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Original Article

Community Section

# Awareness and Consumption of Fortified Foods, Role of Demographic Factors and Associated Barriers among Rural Households in Chengalpattu District: A Cross-sectional Study

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## ABSTRACT

**Introduction:** Food fortification is recognised as a crucial public health measure to combat micronutrient deficiency. In India, food fortification has gained significant attention due to the country's high burden of malnutrition. Though the government has taken initiatives to decrease the burden of malnutrition through food fortification, the prevalence of micronutrition deficiency is still high.

**Aim:** To evaluate the consumer awareness and consumption of fortified foods, as well as to identify demographic, socio-economic, and cultural factors influencing these behaviours.

**Materials and Methods:** This was a cross-sectional study conducted in the field practice area of tertiary care hospital in Chengalpattu district, Tamil Nadu, India, among 341 participants aged 18 to 65 years, from September 2023 to November 2023. Data was collected through face-to-face interviews using a pretested semi-structured questionnaire covering two domains: (a) sociodemographic details such as age, gender, education, occupation, monthly family income, type of family, socioeconomic status, marital status, religion, and co-morbidities; and (b) a questionnaire assessing consumer awareness and consumption of fortified foods. Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 22.0. Chi-square test was used, and a p-value <0.05 was considered statistically significant. Bivariate logistic regression was done to obtain an unadjusted odds ratio and variables with a p-value <0.05 were added to the multivariate model to obtain an adjusted odds ratio (95% CI).

**Results:** The mean (SD) age of the participants was 44.14 (11.8) years. Among the study participants, 95 (27.9%) (95% CI: 23.2-32.9) were aware of food fortification. Around 109 (32%) understood the benefits of consuming fortified foods, and 103 (30.2%) were aware of their availability. Fortified foods were consumed by 88 (25.8%) of the participants. Factors such as occupation, socioeconomic status, and educational status were significantly associated with awareness of fortified foods (p<0.05).

**Conclusion:** About 27.9% of the study participants have awareness regarding food fortification and consumption of fortified foods. Therefore, it is important to create awareness about the impact and burden of diseases due to micronutrient deficiencies and the importance of consuming and awareness of fortified foods.

**Keywords:** Food preferences, Hidden hunger, Health promotion, Malnutrition, Socioeconomic factors

## INTRODUCTION

The World Health Organisation (WHO) defined food fortification as "the practice of deliberately increasing the content of one or more micronutrients (i.e., vitamins and minerals) in food or condiment to improve the nutritional quality of the food supply and provide a public health benefit with minimal health risk". As well as increasing the nutritional content of staple foods, adding micronutrients can help restore the micronutrient content lost during processing [1].

Micronutrient deficiencies contribute to the global disease burden and increased morbidity and mortality rates. Globally, an estimated one-third of people suffer from at least one form of micronutrient deficiency [2]. The 2020 Global Nutrition Report highlighted dramatic inequities in the burden of micronutrient deficiencies [3]. Common micronutrient deficiencies, including iron, vitamin A, iodine, folate, and zinc deficiencies, contribute to severe and even life-threatening conditions [4].

Food fortification is recognised as a crucial public health measure globally to combat nutrient deficiency. It is a cost-effective strategy to improve public health, particularly in regions where access to diverse and nutritious foods is limited. Food fortification is done by adding vitamins and minerals to staple foods. Fortification programs have been implemented in several countries to combat nutrient deficiencies and enhance overall health status [5]. Most commonly, the programs focus on nutrients like iron, folic acid, iodine, vitamin A, and vitamin D [6].

In India, food fortification has gained significant attention due to the country's high burden of malnutrition. The estimated prevalence rates of micronutrient deficiencies are iodine (17%), folic acid (37%), iron (54%), vitamin B12 (53%), vitamin A (19%), and vitamin D (61%) with high heterogeneity. Iron deficiency was most prevalent (61%) in pregnant women [7].

The Government of India, in collaboration with various stakeholders, including food manufacturers, Non-governmental Organisations (NGOs), and international organisations, has implemented fortification programs that address specific nutrient deficiencies. Some key fortification initiatives in India are done under the Food Safety and Standards Authority of India (FSSAI), which includes double fortified salt, wheat flour, rice, milk, and edible oil [8]. These initiatives are part of broader efforts to improve nutrition and public health in India.

Despite government initiatives aimed at reducing malnutrition through food fortification, micronutrient deficiencies remain

prevalent. Limited awareness of food fortification may contribute to widespread micronutrient deficiencies. There is a lack of published literature on the awareness levels of food fortification among the rural population. This study aims to address this gap by assessing consumer awareness and consumption of fortified foods while also evaluating the influence of demographic factors and the barriers faced by the rural population.

## MATERIALS AND METHODS

The present cross-sectional study was conducted for three months from September 2023 to November 2023 in the field practice area under the Rural Training Health Centre, Department of Community Medicine, Chettinad Hospital and Research Institute in Chengalpattu district, Tamil Nadu, India. Ethical clearance for this study was obtained from the Institutional Human Ethics Committee (Approval. No: IHEC-II/0441/23). Written informed consent was obtained from each participant before the start of the study.

**Inclusion criteria:** Participants aged between 18 and 65 years were included in this study.

**Exclusion criteria:** Temporary residents (those residing for less than six months) were excluded.

**Sample size calculation:** The sample size was calculated considering 73.7% as the prevalence from the study conducted by Haripriya A et al., with 5% absolute error, 95% confidence interval, resulting in a required sample size of 310 [9].

$$\text{Sample size (n)} = \frac{4\,PQ}{d2}$$

$$\text{Sample size (n)} = \frac{4*73.7*26.3}{25} = 310$$

With an additional non-response rate of 10%, the final sample size was calculated to be 341.

**Sampling Method:** The study participants were selected by multistage sampling method. Out of the 12 villages under the rural field practice area, 04 villages were selected by lottery method. A line list of individuals aged ≥18 years and ≤65 years was prepared from the family survey registers of the rural training health centre under the department of community medicine. The sample interval was calculated to be 18. The first Sample was selected randomly by lottery method. Subsequently, the remaining samples were selected by systematic sampling method for every 18$^{th}$ house until the sample size was reached. The study was conducted by a postgraduate researcher and assistant professors from the department of community medicine, all with expertise in public health, epidemiology, nutrition, and survey-based research.

### Data Collection Method

Data was collected by face-to-face interviews with a pretested semi-structured questionnaire under two domains. The duration of the interview lasted for 20 to 30 minutes.

A) Sociodemographic details containing participant ID number, age, gender, education, occupation, monthly family income, total number of family members, type of family, socioeconomic status, marital status, religion, and co-morbidities.

B) Questionnaire regarding consumer awareness and consumption of fortified foods.

A pilot study was conducted among 30 participants using the semi-structured questionnaire. Based on the responses and feedback received the questionnaire was modified. Responses of the 30 participants were not included in the final data analysis. The socioeconomic status was classified using the Modified BG Prasad (2024) scale [10]. The questions to assess the awareness of food fortification were adapted from a study by Premkumar GV eight questions were framed, pretested and validated in the pilot study [11]. Reliability analysis for the questions was done, yielding a Cronbach's alpha of 0.88. All eight dichotomous questions were measured on a yes/no scale, with a score of 0 (No) given for a negative response and 1 (Yes) for a positive response. The maximum score that could be obtained was 8, with the lowest score being 0. The median score was calculated to analyse awareness of food fortification. The median score obtained was 4. Those who scored more than 4 were categorised as having good awareness of food fortification, and those who scored ≤4 as having poor awareness.

## STATISTICAL ANALYSIS

Collected data were entered using MS Excel and analysed using SPSS version 22. Categorical variables were expressed in frequencies and percentages. The normality of quantitative variables was assessed through histograms and the Shapiro-Wilk test. Chi-square test was used, and a p-value <0.05 was considered statistically significant. Bivariate logistic regression was done to obtain an unadjusted odds ratio, and those variables with a p-value <0.05 were added to the multivariate model to obtain an adjusted odds ratio, and 95% CI was constructed to gauge the estimate.

## RESULTS

Among the study participants, the majority were females 213 (62.5%), 171 (50.1%) were ≤47 years (the mean (SD) age of the study participants was 44.14) and 285 (83.6%) were Hindu. Most participants were married 260 (76.2%). Educational levels varied, with 95 (27.8%) being illiterate, 50 (14.7%) having completed primary school, 111 (32.6%) having secondary education, 60 (17.6%) being graduates, and 25 (7.3%) holding postgraduate qualifications [Table/Fig-1].

| Variables | Frequency (n) | Percentage (%) |
|---|---|---|
| **Age** | | |
| ≤47 years | 171 | 50.1 |
| >47 years | 170 | 49.9 |
| **Gender** | | |
| Male | 128 | 37.5 |
| Female | 213 | 62.5 |
| **Religion** | | |
| Hindu | 285 | 83.6 |
| Christian | 35 | 10.3 |
| Muslim | 21 | 6.2 |
| **Marital status** | | |
| Married | 260 | 76.2 |
| Unmarried | 81 | 23.8 |
| **Education** | | |
| Illiterate | 95 | 27.8 |
| Primary school | 50 | 14.7 |
| Secondary school | 111 | 32.6 |
| Graduate | 60 | 17.6 |
| Postgraduate | 25 | 7.3 |
| **Occupation** | | |
| Unemployed | 79 | 23.2 |
| Unskilled worker | 133 | 39.0 |
| Semiskilled worker | 70 | 20.5 |
| Skilled worker | 28 | 8.2 |
| Professional | 31 | 9.1 |
| **Socioeconomic status (Modified BG Prasad classification)** | | |
| Class 4 | 56 | 16.4 |
| Class 3 | 109 | 32.0 |
| Class 2 | 128 | 37.5 |
| Class 1 | 48 | 14.1 |

| | | |
|---|---|---|
| **Type of family** | | |
| Nuclear | 255 | 74.8 |
| Joint | 86 | 25.2 |
| **Co-morbidities** | | |
| Present | 205 | 60.1 |
| Absent | 136 | 39.9 |

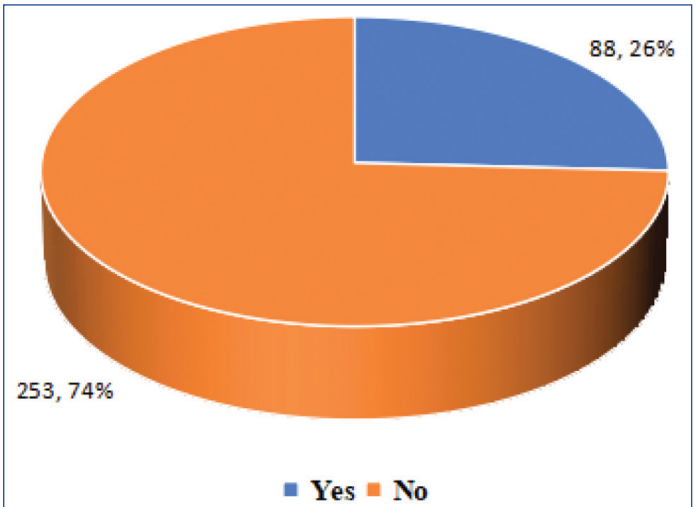
**[Table/Fig-1]:** Sociodemographic profile of the study participants (n=341).

Awareness of food fortification among participants was generally low. Only 113 participants (33.1%) had heard of it, and even fewer were aware of its availability (103, 30.2%) or the addition of nutrients (108, 31.7%). Knowledge about the fortification logo (33, 9.7%), label reading practices (36, 10.6%), and government regulations (45, 13.2%) was minimal. Just 18 (5.3%) had consulted a healthcare professional regarding fortified food consumption [Table/Fig-2].

| Variables | Yes n (%) | No n (%) |
|---|---|---|
| Do you know about food fortification | 113 (33.1) | 228 (66.9) |
| Do you know about the availability of fortified foods | 103 (30.2) | 238 (69.8) |
| Do you know that nutrients or vitamins are added to fortified food | 108 (31.7) | 233 (68.3) |
| Are you aware of the benefits of consuming fortified foods | 109 (32.0) | 232 (68.0) |
| Do you know about the food fortification logo used on the food label in India | 33 (9.7) | 308 (90.3) |
| Do you read the labels or packaging information of fortified foods before purchasing them | 36 (10.6) | 305 (89.4) |
| Do you know that the Indian government made fortification compulsory | 45 (13.2) | 296 (86.8) |
| Have you ever consulted a healthcare professional or nutritionist regarding the consumption of fortified foods | 18 (5.3) | 323 (94.7) |

**[Table/Fig-2]:** Consumer awareness of food fortification (n=341).

[Table/Fig-3] shows that only 88 (26%) participants reported consuming fortified foods, while a majority 253 (74%) did not. [Table/Fig-4] shows that the most common source of information on food fortification was advertisements or news, reported by 70 participants (79.6%). This was followed by books or magazines 36 (41.5%), family or friends 21 (23.8%), food labels 20 (22.1%), physicians or dieticians 15 (17.6%), and the internet 14 (15.9%).




**[Table/Fig-3]:** Consumption of fortified foods by the study participants (n=341).

[Table/Fig-5] highlights that the most commonly consumed fortified food was salt, reported by 36 participants (40.2%), followed by edible oil 25 (28.4%), wheat flour 13 (14.6%), rice 10 (11.1%), and milk 09 (10.9%). [Table/Fig-6] shows that among those who consumed fortified foods, the factors influencing the decision to purchase and consume fortified foods were nutritional value reported by 81 (92.9%) participants. This was followed by taste and flavour

| S. No. | Variables | Frequency (n) | Percentage (%) |
|---|---|---|---|
| 1. | Advertisement/News | 70 | 79.6 |
| 2. | Books/Magazines | 36 | 41.5 |
| 3. | Family/Friends | 21 | 23.8 |
| 4. | Food labels | 20 | 22.1 |
| 5. | Physicians/Dietitians | 15 | 17.6 |
| 6. | Internet | 14 | 15.9 |

**[Table/Fig-4]:** Sources of information on food fortification (n=113)*.
*Multiple responses

| S. No. | Variables | Frequency (n) | Percentage (%) |
|---|---|---|---|
| 1. | Salt | 36 | 40.2 |
| 2. | Edible oil | 25 | 28.4 |
| 3. | Wheat flour | 13 | 14.6 |
| 4. | Rice | 10 | 11.1 |
| 5. | Milk | 09 | 10.9 |

**[Table/Fig-5]:** Types of fortified foods consumed among study participants (n=88)*.
*Multiple responses

53 (60.1%), availability in stores 29 (33.6%), convenience 20 (22.1%), recommendations from healthcare professionals or nutritionists 18 (20.3%), brand reputation 05 (5.3%), and price 03 (3.5%).

| S. No. | Variables | Frequency (n) | Percentage (%) |
|---|---|---|---|
| 1. | Nutritional value | 81 | 92.9 |
| 2. | Taste and flavour | 53 | 60.1 |
| 3. | Availability in stores | 29 | 33.6 |
| 4. | Convenience | 20 | 22.1 |
| 5. | Recommendations from healthcare professionals or nutritionists | 18 | 20.3 |
| 6. | Brand reputation | 05 | 5.3 |
| 7. | Price | 03 | 3.5 |

**[Table/Fig-6]:** Factors influencing the decision to purchase and consume fortified foods (n=88)*.
*Multiple responses

[Table/Fig-7] shows the barriers and challenges affecting the consumption of fortified foods among the study participants were lack of knowledge or understanding about fortified foods was reported by 117 participants (46.2%). This was followed by a preference for natural or unfortified foods (73, 28.9%), concerns about high cost or affordability (47, 18.6%), limited availability (33, 13%), and worries about potential side effects or safety (10, 3.9%).

| S. No. | Variable | Frequency (n) | Percentage (%) |
|---|---|---|---|
| 1. | Lack of knowledge or understanding about fortified foods | 117 | 46.2 |
| 2. | Preference for natural or unfortified foods | 73 | 28.9 |
| 3. | High cost or affordability | 47 | 18.6 |
| 4. | Lack of availability in their area | 33 | 13 |
| 5. | Concerns about potential side effects or safety | 10 | 3.9 |

**[Table/Fig-7]:** Barriers and challenges affecting the consumption of fortified foods (n=253)*.
*Multiple responses

The findings suggest that demographic and socioeconomic factors influence awareness of food fortification. Females and married individuals demonstrated higher awareness levels. Lower socioeconomic status was associated with significantly reduced awareness. Additionally, higher education and skilled professions were linked to greater awareness. These findings suggest that sociodemographic factors play significant roles in determining awareness levels regarding food fortification [Table/Fig-8].

| S. No. | Variables | Awareness of food fortification | | Total (n=341) | Chi-square $\chi^2$ | Unadjusted odds ratio (95% CI) | p-value |
|---|---|---|---|---|---|---|---|
| | | Poor n (%) n=246 (72.1%) | Good n (%) n=95 (27.9%) | | | | |
| 1. | **Age** | | | | | | |
| | ≤47 years | 119 (48.4%) | 52 (54.7%) | 171 (50.1%) | 1.110 | 0.775 (0.48-1.2) | 0.292 |
| | >47 years | 127 (51.6%) | 43 (45.3%) | 170 (49.9%) | | | |
| 2. | **Gender** | | | | | | |
| | Male | 101 (41.1%) | 27 (28.4%) | 128 (37.5%) | 4.667 | 1.754 (1.05-2.93) | 0.031* |
| | Female | 145 (58.9%) | 68 (71.6%) | 213 (62.5%) | | | |
| 3. | **Marital status** | | | | | | |
| | Unmarried | 66 (26.8%) | 15 (15.8%) | 81 (23.8%) | 4.612 | 1.956 (1.05-3.63) | 0.032* |
| | Married | 180 (73.2%) | 80 (84.2%) | 260 (76.2%) | | | |
| 4. | **Socioeconomic status (Modified BG Prasad classification)** | | | | | | |
| | Class 4 | 51 (20.7%) | 5 (5.3%) | 56 (16.4%) | 82.283 | 30.76 (12.2-58.8) | 0.004* |
| | Class 3 | 93 (37.8%) | 16 (16.8%) | 109 (32.0%) | | 22.08 (9.2-53.01) | 0.006* |
| | Class 2 | 92 (37.4%) | 36 (37.9%) | 128 (37.5%) | | 9.711 (4.3-21.5) | 0.034* |
| | Class 1 | 10 (4.1%) | 38 (40.0%) | 48 (14.1%) | | 1 | 1 |
| 5. | **Education** | | | | | | |
| | Illiterate | 93 (37.8%) | 2 (2.1%) | 95 (27.8%) | 91.419 | 35.6 (20.56-65.5) | 0.001* |
| | Primary school | 44 (17.9%) | 6 (6.3%) | 50 (14.7%) | | 29.33 (8.1-66.3) | 0.006* |
| | Secondary school | 85 (34.6%) | 26 (27.4%) | 111 (32.6%) | | 13.07 (4.4-38.27) | 0.002* |
| | Graduate | 19 (7.7%) | 41 (43.2%) | 60 (17.6%) | | 1.854 (0.60-5.6) | 0.280 |
| | Postgraduate | 5 (2.0%) | 20 (21.0%) | 25 (7.3%) | | 1 | 1 |
| 6. | **Occupation** | | | | | | |
| | Unemployed | 62 (25.2%) | 17 (17.9%) | 79 (23.2%) | 72.045 | 18.95 (6.33-56.18) | 0.001* |
| | Unskilled | 116 (47.2%) | 17 (17.9%) | 133 (39.0%) | | 35.48 (12.01-66.8) | 0.001* |
| | Semi-skilled | 51 (20.7%) | 19 (20.0%) | 70 (20.5%) | | 13.958 (4.68-41.61) | 0.001* |
| | Skilled | 12 (4.9%) | 16 (16.8%) | 28 (8.2%) | | 3.90 (1.157-13.14) | 0.028* |
| | Professional | 5 (2.0%) | 26 (27.4%) | 31 (9.1%) | | 1 | 1 |
| 7. | **Religion** | | | | | | |
| | Muslim | 14 (5.7%) | 7 (7.4%) | 21 (6.2%) | 0.356 | 0.75 (0.29-1.94) | 0.964 |
| | Christian | 25 (10.2%) | 10 (10.5%) | 35 (10.3%) | | 0.94 (0.43-2.18) | 0.567 |
| | Hindu | 207 (84.1%) | 78 (82.1%) | 285 (83.6%) | | 1 | 1 |
| 8. | **Type of family** | | | | | | |
| | Joint | 63 (25.6%) | 23 (24.2%) | 86 (25.2%) | 0.071 | 1.08 (0.62-1.87) | 0.808 |
| | Nuclear | 183 (74.4%) | 72 (75.8%) | 255 (74.8%) | | 1 | 1 |
| 9. | **Co-morbidities** | | | | | | |
| | Present | 148 (60.2%) | 57 (60%) | 205 (60.1%) | 0.001 | 1.01 (0.62-1.63) | 0.314 |
| | Absent | 98 (39.8%) | 38 (40%) | 136 (39.9% | | 1 | 1 |

**[Table/Fig-8]:** Association between awareness of food fortification and sociodemographic variables.
*p-value <0.05 - Statistically significant at 95% CI: Confidence interval; OR: Odd's ratio, $\chi^2$- Chi-square

The findings highlight that lack of awareness about food fortification is significantly associated with lower education levels and lower socioeconomic status. Additionally, unemployed, unskilled, and semi-skilled workers were more likely to lack awareness. These findings suggest that education level, socioeconomic status, and occupation are important factors associated with a lack of awareness about food fortification [Table/Fig-9].

| S. No. | Variables | p-value | Adjusted odds ratio | 95% CI |
|---|---|---|---|---|
| 1. | Female | 0.132 | 1.712 | 0.8-3.4 |
| 2. | Unmarried | 0.805 | 0.875 | 0.3-2.5 |
| 3. | **Education** | | | |
| | Illiterate | **0.003*** | 2.706 | 1.1-4.46 |
| | Primary school | **0.001*** | 1.617 | 1.5-2.67 |
| | Secondary school | **0.023*** | 1.138 | 1.04-8.3 |
| 4. | **Socioeconomic status** | | | |
| | Class 4 | **0.023*** | 7.661 | 1.3-14.3 |
| | Class 3 | **0.028*** | 5.563 | 1.2-12.4 |
| | Class 2 | **0.025*** | 5.182 | 1.2-14.4 |
| 5. | **Occupation** | | | |
| | Unemployed | **0.033*** | 6.163 | 1.19-19.2 |
| | Unskilled | **0.002*** | 4.891 | 1.7-18.5 |
| | Semi-skilled | **0.009*** | 2.850 | 1.2-4.8 |
| | Skilled | **0.002*** | 2.466 | 1.4-5.2 |

**[Table/Fig-9]:** Binomial logistic regression analysis between awareness of food fortification and sociodemographic variables.
"Enter method" was used for binomial logistic regression; *p-value <0.05 - Statistically significant at 95% Confidence interval, OR: Odd's ratio; AOR: Adjusted odd's ratio

## DISCUSSION

This study aimed to assess the awareness of food fortification and consumption of fortified foods among rural households in

Chengalpattu district. The results have provided significant insights into the understanding and usage of food fortification in this population.

The mean (SD) age of the study participants was 44.14 (11.8) years and majority were female (62.5%). Awareness of food fortification was found to be relatively low, with only 27.9% (95% CI: 23.2-32.9) of participants being aware. Previous studies have also reported varying levels of awareness. Ahuja R et al., found that 33% of participants in Vadodara were aware of fortified foods [12], while Premkumar GV reported 56.6% awareness among women in urban Delhi [11]. Similarly, in Kenya Linda AA et al., observed 28% awareness [13] and Kasankala L et al., found that only 7.9% of mother/child caretakers had heard of food fortification [14]. Conversely, Battalwar R et al., in Mumbai City reported high awareness among nearly all participants [15].

These findings indicate that awareness and consumption of fortified foods tend to be higher in urban areas compared to rural populations. These variations may be due to differences in geographical locations, urban-rural divides, and the target populations studied. This highlights the need for targeted and ongoing awareness programs, especially in rural areas where knowledge of food fortification remains low [6].

The sources of information about fortified foods in the present study highlight advertisements/news as the primary source, followed by books/magazines, family/friends, and food labels. Battalwar R et al., have stated the major sources of information were friends, relatives, the internet, and media [15]. In contrast, Mugilan K et al., emphasised books, word of mouth, and social media [16], while Varshini SS et al., mentioned newspapers or magazines, word of mouth, and television advertisements as the primary sources [17]. These differences suggest that information dissemination strategies should be adapted to cultural and media preferences to maximise awareness.

Among those aware of fortified foods (27.9%), the primary factor influencing consumption was nutritional value, followed by taste, availability, convenience, healthcare recommendations, brand reputation, and price. This aligns with Mugilan K et al., who found that reducing nutritional deficiencies and convenience were key motivators [16]. Pinho MGM et al., highlighted taste preferences as a major factor to healthy eating [18]. Globally, there is an increasing trend towards health-conscious consumer behaviour, with fortified foods being recognised for their nutritional benefits [19,20].

For the 72.1% of participants unaware of fortified foods, the factors hindering them from consuming fortified foods were majorly lack of knowledge or understanding about fortified foods, followed by preference for natural or unfortified foods, high cost or affordability, lack of availability and concerns about potential side effects or safety. Similar findings were reported by Bromage S et al., and Varshini SS et al., who identified lack of awareness as a significant barrier [17,21]. This highlights a crucial gap in public awareness regarding fortified foods, indicating a need for targeted education and awareness campaigns to address this issue [22]. Other studies have noted a preference for traditional foods and family influences as additional barriers [23,24]. Cultural norms, taste preferences, and perceptions of naturalness play a crucial role in food choices [25].

In this study, high cost and limited availability were also significant barriers, as seen in studies by Lima JPM et al., and Varshini SS et al., [17,26]. Limited market availability and lack of awareness about fortified foods can indirectly lead to perceived higher costs or affordability concerns among consumers, leading them to opt for non-fortified foods [27]. Addressing affordability concerns through subsidies, pricing interventions, and collaborations with manufacturers can improve accessibility [28]. Additionally, educating consumers on the long-term health and cost benefits of fortified foods can influence purchasing decisions [29].

This study found that awareness of food fortification was lower among individuals who were illiterate, unemployed, and from lower socioeconomic background. Linda AA et al., in Kenya reported higher awareness among individuals with secondary and tertiary education [13]. Similarly, Büyükkaragöz A et al., and Premkumar GV found that higher education and socioeconomic status were associated with greater awareness [11,30]. Ahuja R et al., reported that awareness, perception, and purchase of fortified foods increased following an e-intervention method [31]. This highlights that education increases exposure to health-related information, while higher socioeconomic status provides better access to health resources [32].

These findings indicate that awareness of food fortification is high among people with high socioeconomic status, higher education levels, and residing in urban areas. Therefore, the findings suggest that increasing the level of awareness of food fortification and consumption of fortified foods can improve the nutritional level of the population.

### Limitation(s)

Awareness and consumption of fortified foods are keys to addressing micronutrient deficiencies, but longitudinal studies are needed to establish causal links with demographic factors. This cross-sectional study estimates prevalence and associated factors but cannot assess changes over time. Cohort studies are required to evaluate long-term impacts. The study's feasibility was limited by time and resources, and its findings may not be generalisable beyond rural Chengalpattu. A broader sample, including urban areas could provide deeper insights.

## CONCLUSION(S)

Less than 50% of the study participants only have awareness regarding food fortification and consumption of fortified foods. This highlights the need for tailored interventions to improve awareness and accessibility of fortified foods, particularly in rural areas. Increasing awareness, addressing economic barriers, and promoting fortified foods through culturally relevant channels can enhance consumption and contribute to improved public health outcomes. Future research can focus on assessing the effectiveness of different awareness strategies, exploring long-term behavioural changes in fortified food consumption, and evaluating policy interventions aimed at improving access and affordability of fortified foods among the rural population.

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## REFERENCES

[1] Food fortification [Internet]. [cited 2024 Feb 16]. Available from: https://www.who.int/health-topics/food-fortification.
[2] Pingault N, Caron P, Kalafatic C, Allahoury A, Fresco LO, Kennedy E, et al. Nutrition and food systems. A report by the high level panel of experts on food security and nutrition of the committee on world food security. Rome: FAO; 2017:151 p. Available from: https://www.fao.org/cfs/cfs-hlpe/en
[3] Mannar V, Micha R, Allemandi L, Afshin A, Baker P, Battersby J, et al. 2020 Global nutrition report: Action on equity to end malnutrition. 2020;2020:89023.
[4] Han X, Ding S, Lu J, Li Y. Global, regional, and national burdens of common micronutrient deficiencies from 1990 to 2019: A secondary trend analysis based on the global burden of disease 2019 study. EClinicalMedicine. 2022;44:101299.
[5] Rohner F, Wirth JP, Zeng W, Petry N, Donkor WES, Neufeld LM, et al. Global coverage of mandatory large-scale food fortification programs: A systematic review and meta-analysis. Adv Nutr. 2023;14(5):1197-210.
[6]6. Olson R, Gavin-Smith B, Ferraboschi C, Kraemer K. Food fortification: The advantages, disadvantages and lessons from sight and life programs. Nutrients. 2021;13(4):1118.
[7] Venkatesh U, Sharma A, Ananthan VA, Subbiah P, Durga R. Micronutrient's deficiency in India: A systematic review and meta-analysis. J Nutr Sci. 2021;10:e110.
[8] Fortification: Fortification [Internet]. [cited 2024 Feb 16]. Available from: https://fortification.fssai.gov.in/.

[9] Haripriya A, Uma Mageshwari S. A study on consumer's knowledge, attitude and consumption pattern of functional foods and nutraceuticals in Tamil Nadu, India. Annals of the Romanian Society for Cell Biology. 2021;25(6):14686-96.
[10] KJA, Mishra A, Borle AL. Updated B.G. Prasad Scale for socioeconomic status classification for the year 2024. Indian J Pediatr. 2024;91(6):643.
[11] Premkumar GV. Consumer knowledge, attitude and practice of using fortified food in India: A study among women in urban Delhi. Int J Health Sci Res. 2020;10(7):277-82.
[12] Ahuja R, Sheth M. A cross-sectional study on consumer awareness of fortified foods in Vadodara City. Paripex-Indian Journal of Research. 2021;10(06):85-86.
[13] Linda AA, Kyallo F, Okoth JK, Kahenya P, Makokha A, Sila D, et al. Food fortification: The level of awareness among Kenyan consumers. J Nutr Metab. 2020;2020:e8486129.
[14] Kasankala L, Kitunda M, Mushumbusi D, Cyprian C, Meghji W, Mgoba M, et al. Knowledge and awareness on food fortification among mother/child caretakers of Kinondoni Municipality, Tanzania. Asian Food Science Journal. 2018;2:01-13.
[15] Battalwar R, Syed BF. A study on awareness and consumption of fortified foods among female adults of Mumbai. Int J Sci Res. 2017;6(4):1242-52.
[16] Mugilan K, Samsai T, Mahendran K, Prahadeeswaran M, Gangai Selvi R. A study on consumer preferences towards fortified edible oils in Coimbatore city. The Pharma Innovation Journal. 2023;12(8):2044-50.
[17] Varshini SS, Samsai T, Velavan C, Prahadeeswaran M, Raja K. A study on consumer preference towards fortified flour products and constraints encountered in the purchase of fortified flour products in Coimbatore City. The Pharma Innovation Journal. 2023;12(9S):662-72.
[18] Pinho MGM, Mackenbach JD, Charreire H, Oppert JM, Bárdos H, Glonti K, et al. Exploring the relationship between perceived barriers to healthy eating and dietary behaviours in European adults. Eur J Nutr. 2018;57(5):1761-70.
[19] Dwyer JT, Wiemer KL, Dary O, Keen CL, King JC, Miller KB, et al. Fortification and health: Challenges and opportunities. Adv Nutr. 2015;6(1):124-31.
[20] Eze NM, Maduabum FO, Onyeke NG, Anyaegunam NJ, Ayogu CA, Ezeanwu BA, et al. Awareness of food nutritive value and eating practices among Nigerian bank workers. Medicine (Baltimore). 2017;96(10):e6283.
[21] Bromage S, Gonchigsumlaa E, Traeger M, Magsar B, Wang Q, Bater J, et al. Awareness and attitudes regarding industrial food fortification in Mongolia and Harbin. Nutrients. 2019;11(1):201.
[22] Pounis GD, Makri S, Gougias L, Makris H, Papakonstantinou M, Panagiotakos DB, et al. Consumer perception and use of iron fortified foods is associated with their knowledge and understanding of nutritional issues. Food Quality and Preference. 2011;22(7):683-88.
[23] Farahmand M, Tehrani FR, Amiri P, Azizi F. Barriers to healthy nutrition: Perceptions and experiences of Iranian women. BMC Public Health. 2012;12:1064.
[24] Haghighian Roudsari A, Vedadhir A, Rahmani J, Milani Bonab A. Explaining the barriers and facilitators of ethnic and traditional food choices from the viewpoints of women. J Ethn Food. 2019;6(1):33.
[25] Jeong S, Lee J. Effects of cultural background on consumer perception and acceptability of foods and drinks: A review of latest cross-cultural studies. Current Opinion in Food Science. 2021;42:248-56.
[26] Lima JPM, Costa SA, Brandão TRS, Rocha A. Food consumption determinants and barriers for healthy eating at the workplace- A University setting. Foods. 2021;10(4):695.
[27] Monroy-Gomez J, Ferraboschi C, van Zutphen KG, Gavin-Smith B, Amanquah D, Kraemer K. Small and medium enterprises' perspectives on food fortification amid the growing burden of malnutrition. Nutrients. 2022;14(18):3837.
[28] Fanzo J, McLaren R, Bellows A, Carducci B. Challenges and opportunities for increasing the effectiveness of food reformulation and fortification to improve dietary and nutrition outcomes. Food Policy. 2023;119:102515.
[29] Tian Y, Zhu H, Zhang L, Chen H. Consumer preference for nutritionally fortified eggs and impact of health benefit information. Foods. 2022;11(8):1145.
[30] Büyükkaragöz A, Bas M, Sağlam D, Cengiz ŞE. Consumers' awareness, acceptance and attitudes towards functional foods in Turkey. International Journal of Consumer Studies. 2014;38(6):628-35.
[31] Ahuja R, Sheth M. Action research on advocating use of fortified foods in the free-living population of urban vadodara using diffusion of innovation model. Asian Pac J Health Sci. 2021;8(4):199-204.
[32] Hamulka J, Wadolowska L, Hoffmann M, Kowalkowska J, Gutkowska K. Effect of an education program on nutrition knowledge, attitudes toward nutrition, diet quality, lifestyle, and body composition in polish teenagers. The ABC of Healthy Eating Project: Design, Protocol, and Methodology. Nutrients. 2018;10(10):1439.

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