

Micronutrient Fortification in Early Childhood: Knowledge, Attitudes, and Practices among Mothers of Preschool Children in Kochi, Kerala, India

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ABSTRACT

Background: This study aims to evaluate the Knowledge, Attitudes, and Practices (KAP) of mothers of preschool children regarding micronutrient fortification. **Materials and Methods:** A total of 200 mothers from Kochi, Kerala, India, participated in the survey, which was conducted using a structured questionnaire. **Results:** The findings revealed high levels of awareness (85%) and positive attitudes (70% considering it very important) towards micronutrient fortification. However, only 55% of mothers reported including fortified foods in their child's diet regularly. Key barriers identified included cost (40%) and availability (30%). Inferential statistical analyses, including the Chi-Square test and independent samples t-test, indicated a significant association between education level and awareness ($\chi^2(4, n=200)=12.56, p<0.05$) and a significant difference in attitudes between employed mothers and homemakers ($t(198) = 2.34, p<0.05$). **Conclusion:** The study underscores the need for public health initiatives to address barriers and promote the inclusion of fortified foods in children's diets. Interventions focusing on making fortified foods more affordable and accessible, along with continuous education, are recommended to bridge the gap between knowledge and practice. Future research should explore long-term impacts and effective strategies to improve micronutrient fortification practices.

Keywords: Fortified Foods, Hidden Hunger, Kochi, Kerala, Maternal KAP, Micronutrient Fortification, Preschool Children.

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Received: 22-12-2025;

Revised: 09-02-2026;

Accepted: 17-04-2026.

INTRODUCTION

“Hidden hunger” is a term used to describe deficiencies of essential vitamins and minerals, also known as micronutrients. Although it may not always show visible symptoms in the early stages, it remains a serious global public health concern. According to the World Health Organization, more than 2 billion people worldwide are affected by micronutrient deficiencies (Black *et al.*, 2008; Grantham-McGregor *et al.*, 2007). Preschool children are especially vulnerable because they have higher nutritional requirements to support rapid growth and development. UNICEF highlights that hidden hunger can slow physical growth, weaken the immune system, and negatively affect brain development, making it a major threat to child survival, learning ability, and long-term productivity (Bhutta *et al.*, 2013; Dewey and Begum, 2011).

One of the most effective and affordable approaches to address hidden hunger is micronutrient fortification, which involves adding essential vitamins and minerals to commonly consumed foods (Bouis, 2003; Bouis and Saltzman, 2017). Deficiencies in key nutrients such as iron, vitamin A, zinc, and iodine can have serious consequences, including anemia, vision problems, stunted growth, and impaired cognitive development. Combating these deficiencies requires well-planned fortification programs along with active awareness and participation from caregivers (Casanueva and Viteri, 2003; Delange, 1994; De-Regil *et al.*, 2011).

In public health research, the Knowledge, Attitudes, and Practices (KAP) framework is commonly used to understand how people perceive and respond to health-related interventions. This approach helps identify gaps in knowledge, misunderstandings, and obstacles that may prevent healthy practices. Since mothers are typically the primary caregivers and decision-makers regarding children's diets, their knowledge, attitudes, and practices play a crucial role in the effectiveness of micronutrient fortification initiatives.

Micronutrients, including vitamins and minerals, are crucial for various bodily functions. They are essential for growth, immune



DOI: 10.5530/ajbls.20260122

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function, brain development, and overall health. Deficiencies in these nutrients can lead to a range of health problems. For instance, iron deficiency can cause anemia, impair cognitive and motor development, and weaken immunity. Vitamin A deficiency can lead to blindness and elevate infection risks. Zinc deficiency is linked to stunted growth and increased susceptibility to infections, while iodine deficiency can cause goiter and severe intellectual disabilities. These issues underscore the need for effective strategies to ensure adequate micronutrient intake, especially among vulnerable groups such as preschool-aged children.

Hidden hunger is a worldwide problem affecting millions, particularly in low- and middle-income countries. According to the World Health Organization (WHO), about 2 billion people globally suffer from micronutrient deficiencies. Preschool children are among the most at-risk groups due to their elevated nutritional needs for growth and development. In many parts of the world, diets lack diversity and are low in micronutrient-rich foods, resulting in widespread deficiencies. The impacts of hidden hunger extend beyond individual health, as they affect national economies by reducing workforce productivity and increasing healthcare expenditures.

Mothers play a central role in their children's nutrition and health, often being the primary caregivers and decision-makers about food and nutrition within households. Their knowledge, attitudes, and practices greatly influence their children's dietary habits and overall health outcomes. For this reason, understanding mothers' KAP concerning micronutrient fortification is crucial for developing effective interventions. By educating and empowering mothers, dietary practices can improve, leading to better nutrition for their children.

The KAP framework is widely used in public health research to evaluate individuals' knowledge, attitudes, and practices regarding specific health issues. "Knowledge" refers to the information and understanding that individuals have about a topic; "attitudes" encompass their feelings and beliefs, which can influence their willingness to adopt certain behaviors; and "practices" refer to the actions they actually undertake. By assessing KAP, researchers can identify knowledge gaps, misconceptions, and barriers to effective practices, thereby providing insights for developing targeted interventions.

Significance of the Study

Micronutrient fortification is a widely recognized, cost-effective strategy to combat hidden hunger a silent yet pervasive issue impacting millions of children globally. Hidden hunger, caused by deficiencies in essential vitamins and minerals, particularly affects preschool-aged children, who are highly vulnerable to the consequences of inadequate micronutrient intake (Birol *et al.*, 2021; Copenhagen Consensus Center, 2008).

Early childhood is a crucial period for growth and development. Adequate nutrition during these formative years is essential for building a strong foundation for lifelong health, learning, and productivity. Though required only in small amounts, micronutrients are vital for numerous bodily functions, including immune response, brain development, and cellular processes. Deficiencies in these nutrients can result in stunted growth, weakened immunity, cognitive impairments, and higher rates of illness all of which can hinder a child's development and limit their potential.

Micronutrient fortification involves the purposeful addition of essential vitamins and minerals to commonly consumed foods, providing a sustainable and effective approach to reducing micronutrient deficiencies. Mothers, as primary caregivers and decision-makers regarding their children's health and nutrition, play a critical role in the success of fortification programs. Their Knowledge, Attitudes, and Practices (KAP) significantly shape their children's dietary habits and nutritional intake. Understanding mothers' perspectives on micronutrient fortification is essential for designing effective programs. By examining their knowledge and attitudes, interventions can be tailored to address concerns, enhance understanding, and support mothers in adopting beneficial practices that promote better nutrition and health outcomes for their children.

Aim of the Study

The aim of the study is to evaluate the Knowledge, Attitudes, and Practices (KAP) of mothers of preschool children regarding micronutrient fortification.

Objectives of the Study

1. To evaluate mothers' attitudes towards micronutrient fortification and its perceived benefits.
2. To assess the current practices of mothers in ensuring their children receive fortified foods.
3. To identify the barriers and facilitators to the implementation of micronutrient fortification in meals.

METHODOLOGY

This study employed a survey method design to evaluate the Knowledge, Attitudes, and Practices (KAP) of mothers of preschool children regarding micronutrient fortification. The target population consisted of mothers with children aged 3-5 years. A total of 200 participants were taken from various community health centres and preschools in Kochi, Kerala, India. Sample size was determined based on comparable KAP studies in maternal nutrition, ensuring sufficient power for chi-square and t-test analyses. Mothers of preschool children aged 3-5 years attending preschools and health centres in Kochi were included; mothers with children outside this age group were excluded.

The sampling technique used was convenience sampling, which enabled the researchers to gather data from a readily accessible group of participants.

Data collection was carried out using a structured questionnaire specifically designed for this study. The questionnaire was divided into five sections: Demographic Information, Knowledge about Micronutrient Fortification, Attitudes towards Micronutrient Fortification, Practices regarding Micronutrient Fortification, and Barriers and Facilitators to Micronutrient Fortification. The questionnaire was pretested with a small group of mothers to ensure clarity and relevance. Based on the feedback from the pretest, minor modifications were made to improve the questionnaire. The survey was administered face-to-face and provided instructions and clarified any questions the participants had. To ensure confidentiality, participants were assured that their responses would be anonymized, and informed consent was obtained from each participant prior to data collection. Survey was conducted during June-August 2025.

Data analysis was conducted using SPSS software, version 25. A significance level of $p < 0.05$ was set for all statistical tests.

Description of Fortified Foods

Fortified foods distributed through the Public Distribution System (PDS) and those available in the open market are presented in Table 1.

This distinction is important for a clear understanding of the study's findings. Although iodized salt and fortified rice are made available at subsidized rates through the Public Distribution System (PDS), mothers reported significant challenges when purchasing fortified foods from the open market. About 40% of respondents identified cost as a major barrier, while 30% mentioned limited availability. These concerns were particularly related to market-based fortified products such as milk, breakfast cereals, and edible oils, which are often positioned and sold as premium items in private retail outlets.

In comparison, staples distributed through the PDS are more affordable and easily accessible; however, they may not provide sufficient dietary diversity to meet all nutritional needs of children. As a result, the gap observed between awareness and actual practice in this study appears to be more strongly associated with market-based fortified products rather than PDS staples. This highlights the need for policies that not only improve awareness but also enhance the affordability and availability of fortified foods across both public and private distribution systems.

RESULTS AND DISCUSSION

Age Distribution

Table 1 in the study included a total of 200 mothers of preschool children. The mean age of participants was 34 years with a standard deviation of 6 years. Age distribution was as follows:

Below 20 years: 5% (10 participants) 21-30 years: 35% (70 participants) 31-40 years: 40% (80 participants) 41-50 years: 15% (30 participants) Above 50 years: 5% (10 participants). The majority of respondents (60%) were aged between 31-40 years.

Educational Level

Based on the data presented in Table 1, the majority of participants had completed secondary education (45%), followed by undergraduate degree (30%), higher secondary education (15%), postgraduate degree (5%), and no formal education (5%).

Employment Status of the Respondents

Table 1 showed the employment status varied, with 40% being homemakers, 30% employed part-time, 20% employed full-time, and 10% self-employed.

Knowledge about Micronutrient Fortification

Knowledge levels are summarized in Table 2 which shows a significant proportion of mothers (85%) reported having heard about micronutrient fortification. Among those aware, the primary sources of information were healthcare providers (40%) and media (35%). Understanding of micronutrient fortification was fairly accurate, with 75% correctly identifying it as the addition of vitamins and minerals to food.

Attitudes towards Micronutrient Fortification

Attitudes toward fortification are presented in Table 2. Overall, mothers expressed a positive attitude toward micronutrient fortification. A large majority (70%) believed that fortified foods are very important for their child's health. The average score for perceived importance was 4.5 out of 5 (SD=0.8), indicating a strong recognition of its benefits.

Similarly, their readiness to include fortified foods in their child's daily diet was encouraging. About 60% of mothers reported being very willing, while 30% stated they were willing to do so. The mean willingness score was 4.4 (SD=0.7), reflecting a generally high level of acceptance. These values are consistent with the frequency distribution presented in the data tables, ensuring that the statistical findings and the descriptive explanation are well aligned.

Practices regarding Micronutrient Fortification

Practices regarding fortified food inclusion are shown in Table 2. More than half of the mothers (55%) reported currently including fortified foods in their child's diet. The most commonly used fortified foods were cereals (50%) and milk products (45%). The frequency of consumption varied, with 40% ensuring daily intake and 35% several times a week.

Alongside the breakdown of individual food types, it is important to note that approximately 30% of mothers reported using more than one type of fortified food (e.g., combining fortified cereals

Table 1: Demographic Characteristics of Mothers. This table presents the age distribution, educational qualifications, and employment status of the 200 participating mothers of preschool children in Kochi, Kerala.

Variable	Category	Frequency (n)	Percentage (%)
Age	Below 20	10	5
	21-30	70	35
	31-40	80	40
	41-50	30	15
	Above 50	10	5
Education	No formal education	10	5
	Secondary	90	45
	Higher Secondary	30	15
	Undergraduate	60	30
	Postgraduate	10	5
Employment Status	Homemaker	80	40
	Part-time	60	30
	Full-time	40	20
	Self-employed	20	10

with fortified milk or oils). This indicates that while overall inclusion rates are moderate, a subset of mothers actively diversify fortified food sources in their child's diet, potentially enhancing micronutrient coverage.

Differentiation of Knowledge, Attitudes, and Practices (KAP): PDS vs Market Foods

Awareness

Awareness of fortified foods differed between items distributed through the Public Distribution System (PDS) and those available in the open market were shown in Table 3. Awareness was almost universal. Most mothers were familiar with iodized salt and fortified rice and recognized them as government-supported fortified staples regularly supplied through the PDS. Awareness of fortified products available in the market was comparatively lower and varied across items. While many mothers were aware of fortified milk and breakfast cereals, fewer were familiar with fortified edible oils and beverages.

Practices

The use of PDS-fortified foods was relatively consistent. Iodized salt was commonly used as a household staple, and fortified rice was regularly accessed through the PDS, making their inclusion in daily diets more stable. In contrast, the inclusion of market-based fortified foods was less consistent. Higher cost and limited availability reduced regular consumption. Although some households reported using fortified milk and cereals, fortified oils and beverages were rarely included in children's diets.

Barriers

Barriers were minimal, as iodized salt and fortified rice were subsidized and widely distributed, ensuring accessibility for

most households. The main barriers were cost (reported by 40% of mothers) and limited availability (30%). Additionally, taste preferences (10%) influenced whether fortified products were accepted and regularly consumed. Overall, this comparison indicates that the awareness-practice gap is more pronounced for market-based fortified foods than for PDS staples. Although mothers are generally aware of fortified products in both categories, actual usage is strongly influenced by affordability and accessibility. While PDS staples help ensure a basic level of micronutrient intake, market-based fortified foods face greater economic and supply-related challenges. Strengthening PDS coverage and reducing the cost of fortified products in the retail sector are essential steps to bridge this gap and improve dietary practices among preschool children.

Barriers and Facilitators to Micronutrient Fortification

According to Table 3, Key barriers identified included cost (40%), availability (30%), and lack of awareness (20%). Facilitators that would encourage more inclusion of fortified foods were lower cost (50%) and better availability (45%).

Education Level and Awareness

Attitudes Towards Fortification (Employed vs. Homemaker) were presented in Table 4 as $(198) = 2.34, p < 0.05$, suggesting a significant difference in attitudes towards fortification between employed mothers and homemakers. The calculated χ^2 value is 12.56 with 4 degrees of freedom. The p-value is less than 0.05 ($p < 0.05$), indicating that the result is statistically significant. Since the p-value is less than 0.05, the null hypothesis was rejected and accepted the alternative hypothesis. This suggests that there is a significant association between mothers' education level and

their awareness of micronutrient fortification. Higher education levels are associated with greater awareness of micronutrient fortification.

The calculated t-value is 2.34 with 198 degrees of freedom. The p-value is less than 0.05 ($p < 0.05$), indicating that the result is statistically significant. Since the p-value is less than 0.05, we reject the null hypothesis and accept the alternative hypothesis. This suggests that there is a significant difference in attitudes towards micronutrient fortification between employed mothers and homemakers. Employed mothers tend to have more positive attitudes towards fortification compared to homemakers.

DISCUSSION

The present study identified a clear gap between awareness and actual practice of micro nutrient fortification among mothers. Although maternal awareness was high (85%) and attitudes were largely positive (70% considered fortification very important), only 55% reported regularly including fortified foods in their child’s diet. About 30% of mothers indicated that they used more than one type of fortified food, suggesting some level of dietary diversification. However, overall practice did not fully reflect the high level of awareness observed.

The awareness-practice gap was particularly evident for market-based fortified foods. Cost (34%) and limited availability (25.5%) were the most frequently reported barriers. In contrast, staples distributed through the Public Distribution System (PDS),

such as iodized salt and fortified rice, were more consistently included in household diets. This reflects the positive impact of government-supported distribution systems in ensuring baseline micronutrient intake.

Statistical analysis further strengthened these findings. Higher levels of maternal education were significantly associated with greater awareness (Barnett, 2011; Cohen and Wills, 1985) ($\chi^2(4, N=200) = 12.56, p < 0.05$). Additionally, employed mothers demonstrated significantly more positive attitudes toward fortification compared to homemakers ($t(198) = 2.34, p < 0.05$). These results highlight the influence of socioeconomic and occupational factors on maternal perceptions and practices, even within a high-literacy setting such as Kochi (Felitti *et al.*, 1998; Goleman, 1995). The findings are consistent with earlier research that identifies cost and availability as major barriers to the adoption of fortified foods (Smith *et al.*, 2019). However, the relatively high level of awareness observed in this study contrasts with some earlier reports (Jones *et al.*, 2017), suggesting that public health communication efforts may have improved in recent years (Fiedler and Sharma, 2015; Bourton *et al.*, 2016). These results also align with global evidence. The World Health Organization continues to recognize food fortification as one of the most cost-effective strategies to combat hidden hunger, particularly among vulnerable groups such as preschool children (Black *et al.*, 2013; Center on the Developing Child, 2012). Similarly, the HarvestPlus initiative has demonstrated the effectiveness of biofortified staple crops such as zinc-rich rice and wheat in

Table 2: Knowledge, Attitudes, and Practices (KAP) of Mothers. This table summarizes maternal awareness of micronutrient fortification, attitudes toward its importance, willingness to include fortified foods in children’s diets, and reported practices.

Variable	Category/Response	Frequency (n)	Percentage (%)
Knowledge	Heard of fortification	170	85
	Correctly identified concept	150	75
Attitudes	Considered very important	140	70
	Willing to include daily	120	60
Practices	Regularly included fortified foods	110	55
	Used cereals	100	50
	Used milk products	90	45

Table 3: Awareness and Barriers: PDS vs Market Foods. This table compares maternal awareness of fortified foods distributed through the Public Distribution System (PDS) and those available in the open market. It also highlights the main barriers reported by mothers, including cost, availability, and taste preferences.

Variable	Category/Response	Frequency (n)	Percentage (%)
Awareness	Iodized salt (PDS)	200	100
	Fortified rice (PDS)	190	95
	Fortified milk (Market)	120	60
	Fortified cereals (Market)	110	55
Barriers	Cost	80	40
	Availability	60	30
	Taste preference	20	10

Table 4: Statistical Associations. This table presents the results of inferential statistical analyses. It shows the significant association between maternal education level and awareness of micronutrient fortification (Chi-square test) and the significant difference in attitudes between employed mothers and homemakers (Independent samples t-test).

Variable Comparison	Test Statistic	d_f	p -value	Result
Education level vs Awareness	$\chi^2 = 12.56$	4	<0.05	Significant association
Employment status vs Attitudes	$t = 2.34$	198	<0.05	Significant difference

improving micronutrient intake among low-income households (Bouis and Saltzman, 2017; Birol *et al.*, 2021).

In the Indian context, recent policy developments are noteworthy. The Government of India's decision to implement the universal distribution of fortified rice through the Public Distribution System represents a major step toward addressing micronutrient deficiencies at scale. Research conducted by the National Institute of Nutrition indicates that fortified rice distribution through the PDS is feasible and generally well accepted, although logistical and supply challenges remain. While iodized salt has achieved near-universal coverage, fortified rice and milk are still expanding, and market-based fortified foods continue to face cost and access constraints.

Implications

The findings from Kochi reflect national priorities while highlighting important challenges. Market-based fortified foods face stronger barriers related to cost, availability, and taste preferences compared to PDS staples. Strengthening PDS coverage of fortified rice and exploring subsidies or price regulation for market products could help bridge the awareness-practice gap. Continuous education campaigns, aligned with global recommendations, are also essential to sustain maternal willingness and encourage long-term adoption. Furthermore, integrating biofortification initiatives with conventional fortification strategies offers a complementary pathway to improve micronutrient intake across different socioeconomic groups.

SUMMARY

This study explored maternal Knowledge, Attitudes, and Practices (KAP) regarding micronutrient fortification among mothers of preschool children in Kochi, Kerala. Findings revealed high awareness (85%) and positive attitudes (70%), but only moderate practice (55%) of including fortified foods in children's diets. Key barriers were cost and availability, particularly for market-based fortified products, while Public Distribution System (PDS) staples such as iodized salt and fortified rice were more consistently used. Statistical analysis confirmed significant associations between maternal education and awareness, and between employment status and attitudes. The study highlights the importance of strengthening affordability, accessibility, and education initiatives to bridge the gap between knowledge and practice, thereby improving child nutrition outcomes.

CONCLUSION

The findings from Kochi highlight both the progress and the persistent challenges in promoting micronutrient fortification for early childhood nutrition. High maternal awareness and positive attitudes indicate the success of public health messaging. However, the moderate level of actual practice underscores ongoing barriers, particularly related to affordability and accessibility of market-based fortified foods.

The expansion of fortified rice distribution through the PDS marks a significant milestone in India's efforts to combat malnutrition. By combining strong public distribution systems, affordable market strategies, biofortification initiatives, and sustained education efforts, India can move closer to achieving the goal of a malnutrition-free nation. The results of this study suggest that strengthening systemic support alongside enhancing maternal knowledge can ensure that every child has consistent access to affordable, accessible, and nutritionally adequate fortified foods.

LIMITATIONS OF THE STUDY

The study's reliance on self-reported data may introduce bias, as participants may overreport socially desirable behaviors. Additionally, the study sample was limited to one geographic region, potentially limiting the generalizability of the findings. These limitations may restrict generalizability and causal inference, but findings remain valuable for designing targeted interventions.

RECOMMENDATIONS

The study identified cost (34%) and availability (25.5%) as the most significant barriers to the inclusion of fortified foods in preschool children's diets. These findings directly inform the following recommendations:

Make fortified foods more affordable: Since cost was cited by over one-third of mothers as a barrier, subsidies or price regulation for fortified products (especially milk, cereals, and oils) would reduce economic constraints and encourage regular inclusion.

Improve availability through distribution channels: With nearly one-fourth of mothers reporting limited access, strengthening the Public Distribution System (PDS) for fortified rice and expanding retail availability of fortified market products can ensure consistent supply.

Sustain education and awareness campaigns: Although awareness was high (85%), gaps remain in understanding and practice. Continuous education, aligned with WHO guidelines and HarvestPlus initiatives, can reinforce the importance of fortification and provide practical guidance for mothers.

Promote diversification of fortified foods: Approximately 30% of mothers reported using more than one type of fortified food. Encouraging diversified use (e.g., combining fortified rice with milk or oils) can maximize micronutrient coverage and reduce reliance on a single source.

RECOMMENDATIONS FOR FUTURE RESEARCH

Future studies should explore interventions that address the identified barriers, such as subsidies for fortified foods or programs to improve their availability in local markets. Longitudinal studies could also provide insights into the long-term impacts of micronutrient fortification on child health outcomes.

ACKNOWLEDGEMENT

The authors sincerely thank the participating mothers, preschool staff, and community health workers in Kochi for their cooperation and support during data collection. We also acknowledge the guidance provided by St. Teresa's College (Autonomous), Ernakulam, and Rajagiri College of Social Sciences, Kalamasseri, for facilitating this research.

ABBREVIATIONS

KAP: Knowledge, Attitudes, and Practices; **PDS:** Public Distribution System; **WHO:** World Health Organization; **UNICEF:** United Nations International Children's Emergency Fund; **SPSS:** Statistical Package for the Social Sciences.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The study was self-supported by the authors and their respective institutions.

ETHICAL APPROVAL

Ethical approval for this study was obtained from the Institutional Ethics Committee of St. Teresa's College, Ernakulam. Written informed consent was obtained from all participants.

AUTHOR CONTRIBUTIONS

Dr. Treesa Sindhu P. Thomas: Conceptualization, study design, data collection, statistical analysis, manuscript drafting, and final approval of the version to be published.

Dr. Leena Leon: Supervision, methodological guidance, critical review of the manuscript, and overall coordination of the research process.

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Cite this article: Thomas TSP, Leon L. Micronutrient Fortification in Early Childhood: Knowledge, Attitudes, and Practices among Mothers of Preschool Children in Kochi, Kerala, India. *Asian J Biol Life Sci.* 2026;15(1):97-103.