2DM), yet it is unclear whether adolescents regard the two conditions as linked. Describing the different knowledge profiles that exist within a student population, instead of reporting only average awareness, may help schools target prevention more precisely. **Objective:** To segment school-going adolescents by their knowledge of T2DM and obesity using K-means clustering, to pinpoint specific misconceptions, and to test whether knowledge in the two domains is related. **Methods:** This cross-sectional study enrolled 960 students in classes 8 to 12 from eight secondary schools in Prayagraj, Uttar Pradesh, in 2025. An interviewer-administered questionnaire measured T2DM knowledge (7 items) and obesity knowledge (14 items), each converted to a composite score from 0 to 100. K-means clustering was run separately for each domain. Score-level association was tested with Pearson and Spearman correlations, and cluster-level association with the chi-square test. Scores were compared by sex, school class, body mass index (BMI) category, dietary preference and family history of non-communicable disease (NCD).**Results:** The mean diabetes score was 43.4 ± 26.3 and the mean obesity score was 58.0 ± 25.2 (942 students with sufficient obesity data). Four profiles, from very low to high knowledge, emerged in each domain. Only 47.8% of students had heard of diabetes, and just 10.0% and 5.3% correctly identified its risk factors and target organs. Although obesity knowledge was higher, 86.3%, 87.2% and 89.3% of students endorsed or were unsure about meal skipping, anti-obesity medication and meal-replacement products, respectively, as sound weight-management strategies. Overall diabetes and obesity scores were uncorrelated (Pearson $r = 0.017$, $p = 0.599$; Spearman $= 0.021$, $p = 0.521$), yet the profiles were associated ($^2 = 112.50$, $df = 9$, $p < 0.001$): 72.7% of students in the high diabetes profile were also in the high obesity profile. Girls scored higher than boys in both domains, and diabetes knowledge rose with school class.**Conclusions:** Diabetes and obesity knowledge behaved as separate domains in these adolescents, and widespread misconceptions about weight management were evident. School programs that teach obesity, insulin resistance and T2DM together, and that explicitly address weight-loss myths, deserve evaluation as a route to earlier prevention.

KEYWORDS : Adolescents; Type 2 Diabetes Mellitus; Obesity; Health Literacy; Knowledge Profiles; K-means Clustering; School Health; India; Non-communicable Diseases

INTRODUCTION

Non-communicable diseases (NCDs) are the main cause of premature death worldwide, and type 2 diabetes mellitus (T2DM) and obesity are among the most consequential of them. India now has roughly 101 million people with diabetes, the largest national burden anywhere, and the International Diabetes Federation expects the figure to climb steeply over the next decade [1,2]. The disease is also no longer confined to adults. The share of T2DM among children has been reported at 12% in Lucknow and as high as 26.7% in Chennai, which points to a pediatric dimension of the epidemic that needs prompt attention [21,22].

Excess weight is rising in parallel. Dietary change, lower physical activity and urbanization are driving up overweight and obesity among Indian children and adolescents, and national nutrition surveys place the prevalence in school-age children at 5% to 20%, with wide differences between states and relatively little published work from the north [3,4]. The World Obesity Atlas 2022 projects more than 27 million children with obesity in India by 2030, equivalent to one child in ten. South Asians also carry more total and visceral body fat than Caucasians at the same BMI, a feature present from birth that speeds the onset of insulin resistance and metabolic syndrome at lower BMI values [16,17]. Prolonged COVID-19 lockdowns, with more screen time and less outdoor activity, probably magnified these risks in the present adolescent generation [12].

Adolescence is a key window for acquiring health knowledge and forming attitudes that carry into adulthood. Because adolescents spend much of their formative years in school, they are easy to reach with health education and can influence the habits of their families and communities. Even so, what adolescents in northern India know about T2DM and obesity remains poorly described. Existing studies have concentrated on South India or large metropolitan areas, or have treated diabetes and obesity knowledge as unrelated constructs [5,6]. Uttar Pradesh, with over 200 million residents, adds substantially to the national NCD burden but is rarely represented in school-based awareness research. Prayagraj, a major educational center in the state, is a suitable setting in which to fill this gap.

Earlier studies typically labelled students as aware or unaware, or placed them on a simple ordinal scale. Such summaries hide the variety of knowledge patterns within a population. Applying K-means clustering to item-level scores can reveal groups of students with distinct profiles and so support interventions matched to each group. To our knowledge, no Indian study has segmented adolescents on both T2DM and obesity knowledge, reported item-level results for both, and examined whether the two types of knowledge are related.

We therefore set out to (1) identify knowledge profiles for T2DM and for obesity among school-going adolescents in Prayagraj; (2) locate the specific items and misconceptions that account for the largest knowledge gaps; (3) test whether knowledge in the two domains is associated at the level of

scores and of profiles; and (4) compare knowledge by sex, school class, BMI category, dietary preference and family history of NCD.

Methods

Design, setting and ethics

We carried out a cross-sectional survey in eight secondary schools (from rural & urban area) in Prayagraj district, Uttar Pradesh, India, during 2025, and report it according to the STROBE guidelines (checklist in the Supplementary File) [7]. The Ethics Committee of Motilal Nehru Medical College (MLNMC), Prayagraj, approved the study (registration no. ECR/922/Inst/UP/2017/RR-22; approval no. IEC/MLNMC/2025/No.08). Every adolescent gave written assent, and written parental or guardian consent was obtained for participants younger than 18 years.

Participants

Schools were chosen by convenience sampling. All students in classes 8 to 12 who were present on the day of data collection and had valid assent and, where applicable, parental consent were eligible. Records from 960 unique participants were analyzed.

Data collection

Trained interviewers administered a structured questionnaire with four parts: sociodemographic details (age, sex, school class, medication use, previous surgery, substance use and family history of NCD); dietary preference; anthropometry (weight, height, waist and hip circumference); and knowledge items on T2DM and obesity. Weight was recorded to the nearest 0.1 kg on a calibrated digital scale, and height to the nearest 0.1 cm using a stadiometer with the head in the Frankfurt plane. BMI was computed as weight in kilograms divided by height in meter squared and categorized with the WHO sex-specific percentile reference for ages 5 to 19 years [8].

Diabetes knowledge score

Seven items covered T2DM: whether the student had heard of diabetes (D1); whether more people are being affected (D2); whether diabetes can harm other organs (D3); which organs are affected (D4, nine correct organs); the risk factors for diabetes (D5, six correct factors); whether diabetes can be prevented (D6); and how it can be prevented (D7, two correct methods). Binary items scored 1 for a correct or affirmative answer and 0 otherwise. Multi-select items (D4, D5, D7) received partial credit equal to the proportion of correct options chosen, with no deduction for incorrect choices. The diabetes score was the mean of the seven item scores multiplied by 100 (range 0 to 100).

Obesity knowledge score

Fourteen Likert-type items (1 = definitely, 2 = probably, 3 = probably not, 4 = definitely not, 5 = don't know) covered three areas: BMI and disease associations (5 items), dietary and lifestyle contributors to weight gain (6 items) and weight-management misconceptions (3 reverse-scored items: O6, O13, O14). For forward-scored items, the responses definitely, probably, probably not, definitely not and don't know received 1.00, 0.75, 0.25, 0.00 and 0.00, respectively. Reverse-scored items used the inverted scale, so that definitely not earned 1.00. The obesity score was the mean of valid item scores multiplied by 100. Students with fewer than 10 valid responses out of 14 were excluded from obesity scoring (n = 18), leaving 942.

Clustering

K-means clustering was applied separately to each domain, using z-standardized item-level scores (7 items for diabetes, 14 for obesity). Missing item scores were imputed with the within-item median before standardization. We chose a four-cluster solution because it gave clinically interpretable profiles with adequate separation, in line with earlier health-literacy segmentation work. Analyses used Python 3.10 (scikit-learn) with a fixed random seed of 42. Clusters were ranked by mean score and labelled D1 to D4 for diabetes and O1 to O4 for obesity.

Statistical analysis

Continuous variables are summarized as mean ± standard deviation (SD), and categorical variables as counts and percentages. Item-level results are given as mean standardized score (0 to 1) and percentage. Welch's t-tests compared scores by sex and by family history of NCD. One-way ANOVA with Tukey HSD post hoc tests compared scores across school classes, BMI categories and dietary preferences. Effect sizes were Cohen's d for t-tests and eta-squared (^{2}) for ANOVA. The association between the two domain scores was assessed with Pearson's correlation, with Spearman's rho as a sensitivity analysis for non-normality, and the association between profiles was assessed with the chi-square test. Subgroup analyses were not adjusted for multiple comparisons. Two-tailed $p < 0.05$ defined statistical significance. Tests were run in Python 3.10 with SciPy. Stats.

RESULTS

Participant characteristics

The 960 participants had a mean age of 16.01 ± 1.01 years (range 15 to 19), and 53.9% were female. Class 12 was the largest group (33.1%). Three-quarters (76.2%) had a healthy BMI, 14.8% were underweight, 5.6% were overweight and 3.3% were obese, so undernutrition and overnutrition were both present. Full details appear in Table 1.

Table 1. Characteristics of the study participants (N = 960)

Characteristic	Category	n (%) or mean ± SD
Demographic		
Age, years	Mean ± SD (range 15–19)	16.01 ± 1.01
	15 years	391 (40.8%)
	16 years	255 (26.6%)
	17 years	235 (24.5%)
	18 years	72 (7.5%)
	19 years	6 (0.6%)
Sex	Female	517 (53.9%)
	Male	442 (46.1%)
School class	Class 8	16 (1.7%)
	Class 9	234 (24.4%)
	Class 10	187 (19.5%)
	Class 11	205 (21.4%)
	Class 12	317 (33.1%)
Lifestyle and health background		
Dietary preference	Vegetarian	510 (54.3%)
	Non-vegetarian	361 (38.4%)
	Eggetarian	69 (7.3%)
Family history of NCD	Yes	247 (25.7%)
	No	712 (74.2%)
Taking any medication	Yes	74 (7.7%)
	No	885 (92.2%)
Previous surgery	Yes	20 (2.1%)
Substance use	Yes	2 (0.2%)
Anthropometry		
Weight, kg	Mean ± SD	50.86 ± 10.94
Height, cm	Mean ± SD	160.32 ± 10.06
BMI, kg/m^2	Mean ± SD	19.73 ± 3.47
BMI category	Underweight	142 (14.8%)
	Healthy weight	731 (76.2%)
	Overweight	54 (5.6%)
	Obese	32 (3.3%)

Percentages are based on the responses available for each variable. NCD, non-communicable disease; BMI, body mass index; SD, standard deviation.

Knowledge profiles

K-means clustering yielded four profiles in each domain (Table 2). For diabetes (n = 960), the Very low, Basic, Moderate and High profiles contained 30.4%, 32.5%, 30.2% and 6.9% of students. Almost one-third therefore fell into the Very low profile, while fewer than one in ten reached the High profile. For obesity (n = 942), the pattern was reversed: the High profile was the largest (40.4%), followed by the Basic (26.0%), Moderate (23.9%) and very low (9.7%) profiles. The overall mean was 43.44 ± 26.31 for diabetes and 58.02 ± 25.17 for obesity, indicating limited diabetes knowledge and somewhat better obesity knowledge, with large variation within both.

Table 2. Knowledge profiles identified by K-means clustering, by domain

Profile (rank)	Diabetes: n (%)	Diabetes: mean ± SD	Obesity: n (%)	Obesity: mean ± SD
Very low (1)	292 (30.4%)	11.98 ± 12.05	91 (9.7%)	11.17 ± 8.27
Basic (2)	312 (32.5%)	43.50 ± 10.45	245 (26.0%)	35.05 ± 7.01
Moderate (3)	290 (30.2%)	68.68 ± 12.49	225 (23.9%)	60.36 ± 7.18
High (4)	66 (6.9%)	71.34 ± 16.24	381 (40.4%)	82.61 ± 3.93
All students	960 (100%)	43.44 ± 26.31	942 (100%)	58.02 ± 25.17

Scores range from 0 to 100. Profile ranks 1 to 4 correspond to D1–D4 (diabetes) and O1–O4 (obesity). Obesity figures exclude 18 students with fewer than 10 valid responses.

Item-level diabetes knowledge

Awareness of diabetes in general was moderate: 47.8% had heard of the condition and 62.9% knew that it is becoming more common (Table 3). Knowledge of specifics was very limited. Only 5.3% identified the organs diabetes affects, 10.0% recognized its main risk factors and 18.9% knew methods of prevention. These figures suggest that students had a superficial awareness of diabetes without much understanding of how it develops or how it can be prevented.

Item-level obesity knowledge and misconceptions

Most items on disease associations and lifestyle contributors were answered correctly by roughly 43% to 50% of students, and 53.5% knew that BMI can be used to assess obesity (Table 3). The three weight-management misconceptions stood out sharply. Only 13.7% rejected the idea that fasting or skipping meals is good for weight loss, 12.8% rejected anti-obesity drugs as the preferred approach, and 10.7% rejected meal-replacement products as healthier. Consequently, between 86.3% and 89.3% of students either endorsed these misconceptions or were uncertain about them.

Table 3. Item-level knowledge scores for diabetes (N = 960) and obesity (n = 942)

Item	Statement (abbreviated)	Scoring / domain	Mean score (0–1)	% correct / aware
Diabetes knowledge (N = 960)				
D1	Has heard of diabetes	Binary	0.478	47.8%
D2	More people are being affected	Binary	0.629	62.9%
D3	Diabetes can affect other organs	Binary	0.398	39.8%
D4	Specific organs affected	Partial	0.053	5.3%
D5	Risk factors for diabetes	Partial	0.100	10.0%
D6	Diabetes can be prevented	Binary	0.551	55.1%
D7	Methods of prevention	Partial	0.189	18.9%
	Diabetes composite (mean of D1–D7)		0.434	43.4 / 100
Obesity knowledge (n = 942)				
O1	BMI can be used to assess obesity	BMI/disease	0.647	53.5%
O2	Abdominal fat is more dangerous	BMI/disease	0.614	42.8%
O3	Obesity is linked to heart disease	BMI/disease	0.609	46.9%
O4	Obesity is linked to diabetes	BMI/disease	0.662	48.0%
O5	Obesity is linked to osteoarthritis	BMI/disease	0.615	43.0%
O6	Fasting or skipping meals is good	Misconception [R]	0.553	13.7%
O7	Excess sugar leads to weight gain	Diet/lifestyle	0.615	46.0%
O8	Sugary beverages lead to weight gain	Diet/lifestyle	0.635	48.9%
O9	Fried food leads to weight gain	Diet/lifestyle	0.607	48.0%
O10	Refined food leads to weight gain	Diet/lifestyle	0.640	49.8%
O11	Constant stress leads to weight gain	Diet/lifestyle	0.660	43.7%
O12	Regular aerobic exercise helps	Diet/lifestyle	0.621	46.6%
O13	Anti-obesity drugs are the preferred approach	Misconception [R]	0.533	12.8%
O14	Meal-replacement products are healthier	Misconception [R]	0.504	10.7%
	Obesity composite (mean of O1–O14)		0.580	58.0 / 100

The association was driven mainly by the High diabetes profile, in which 72.7% of students also belonged to the High obesity profile. Students in the Moderate diabetes profile were over-represented in the Basic obesity profile (41.5%). Thus, for most students the two kinds of knowledge developed separately, while a small subgroup of well-informed students scored highly in both.

Table 4. Concordance between diabetes and obesity knowledge profiles (n = 942)

Diabetes profile (n)	Obesity: Very low	Obesity: Basic	Obesity: Moderate	Obesity: High
Very low (284)	44 (15.5%)	59 (20.8%)	84 (29.6%)	97 (34.2%)
Basic (308)	19 (6.2%)	58 (18.8%)	101 (32.8%)	130 (42.2%)
Moderate (284)	23 (8.1%)	118 (41.5%)	37 (13.0%)	106 (37.3%)
High (66)	5 (7.6%)	10 (15.2%)	3 (4.5%)	48 (72.7%)

Cells shown (row %). Row totals are smaller than the diabetes profile sizes in Table 2 because 18 students lacked sufficient obesity data. Chi-square $\chi^2 = 112.50$, $df = 9$, $p < 0.001$.

Factors associated with knowledge

Girls scored significantly higher than boys in both diabetes ($p = 0.0005$, $d = 0.23$) and obesity ($p = 0.0035$, $d = 0.22$), although both effects were small. Diabetes knowledge rose steadily with school class ($\eta^2 = 0.056$, $p < 0.001$), whereas the class effect on obesity knowledge was modest ($\eta^2 = 0.008$, $p = 0.0485$). Obesity knowledge differed by BMI category ($\eta^2 = 0.009$, $p = 0.041$), with overweight students scoring higher than underweight students, but diabetes knowledge did not ($p = 0.202$). Neither dietary preference nor family history of NCD

was significantly related to knowledge in either domain. Group means are shown in Table 5 and test results in Table 6.

Table 5. Mean knowledge scores by subgroup (mean ± SD)

Factor	Group	n	Diabetes score	Obesity score
Sex				
	Female	517	46.22 ± 26.26	61.26 ± 23.82
	Male	442	40.28 ± 25.98	55.59 ± 26.74
School class				
	Class 8	16	22.97 ± 22.76	52.68 ± 22.48
	Class 9	234	36.44 ± 18.92	57.64 ± 23.09
	Class 10	182	39.89 ± 28.66	53.55 ± 27.51
	Class 11	202	43.38 ± 27.01	60.01 ± 24.86
	Class 12	308	51.90 ± 26.73	59.93 ± 25.34
BMI category				
	Underweight	142	39.19 ± 26.82	53.29 ± 25.45
	Healthy weight	731	44.13 ± 26.27	58.41 ± 25.02
	Overweight	54	45.69 ± 24.11	63.79 ± 23.70
	Obese	32	43.85 ± 26.97	60.38 ± 27.62
Dietary preference				
	Vegetarian	503	45.49 ± 26.77	58.53 ± 24.67
	Non-vegetarian	357	41.37 ± 25.79	57.01 ± 25.59
	Eggetarian	63	43.55 ± 26.28	56.49 ± 26.35
Family history of NCD				
	Yes	247	44.12 ± 26.15	58.45 ± 24.80
	No	712	43.21 ± 26.35	57.88 ± 25.28

Obesity scores are restricted to students with at least 10 of 14 valid responses.

Table 6. Summary of subgroup tests and effect sizes

Factor	Test	Diabetes: p (effect size)	Obesity: p (effect size)
Sex	Welch t-test	0.0005 (d = 0.23)*	0.0035 (d = 0.22)*
School class	One-way ANOVA	<0.001 (η^2 = 0.056)*	0.0485 (η^2 = 0.008)*
BMI category	One-way ANOVA	0.202 (η^2 = 0.005)	0.041 (η^2 = 0.009)*
Dietary preference	One-way ANOVA	0.078 (η^2 = 0.005)	0.622 (η^2 = 0.001)
Family history of NCD	Welch t-test	0.63 (d = 0.03)	0.75 (d = 0.02)

** p < 0.05. d, Cohen's d; ^{2}, eta-squared. No adjustment was made for multiple comparisons.*

DISCUSSION

Principal findings

By segmenting students into knowledge profiles rather than reporting only mean awareness, this study shows considerable diversity in how adolescents in Prayagraj understand metabolic health. Four profiles appeared in each domain. Diabetes knowledge was low overall, with fewer than half of students having heard of the disease, whereas obesity knowledge was higher but marked by three persistent misconceptions about weight management. Overall scores for the two domains were unrelated, although a small group of well-informed students scored highly in both.

Diabetes and obesity knowledge as separate domains

Obesity is the principal modifiable risk factor for T2DM, so one might expect students who know more about obesity to know more about diabetes. We found no such relationship. This implies that students may not see the two conditions as parts of one metabolic continuum, a pattern in line with adolescent health-literacy research showing that knowledge in one area does not reliably predict knowledge in a related one [15,19]. A plausible explanation, which our data cannot test, is that the topics are met through different sources or lessons.

The significant profile-level association shows why score-level analysis alone can mislead. The association came chiefly from a minority who combined high knowledge in both domains, a subgroup that comparisons of average scores would not have revealed. For curriculum design, the independence of the two domains argues against teaching obesity and diabetes as separate topics. Because obesity is the main modifiable driver of insulin resistance and T2DM, an integrated approach that makes this causal link explicit may help students connect the two and support healthier dietary and lifestyle choices before metabolic complications arise [9,16,17].

Misconceptions about weight management

More than 85% of students endorsed, or were unsure about, meal skipping, anti-obesity medication and meal-replacement products as ways to manage weight. These beliefs matter clinically because they can shape behavior and conflict with current evidence-based guidance on obesity management [9,10]. Similar beliefs have been described among adults with obesity in India, which suggests that they are not confined to adolescents [10]. Exposure to commercial weight-loss advertising, social media influencers and digital marketing may contribute [12,13], although this study did not measure media exposure. Since adolescents are heavy users of digital media, media literacy could usefully form part of school health education. Programs should go beyond raising awareness and directly challenge inaccurate beliefs about diet, physical activity and commercial weight-loss products.

An important caution applies to these figures. Students who answered don't know received the same score as those who gave an incorrect answer, so the 86% to 89% combines active endorsement with uncertainty. The two may call for different educational responses.

Limited diabetes knowledge and its correlates

Despite India's growing diabetes burden, students knew little about the disease: few could identify its risk factors, target organs or preventive measures, in agreement with earlier Indian studies of adolescents and young adults [5,6,21–24]. Knowledge increased with school class, which suggests that students pick up information gradually through general schooling rather than structured diabetes teaching. Even in the senior classes, mean scores were only moderate, so the current curriculum seems insufficient preparation for the diabetes burden these students will face.

Girls scored higher than boys in both domains, consistent with earlier Indian adolescent studies [5,6], though the effects were small. Greater involvement of girls in household health conversations and in contact with health services could contribute, but this is speculative. The result nonetheless suggests that programs should include approaches designed to engage boys. Obesity knowledge was higher among overweight than underweight students, with a very small effect size, and was not otherwise patterned by diet or family history.

Implications for school health programs

The profiles show that students do not share a single educational need, so uniform awareness campaigns may serve many of them poorly. Programs could pair broad teaching on diet, physical activity and evidence-based weight management with targeted content for students in the lowest profiles, and could explicitly link obesity, insulin resistance and T2DM [5,9]. Schools should also consider anthropometric screening that goes beyond BMI. Asian Indian adolescents carry more abdominal fat at lower BMI than many other groups, so waist circumference is a useful complementary

measure of metabolic risk [16,17]. Identifying adolescents with central adiposity early, and pairing screening with health education and lifestyle support, might reduce later obesity-related metabolic disease.

Strengths and limitations

Strengths include a large sample, measured rather than self-reported anthropometry, a single scoring framework for both conditions, item-level reporting and a formal test of the relationship between domains. To our knowledge, it is among the first Indian studies to apply K-means clustering to adolescent knowledge of both T2DM and obesity.

Several limitations apply. The cross-sectional design rules out causal inference, and convenience sampling of three schools in one district limits generalizability. The four-cluster solution was chosen for interpretability, not by formal optimization, and the Moderate and High diabetes profiles had similar mean scores (68.7 and 71.3), so they may differ more in item-level response pattern than in overall level. Future work should validate the profiles in independent samples and report cluster-validity indices such as the silhouette coefficient or Davies–Bouldin index. Partial credit for multi-select items carried no penalty for incorrect choices, and missing item scores were median-imputed. Subgroup analyses were unadjusted for multiple testing, and several effects were small. Waist circumference was measured but not analyzed, so central adiposity could not be related to knowledge. Longitudinal studies and measures of health behaviors are needed to learn how these profiles relate to behavior and metabolic outcomes.

CONCLUSION

Adolescents in this northern Indian sample fell into distinct knowledge profiles, and knowledge of diabetes and of obesity behaved as largely independent domains despite the close biological link between the two conditions. Diabetes knowledge was poor, and misconceptions about meal skipping, anti-obesity medication and meal-replacement products were widespread. These findings support testing integrated school-based programs that connect obesity with insulin resistance and T2DM and that directly correct weight-management myths, as a way to strengthen primary prevention of metabolic disease in India.

Declarations

Ethics approval and consent: Approved by the Ethics Committee of Motilal Nehru Medical College, Prayagraj (IEC/MLNMC/2025/No.08). Written assent was obtained from all participants and written parental or guardian consent for those under 18 years.

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