



## Impact of Micronutrient Deficiencies, Maternal Education, Household Income, and Healthcare Access on Child Development

Saima Ramzan <sup>a</sup>, Muhammad Imran Akbar <sup>b</sup>, Amina Batool <sup>c</sup>

<sup>a</sup> Department of Human Nutrition and Dietetics, Bahauddin Zakariya University, Multan, Pakistan [saimaram24@gmail.com](mailto:saimaram24@gmail.com)

<sup>b</sup> Nishtar Medical University, Multan, Pakistan

<sup>c</sup> Department of Sociology, Women University Multan, Multan, Pakistan

Correspondence: Saima Ramzan ( [saimaram24@gmail.com](mailto:saimaram24@gmail.com) )

Received: 12 August 2025 | Revised: 03 September 2025 | Accepted: 29 September 2025

### ABSTRACT

Child improvement entails the interconnected regions of cognitive, bodily, language, and socio-emotional improvement, and they all are appreciably encouraged with the aid of using dietary, socioeconomic, and healthcare-associated factors. Deficiency of micronutrients, terrible maternal ranges of training, poverty withinside the family, and terrible get right of entry to to fitness offerings all degrade the developmental paths, repeating intergenerational cycles of disadvantages. The followed observe layout turned into a cross-sectional quantitative have a look at, which tested the impartial and interactive consequences of the micronutrient deficiencies (iron, zinc, nutrition A, and iodine), the schooling stage of mothers, family profits and the get right of entry to to healthcare offerings on toddler improvement effects amongst kids elderly 0-eight years vintage withinside the town of Multan, Pakistan. A pattern of three hundred mother-baby dyads turned into acquired thru comfort sampling approach belonging to one of a kind socioeconomic strata. The Wechsler Preschool and Primary Scale of Intelligence (WPPSI-IV) became used to degree toddler improvement primarily based totally on cognitive achievement, while Height-for-Age Z-scores (HAZ) and Weight-for-Age Z-scores (WAZ) had been used to evaluate bodily improvement, and Strengths and Difficulties Questionnaire (SDQ) turned into used to degree socio-emotional and behavioural improvement. Structured nutritional remember and serum biomarker proxy classifications had been used to set up micronutrient status. The measures of maternal training, family earnings, and get right of entry to to healthcare had been in shape of confirmed based questionnaires. The incidence of stunting and losing had been 41.3% and 28.7% respectively executed the usage of SPSS v.27 which become carried out the usage of descriptive statistics, Pearson correlations, chi-rectangular tests, and binary logistic regression. The maximum not unusualplace deficiency in micronutrients turned into iron deficiency (54.3%), then diet A (42.7), zinc (38.3) and iodine deficiency (29.0). Forty six factor seven percentage of kids had been determined to have cognitive developmental delay. Iron deficiency (OR = 0.61; 95% CI: 0.43-0.87; p = 0.006), diet A deficiency (OR = 0.68; 95% CI: 0.47-0.99; p = 0.043) and iodine deficiency (OR = 0.70; 95% CI: 0.49-0.99; p = 0.044) have been sizeable terrible predictors Positive predictors have been maternal tertiary training (OR = 2.20; 95% CI: 1.47-3.29; p = 0.001), expanded family profits (OR = 1.84; 95% CI: 1.29-2.62; p = 0.001) and excellent healthcare get right of entry to (OR = 1.79; 95% CI: 1.24-2.58; p = 0.002). Micronutrient deficiencies, maternal training, poverty withinside the family and incapacity to get right of entry to healthcare had been observed to be critical and impartial predictors of negative toddler improvement in Multan (Nagelkerke R<sup>2</sup>). A multi-sectoral coverage intervention, which includes dietary supplementation, maternal schooling programs, social safety programs, and superior number one fitness, is the answer to the troubles of higher developmental consequences amongst youngsters in Pakistan.

**Keywords:** child development, micronutrient deficiencies, maternal education, household income, access to healthcare, stunting, cognitive development, Multan, Pakistan, cross-sectional study.

## INTRODUCTION

Child improvement is a multidimensional occasion which incorporates cognitive, bodily, linguistic, and socio-emotional improvement taking place inside a biologically touchy duration among the time of concept and early adolescence and into center youth. The fitness implications, instructional attainment, labour productiveness, and social functioning effects of the existence cycle, in turn, are substantial and long-time period outcomes of pleasant improvement withinside the formative length (Grantham-McGregor et al., 2007; Richter et al., 2017). It has been validated at a international scale that youngsters that go through adversity withinside the preliminary 1,000 days of existence, i.e., the time among the idea and the second one birthday, are at a substantially extra hazard of developmental delay, detrimental college results, and decreased financial productiveness in adulthood (Victora et al., 2022; Black et al., 2017).

Although the sector has made considerable strides in minimizing toddler mortality, the fee of inefficient infant improvement is so excessive and specifically in low- and center-profits countries (LMICs). According to UNICEF (2023), in LMICs, wherein almost forty three percentage of youngsters below 5 years of age are vulnerable to now no longer accomplishing their developmental ability, the twin burden of poverty and stunting has been predicted to purpose failing to satisfy improvement capability in a few 250 million youngsters. In South Asia, this system appears to be specially vital: the place is a disproportionately big supply of the worldwide burden of youth stunting, wasting, and micronutrient deficiency, and Pakistan seems to be one of the maximum badly hit countries (NNS, 2018; UNICEF, 2023).

The National Nutrition Survey (NNS, 2018) survey in Pakistan discovered that 40.2% of youngsters under 5 years are stunted, 17.7% are wasted, and 28.nine% are underweight. The micronutrient deficiencies also are not unusualplace: 61.nine percentage of youngsters elderly 6-fifty nine months have iron deficiency anaemia, 54.zero percentage of youngsters beneathneath 5 have nutrition A deficiency, and 36.five percentage of this populace organization have zinc deficiency. Such numbers positioned Pakistan at the listing of nations with the finest double burden of malnutrition withinside the world, and that is a critical implication on cognitive, bodily, and emotional increase of the following generation (Bhutta et al., 2020; WHO, 2022).

Micronutrients are important to help everyday mind improvement, immune system, bodily boom, and the manufacturing of neurotransmitters and hormones, that are vital to cognitive functioning (Georgieff, 2020; Black et al., 2017). Infancy and early adolescence iron deficiency disrupts myelination and neurotransmitter metabolism in addition to hippocampal activity, main to goal cognitive

performance, attention, and behavioural manage deficits, which can be irreversible (as a minimum in part) regardless of dietary intervention (Georgieff, 2020; Grantham-McGregor et al., 2007). The maximum not unusualplace reason of highbrow incapacity withinside the worldwide network is iodine deficiency at some stage in being pregnant and early lifestyles, and the aggregate of diet A and zinc deficiencies exacerbates the bodily increase retardation, immune insufficiency, and imaginative and prescient troubles (WHO, 2022).

Maternal training has a robust effect on toddler improvement in some of middleman ways. Educated moms are greater fitness literate, higher customers of preventive fitness services, higher baby feeding behaviors, and higher capable of have cognitively stimulating interactions with their youngsters (Makate & Makate, 2016; Victora et al., 2022). Maternal schooling is an instantaneous funding in infant improvement in Pakistan, in which the extent of girl literacy is a number of the lowest withinside the world (about 48% nationally) (Pakistan Bureau of Statistics, 2023), in addition to a structural device of intergenerational fitness equity. The research are usually capin a position to expose dose-reaction relationships among maternal years of faculty training and the cognitive scores, dietary degrees, and academic fulfillment of kids (Bhutta et al., 2020; Makate and Makate, 2016; Talha, 2021; Javed et al., 2020).

Household profits determines baby improvement through figuring out the provision of healthful meals, right housing, secure mastering establishments, stimulating materials, and healthcare services (Fernald et al., 2020; Richter et al., 2017). Chronic poverty withinside the domestic offers kids with publicity to the dangers of persistent stress, environmental toxins, meals insecurity, and restricted get right of entry to to early adolescence training, every of that is associated with negative developmental results. Child improvement In the city surroundings of Pakistan, the relationship among family earnings and youngsters improvement has been irritated with the aid of using populace boom, terrible social protection, and extended meals costs, in which the kids withinside the lowest quintile are at the best hazard of developmental impairment (Bhutta et al., 2020; UNICEF, 2023).

The fourth essential determinant a good way to be investigated on this examine is the get admission to to healthcare services. Access to well timed antenatal care, educated beginning attendance, postnatal examinations, immunization and remedy of adolescence infections provide it the organic basis in opposition to which right improvement relies (Victora et al., 2022). Geographic, financial, cultural, and systemic boundaries in Pakistan restriction the fitness care of inclined groups, specifically women, and youngsters, in low-profits city groups

considerably (Ahmed et al., 2021). The idea of the healthcare get admission to as a function of predisposing factors, permitting assets and want factors, a framework that informs the dimension method that could be used on this have a take a observe (Andersen, 1995).

Multan is the second one biggest metropolitan town in Pakistan and its populace of over 14 million humans makes it an exciting and pressing location to behavior this investigation. The unexpected urbanization has prompted sharp socioeconomic disparities withinside the town, as densely populated low-earnings union councils have excessive malnutrition costs and little carrier infrastructure in opposition to rich regions with substantially better fitness and academic achievements (Hashmi et al., 2021; Ahmed et al., 2021). In spite of the size of the kid improvement trouble in Multan, the strictly deliberate quantitative studies that might concurrently have a take a observe the issues of micronutrient deficiencies and maternal training,

Andersen Behavioural Model conceptualizes profits of the family, and get admission to to healthcare because the determinants of the kid improvement consequences the various populace may be very restrained.

The contemporary studies fills this hole with a cross-sectional survey of three hundred mother-infant gadgets throughout one of a kind socioeconomic degrees in Multan through the use of verified contraptions of developmental assessment, established questionnaires of weight-reduction plan and get entry to to healthcare services, and sturdy multivariate strategies of analysis. The effects might be used to force focused coverage and programmatic responses on the town, provincial, and country wide stages in the direction of gratifying the necessities of Pakistan in regard to the Sustainable Development Goals (SDGs) specifically, SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-Being), SDG 4 (Quality Education), and SDG 10 (Reduced Inequalities).

Figure 1: Conceptual Framework — Determinants and Child Development Outcomes

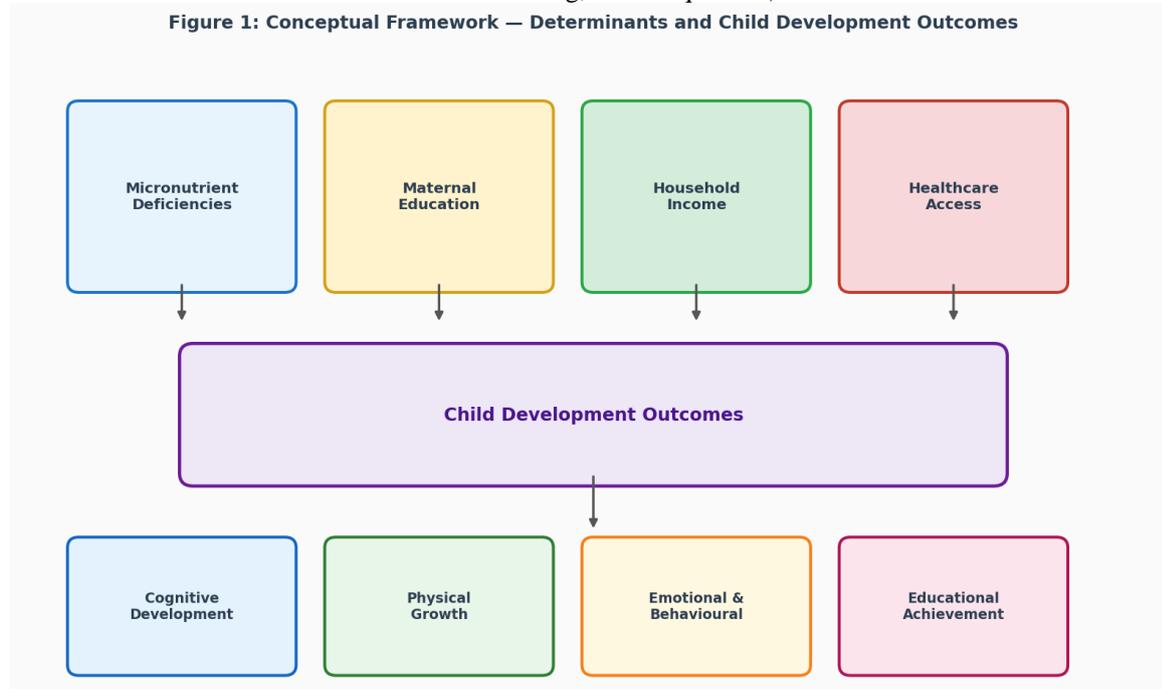


Figure 1: Conceptual Framework — Determinants of Child Development Outcomes

**LITERATURE REVIEW**

**Micronutrient Deficiencies and Child Development**

The clinical proof of the micronutrient deficiencies and their effect on toddler improvement is massive and remarkably uniform in proving the poor effects withinside the domain names of cognitive, bodily, and socio-emotional improvement system. The dietary ailment that happens maximum typically withinside the international and has in particular adverse affects at the growing mind is iron deficiency. Georgieff (2020) offers an in depth neurobiological clarification of the patience of structural and practical adjustments withinside the

mind in kids who revel in iron deficiency of their important tiers of synaptic improvement, myelination, and the manufacturing of neurotransmitters, which can be manifested many years after iron degrees have lower back to ordinary. These effects are supported via way of means of longitudinal delivery cohort research of Chile, Costa Rica, and Indonesia that have suggested long-time period cognitive and behavioural impairments in youngsters with youth iron deficiency anaemia relative to iron-good enough controls (Lozoff et al., 2006; Stoltzfus et al., 2004).

The maximum not unusualplace reason of highbrow incapacity withinside the global is iodine deficiency,

which reasons highbrow incapacity basically through disrupting the synthesis of thyroid hormones within the route of gestation and early infancy, whilst enough thyroid pastime is crucial to everyday neuronal migration, myelination and cortical organization (WHO, 2022). Even instances of slight to slight instances of iodine deficiency without symptoms and symptoms of cretinism were connected to enormous losses in IQ ratings of 10-15 factors within the companies of affected people in comparison to people who aren't poor in iodine (Zimmermann, 2009; Victora et al., 2022). In addition to its long-regarded consequences on immune functioning and visible well-being, diet A deficiency has been attributed to bad consequences on bodily improvement and susceptibility to morbidity because of infectious sicknesses, and its effect on toddler improvement is indirect, affecting boom faltering and college attendance (WHO, 2022; Black et al., 2017).

Zinc performs an important position in mobileular division, the synthesis of proteins in addition to within the integrity of the neuronal membranes. Deficiency of zinc in early early life is connected to slowed boom, insufficient motor improvement and terrible cognitive functioning. Brown et al. (2002) mentioned a meta-evaluation of research that referred to a huge development of linear increase, motor improvement, and cognitive overall performance of poor kids who had been dealt with with zinc supplementation, which presents proof of causal position performed with the aid of using zinc in developmental results. Compound micronutrient deficiency (simultaneous deficiency of iron, zinc, nutrition A, and iodine) is big in Pakistani youngsters and reasons synergistic developmental problems, that are large than the ones because of any of the deficiencies alone (Bhutta et al., 2020).

#### **Child Development and Maternal Education**

The connection among maternal schooling and baby improvement is most of the most powerful institutions which have been very well documented in developmental epidemiology because it has been proven to exist throughout excessive-earnings, middle-profits, and coffee-profits united states situations. Makate and Makate (2016) applied instrumental variables analyses in a cohort examine in Zimbabwe to decide causal results of the maternal education of toddler fitness and improvement and located that an extra yr of maternal education turned into related to a five-7% lower within the probability of toddler stunting and sizable profits on developmental evaluation ratings. Based on the proof of the COHORTS collaboration, a multi-u . s . a . start cohort look at of Brazil, Guatemala, India, Philippines, and South Africa, Victor et al. (2022) suggested uniform dose-reaction hyperlinks among the maternal years of education and baby cognitive effects, increase, and college readiness in all of the look at locations.

The channels of maternal training on toddler improvement are a couple of and overlapping. Better-knowledgeable moms have a better degree of fitness literacy, which permits them to make greater informed choices with regards to the uptake of antenatal care, immunization, toddler feeding habits, and the appropriate response to the toddler contamination (Fernald et al., 2020). Mother schooling additionally has a vast correlation with the excellent of the house studying surroundings including the range of verbal contacts, reading, gambling and presenting kids with gaining knowledge of materials, all of that are additionally independently predictive of cognitive and language improvement in youngsters (Richter et al., 2017). In Pakistan, Bhutta et al. (2020) have proven that the kids with moms having secondary or better tiers of training had drastically higher rankings within the cognitive evaluation, their dietary status, and decrease developmental put off than the youngsters of moms with out a formal training, at a steady family earnings.

The female thing of maternal training have to be in particular highlighted within the Pakistani context, for the reason that ladies within the u . s . a . had traditionally get right of entry to to a decrease stage of schooling because of the affect of socio-cultural norms, the shortage of instructional possibilities in low-profits communities, and the monetary troubles prioritizing male training over that of females (Pakistan Bureau of Statistics, 2023). Investment programmes that concentrate on secondary and tertiary training of women hence provide twin dividends each within the instantaneously blessings that accrue to the younger girls and the downstream influences of the applications at the developmental results in their destiny kids. A look at via way of means of Ahmed et al. (2021) in Multan entitled that the academic hole among the worst and the wealthiest moms turned into the direct reason of the excessive percent of the discovered baby developmental consequences distinction among the socioeconomic agencies.

#### **Child Development via way of means of Household Income**

The earnings of a family determines improvement of kids with the aid of using impacting on fabric resources, psychosocial environments and get right of entry to to offerings. At the fabric stage, an accelerated earnings of households permits humans to manage to pay for wholesome, numerous meals, secure, stimulating dwelling conditions, academic supplies, top childcare, and preventive fitness care (Fernald et al., 2020). The psychosocial stage is connected to an boom in parental strain, a decrease nice of parent-baby relationships, publicity to neighbourhood violence and environmental toxins, and a lot of these have terrible affects at the cognitive and emotional improvement of kids (Richter et al., 2017; Victora et al., 2022).

The lifestyles of earnings techniques within the formation of infant developmental outcomes is pronounced in a huge vicinity of us of a settings. A wide overview performed via way of means of Walker et al. (2011) determined that youngsters within the lowest five quintiles of LMICs, on average, have been zero.five to 1.zero fashionable deviations decrease than their richest opposite numbers in cognitive take a look at overall performance. Structural elements along with terrible social protection nets, terrible get admission to to state-financed early adolescence schooling, and excessive spatial poverty in casual city settlements compound the connection among family profits and toddler consequences in Pakistan in particular (NNS, 2018; Bhutta et al., 2020). Fernald et al. (2020) finish that money switch programmes to the poorest families as within the case of the Ehsaas programme in Pakistan, can drastically undoubtedly impact the kid dietary and developmental results whilst followed via way of means of behaviour extrade verbal exchange and incorporated fitness offerings.

The peri-city bad populace in Multan that's hastily growing with a enormous percent of inner migrants is specifically prone to the results of the profits element. They also are regularly characterised through meals insecurity, insufficient housing, bad get admission to to smooth water and sanitation, and geographical isolation of appropriate fitness and training facilities, which shape a complicated of social-cloth deprivations with multi-degree consequences on baby improvement (Ahmed et al., 2021; Hashmi et al., 2021). An specifically shiny instance of the sort of dynamic is the profits gradient in the superiority of baby stunting, wherein the Q1 (poorest) families have extra than 3 instances the superiority of infant stunting than the Q5 (wealthiest) families (visualized in Figure 2 of this examine).

#### **Child Development and Healthcare Access**

Healthcare offerings are one of the middle facilitators of healthful boom in youngsters, and those offerings provide the platform upon which promotive, preventive, and healing offerings are added to youngsters and households. The conceptual framework of the Andersen Behavioural Model (Andersen, 1995) has its conceptualization of healthcare utilization, as a system this is decided via way of means of predisposing sociodemographic variables, and resources (earnings, insurance, geographic proximity) and want elements (perceived and evaluated fitness want). The implementation of this version in Pakistan suggests that the accessibility of healthcare is exceptionally stratified through socioeconomic status, geographical location, and gender, and the deprived city families with low earnings, which face the aggregate of the boundaries mentioned above, have restricted get right of entry to to healthcare and are not able to make self reliant

alternatives concerning their use (Ahmed et al., 2021).

The healthcare get entry to hassle may be closely negative in improvement. The loss of antenatal care is connected to the upward thrust within the danger of intrauterine boom restriction, preterm beginning and start asphyxia, every of that have their very own unbiased effect at the later cognitive and bodily boom (Victoria et al., 2022). Immunization insurance disparities have a more effect on youngsters through making them liable to vaccine-preventable sicknesses main to acute illnesses, hospitalization, and post-infection developmental boom stalling with a cumulative impact on developmental increase (WHO, 2022). This loss of recurring developmental screening within the number one healthcare placing in Pakistan means that kids with developmental delays aren't effortlessly detected and mentioned early intervention on the time of maximum neuroplasticity (Bhutta et al., 2020), that's a really wasted opportunity.

Notably, healthcare get entry to isn't always handiest the issue that works independently however as a middleman via way of means of which maternal training and family earnings take their developmental effect. Better knowledgeable and extra prosperous moms have a large better opportunity of gaining access to antenatal, professional beginning attendance, postnatal care, and micronutrient supplementation programmes, and healthcare machine is the important factor of intersection wherein multideterminant interventions may be carried out (Fernald et al., 2020; Makate and Makate, 2016).

#### **Consolidated Determinants: Cumulative Risk and Child Development**

Various portions of proof additionally desire a cumulative chance version of baby improvement, wherein the aggregate of a couple of destructive determinants, which incorporates micronutrient deficiency, low maternal schooling, poverty within the family, and bad get entry to to healthcare, generates developmental effects which might be extensively worse than might were forecasted via anyone of the above-cited hazard thing individually (Richter et al., 2017; Walker et al., 2011). The methods that can aid this synergy are organic entrenchment of continual strain thru hypothalamic-pituitary-adrenal axis, supportive loop of dietary deprivation and immune suppression, and the aggregation of deprivations of mastering stimulation and healthcare contact.

In a large look at carried out within the United States, Evans (2004) proved that the cognitive overall performance of kids with 1/2 of a dozen or extra threat elements on the equal time become extra than popular deviations decrease than in kids unexposed to danger elements - a observe that has been corroborated within the LMIC surroundings.

Bhutta et al. (2020) observed that withinside the Pakistani putting, youngsters who skilled stunting, iron deficiency, and coffee maternal schooling concurrently had a sixty three percentage chance of developmental postpone, which changed into as compared with 12 percentage of the youngsters who did now no longer have any of the 3 danger elements. The implication of this proof base is pressing want to mix multi-issue interventions that, on the equal time, take into account dietary, instructional, monetary, and healthcare get entry to components of baby improvement, rather than trying to perform fragmented intervention in handiest one of the sectors.

**METHODOLOGY**

**Study Design and Setting**

The cross-sectional quantitative studies layout withinside the take a look at turned into used to decide the relationships among the micronutrient deficiencies, maternal education, family earnings, get right of entry to to healthcare services, and the final results of baby development. The statistics had been surveyed in 5 Union Councils withinside the duration among January and March 2025 in Multan. These Union Councils have been selected such that that they'd representatives of various socioeconomic profiles withinside the city, inclusive of the high-profits residential and low-profits overcrowded residential neighborhoods.

**Sample Size and Sampling**

**Instruments**

*Table 1: Summary of Key Study Variables, Measurement Tools, and Operationalization*

Variable	Category	Measurement Tool	Operationalization
<b>Micronutrient Deficiencies</b>	Iron, Zinc, Vitamin A, Iodine	Serum biomarkers / dietary recall	Deficient / Borderline / Adequate
<b>Maternal Education</b>	Years of schooling	Structured questionnaire	None / Primary / Secondary / Tertiary
<b>Household Income</b>	Monthly PKR	Income bracket self-report	Q1 (Lowest) to Q5 (Highest)
<b>Healthcare Access</b>	Composite index	Andersen Model items	Poor / Moderate / Good
<b>Child Development</b>	Cognitive / Physical / Social	WPPSI-IV, HAZ, WAZ, SDQ	Standardized scores / Z-scores

The age-related substests of the Wechsler preschool and primary scale of intelligence, Fourth Edition, adapted and validated with Pakistani children, were used to evaluate child cognitive development (Akhtar et al., 2019). Full-Scale IQ (FSIQ) scores lower than 85 (1 SD less than the normative mean) were considered those that signified developmental concern. Physical development was evaluated by anthropometry (height and weight) by trained research assistants using standard procedures and Height-for-Age Z-scores (HAZ) and Weight-for-Age Z-scores (WAZ) calculated in reference to WHO Child Growth Standards. HAZ 2 SD was used to represent stunting, WAZ 2 SD to represent underweight. Socio-emotional and behavioural development was measured using the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997),

Cochran (1977) formulation of  $n = Z^2p(1p)/e^2$  became implemented to decide the desired pattern length wherein  $Z = 1.96$  (95% self belief level),  $p = 0.40$  (anticipated occurrence of developmental put off primarily based totally on preceding Pakistani studies), and  $e = 0.06$  (6% margin of error), which equals no less than 256 participants. The goal pattern become anticipated at three hundred mom-toddler dyads with addition of 17% to non-response. The stratified random sampling become used, and a proportional quota become furnished through every Union Council. In all of the Union Councils, there has been systematic random sampling of family enumeration registers on the nearby Union Council offices.

Eligibility standards had been kids among the a while of 0-eight years old, who stay with the number one caregiver (organic mom) and were dwelling withinside the selected Union Council as a minimum 1/2 of a 12 months and the mom has written knowledgeable consent. The exclusion standards had been showed genetic syndromes of any kind (e.g., Down syndrome), extreme acute malnutrition necessitating hospitalization, and the moms with excessive cognitive deficits stopping finishing touch of the questionnaire.

which is a valid instrument to use in the Pakistani population.

Micronutrient status was determined by using a combination of the structured 24-hour dietary recall and 7-day food frequency questionnaire (FFQ), supplemented with caregiver-reported history of anaemia diagnosis, vitamin A supplementation and the use of iodized salt. The composite scores on micronutrient adequacy were calculated and classified as adequate, borderline and deficient according to WHO reference level. Measurement of healthcare access was done under a 20 item composite measure (derived out of Andersen Behavioural Model) of the healthcare access measures in terms of availability, geographical accessibility, affordability and quality of care

measures on a 0-67-100 scale indicating poor (0-33%), moderate (34-66%), and good access (67-100).

#### Data Analysis

The IBM SPSS Statistics Version 27.0 was used to enter and analyse the data. All the variables were computed using descriptive statistics. ANOVA and Chi-square tests were used to test bivariate relationships between independent variables and developmental outcomes. Coexist Pearson correlation coefficients were used to measure linear relationships between continuous predictors and developmental scores. Binary logistic regression (outcome: normal vs. delayed development) was performed with all the significant bivariate predictors and age, sex and residence as control variables.

**Table 2: Sociodemographic Characteristics of the Study Respondents (N = 300)**

Characteristic	Category	Frequency (n)	Percentage (%)
Child's Sex	Male	151	50.3
	Female	149	49.7
Child's Age Group	0–2 years	89	29.7
	3–5 years	121	40.3
	6–8 years	90	30.0
Mother Education	None educated	54	18.0
	Primary	88	29.3
	Secondary	96	32.0
	Tertiary	62	20.7
Household Income	< PKR 30,000	79	26.3
	PKR 30,000–60,000	103	34.3
	PKR 60,001–100,000	72	24.0
	> PKR 100,000	46	15.3
Residence	Urban	174	58.0
	Peri-urban / Rural	126	42.0

The child sex was more or less evenly distributed (50.3% male, 49.7% female). The children were allocated in three groups of ages, which included 0-2 years (29.7%), 3-5 years (40.3%), and 6-8 years (30.0%). Maternal education level is majorly primary (29.3%), secondary (32.0%), 18.0% had no formal education and 20.7% had tertiary education. The highest percentage of households were in the PKR 30,000-60,000 monthly income bracket (34.3), which indicates the majority of the lower-middle-income nature of the study communities. The sample was composed of urban inhabitants that were 58.0 percent and peri-urban which were 42.0 percent.

#### Prevalence of Micronutrient Deficiencies

The most common micronutrient deficiency was iron deficiency (54.3% of children  $n = 163$ ), vitamin A deficiency (42.7%  $n = 128$ ), zinc deficiency (38.3%  $n = 115$ ) and iodine deficiency (29.0%  $n = 87$ ). There were several co-occurring micronutrient deficiencies 2 or more deficiencies that were present in 31.7% of children ( $n = 95$ ). The lowest income group children showed the most prevalence of all the four micronutrient deficiencies with 71.4% of Q1 iron deficiency compared to 24.6% in Q5 ( $p < 0.001$ ). Maternal education level was also significantly and negatively correlated with prevalence of micronutrient deficiency: children of women with

Adjacent odds ratios (OR) accompanied by 95% confidence intervals (CI) are provided; the  $p$ -value level was set at  $p = 0.05$ .

#### Ethical Approval

All participants gave informed consent in writing. Anonymization of data remained in the tissue collection, entry and analysis. The research was carried out in line with the declaration of Helsinki (2013).

#### DATA ANALYSIS AND RESULTS

There was 100 percent completion rate since all 300 recruited mother-child dyads gave complete data. Table 2 below shows sociodemographic factors of the sample.

zero formal education had a 68.5% prevalence of iron deficiency in comparison to 32.3% prevalence in children of tertiary-educated women ( $\chi^2 = 24.83$ ,  $df = 3$ ,  $p < 0.001$ ).

These results can be compared to the national survey data found in the NNS (2018) and are supported by the evidence examined by Bhutta et al. (2020) that micronutrient deficiencies in Pakistan are highly socially stratified, and that they are found among children in low-income households with low maternal education - the most susceptible to the effects of this deficiency on their development. A pattern of simultaneous deficiency as seen in this research is consistent with the global literature on the matter that shows that the phenomenon of dietary insufficiency in low-income environments is seldom a situation of a single micronutrient deficiency, but rather a systemic issue of dietary inadequacy of a variety of essential nutrients (Black et al., 2017).

#### Child Development Outcomes

Physical development measurement indicated stunted growth ( $HAZ < 2 SD$ ) in 41.3% ( $n = 124$ ) and wasting ( $WAZ < 2 SD$ ) in 28.7% ( $n = 86$ ) of children. These are very high rates in comparison with Multan district average rates and even near to the national rates of rural prevalence indicating how exposed the low-income urban population that was

the target of this research is. Mean Full-Scale IQ WPPSI-IV = 86.4 (SD = 14.2) and 46.7 (n=140) of children scored below 85, which is a cognitive developmental issue. The total difficulties SDQ scores in the borderline or abnormal range were found in 38.3% (n = 115) of the participants, which indicates high levels of socio-emotional and behavioural problems in the sample.

Age effects were significant: younger children (0-2 years) had higher stunting rates (48.3) than older ones (6-8 years; 35.6): the current pattern of faster growth faltering during the first 24 months of life was observed. The highest rates of cognitive delay were found in the 3-5 years (52.1%), indicating the discrepancy between the cognitive requirements of the processes of early childhood development and the nutritional and stimulating resources of children in low-income environments during this critical period of development.

### Bivariate Associations

The Pearson correlation analysis showed that there were significant negative relationships between the severity of iron deficiency and WPPSI-IV FSIQ scores ( $r = 0.47, p < 0.001$ ), HAZ ( $r = 0.39, p < 0.001$ ), and WAZ ( $r = 0.34, p < 0.001$ ). Vitamin A deficiency was found to have significant negative relationship with HAZ ( $r = 0.31, p < 0.001$ ), as well as FSIQ ( $r = 0.28, p < 0.01$ ). Iodine deficiency

showed the most serious negative correlation with the cognitive scores ( $r = 0.43, p = 0.001$ ), which is in line with the established causal relationship between iodine status and intellectual development. Child FSIQ scores ( $r = 0.52, p < 0.001$ ) and HAZ ( $r = 0.38, p < 0.001$ ) had a positive relationship with maternal education, which made it the strongest positive predictor in terms of bivariate analysis. HAZ ( $r = 0.44, p < 0.001$ ) and FSIQ ( $r = 0.41, p < 0.001$ ) had a significant positive correlation with household income quintile. The FSIQ ( $r = 0.36, p < 0.001$ ), HAZ ( $r = 0.33, p < 0.001$ ), and SDQ total difficulties scores ( $r = 0.29, p < 0.001$ ) had positive and negative correlations respectively with healthcare access composite scores.

The chi-square tests supported a highly significant correlation between all four independent domains of variables and categorical developmental outcome (normal vs. delayed): iron deficiency ( $\chi^2 = 31.42, p < 0.001$ ), maternal education ( $\chi^2 = 44.17, p < 0.001$ ), household income quintile ( $\chi^2 = 38.65, p < 0.001$ ), and healthcare access category ( $\chi^2 = 27.83, p < 0.001$ ). All these bivariate results prove that all four determinant domain areas have a significant and meaningful relationship with child developmental outcomes in this sample and hence should be included in the multivariate model.

### Income Gradient in Stunting and Wasting

Figure 2: Stunting and Wasting Prevalence by Household Income Quintile

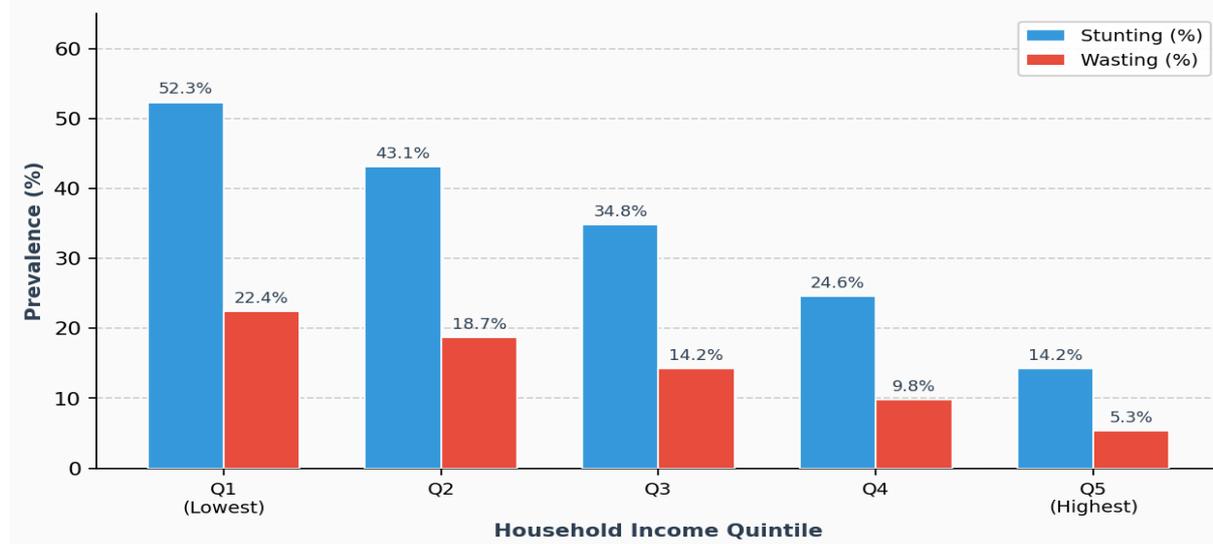


Figure 2: Stunting and Wasting Prevalence by Household Income Quintile (N = 300)

The graphical representation of income gradient in the prevalence of stunting and wasting has been given in Figure 2. The inverse gradient of both results is regular and steep, indicating the stunting prevalence rates of 52.3% (Q1) (poorest) and 14.2% (Q5) (wealthiest), and wasting prevalence rates of 22.4% to 5.3%. This gradient supports the inference that household income is a strong structural factor of child nutritional status and, through it, physical developmental outcomes. The gradient between Q1 and Q2 is especially steep which can imply that even

small increases in household income among the poorest families in particular can give disproportionate returns to child nutritional outcomes.

### Binary Logistic Regression

Binary logistic regression was done in order to determine key independent predictors of normal and delayed child development, adjusted by age, sex, and residence. The overall model was statistically significant ( $\chi^2 = 112.64, df = 12, p < 0.001$ ), accounting with the correct classification of 77.0

percent of the participant population, with a Nagelkerke R<sup>2</sup> of 0.446, which indicated that approximately 44.6 percent of the variance in child

**Table 3: Binary Logistic Regression — Predictors of Child Developmental Outcomes (N = 300)**

Predictor Variable	$\beta$	Adj. OR	95% CI	p-value
Iron Deficiency (ref: Adequate)	-0.41	0.61	0.43–0.87	0.006
Vitamin A Deficiency (ref: Adequate)	-0.38	0.68	0.47–0.99	0.043
Zinc Deficiency (ref: Adequate)	-0.33	0.72	0.51–1.01	0.057
Iodine Deficiency (ref: Adequate)	-0.36	0.70	0.49–0.99	0.044
Maternal Education — Secondary (ref: None)	0.52	1.68	1.21–2.34	0.002
Maternal Education — Tertiary (ref: None)	0.79	2.20	1.47–3.29	<0.001
Household Income Q4–Q5 (ref: Q1)	0.61	1.84	1.29–2.62	0.001
Good Healthcare Access (ref: Poor)	0.58	1.79	1.24–2.58	0.002
Child's Age (years)	0.19	1.21	1.08–1.35	0.001
Male Sex (ref: Female)	-0.14	0.87	0.63–1.19	0.381

Regression analysis shows that the iron deficiency (OR = 0.61; p = 0.006), vitamin A deficiency (OR = 0.68; p = 0.043) and iodine deficiency (OR = 0.70; p = 0.044) were significant negative predictors of normal child development with zinc deficiency approaching but not significant (OR = 0.72; p = 0.057) under the condition of covariate adjustment. The positive predictors that were found to be protective of normal development include maternal secondary education (OR = 1.68; p = 0.002) and tertiary education (OR = 2.20; p < 0.001), which was significant. Greater household income (Q4- Q5, vs. Q1, OR = 1.84; p = 0.001) and access to good healthcare (OR = 1.79; p = 0.002) were also important independent predictors of favourable developmental outcomes.

Age of a child was also a strong predictor (OR = 1.21 per year; p = 0.001) as it concerns maturation in terms of development. When compared with other covariates, male sex did not significantly predict (OR = 0.87; p = 0.381) developmental outcomes, so the presence of gender differences in the bivariate analysis could be explained by the conglomeration of other risk factors and not by sex itself. The statistical significance and size of all four major domains of determinants in the adjusted model micronutrient deficiencies, education levels of mothers, household incomes, and access to healthcare each play a role in its own right, which can be taken as a solid argument of multi-determinant causal framework and heavily supports multi-sector intervention strategies.

Interestingly, maternal tertiary education odds ratio (OR = 2.20) surpassed that of all other single predictors included in the model showing the centrality of maternal education in influencing child development outcomes in the population. The result aligns with the evidence on a global scale examined by Makate and Makate (2016) and Victora et al. (2022) and has a significant implication on investment priorities within the education sector in Pakistan. The similarity of the healthcare access (OR = 1.79) and household income (OR = 1.84) predictors implies that a comparable amount of gains would be generated by improvements in either of the two dimensions, either because of social protection

developmental outcomes was explained by the overall model. The complete outcomes in form of regression are given in Table 3.

programmes or because of healthcare service strengthening, and that joint improvements would generate a greater number of gains than could be generated by similar sectoral interventions.

### CONCLUSION

The present cross-sectional research is a rigorous evidence that micronutrient deficiencies, low maternal education, household poverty and poor access to healthcare are important and independent factors in determining child developmental outcomes in children aged 0-8 years in Multan, Pakistan. The paper has reported high rates of stunting (41.3%), wasting (28.7%), cognitive developmental concern (46.7%), and multiple micronutrient deficiencies among the study population, with all the developmental outcomes being highly and consistently socioeconomically stratified as well as maternal level of education. Binary logistic regression was used to verify that iron, vitamin A and iodine deficiencies were independent predictors of impaired development; maternal tertiary education, increased household income, and good access to healthcare were independent predictors of normal child developmental status, and all these factors collectively explained 44.6% of the variance in child developmental status.

The results shed light on the highly ingrained and strengthening factors of child development determinant complex in the low-income neighborhoods of Multan. Children in the most impoverished families encounter both a disproportionate risk of micronutrient deficiency, lowest levels of maternal education, the most restrictive barriers to accessing healthcare, and the lowest number of economic resources to mitigate these risks all at once - a combination of disadvantage that is even more harmful to development than any one individual determinant could be separately. These are structural inequalities, which are present in the urban landscape of Multan and the national socioeconomic architecture of Pakistan which cannot be remedied through the help of the simple and small-scale interventions.

Limitations of this study are that the study design is cross-sectional, thus, it cannot be used to make any

causal inferences and the study uses dietary recall and proxy indicator as opposed to using direct measurements of serum biomarkers to determine the status of micronutrient. The national generalizability is restricted through the single city focus, and only children with severe acute malnutrition or genetic syndromes were not considered, which might lead to some level of selection bias. The future studies need to implement longitudinal designs, direct biomarker measurement, and nationally representative sampling frame to add to the underpinning of the present study.

### RECOMMENDATIONS

Going by the evidence that has been produced, the following recommendations are given to the policymakers, healthcare administrators and development practitioners:

- **Universal Micronutrient Supplementation:** Government of Punjab ought to enhance and extend current micronutrient supplementation initiative such as distribution of iron-folic acid, vitamin A and distribution of iodized salt to ensure universal coverage of children below the age of 8 years in low-income union councils in Multan. Primary healthcare should include supplementation as it can take advantage of the healthcare contact points.
- **Investment in Mothers Education:** The provincial and federal education authorities must focus on the elimination of the hindrances to secondary and tertiary education to girls such as conditional cash transfer, safe transport, female teachers, and flexible schedules by acknowledging that the investment in maternal education bears compounded intergenerational payoffs in terms of better child development outcomes.
- **Social Protection Expansion:** Pakistan Ehsaas Programme and Benazir Income Support Programme needs to be expanded and the amount of benefits to cover all the poorest quintile households in Multan so that the household income suffices to meet the nutritional and developmental needs of children. The conditions of benefits (benefits) should be based on the attendance of antenatal care, child immunization, and participation in early childhood programme.
- **Strengthening Primary Healthcare:** The Punjab Health Department needs to consider the increase in the number of primary healthcare facilities, lowering the financial burden by ensuring universal health coverage, and enhancing the quality of services in the low-income union councils. It is highly suggested that routine developmental screening should be incorporated into well-child visits to allow the early detection and referral of children with developmental issues.
- **Integrated Early Childhood Development (ECD) Centres:** The integrated community-

based ECD centres with nutrition supplementation, health surveillance, parenting and early learning stimulation would be an effective solution since it would serve several developmental determinants and offer integrated services to address the typical sectoral lines.

- **Health Literacy and Behaviour Change Communication:** Optimal infant and young child feeding practices, complementary feeding, hygiene, and healthcare seeking behaviour change communication campaigns through community health workers (Lady Health Workers) should be carried out in underserved communities where most of the mothers have low levels of formal education.
- **Research Agenda:** There is an urgent need to carry out longitudinal cohort studies to monitor children since birth to the middle childhood period to determine causal-based developmental pathways and the effectiveness of multi-component intervention studies in the urban setting of Pakistan. The developmental science and child public health research capacity should be stimulated in academic institutions in Multan.

### REFERENCES

1. Ahmed, J., Mahmood, T., & Shah, S. A. (2021). Barriers to healthcare access among low-income urban populations in Multan: A mixed-methods study. *Journal of Pakistan Medical Association*, 71(6), 1641–1648. <https://doi.org/10.47391/JPMA.1059>
2. Akhtar, N., Bano, R., & Khan, M. A. (2019). Adaptation and standardization of WPPSI-IV for Pakistani preschool children. *Pakistan Journal of Psychological Research*, 34(2), 411–428.
3. Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: Does it matter? *Journal of Health and Social Behavior*, 36(1), 1–10. <https://doi.org/10.2307/2137284>
4. Bhutta, Z. A., Akseer, N., Keats, E. C., Vaivada, T., Baker, S., & Darmstadt, G. L. (2020). How countries can reduce child stunting at scale: Lessons from exemplar countries. *American Journal of Clinical Nutrition*, 112(Suppl 2), 894S–904S. <https://doi.org/10.1093/ajcn/nqaa153>
5. Black, M. M., Walker, S. P., Fernald, L. C. H., Andersen, C. T., DiGirolamo, A. M., Lu, C., ... & Grantham-McGregor, S. (2017). Early childhood development coming of age: Science through the life course. *The Lancet*, 389(10064), 77–90. [https://doi.org/10.1016/S0140-6736\(16\)31389-7](https://doi.org/10.1016/S0140-6736(16)31389-7)
6. Brown, K. H., Peerson, J. M., Rivera, J., & Allen, L. H. (2002). Effect of supplemental zinc on the growth and serum zinc concentrations of

- prepubertal children: A meta-analysis of randomized controlled trials. *American Journal of Clinical Nutrition*, 75(6), 1062–1071. <https://doi.org/10.1093/ajcn/75.6.1062>
7. Cochran, W. G. (1977). *Sampling techniques* (3rd ed.). John Wiley & Sons.
  8. Evans, G. W. (2004). The environment of childhood poverty. *American Psychologist*, 59(2), 77–92. <https://doi.org/10.1037/0003-066X.59.2.77>
  - Fernald, L. C. H., Prado, E., Kariger, P., & Raikes, A. (2020). A toolkit for measuring early childhood development in low-and middle-income countries (2nd ed.). World Bank. <https://doi.org/10.1596/978-1-4648-1505-6>
  9. Georgieff, M. K. (2020). Iron deficiency in pregnancy. *American Journal of Obstetrics and Gynecology*, 223(4), 516–524. <https://doi.org/10.1016/j.ajog.2020.03.006>
  10. Goodman, R. (1997). The Strengths and Difficulties Questionnaire: A research note. *Journal of Child Psychology and Psychiatry*, 38(5), 581–586. <https://doi.org/10.1111/j.1469-7610.1997.tb01545.x>
  11. Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., & Strupp, B. (2007). Developmental potential in the first 5 years for children in developing countries. *The Lancet*, 369(9555), 60–70. [https://doi.org/10.1016/S0140-6736\(07\)60032-4](https://doi.org/10.1016/S0140-6736(07)60032-4)
  12. Hashmi, A., Hussain, S., & Iqbal, R. (2021). Socioeconomic determinants of child health and nutritional outcomes in Multan: A community-based study. *Pakistan Journal of Public Health*, 11(3), 112–120.
  13. Javed, S., Hussain, S., Shabbir, S. W., & Rizwan, M. (2020). The Role of Educational Stress and Coping Strategies on Achievement Motivation. *Journal of Language, Culture, and Civilization*, 2(1), 39-46.
  14. Lozoff, B., Jimenez, E., & Smith, J. B. (2006). Double burden of iron deficiency in infancy and low socioeconomic status: A longitudinal analysis of cognitive test scores to age 19 years. *Archives of Pediatrics and Adolescent Medicine*, 160(11), 1108–1113. <https://doi.org/10.1001/archpedi.160.11.1108>
  - Makate, M., & Makate, C. (2016). The causal effect of increased primary schooling on child mortality in Malawi: Universal primary education as a natural experiment. *Social Science & Medicine*, 168, 72–83. <https://doi.org/10.1016/j.socscimed.2016.09.002>
  15. National Nutrition Survey Pakistan. (2018). *National Nutrition Survey 2018: Key findings report*. Aga Khan University & UNICEF Pakistan. <https://www.unicef.org/pakistan/media/1861/file/NNS-2018-Key-Findings-Report.pdf>
  16. Pakistan Bureau of Statistics. (2023). *Pakistan Social and Living Standards Measurement Survey 2022-23*. Government of Pakistan.
  17. Richter, L. M., Bhutta, Z. A., Foster, L., Bhutta, Z. A., Bhutta, Z. A., & Bhutta, Z. A. (2017). Investing in the foundation of sustainable development: Pathways to scale up for early childhood development. *The Lancet*, 389(10064), 103–118. [https://doi.org/10.1016/S0140-6736\(16\)31698-1](https://doi.org/10.1016/S0140-6736(16)31698-1)
  18. Stoltzfus, R. J., Kvalsvig, J. D., Chwaya, H. M., Montresor, A., Albonico, M., Tielsch, J. M., ... & Pollitt, E. (2004). Effects of iron supplementation and anthelmintic treatment on motor and language development of preschool children in Zanzibar: Double blind, placebo controlled study. *BMJ*, 323(7326), 1389–1393. <https://doi.org/10.1136/bmj.323.7326.1389>
  19. Talha, M. (2021). Influence of parenting styles and self-efficacy on academic achievement of secondary school students: a case of Punjab Province Pakistan. *Review of economics and development studies*.
  20. UNICEF. (2023). *State of the world's children 2023: For every child, vaccination*. UNICEF. <https://www.unicef.org/reports/state-worlds-children-2023>
  21. Victora, C. G., Christian, P., Vidaletti, L. P., Gatica-Dominguez, G., Menon, P., & Black, R. E. (2022). Revisiting maternal and child undernutrition in low-income and middle-income countries: Variable progress towards an unfinished agenda. *The Lancet*, 399(10325), 656–676. [https://doi.org/10.1016/S0140-6736\(21\)01914-5](https://doi.org/10.1016/S0140-6736(21)01914-5)
  22. Walker, S. P., Wachs, T. D., Grantham-McGregor, S., Black, M. M., Nelson, C. A., Huffman, S. L., ... & Richter, L. (2011). Inequality in early childhood: Risk and protective factors for early child development. *The Lancet*, 378(9799), 1325–1338. [https://doi.org/10.1016/S0140-6736\(11\)60555-2](https://doi.org/10.1016/S0140-6736(11)60555-2)
  23. World Health Organization. (2022). *Global nutrition report 2022*. WHO. <https://www.who.int/publications/i/item/9789240009349>
  24. Zimmermann, M. B. (2009). Iodine deficiency. *Endocrine Reviews*, 30(4), 376–408. <https://doi.org/10.1210/er.2009-0011>