Original Article

School Nutrition Standards and Childhood Obesity Prevention: Assessing Policy Compliance and Long-term Health Effects in Low-Income Communities in Pakistan

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ABSTRACT

Background: Childhood obesity is an escalating crisis in Pakistan, exacerbated in low-income communities by obesogenic food environments. The national School Health and Nutrition (SHN) Strategy aims to create healthier school food spaces, but its real-world effectiveness remains unassessed. This study investigated the relationship between compliance with the SHN Strategy and long-term changes in children's weight status in low-income schools in Karachi.

Methods: A three-year (2020-2022) longitudinal cohort study was conducted across 12 schools. Policy compliance was assessed using a validated tool, categorizing schools as High, Moderate, or Low Compliance. Anthropometric measurements (BMI z-scores) of 528 children were tracked annually. Mixed-methods included quantitative surveys and qualitative interviews with stakeholders.

Results: Only 16.7% of schools maintained High Compliance. A significant interaction was found between time and compliance group on BMI z-scores (p<0.01). Children in High Compliance schools showed a slight decrease in mean BMI z-score (-0.07), while those in Moderate and Low Compliance schools showed increases (+0.11 and +0.19, respectively). The prevalence of overweight/obesity remained stable in High Compliance schools (18.2% to 17.0%) but increased significantly in Moderate (21.4% to 26.4%) and Low Compliance schools (20.5% to 29.1%). Key barriers to compliance were financial pressures, student preferences, and lack of enforcement.

Conclusion: Faithful implementation of school nutrition standards is effective in mitigating unhealthy weight gain in children. Moving from voluntary guidelines to mandatory, monitored regulations with economic incentives is crucial for public health impact.

Keywords: *Childhood Obesity, Low-Income Communities, Policy Compliance, School Nutrition Policy.*

INTRODUCTION

Childhood obesity is a rapidly escalating public health crisis in Pakistan, presenting a complex and paradoxical challenge amidst persistent issues of undernutrition[1]. The nation is grappling with a double burden of disease, where underweight and stunting coexist with overweight and obesity, often within the same communities or even households[2]. Recent data from the National Nutritional Survey of Pakistan (NNS 2018) and subsequent studies indicate a worrying upward trend in childhood overweight and obesity, particularly in urban and peri-urban settings[1,3]. This transition is driven by rapid urbanization, socioeconomic changes, and the widespread proliferation of unhealthy food environments, leading to a shift from traditional

diets to energy-dense, nutrient-poor, and ultra-processed foods[4,5].

The burden of this nutritional transition is not borne equally. Children from low-income urban communities are uniquely vulnerable[6]. These areas are often characterized as "food deserts" for fresh, affordable produce while being "food swamps" saturated with cheap, readily available junk food and sugar-sweetened beverages (SSBs)[4,7]. Factors such as food insecurity, limited knowledge of nutrition, aggressive marketing by transnational food corporations, and a lack of safe spaces for physical activity create an obesogenic environment that disproportionately affects the poor[5,8]. The consequences are severe, with childhood obesity being a primary risk factor for the early onset of non-communicable diseases (NCDs) like type 2 diabetes, hypertension, and dyslipidemia, which are already reaching epidemic proportions in the Pakistani adult population[9,10].

In this challenging landscape, schools emerge as a critical and strategic setting for public health intervention[11,12]. With over 40 million children enrolled in primary and secondary education, schools represent a captive audience where lifelong dietary habits are formed. Children consume a significant portion of their daily caloric intake at school, sourced from school canteens, tuck shops, and nearby street vendors[7,13]. Recognizing this potential, Pakistan's Ministry of National Health Services, Regulations and Coordination launched the School Health and Nutrition (SHN) Strategy in 2018, which includes guidelines for healthy school canteens[12]. These guidelines recommend restricting the sale of SSBs, deep-fried snacks, and high-sugar confectionaries, while promoting the availability of fruits, vegetables, and healthy snacks.

However, the existence of a national strategy on paper and its effective implementation on the ground are two vastly different realities[14,15]. The potential of the SHN Strategy to curb the rising tide of childhood obesity hinges entirely on two critical factors: consistent policy compliance and its demonstrable long-term health impact. Schools in low-income communities face formidable barriers to implementation, including

a lack of monitoring, insufficient funding, inadequate infrastructure (e.g., no clean water or refrigeration), and pressure from vendors whose profitability relies on selling popular, unhealthy items[14,7].

This study seeks to address a critical gap in the public health literature of Pakistan. While the problem of childhood obesity is increasingly recognized [3], there is a scarcity of longitudinal, empirical data linking school nutrition policy compliance to concrete health outcomes[15]. This research aims to investigate the real-world effectiveness of the SHN Strategy by assessing both the degree of policy adherence in a sample of low-income schools in Karachi and its association with long-term changes in students' weight status and metabolic health. The findings will provide crucial evidence to policymakers, educators, and public health stakeholders on the viability of school-based nutrition policies as a cornerstone for obesity prevention and the promotion of health equity in Pakistan.

METHODOLOGY

Study Setting and Design
This investigation employed a mixed-methods, longitudinal cohort design conducted over a three-year period (January 2022 - December 2024). The study was set in 12 randomly selected private and public primary schools across three low-income administrative towns (District Central, District East, and Korangi) in Karachi, Pakistan. These schools were purposively selected to serve communities with a similar socio-economic profile, as defined by the Pakistan Bureau of Statistics.

Study Participants and Sampling
The participant cohort consisted of children who were in Grade 1 at the baseline of the study (2020). A multistage cluster sampling technique was used. First, the 12 schools were selected as clusters. Second, from each school, two sections of Grade 1 were randomly selected, and all children from those sections were invited to participate.

Inclusion Criteria:
- Children aged 5-7 years, enrolled in Grade 1 at a participating school

- Parents provided written informed consent

Exclusion Criteria:
- Pre-existing medical conditions affecting growth or weight (e.g., thyroid disorders, type 1 diabetes)
- Long-term corticosteroid therapy
- Physical disabilities limiting mobility

At baseline, 612 children were enrolled. After accounting for attrition due to family migration, school transfers, and absenteeism during data collection cycles, a total of 528 children (86.3% retention rate) completed the three-year follow-up and were included in the final analysis.

Data Collection
Data collection occurred at three time points: Baseline (T1: Jan-Feb 2020), Mid-line (T2: Jan-Feb 2021), and End-line (T3: Jan-Feb 2022).

1. **Policy Compliance Assessment**
   A validated School Canteen Compliance Tool (SCCT), adapted from WHO SEAN-IT tools for the Pakistani context[12], was used. Trained data collectors conducted unannounced audits at each school biannually. The tool assessed: availability (presence of prohibited and promoted items), accessibility (prominence of display for healthy vs. unhealthy items), and affordability (price comparison of key items). Schools were scored on a 100-point scale. Schools scoring ≥75 were classified as "High Compliance," 50-74 as "Moderate Compliance," and <50 as "Low Compliance."

2. **Anthropometric Measurements**
   Height and weight were measured by trained researchers using standardized protocols and calibrated equipment (Seca stadiometers and digital scales). BMI was calculated as weight (kg) / height (m²). Age- and sex-specific BMI z-scores were determined using the WHO Growth Reference for children16. Weight status was categorized as underweight, normal weight, overweight, or obese based on WHO cut-offs.

3. **Dietary Intake**
   A simplified, pictorial Food Frequency Questionnaire (FFQ) focused on key food groups of interest (SSBs, fried snacks, fruits, vegetables) was administered to a subsample of children (n=150) and their parents to assess habitual consumption.

4. **Qualitative Data**
   Semi-structured interviews were conducted with school principals (n=12), canteen operators (n=12), and parents (n=30) to explore barriers and facilitators to policy implementation.

Data Analysis
Quantitative data were analyzed using SPSS version 26. Descriptive statistics (frequencies, means, standard deviations) were used to summarize the data. A repeated-measures ANOVA was conducted to examine changes in mean BMI z-scores over time between compliance groups. Chi-square tests were used to compare the prevalence of overweight/obesity across groups at different time points. Multilevel mixed-effects linear regression models were employed to account for the clustering of children within schools and to identify predictors of BMI z-score change, controlling for covariates like gender, parental education, and physical activity. Qualitative interviews were transcribed verbatim and analyzed using thematic analysis.

RESULTS

Of the 12 schools, only two (16.7%) consistently maintained a "High Compliance" status throughout the study period. Five schools (41.7%) were categorized as "Moderate Compliance," and the remaining five (41.7%) were in the "Low Compliance" category. The primary barriers identified from qualitative interviews were financial pressure on canteens, student preference for unhealthy foods, and a lack of enforcement from education authorities [14, 7].

Table1 School Canteen Compliance and Student Demographics at Baseline (T1, 2020)

Compliance Group	No. of Students	Mean Age (years)	Male %	Female %	Mean Baseline BMI z-score
High Compliance (n=2)	88	5.9 ± 0.8	52.3%	47.7%	0.45 ± 1.12
Moderate Compliance (n=5)	220	6.0 ± 0.7	48.6%	51.4%	0.62 ± 1.24
Low Compliance (n=5)	220	5.9 ± 0.9	50.9%	49.1%	0.59 ± 1.31
Total	**528**	**5.9 ± 0.8**	**50.2%**	**49.8%**	**0.58 ± 1.25**

The longitudinal analysis of BMI z-scores revealed a significant interaction between time and school compliance group ($p < 0.01$).

The prevalence of combined overweight and obesity showed a divergent trend. In High Compliance schools, the prevalence remained

Table-2 Longitudinal Change in Mean BMI z-score by School Compliance Group

Compliance Group	Baseline (T1) Mean ± SD	Mid-line (T2) Mean ± SD	End-line (T3) Mean ± SD	Change T1 to T3
High Compliance	0.45 ± 1.12	0.41 ± 1.08	0.38 ± 1.05	**-0.07**
Moderate Compliance	0.62 ± 1.24	0.67 ± 1.28	0.73 ± 1.32	**+0.11**
Low Compliance	0.59 ± 1.31	0.65 ± 1.35	0.78 ± 1.40	**+0.19**

stable (18.2% to 17.0%). In contrast, it increased from 21.4% to 26.4% in Moderate Compliance

schools and from 20.5% to 29.1% in Low Compliance schools ($p < 0.05$ for trend).

Table-3 Prevalence of Overweight and Obesity (%) by Compliance Group Over Time

Compliance Group	Baseline (T1)	Mid-line (T2)	End-line (T3)
High Compliance	18.2%	17.0%	**17.0%**
Moderate Compliance	21.4%	23.2%	**26.4%**
Low Compliance	20.5%	24.1%	**29.1%**

The mixed-effects regression model confirmed that being in a High Compliance school was a significant negative predictor of an increase in BMI z-score ($\beta = -0.15$, $p = 0.008$), even after adjusting for socio-demographic factors.

DISCUSSION

This three-year longitudinal study provides some of the first compelling evidence from Pakistan on the critical role of school nutrition policy

compliance in moderating the trajectory of childhood obesity in low-income settings[15]. The central finding is clear: the mere existence of a national School Health and Nutrition Strategy is insufficient. Its power to alter public health outcomes is entirely dependent on the degree of its faithful implementation at the school level[14, 13].

Our results demonstrate a dose-response relationship between policy compliance and

weight status. Children in schools with high compliance not only avoided the significant increase in BMI z-score observed in other groups but showed a slight, non-significant improvement. This suggests that a consistently healthy school food environment can act as a protective buffer against the obesogenic pressures of the wider community. The stability in the prevalence of overweight/obesity in these schools, in stark contrast to the rising trends in less compliant schools, underscores the potential of well-enforced policies as a primary prevention tool. These findings align with studies from other low- and middle-income countries (LMICs) facing similar nutrition transitions, which have found that school-based interventions focusing on the food environment are more effective than those focusing solely on education[11, 17].

The qualitative data from this study illuminate the "why" behind the compliance gap. The primary barriers—financial viability, student demand, and lack of enforcement—are interlinked. Canteen operators in low-compliance schools reported that healthy foods like fruit have a shorter shelf life and are less profitable than packaged snacks, a concern echoed in other studies from the region[14,7]. Furthermore, without strong school leadership and district-level monitoring, there is little incentive for vendors to adhere to guidelines, especially when students can easily access unhealthy alternatives from nearby shops. This highlights a fundamental challenge: the policy operates in a vacuum unless it is supported by a robust system of accountability and economic incentives.

The rising BMI z-scores in moderate and low-compliance schools are a cause for serious concern and reflect the powerful influence of the broader food environment. These schools effectively function as microcosms of the unregulated external market, normalizing the daily consumption of ultra-processed foods [5, 8]. This continuous exposure likely undermines parental efforts at home and accelerates the adoption of unhealthy dietary preferences, contributing to the observed upward trend in obesity prevalence.

Strengths and Limitations

A key strength of this study is its longitudinal design, which allows for the observation of trends over a critical period of child development[3]. The mixed-methods approach provided both quantitative outcomes and rich contextual data to explain them. The focus on low-income communities in a mega-city like Karachi fills a significant gap in the literature. However, limitations must be acknowledged. The study was conducted in one city, which may limit the generalizability to rural or other urban contexts in Pakistan. While we controlled for several confounders, residual confounding from unmeasured factors at the household level (e.g., detailed parental income, dietary practices at home) is possible. The reliance on BMI as the primary outcome, while standard, does not capture changes in body composition or metabolic health parameters like blood glucose or lipid profiles[10].

Recommendations

Based on our findings, we propose a multi-level set of recommendations to translate policy into effective practice. For federal and provincial policymakers, it is imperative to move from voluntary guidelines to mandatory regulations, giving the SHN Strategy the legal weight needed for enforcement. This must be coupled with the establishment of a simple, digital monitoring framework for district-level officers to conduct regular audits and the introduction of economic incentives, such as subsidizing healthy foods or providing small grants to high-performing schools, to make compliance financially viable.

At the school level, administration and principals must demonstrate strong leadership by taking ownership of the nutrition policy and integrating it into the school's core values, actively engaging Parent-Teacher Associations for grassroots support. Schools should proactively brand healthy choices through student committees and fun activities, rebranding their canteens as "Healthy Tuck Shops" to create a positive social norm. Furthermore, the policy's scope should be expanded in collaboration with local authorities to regulate all food sources, including packed lunches and the vendors operating immediately outside school gates, ensuring a consistent food environment.

To build upon this research, future studies should conduct cost-effectiveness analyses of different implementation models to guide scalable solutions. Researchers should also investigate the synergistic impact of combining environmental changes with a formal nutrition education curriculum. Finally, expanding this line of inquiry to include adolescents in secondary schools and to the diverse contexts of rural Pakistan is crucial for developing a comprehensive national response.

CONCLUSION

This study demonstrates that robust compliance with school nutrition standards can effectively mitigate the rise of childhood obesity in Pakistan's low-income communities. The school food environment is not a peripheral issue but a central determinant of child health. Navigating the double burden of malnutrition requires a steadfast commitment to creating healthy food environments for all children. Ensuring that schools are a safe haven from the relentless tide of unhealthy food is not just a policy option—it is a public health and moral imperative for the future of Pakistan.

Author Contributions
Shahzad Rauf conceptualized the study and supervised the research process. **Waseem Ahmed** contributed to study design and data analysis. **Umama Lakhani** assisted in data collection and literature review. **Hira Aamir** contributed to manuscript drafting and data interpretation. **Muhammad Hammad Mursaleen** supported statistical analysis and results formatting. **Nusrat Naseem** critically reviewed the manuscript and provided final approval of the version to be published.

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