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Maternal Knowledge and Practices Regarding Iodized Salt and Their Association with Nutritional Status and Cognitive Performance of School-Going Pre-Adolescent Children (6–12 Years) in Tehsil Katlang, Khyber Pakhtunkhwa, Pakistan

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Research Article

Keywords: Iodine deficiency disorder, Iodized salt, Maternal knowledge and practice, Height-for-age Z-score, and Cognitive performance

Posted Date: August 10th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10506433/v1

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Additional Declarations: No competing interests reported.

Abstract

Background: Iodine deficiency disorder (IDD) is still a public-health problem in developing countries, and children in school are particularly vulnerable, since thyroid hormones play a key role in the neuro-cognitive development. Intake of iodine is determined by household knowledge and practice, but few studies have been done on the relation between these factors and children's cognitive outcomes in rural Khyber Pakhtunkhwa (KP), Pakistan. In this study, the degree of knowledge and practices of mothers on iodized salt and the relationship between maternal knowledge and practice with nutritional status and cognitive performance of school going children was assessed in Tehsil Katlang, KP.

Methods: A cross sectional study, involving 300 mother–child pairs (aged 6-12 years) from 6 schools selected by stratified systematic random sampling was conducted in the community setting. Maternal knowledge and practice on iodized salt, dietary iodine intake, physical activity, sleep quality and screen-time were collected using structured questionnaires. Nutritional status was measured using height-for-age (HAZ) and BMI-for-age (BAZ) Z-scores, and cognitive performance was measured using Raven's Standard Progressive Matrices (SPM). Independent-samples t-tests, one-way ANOVA, chi-square tests and hierarchical multiple linear regression were used (at a significant level $p<0.05$).

Results: Children's mean age was 8.41±2.04 years (50% male); 19.3% were stunted and 14.7% were thin. The majority of children (66.0%) had an average IQ, 22.7% above and 11.3% below average. The cognition was significantly associated with HAZ, BAZ, sleep quality and maternal knowledge of using iodized-salt, with higher scores for mothers of children with above-average-IQ (5.10±1.82) than for mothers of children with below-average-IQ (3.68±1.58). Age (β=0.386), HAZ (β=0.167), BAZ (β=0.109), sleep quality (β=0.121), maternal knowledge (β=0.173) and maternal practice (β=0.117) were independent positive predictors of IQ (all $p<0.05$) as revealed by hierarchical regression.

Conclusions: Maternal knowledge and practices about iodised salt, the nutritional status of children and sleep quality are significantly related to cognitive performance in pre-adolescent children. The improvement of maternal nutrition education and salt-iodization in the households could have beneficial effects on developmental outcomes of children in rural Pakistan.

Introduction

Although public health measures have been taken for many years, iodine deficiency disorder (IDD) continues to be one of the most common micronutrient deficiencies in the world. The school age is a crucial period of biological and hormonal growth, coupled with increased cognition needs, that affects attention, memory, problem-solving and intelligence quotient (IQ) which can have lifelong academic and economic impacts (Nur et al., 2021). Based on WHO estimates, almost 2 billion people have iodine deficiency, children in their school-going years being the most affected population, and even a moderate population-level deficiency has measurable impacts on cognitive function, and can have a cumulative effect on the educational and economic productivity of the population (Louis et al. 2021).

The deficiency of thyroid hormones (T3, T4) alters the neurogenesis, migration, myelination and formation of synapses, which leads to a reduction in connectivity between neurons and synaptic plasticity, thereby affecting memory, attention and executive function during the first 10 years of life (Abel et al., 2019; Haider et al., 2020). The severity of the chronic iodine deficiency is from mild goiter to cretinism, and mild-to-moderate deficiency has consistently been associated with reduced IQ, attention and school performance compared to iodine-sufficient children, aggravated by concurrent stunting or other undernutrition (Santiago-Fernandez et al., 2004; Parag et al., 2019). Although the household “last mile” of correct, consistent use of iodized salt is the most important factor to consider to ensure programme success, a persistent knowledge-practice gap exists, as knowledge of correct use of iodized salt exceeds practice in South Asia, and the public-health return from USI is limited in the region by this gap (Mohammed et al., 2020; Karmakar et al., 2019; Tadesse et al., 2022; Molla et al., 2023).

The general nutritional situation also influences cognitive function; chronic under nutrition, as seen in stunting and low BMI-for-age, is associated with impairment in brain development and learning capacity (Haile et al., 2016) and Pakistan's National Nutrition Survey (2018) reported that stunting was very high and the coverage of iodized-salt was variable, particularly in rural areas. Few studies in the rural KP have assessed the maternal knowledge and household practices of iodized salt and children's cognitive outcomes together. The study thus aimed to measure the level of maternal knowledge, practices and their relationship with the nutritional status and cognition of school-going pre-adolescent children (6-12 years) in Tehsil Katlang, KP, with the hypothesis that there is significant relationship between maternal knowledge and practice and the cognitive performance of school-going pre-adolescent children (6-12 years).

MATERIALS AND METHODS

Study Design and Setting

The study took an institution based cross sectional design in Tehsil Katlang of District Mardan in Khyber Pakhtunkhwa (KP), Pakistan, and was conducted in accordance with the ethical principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Faculty of Nutrition Sciences Ethics Committee & Human Studies Review Board Reference number 2024-006. School principals granted permission for data collection in their schools, and written informed consent was obtained from the mother or main female caregiver of each participating child prior to enrolment.

The number of items in a sample and the process of sampling.

Sample size estimation was done using Cochran's (1977) single population proportion formula (95% confidence level, 5% margin of error) based on the previously reported prevalence of iodine-deficiency risk among children in KP (Lowe et al., 2015), which was 25.7%. Minimum sample size was calculated to be 293 with 300 rounded to make up the sample size. We used stratified systematic random sampling technique to select six schools, three public school and three private school from the list of schools in

the District Education Department with a stratified design aimed at reducing the clustering of schools, involving a total of 150 boys and 150 girls.

Eligibility Criteria

Eligible children were those from ages 6 to 12 years attending the chosen schools who had a mother or main female caregiver to give consent. Children who were diagnosed with any chronic disease that impacted nutrition or cognition, and mother–child dyads who returned the questionnaire incomplete and/or refused to do so were excluded. Data Collection Tools

Socio-demographic and socio-economic information were collected through a pre-tested semi-structured questionnaire. Weight, height were measured using a digital scale and stadiometer and Z scores for height-for-age (HAZ) and BMI-for-age (BAZ) were calculated with WHO AnthroPlus (v1.0.4) from WHO growth references (2007), with a score below −2 SD considered as stunted/thin. The Raven's Standard Progressive Matrices (SPM: 60 items, 60 minutes) were used to assess cognitive performance with age adjusted percentile scores classified as above-average (≥75th percentile), average (25th–75th percentile) or below-average (<25th percentile) (John and Raven, 2003). The dietary intake of iodine was estimated by a 17-item iodine rich food questionnaire (IRFQ) (maximum score 119) and an 11-item goitrogenic food questionnaire (GFQ) (maximum score 77), both of which were categorized into tertiles. A structured questionnaire was developed for the present study to score maternal knowledge and practice on iodized salt (1=correct/appropriate, 0=incorrect/“don't know”) and regular/irregular use of salt (based on predefined criteria); this instrument was not previously published and is provided in full as Additional file 1 (Supplementary Questionnaire). Physical activity level, sleep quality and screen-based sedentary behavior were assessed by maternal-report questionnaire and categorized as low/moderate/vigorous activity, good/moderate/poor sleep, and acceptable (<840 min/week) or high (≥840 min/week) sedentary time.

Statistical Analysis

Using SPSS v20, data were coded and analyzed. Independent-samples t-tests were used to compare continuous variables between two groups, one-way ANOVA were used to compare continuous variables across the 3 IQ categories, and chi-square tests were used to test associations between categorical variables. Hierarchical multiple linear regression was used to identify independent predictors of children's raw score IQ: child age and gender (Block 1), HAZ and BAZ (Block 2), physical activity level and quality of sleep (Block 3) and maternal knowledge and practice scores (Block 4). Throughout, a p value <0.05 was regarded as statistically significant.

Results

Mean age of the children in the enrolled population (300, 6–12 years old) and their mothers in Tehsil Katlang was 8.41±2.04 years, and there was a balance of child and mother sex (50:50), of which 45.0% of the children were aged 6–8 years. The mean age of mothers was 27.56±4.28 years, 44.0% with a

SSC/HSSC qualification, 40.0% with a graduate qualification, 16.0% illiterate or minimally educated and 73.7% were housewives. The mean monthly household income was 96.30±20.57 thousand PKR, showing a relatively low-to-middle resource setting in line with previous national studies that revealed a correlation between family schooling, family economy and child developmental outcomes (Akram et al., 2024; Babar et al., 2010). The overall prevalence of stunted children was 19.3%, that of thin children 14.7% and that of below-average IQ children 11.3% (Table 1).

No significant difference in cognitive performance between males and females was detected (IQ raw score: males 23.16±9.38, females 22.48±9.27, $p>0.05$), which corroborates international evidence that boys and girls do not differ in their non-verbal intellectual functioning during childhood (Lynn and Kanazawa, 2011; Ritchie and Tucker-Drob, 2018). Mean BMI was significantly higher in boys (14.04±0.97 vs. 13.55±1.10 kg/m²; $p<0.001$), while girls showed significantly higher rates of stunting (44.7% vs. 32.0%; $p<0.05$) and underweight (38.0% vs. 27.3%; $p<0.05$). Physical activity level was not significantly different by gender ($p>0.05$), but girls also reported poor sleep quality significantly more often compared to boys (60.7% vs. 46.7% poor sleepers; $p<0.05$) and more high sedentary time (39.3% vs. 26.7%; $p<0.05$) (Table 1).

There was a significant difference in growth indicators across the IQ groups, with older, heavier and taller children having higher BMI, HAZ and BAZ than the average- and below-average-IQ children (all $p\leq0.05$), and with the prevalence of stunting increasing sharply from 23.5% of those above-average-IQ to 55.9% of those below-average-IQ ($p<0.005$), while there was no significant difference in the prevalence of BAZ-based malnutrition across IQ groups ($p>0.05$). The tertile of intake of iodine-rich food was positively associated with IQ category, although this association was not significant ($p=0.063$), and there was no significant association between goitrogenic food intake and IQ category ($p>0.05$). There was a significant ($p<0.05$) non-linear relationship between physical activity level and IQ category, with the most frequent category being above-average activity in both groups, and the majority of participants with below-average IQ were sedentary. Sleep quality was also significantly different by IQ category ($p<0.05$), but was not significantly different by physical activity level ($p>0.05$). Significant differences between the two IQ groups were found with maternal knowledge score, which decreased significantly from the above-average-IQ group (5.10 ± 2.00) to the below-average-IQ group (3.68 ± 1.96) ($p<0.05$), but not with maternal practice score and regular-practice prevalence ($p>0.05$) (Table 2).

The children of the mothers with adequate knowledge about iodized-salt had significantly greater anthropometric outcomes (weight, height, BMI, HAZ and BAZ) than children of the mothers with inadequate knowledge (all $p<0.001$); children of mothers with regular practice of iodized-salt had also better anthropometric outcomes than those with irregular practice ($p<0.001$ for most indicators). The association between knowledge and practice was also evident as mothers with adequate knowledge were more likely to use regular iodized salt (56.6%) than those with inadequate knowledge (43.4%). (Aboud et al., 2017; Karmakar et al., 2019).

When all the variables were included in the fully adjusted hierarchical regression model, child age emerged as the strongest independent predictor of IQ raw score (β=0.386, p<0.001) followed by maternal knowledge (β=0.173, p<0.001), HAZ (β=0.167, p<0.001), maternal practice (β=0.117, p<0.001), sleep quality (β=0.114, p<0.001) and BAZ (β=0.109, p<0.001) whereas gender and physical activity level were not significant independent predictors (p>0.05) (Table 3).

Discussion

The evidence from this community-based study of 300 mother–child dyads in Tehsil Katlang indicated a significant level of under nutrition, knowledge–practice gap on maternal iodized-salt behaviors', and consistent links between children's nutritional status, sleep quality and maternal understanding/practice with cognitive performance, which largely corroborated the existing evidence base in South Asia. The observed prevalence of stunting (19.3%) and thinness (14.7%) along with the significantly higher disadvantage of girls over boys in terms of HAZ and BAZ are comparable to the national and regional trends, where girls in resource-poor rural households are likely to have poorer nutrition and developmental outcomes than boys (Milasinovic et al., 2019; Darling et al., 2020), and also similar to the evidence that parental education and household economic status influence child nutrition and developmental outcomes in Pakistan (Akram et al., 2024; Anwar et al., 2023; Babar et al., 2010).

There was no significant difference between boys and girls in overall cognitive performance, in line with international studies that show that there are few or no sex differences in the development of non-verbal intelligence in childhood (Lynn and Kanazawa, 2011; Ritchie and Tucker-Drob, 2018; Abdelrasheed et al., 2021). In contrast, a strong gradient between growth status and their IQ classification, with prevalence of stunting increasing from 23.5% of above-average-IQ children to 55.9% of below-average-IQ children, supports a large body of longitudinal evidence that early under nutrition, and stunting in particular, are associated with poorer lifetime cognitive and educational outcomes (Grantham-McGregor et al., 2007; Black et al., 2013; Woldehanna et al., 2017; Lestari et al., 2024; Awaludin et al., 2025). In this mixed dietary environment of rural population, neither the dietary iodine source, nor the goitrogen exposure, was a significant independent correlate of cognition when other factors were considered, and this was also reported by Choudhry and Nasrullah (2018) in Pakistan where confirmed adequate dietary iodine intake resulted in no simple cognitive advantage.

Both descriptive comparisons and the regression model showed sleep quality as an important independent correlate of cognitive performance, which is consistent with previous studies that found sleep patterns are correlated with childhood cognitive and academic functioning in other Asian groups (Cai et al., 2023; Urrila et al., 2017; Wang et al., 2025) and with systematic-review evidence that suggests adequate sleep duration is associated with improved health and cognitive-related outcomes in school-aged children and youth (Chaput et al., 2016). The higher incidence of poor sleep and high sedentary time among girls is similar to the international reports (Sampasa-Kanyinga et al., 2020) and the significant but non-linear relationship between physical activity and IQ category differs from the more

consistent relationship found in systematic reviews (Bidzan-Bluma and Lipowska, 2018) which may be due to the cross-sectional design and residual confounding by age and household resources.

Maternal knowledge of iodized-salt use was always positively associated with child cognitive performance and nutrition status, and mothers with adequate knowledge were significantly more likely to use iodized-salt regularly, which aligned with previous evidence in South Asia and the region that maternal knowledge and maternal practices are associated with child cognitive and nutrition outcomes (Kar et al., 2020; Khan et al., 2012; Shaikh et al., 2022; Karmakar et al., 2019) and that improved household iodized-salt use was associated with improved child cognitive development in trial settings (Aboud et al., 2017; Mohammed et al., 2020). Even though maternal practice scores were not as different across IQ groups as knowledge scores, the fact that maternal practice remained an independent regression predictor suggests a gap between maternal knowledge and consistent household practice that may relate to cost, availability or storage issues or might result from a limited ability to translate maternal knowledge into consistent household practice (Karmakar et al., 2019; Tadesse et al., 2022; Mohammed et al., 2020).

The results should be considered with a number of limitations. The cross-sectional design does not allow the inference of causality and maternal knowledge and practice, dietary intake, sleep and physical activity were assessed by self-report, which was subject to recall and social-desirability bias, and the study was limited to one tehsil and may not be representative. The strengths are a relatively large and well-balanced community sample, a validated non-verbal cognitive assessment tool, a standardised anthropometric measurement against WHO growth reference and the hierarchical regression approach to determining the independent contributions of maternal knowledge and practice to nutritional and lifestyle factors.

CONCLUSION AND RECOMMENDATIONS

Undernutrition is highly prevalent in Tehsil Katlang among the school going pre-adolescent children with higher prevalence of stunting and underweight among girls. In the hierarchical regression model, cognitive performance, as well as child's age, was significantly and independently associated with the nutritional status of children (not only with HAZ and BAZ, but also with nutritional status measured as weight-for-age and height-for-age), sleep quality, and maternal knowledge and practice about iodized salt. Improving maternal nutrition education and home salt iodine status, therefore, may have a significant impact on the nutritional and cognitive development of children in rural Pakistan. Based on the above results, the following recommendation is made: (i) Strengthening the monitoring and quality control of the universal salt iodization programmed, especially in rural areas; (ii) scaling up maternal nutrition-education programmed to raise awareness for the importance of iodine in child growth and cognition, and proper salt storage/cooking practices in the community; (iii) conducting community-based nutrition awareness through community-based primary health care workers and Lady Health Workers for dissemination of actionable messages about proper salt storage/cooking practices, and identification of the iodized salt; (iv) promoting healthy eating, sleep and physical activity practices in

school health programmed; and (v) future studies using biochemical iodine markers (e.g., urinary iodine concentration) and longitudinal designs to clarify causal pathways between iodine intake, maternal practices, nutritional status and cognitive development.

Declarations

Faculty of Nutrional Sciences, Ethics Committee & Human Studies Review Board, Reference number 2024-006

Funding

No funding or specific grant was received for this research from agencies in the public or commercial or not-for-profit sectors.

MOTHER/PARENT INFORMED CONSENT FORM

I have been informed about a research study being conducted to assess the association of maternal knowledge and practices regarding iodized salt with the nutritional status and cognitive performance of school-going children. I understand that my participation will involve providing information about household characteristics, dietary practices, and lifestyle behaviors, while my child's height and weight will be measured and a simple cognitive test will be conducted. I have been assured that all information collected will be kept strictly confidential and will be used only for research purposes, with no disclosure of personal identity. I understand that participation in this study is entirely voluntary and that I have the right to refuse or withdraw at any time without any consequences. I am aware that there is no risk involved in participating in this study, and the findings may help improve child health and nutrition programs. By signing or providing my thumb impression below, I willingly agree to participate in this study.

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the **Faculty of Nutrition Sciences, Ethics Committee & Human Studies Review Board** reference number number: 2024-006. School principals granted permission for data collection in their schools, and written informed consent was obtained from the mother or main female caregiver of each participating child prior to enrolment.

Consent for publication

Written informed consent was obtained from the parents/guardians of all participating children for their participation in the study and use of the collected study data. No identifying images, photographs, case details, or individually identifiable clinical information are included in this manuscript. Therefore, consent for publication of identifying material is not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Tables

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