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Original Article

Urban vs Rural Disparities in Micronutrient Deficiency Among School Children

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ABSTRACT

Introduction: Micronutrient deficiencies and a diversity of diet are important nutritional issues among school age children. Geographic disparities might play a role in the heterogeneity of nutritional status among children in various geographic locations. Objective: To compare selected micronutrient profiles, dietary diversity and growth measurements among rural and urban school-aged children and test for their cross sectional associations. Design: Comparative cross sectional study was conducted among 100 school age children, aged 6-12 years, from Attock, Northern Punjab. Fifty children each from rural and urban community. Serum ferritin, serum retinol, urinary iodine (UI) concentration, Individual Dietary Diversity Score (IDDS), Height for age z-score (HAZ) and BMI for age z-score (BAZ) were determined. Data analysis of these measures between the groups was carried out using t-test and chi-square and correlation among these measures using Pearson correlation. Results: Rural children had significantly lower mean values of ferritin (18.4±6.2 versus 29.1±8.5 g/L), retinol (0.82±0.21 versus 1.15±0.28mol/L), UI concentration(108.5±28.4 versus142.3±31.6g/L)and IDDS(3.6±0.9 versus 5.8±1.2; P <0.001 for all). Iron deficiency was more common among the children of rural community (38.0%) than in those of the urban community (14.0%; RR 2.71, 95%CI 1.25-5.88) and same was the case for vitamin A deficiency (32.0% vs. 10.0%; RR 3.20, 95%CI 1.27-8.07). Rural children had poorer stature and weight as against the urban children based on HAZ and BAZ measurements. The correlations of IDDS with ferritin, retinol, UI, HAZ and BAZ were all positive. Conclusion: Rural school children had poorer micronutrient biomarkers, dietary diversity and physical development compared with urban counterparts with an evidence of association of diversity measures with micronutrient biomarkers and physical measurements. Keywords: Micronutrient, Diversity, Iron Deficiency, Vitamin A Deficiency, Urinary Iodine, School Age Children, rural and urban health.

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INTRODUCTION

The problem of the multiple burden of malnutrition is of particular concern among school-aged children and adolescents in many of the low- and middle-income countries of the world and continues to include micronutrient deficiencies as a component. In South Asia, challenges throughout the school years, from undereat to micronutrient deficiencies with stunting or thinness to high risks of overweight or diet-related imbalanced nutritional status, are apparent. However, the evidence for the impacts and inter-ventions of micronutrient deficiencies in children aged 5-19 years are in fragments across countries and populations (1).

New evidence from the Indian subcontinent multicenter study highlighted the persistent prevalence of iron or several vitamins/minerals deficiency even among the urban school children, confirming that attending to school does not guarantee adequate micronutrient status just like being a city dweller (2).

Population level evidence of school-aged Indonesia show that micronutrient deficiencies exist concurrently with stunting, thinness, other anthropometric anomalies (3). Deficiencies of Iron, Vitamin A and Iodine become paramount during the childhood years since healthy micronutrient status is critical to support normal physiological growth and development. These may also exist along with anthropometric and nutritional impairment, often without clinical diagnosis. Several recent evidence in school age population shows measurable deficiencies in micronutrients like iron or Vitamin A and statistically significant association between micronutrient biomarkers and other anthropometric measures that support assessment of nutritionally at risk population by biochemical measure, which cannot be detected by anthropometry only (2,3). Measuring micronutrientstatusalongwithgrowthislikelytoserveasa better assessment of the nutritional well-being of school-aged population than either one alone.

The local geographic and socioeconomic context can have significant impacts on children's access to diversified, nutritionally sound diets. While cities may offer wider access to markets, dairy products, foods of animal origin, fortified foods and health services, they can also be characterised by severe socioeconomic inequality and increased access to energy-dense and nutrient-poor diets. Rural Households encounter their own constraints, including availability, affordability, seasonality, and access to various nutrient-dense foods.

A recent analysis modelling the dietary intake of school children in the provinces of Sindh and Punjab, Pakistan found some gaps in iron, vitamin A and other micronutrients in school age children (4) and highlighted how the quality of diet in these age ranges remains relevant.

The data also show that in a mixed urban rural setting in the South Asia Region diversity in diet quality and anthropometric outcomes appear to correlate to Geographic and socioeconomic contexts (5). Dietary diversity has been accepted in general terms to a widely accessible population level indicator and an index of quality and micronutrient adequacy . This has been validated in multicounty analysis which concluded food group diversity is a good proxy ofmicronutrient adequacy in low and middle-income country children and adolescence (6), In India food diversity score and variety score shows a correlation between the nutritional and health outcomes (7), multicentre biological study shows that there are certain micronutrients where inadequacy of diet and corresponding deficiencies are observed among school aged children (8). It implies that if you study nutritional inequality it is useful to study diet quality both using variety score as well as biological measurements.

Notwithstanding this growing literature base, the school-aged population in South Asia has been relatively neglected in research studies on nutrition and often the available studies either focus on anthropometry or dietary intake or on individual micronutrients as separated items, rather than as interlinked components in urban and rural communities (1). Thus, evidence combining urinary iodine concentration, biochemical micronutrient status, diversity of diet and measures of growth in the same age group of schoolchildren is important to determine possible patterns of nutritional disadvantage by geography. To this purpose this comparative cross-sectional study compared serum ferritin, urinary iodine, serum retinol, dietary diversity and growth outcomes among the male and female urban and rural schoolchildren of age group 6-12 years resident of Attock Northern Punjab and it was to assess cross-sectional relationships of diet diversity and of micronutrient biochemical markers with their ht/age and BMi/age z scores.

MATERIALS AND METHODS

This comparative cross-sectional study was carried out in Attock district, Northern Punjab, Pakistan from August to November 2005. Children of 6 to 12 years from urban and rural primary schools were recruited by means of multistage random sampling. A multistage random sampling approach was used to recruit children of 6 to 12 years from various urban areas and rural villages who were apparently healthy children attending selected schools were recruited.

Selection criteria included: children should be apparently healthy school-attending children of 6 to 12 years of age who had their primary caregivers give the written informed consent and the child was able to give the assent for participation.

Exclusion criteria were: children who had any known chronic illness, any acute systemic infection in the two weeks preceding study, severe skeletal deformities hindering the anthropometric evaluation and any child who was on therapeutic micronutrient supplement at the moment in time. Out of 110 eligible children screened, 100 completed the clinical, biochemical, dietary and anthropometric assessments and were used as the complete-case analytic sample, consisting of 50 children each in the urban and rural cohort. Biochemical assessment ofironstatus The biological measurements include markers of iron and vitamin A status and iodine status. Blood sample was collected by expert technicians under aseptic conditions with the use of venous sampling technique by means of a disposable needle and syringe.

We measured serum ferritin by an ELISA method to estimate body stores of iron and we measured serum retinol by the use of the High-Performance Liquid Chromatography technique.

Iron deficiency was operationally defined for the purpose of this study as a serum concentration <15 g/L. Vitamin A deficiency was operationally defined for the purpose of this study as a serum concentration <0.70 mol/L. C-reactive protein, (1-acid glycoprotein) which is a systemic inflammation biomarker were not measured in this study.

Feritin and serum retinol levels were analyzed without adjusting for any systemicinflammation. This would lead to potentially misleading estimates, primarily for iron status; indeed, in the presence of a systemic inflammatory response, the level ofcirculatingferritin increases and is therefore potentially a poor reflection of iron store. Contemporary recommendations note that any report of the population's total body stores in iron from the assessment of circulating ferritin is only appropriate if the population is known not to be inflamed or if adequate measure are taken to adjust to accommodate theinflammatory state (9,10).

We determined urinary iodine concentration (UIC) in the morning spot-urine and we measure iodin by ammonium persulfate digestion.

The UIC variable was treated as continuous for this comparative study and then used as an indicator for the iodine status estimation in place of measuring individual definition based on a single specimen UIC (11,12).

Dietary consumption was assessed using a 24-hour dietary recall protocol, based on the Food and Agriculture Organization system. The individual dietary diversity score (IDDS) was computed by sum the scores of pre-defined food group items consumed in the previous 24-hours, wherein higher scores correspond to higher food groups diversity; it serves as a widely utilized as an indicator of dietary quality, and as a proxy for micronutrientadequacy at the population level in children and adolescents (6,13). Anthropometric measurements in terms of Height and Body Weight were measured by Seca stadiometers and weighing scalerespectivelyand height-for-age z-score (HAZ) and body-mass-index-for-age z-score (BAZ) was calculated by the World Health Organization (WHO) growth reference on the data for children 5-19 years of age (14).

Data were analyzed using IBM SPSS Statistics version 26.0. Shapiro- Wilk test was applied to check normality assumptions of all continuous variables. Variables which was normally distributed were described as mean and standard deviation, while categorical variables were given in frequencies and proportions. Comparison of urban and rural subject on continuously assessed measures (biochemical, dietary and anthopometric indicators) was done with two independent samples of students't-test. The Iron and Vitamin A deficiency classifications, between rural and urban sub-groups, were tested by Chi-square tests of independence. Pearson correlation coefficients were computed to evaluate the unadjusted associations between IDDS andmicronutrientbiomarkers, HAZ and BAZ. These coefficients were examined as a cross-sectional association and should not be considered as reflecting cause and effect relationships. All tests were two-tailed, and p values <0.05 was considered significant. Analyses used anthropometric, clinic, bio-chemical, and dietary data for the 100 subjects who provided complete assessments. Institutional ethical approval was granted for the study and written informed consent was obtained from primary caregivers and children prior to their participation in this study.

RESULTS

Overall. Of 110 eligible school children screened, 100 completed clinical, biochemical, dietary, and anthropometric assessments, giving an overall completion rate of 90.9%. The analytic study sample included 50 children each from an urban and rural area.

The overall mean age of children was 9.1 1.8 y; 52% were boys (52.0%), and 48% were girls (48.0%).

Age and sex composition were not significantly different between the urban and rural children. Urban children were taller and more heavier than children in the rural groups. HAZ and BAZ z-scores were higher in the urban group (Table 1) with differences of 0.66 and 0.32, respectively (0.35-0.97 and 0.32-1.00) [HAZ, BAZ], but these did not reach the stringent Bonferroni-corrected significance level, adjusted for 3 primary outcomes (0.05/3). Micrountrient concentrations by place of residence.

Micronutrient concentrations were substantially higher in the urban population than in the rural population (Table 2).

The mean level of serum ferritin for urban children (29.1 8.5 g/L) was almost twice that for rural children (18.4 6.2 g/L; 10.70; 95% CI 7.74-13.66;p<0.001). Similarly, urban children had 0.33 mol/L higher levels of serum retinol (95% CI 0.23-0.43;p<0.001). The geometric mean urinary iodine concentrations for the urban (142.3 31.6 g/L) and rural groups (108.5 28.4 g/L) differed by 33.80 g/L (95% CI 21.87-45.73;p<0.001).

Among both groups 14% of the urban and 38% of the rural children had evidence of iron deficiency anemia [2.71 (1.25-5.88); p=0.006], and while 10% of urban children had signs of vitamin A deficiency, a quarter did so among children in the rural school group [3.20 (1.27-8.07); p=0.007].

Table 1. Demographic and Anthropometric Characteristics of Participants

Variable	Total Sample (N=100)	Urban (n=50)	Rural (n=50)	Urban–Rural Difference (95% CI)	Hedges g	p-value
Age, years	9.1 ± 1.8	9.2 ± 1.7	9.0 ± 1.9	0.20 (−0.52 to 0.92)	0.11	0.582
Male sex, n (%)	52 (52.0)	27 (54.0)	25 (50.0)	—	—	0.687
Female sex, n (%)	48 (48.0)	23 (46.0)	25 (50.0)	—	—	—
Height, cm	128.4 ± 11.2	131.2 ± 10.5	125.6 ± 11.3	5.60 (1.27 to 9.93)	0.51	0.012
Weight, kg	26.8 ± 6.4	29.1 ± 6.2	24.5 ± 5.8	4.60 (2.22 to 6.98)	0.76	<0.001
HAZ	−0.91 ± 0.85	−0.58 ± 0.74	−1.24 ± 0.81	0.66 (0.35 to 0.97)	0.84	<0.001
BAZ	−0.65 ± 0.91	−0.32 ± 0.82	−0.98 ± 0.88	0.66 (0.32 to 1.00)	0.77	<0.001

Values are mean ± SD unless otherwise indicated. Mean differences are calculated as urban minus rural. HAZ, height-for-age z-score; BAZ, BMI-for-age z-score. Hedges g represents the standardized mean difference.

Table 2. Micronutrient Status According to Urban and Rural Residence

Micronutrient Measure	Total Sample (N=100)	Urban (n=50)	Rural (n=50)	Effect Estimate (95% CI)	Hedges g	p-value
Serum ferritin, µg/L	23.7 ± 9.1	29.1 ± 8.5	18.4 ± 6.2	MD 10.70 (7.74 to 13.66)	1.43	<0.001
Iron deficiency, n (%)	26 (26.0)	7 (14.0)	19 (38.0)	RR 2.71 (1.25 to 5.88)	—	0.006
Serum retinol, µmol/L	0.98 ± 0.29	1.15 ± 0.28	0.82 ± 0.21	MD 0.33 (0.23 to 0.43)	1.32	<0.001
Vitamin A deficiency, n (%)	21 (21.0)	5 (10.0)	16 (32.0)	RR 3.20 (1.27 to 8.07)	—	0.007
Urinary iodine concentration, µg/L	125.4 ± 34.2	142.3 ± 31.6	108.5 ± 28.4	MD 33.80 (21.87 to 45.73)	1.12	<0.001

Continuous variables are mean ± SD. MD represents the urban-minus-rural mean difference. RR represents risk in rural children relative to urban children. Iron deficiency was defined as serum ferritin <15 µg/L and vitamin A deficiency as serum retinol <0.70 µmol/L. Individual iodine-deficiency classification is not presented because urinary iodine concentration from a single spot specimen is retained as a continuous population-level biomarker.

Dietary diversity also differed markedly between groups. Mean IDDS was 5.8 ± 1.2 among urban children compared with 3.6 ± 0.9 among rural children, yielding a mean difference of 2.20 points (95% CI 1.78–2.62; p<0.001) and a large standardized group difference (Hedges g=2.06). Consumption of staple foods was universal in both groups. Urban children more frequently consumed dairy products, flesh foods, eggs, vitamin A-rich fruits or vegetables, and other fruits. Differences in pulses/legumes/nuts and other vegetable consumption were smaller and were not statistically significant (Table 3).

Table 3. Dietary Diversity and Reported Food-Group Consumption

Dietary Measure	Urban (n=50)	Rural (n=50)	Urban–Rural Difference	p-value
Mean IDDS, mean ± SD	5.8 ± 1.2	3.6 ± 0.9	2.20 (95% CI 1.78 to 2.62)	<0.001
Staples (cereals/tubers), n (%)	50 (100.0)	50 (100.0)	0 percentage points	1.000
Pulses/legumes/nuts, n (%)	38 (76.0)	31 (62.0)	14 percentage points	0.134
Dairy products, n (%)	42 (84.0)	22 (44.0)	40 percentage points	<0.001
Flesh foods, n (%)	31 (62.0)	8 (16.0)	46 percentage points	<0.001
Eggs, n (%)	29 (58.0)	11 (22.0)	36 percentage points	<0.001
Vitamin A-rich fruits/vegetables, n (%)	33 (66.0)	14 (28.0)	38 percentage points	<0.001
Other vegetables, n (%)	41 (82.0)	35 (70.0)	12 percentage points	0.161
Other fruits, n (%)	26 (52.0)	9 (18.0)	34 percentage points	<0.001

IDDS, Individual Dietary Diversity Score. The maximum possible score for the IDDS is not mentioned, as the component level outcomes provided include eight clearly stated dietary food groups, though an initial description of the methodology mentions nine dietary food groups. Percent point differences (urban - rural).

Preliminary unadjusted Pearson correlation results showed a positive association between dietary diversity, micronutrient outcome measures and measures of growth (IDDS showed an association with serum ferritin (r=0.58), serum retinol (r=0.62), urinary iodine concentration (r=0.44) HAZ (r=0.49) and BAZ (r=0.41), all p-values <0.001).

Serum retinol and serum ferritin showed associations with HAZ and BAZ respectively. This will lead to the estimation of a relationship between HAZ and BAZ (r=0.63). These represent unadjusted association with all participants and do not imply that the results were independent of Urban rural disparities or the effect of other variables.

Table 4. Unadjusted Pearson Correlations Between Dietary Diversity, Micronutrient Biomarkers, and Growth Indicators

Variable Pair	r	95% CI	p-value
IDDS – Serum ferritin	0.58	0.43 to 0.70	<0.001
IDDS – Serum retinol	0.62	0.48 to 0.73	<0.001
IDDS – Urinary iodine concentration	0.44	0.27 to 0.59	<0.001
IDDS – HAZ	0.49	0.33 to 0.63	<0.001
IDDS – BAZ	0.41	0.23 to 0.56	<0.001
Serum ferritin – Serum retinol	0.51	0.35 to 0.64	<0.001
Serum ferritin – Urinary iodine concentration	0.38	0.20 to 0.54	<0.001
Serum ferritin – HAZ	0.45	0.28 to 0.59	<0.001
Serum ferritin – BAZ	0.39	0.21 to 0.55	<0.001
Serum retinol – Urinary iodine concentration	0.42	0.24 to 0.57	<0.001
Serum retinol – HAZ	0.52	0.36 to 0.65	<0.001
Serum retinol – BAZ	0.46	0.29 to 0.60	<0.001
Urinary iodine concentration – HAZ	0.35	0.17 to 0.51	<0.001
Urinary iodine concentration – BAZ	0.28	0.09 to 0.45	0.005
HAZ – BAZ	0.63	0.50 to 0.74	<0.001

Pearson correlations are based on the complete analytic sample (N=100). Confidence intervals and p-values were derived from the reported correlation coefficients and sample size. These are unadjusted associations. IDDS, Individual Dietary Diversity Score; HAZ, height-for-age z-score; BAZ, BMI-for-age z-score.

DISCUSSION

A striking gradient in status of micronutrients, variety of diet and anthropometric parameters between urban and rural among school-going children 6-12 years was found in Attock in a comparable cross-sectional study. The comparison urban and rural showed lower serum ferritin, serum retinol, urinary iodine concentration, IDDS, HAZ and BAZ among rural group. Proportion of children with iron deficiency and vitamin A deficiency was also higher in rural school children and urban/rural relative risks (for Iron & Vitamin A deficiencies) were 2.71 & 3.20 respectively. While in both situations differences were relatively large in quantitative comparison for ferritin, retinol, urinary iodine, dietary diversity. Within entire group Dietary Diversity Score correlated with every micronutrient indicator including both HAZ & BAZ positively. Such study revealed a clear pattern of geographic nutrition based inequality but did not ascertain if being rural

and variety of diet caused these differences in biochemical measurements or physical stature since it was a cross-section study and unadjusted differences.

Results of micronutrient status comparison are broadly in line with available evidence showing that medically important micronutrient deficiencies prevail among school-going children worldwide in middle- and low income settings. Substantial Iron & other micronutrient deficiencies were found even among school going children even with in urban context. They also did not show that rural-urban living makes children free of micronutrient deficiencies as reported by a multicentre study of Indian school going children (2). In Indonesia population based cross-section study children aged 5-12 were studied, it was shown stunting and thinness were prominent in study population along with micronutrient deficiencies and positive correlation with micronutrient status indicators like serum ferritin and biochemical variables with anthropometry indicators (3). Some studies from Asian regions also found high prevalence of vitamin A and iron deficiency and malnutrition (15) showing relation with certain groups. Findings also match a recognized pattern of nutritional deficiency in school age groups at different geographical location & socio-economic group may be worse in more vulnerable part of this geography/society. Whereas results for urban school group does not imply perfect status among others (2).

Among all measures, dietary diversity showed among the largest between-group differences with an urban-rural mean IDDS of 2.20 difference units. Dairy, flesh food, egg, vitamin A-rich fruit or vegetable, and other fruit consumption were all more common in the urban context while the eating of staples was universal. Recent data suggest that population level measures of dietary diversity may be a valid proxy for children's and adolescent's micronutrient status, although are not a measure of biochemical nutrient status (6). Relationships between dietary diversity and food variety were shown to exist in the context of nutritional status in multicenter Indian data (7) and there was an association between nutritionally inadequate food intake and biochemical deficiency in numerous micronutrients (adjusting for demography) (8). Low dietary diversity was also found to be present in rural adolescents and with positive associations between number of foods in each score and micronutrient intake (17). These factors would suggest a reasonable nutritional explanation of the positive correlations between IDDS and ferritin, retinol, Urinary Iodine concentration, HAZ and BAZ found in this work; however, there was likely overlap in between-group differences versus the relationship between dietary diversity as it relates to other factors since it was analyzed in pooled data without multivariable adjustment.

The relationship between residence and dietary quality differs according to population and is not uniformly urban best. Costa Rican adolescents reported greater dietary diversity from rural, non-urban samples (16). This means that residence (urban or rural) is not always associated with better diet quality and in fact local food supply and other socioeconomic circumstances play roles in determining geographic dietary quality. This is an important point in interpreting the study from Attock; this study measured what food items were eaten but not the effect of other influences such as household income, expenditure, market access, education of parents and whether or not there was any food insecurity within the household along with a number of other relevant socioeconomic variables that would confound rural best. It appears in Attock that residence matters in determining the nutrition variables studied and that there seems to be a rural disadvantage but that residence alone is not the sole underlying causal element.

Compared to urban children, the mean group difference inUIC for children living in rural areas was -33.80g/L. While there was a group-level difference in measured exposure, this finding should be evaluated independently from the definition of iron and Vitamin A deficiency. One spot UIC has significant intra-individual variability and it is conventionally utilized for general classification of individual iodine status at the population level by considering the distribution and median rather than classifying an individual child as iodine deficient (11). Other cross-sectional school-age studies utilizing urine to investigate Iodine status do so primarily using the median UIC and distributions across samples as indications of population group status (12). Similarly, our corrected analysis does not diagnose an individual child as iodine deficient based on one UIC. Since summarized data at a group level are given as means, not medians with IQR for UIC in either group, an argument for population diagnosis at group level could be made since there is a between-

group difference in UIC, but cannot declare which group is more or less deficient in meeting WHO standards with available summary data.

A further dimension, anthropometry, exists in the biochemical and dietary differences found between rural and urban children in terms of HAZ, and BAZ differences which appear to exist between rural and urban groups (0.66 z-score units for each). In addition, both the differences in HAZ and BAZ scores were correlated positively with both ferritin and retinol concentration and suggest a nutritional phenotype relationship across our sampled population. Relationships such as that between biochemical markers of micronutrient status and nutrition phenotype were reported for school-age populations with children living in Indonesian shown to have lower concentrations of most nutritional biomarkers in children whose nutritional status was worse, and some biochemical markers correlated weakly but significantly with measures of nutrition status (3). Stunting of Iron deficient anemiac school children was found correlated with the presence of Iron deficiency anemia in adjusted models in Malaysian study conducted among rural school children who appeared to have low concentrations of several nutritional biomarkers with nutritional deficiency associated with lower concentrations of these markers (15). The observed individual correlations in our study were stronger, perhaps reflecting simultaneous correlations at the individual level along with overall grouping of groups. We should still only interpret these as unadjusted associations; any interpretation indicating individual micronutrient deficits causes impaired growth cannot be made from data we used and is based on cross-sectional data.

Several methodological strengths add value to the study. Both urban and rural children were examined within the same school system and within the same time period, and biochemical, dietary, and anthropometric information were collected from these children within each category. Serum ferritin and retinol offered objective measures of selected micronutrient status, UIC informed us about iodine exposure, dietary diversity was measured using information on the range of food groups, and HAZ and BAZ were derived using standard reference values from the WHO school-aged population.

Similar number of children were present in each category which allowed for simple urban-rural comparisons, and the principal continuously varying outcomes were presented with effect estimates and 95% confidence intervals rather than solely from p-values.

It must be taken into account that the cross-sectional nature of the study does not allow for assessment of temporal order and causality, but rather of association. In addition to, the study population was represented by one district only in Punjab and thus does not allow for generalizability at the national and international level. The determination of dietary data was based on a 24 hour recall only, therefore the estimates may not accurately reflect year round and daily fluctuations in dietary patterns. Vitamin A, iron and zinc was measured without any markers for inflammation such as CRP or 1 acid glycoprotein, however this inflammatory response may alter the level of the nutritional biochemical markers measured (9,10).

Furthermore, when calculating UIC in the present study only a single spot urine concentration, rather than median distributions were applied to both urban and rural population which are used at a population level (11,12).

The correlations were made without adjusting for residency, socio-economic, age, or any other potential confounders and that for in absence of the correlation with respect to residency, children were selected from the schools based on a complex sampling strategy which was taken in the description of data analysis however, no correlation of within-school variation with the determined parameters was done in the study that may result in underestimation of estimation errors due to conventional statistical standard errors. Therefore, the interpretation of these findings should be done with caution as regard to their extent of effect and the generality to the whole population. Despite of all above limitations the study demonstrated the benefits of integrated survey and intervention monitoring approach when analysing the anthropometry, dietary intake, and biochemical indices of school aged children.

School-aged children and adolescents in South Asia continue to suffer from disparate manifestations of undernutrition, micronutrient deficiency and of poor quality diet while the promotion of the school meal

program, nutrition education, fortification and supplementation programs have shown promising impact in some context (1). Given the findings, it is proposed for Attock region to conduct a rigorous study to find out the factors responsible behind this observed phenomenon in such regions and for future intervention design.

CONCLUSION

School children from rural Attock experienced higher serum ferritin, serum retinol, urinary iodine concentration, dietary diversity, HAZ and BAZ in comparison to children from urban Attock. Iron and vitamin a deficiency were more prevalent among rural based school children. Dietary diversity and micronutrient status biomarkers were found to have a positive association with the growth parameters onpooled sample although unadjusted andcross sectional analyses. In summary, the data showed clearly a geographic differencein nutritional deprivation and it highlights need for improved study ofdietary quality and biochemical micronutrient status as well as growth parameters among school-aged children, especially in the rural areas.

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