RESEARCH PAPER

From Availability to Consumption: Assessing the Fortified Food Environment in Urban Slums of Delhi, India for Policy Insights

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ABSTRACT
Background: Food Fortification is an important strategy to reduce the prevalence of hidden hunger. The objective of this study was to assess the availability of fortified food products in the urban slums of Delhi. About 204 shops and 351 Women were surveyed from 3 different slums of Delhi were surveyed to understand the availability and consumption of fortified food products and to assess the knowledge of shopkeepers selling these products. Only 48% of the shops were selling fortified products and only 14.7% shopkeepers were aware about fortification. Most of the fortified foods sold were costlier than their non-fortified counterparts. Double Fortified Salt (DFS) was completely absent from all shops surveyed. About 78.9% women were consuming at least one fortified product. Barriers for sale of fortified foods were low demand and preference for unpackaged loosely sold alternatives. Supply assurance and consumer awareness should be prioritized to improve availability and demand for fortified foods.
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INTRODUCTION
Food Fortification offers a cost-effective solution to tackle the persistent problem of micro-nutrient deficiencies. About 93 countries have mandated fortification of wheat flour and 129 countries have mandated salt fortification globally (Global Fortification Data Exchange, 2024). In India, staples like oil and salt were the first ones to get fortified through Government initiatives like fortification of Vanaspati (1953) and Universal Salt Iodization (USI) (1962). According to recent national data, 96.9% of the Indian households have reported consuming iodized salt (International Institute for Population Sciences [IIPS] & Ministry of Health and Family Welfare [MoHFW], 2024). Currently, fortified staples available in the Indian market are salt, rice, oil, milk and wheat flour (Sirohi et al., 2018). Government of India has mandated a +F logo on the packaging of every fortified food in India ((Food Safety and Standards Authority of India [FSSAI], 2018). Efforts have been made to include fortified staples in the Public Distribution Systems (PDS), Mid- Day Meal (MDM) program and Integrated Child Development Service (ICDS) (Duggal et al., 2022).

Studies on impact of fortification on micro-nutrient deficiencies have reported mixed results. Various studies have shown positive effects of fortification to combat micro-nutrient deficiencies in India. Moretti et al. (2006) reported that fortified rice provided through a school lunch feeding program improved iron stores and reduced iron deficiency among Indian schoolchildren. Barkley et al. (2015), reported that among nations with national flour fortification programs, the risks of anemia for non-pregnant women decreased by 2.4% for each year of consuming fortified flour. On the contrary, Field et al. (2020) found that fortifying wheat flour with iron had little or no effect on anemia and had little to no impact on iron deficiency compared to unfortified wheat flour; and that the addition of other micro-nutrients also had little impact on iron deficiency and hemoglobin concentrations compared to wheat flour alone.

Success of fortification depends on sufficient market availability, effective supply chain and marketing as well as awareness (Nutrition International, 2023). Some studies have reported knowledge, attitude and practices of consumers regarding fortified foods across different urban cities in India (Premkumar & Garg 2020; Nagraj et al., 2013; Battalwar et al., 2017). Studies on the availability of fortified foods in markets catering to low SES remain limited. There are studies to show that slum dwellers, especially women consume diets lacking in micro-nutrients (Deshpande et al., 2024). Therefore, this study was designed to understand availability and consumption of fortified products among urban slum communities in Delhi which can provide valuable data for policies related to fortification.

DATA AND METHODS

Study design

A cross-sectional survey was conducted from September 2025-April 2026. The data was collected from three slums namely Khichdipur, Bhati Mines and Nehru Ekta Camp, covering eastern and southern districts of Delhi. All shops within the slum that agreed to participate were included in the study. The data was collected from the shopkeepers through a structured questionnaire. Data on the cost of fortified products and their non-fortified variants was also collected wherever available. A survey was also conducted among women from the slums to gather information about their fortified food consumption patterns using a structured questionnaire. Apart from the primary data, secondary data on available fortified brands of products was also taken from the FSSAI dashboard (FSSAI, n.d.).

Fortified Products in the study are referred to as packaged products which are fortified with one or more micronutrients. These products have a +F logo on their packets as mandated by FSSAI. Currently in India, +F logo is present on packets of wheat flour, rice, oil, Double Fortified Salt (DFS) and milk. Iodized salt however, does not have a +F logo on its packet. Shops covered in the study included wholesale shops, retail shops, milk booths, PDS outlets present within the slums. PDS outlets are licensed under Government of India to distribute essential food items at subsidized prices to eligible households belonging to the low socio-economic group. At the time of data collection, fortified rice was being provided universally through PDS scheme.

Inclusion and Exclusion Criteria

Shops selling foods likely to be fortified such as general stores, wholesale shops, PDS outlets, milk booths were included in the study. Data was collected from only those shops which were open at the time of data collection. Informed consent was taken from the participants prior to data collection.

Data Analysis

Data were collected using a structured survey developed on Jotform and subsequently exported for cleaning and analysis. Descriptive statistics were used to assess fortified food availability, awareness, demand, and pricing across different shop types. Chi-square test was used to examine associations with key outcomes. All analyses were conducted using Statistical Package for the Social Sciences (SPSS) software version 25.

RESULTS

A total of 204 shops were surveyed from the selected slums across Delhi. Out of total shops surveyed, 58.3% were retail (n=119), followed by wholesale (33.3%, n=68), milk booths (7.8%, n=9) and PDS outlets (6.4%, n=8). Fortified food consumption data was taken from women residing in the selected slums (n=351).

Awareness about Fortification

Only 14.7% of the shopkeepers (n=30) were aware about fortified food. About 11.2% (n=23) were able to recognize the +F symbol on food products. Knowledge about fortification was associated with education level; higher education was correlated with better awareness (χ^2=33.9, p <0.001).

Table 1: Association of different variables with awareness about fortification

Variable	Category	%	χ^2 (df)	p-value
Education level — knowledge of fortification	Illiterate	2.7	**33.9 (3)**	**< 0.001**
	10th standard	7.6		
	12th standard	21.7		
	Graduate/PostGraduate	43.7		
Footfall (customers/day) — stocking of fortified foods	< 25	33.8	**23.58(2)**	**< 0.001**
	25–50	38.1		
	> 50	76.6		
Shop type — availability of fortified foods	PDS outlet	100.0	**94.99 (3)**	**< 0.001**
	Retail	29.4		
	Wholesale	66.1		
	Milk booth	100		

Fortified Products Availability

Out of all shops surveyed, 48.03% of shops (n=98) stocked at least one fortified product. Availability of fortified products varied significantly by shop type (χ^2=94.99, p<0.001) wherein all PDS outlets (100%) and milk booths (100%) stocked fortified food while 66.1% wholesale shops and 29.4% retail shops stocked any fortified food products. However, iodized salt was available in all wholesale and retail shops.

There was a statistically significant association between daily footfall and the likelihood of stocking fortified foods. Shops with higher customer footfall were more likely to stock fortified food products (χ^2 =23.58, p < 0.001) as shown in the table 1.

The most widely available fortified product was oil (62.2%), milk (32.65%), rice (8.1%) and wheat flour (7.1%). It is interesting to note that DFS was not available in any of the surveyed shops whereas, iodised salt was available in all shops surveyed. Apart from these products, Ultra Processed Foods (UPF) with enriched micronutrients were also available in the shops. These included instant noodles (28.08%) biscuits (12.2%) and juices (10.08%). All PDS outlets surveyed were supplying fortified rice but fortified wheat flour was not available at any PDS outlet. The only fortified rice variant available in the slums were the one available in the PDS outlets.

Secondary data was studied to account for total number of fortified brands available in India for major food products namely wheat flour, rice, oil, milk and DFS (FSSAI, 2026). Data on brands being sold in the slum shops for these products was also collected and is presented in Table 2.

Table 2: Fortified product brands available in slum shops

S.No	Products	Total number of brands selling fortified products in India*	Fortified product brands available in the slum shops
1.	Wheat flour	7	1
2.	Rice	4**	1
3.	Oil	22	4
4.	Milk	30	2
5.	DFS	11	0

*As per FSSAI dashboard dated 22nd May 2026

**** Also includes PDS variant of rice**

Price-Wise Comparison of Fortified and Non-Fortified Products

Average market price-wise comparison was done for products based on their available fortified and non-fortified alternatives. The non-fortified variant of products like milk were generally the ones sold unpackaged/unbranded, which were 3.5% to 22.2% cheaper than their fortified variant. However, PDS variant of the fortified rice was free for all the underprivileged sections by the Government. Whereas, most commonly used mustard oil for Indian cooking and fortified refined oil were approximately priced at similar values. Additionally, for salt, the price of DFS (MRP) was 29.6% times higher than iodized salt but lower as compared to non-fortified (rock salt).

Barriers and Solutions for Fortified Food Sale

Maximum shopkeepers (37.8%) cited customer preference for cheaper, unbranded alternatives as the primary challenge. About 18.2% reported that customers lack knowledge about the health benefits of fortified foods. Further, 17.8% indicated that low customer demand makes stocking fortified products economically nonviable.

Feedback was taken from the shopkeepers, regarding the solutions that can be opted to increase the sale of fortified foods. Around 55.4% suggested that social media marketing could be an effective solution for the same. Other suggestions included distribution of free samples (41.7%) and door to door campaign (34.18%) to enhance the awareness about health benefits of fortification.

Consumption Patterns

About 78.9% (n=277) of the participants were consuming at-least one fortified product. The most commonly consumed fortified product was oil (58.1%), followed by rice (42.5%), milk (8.8%) and wheat flour (7.1%) as mentioned in Table 3. On the other hand, DFS consumption was reported by none whereas iodized salt was consumed by all participants.

Table 3: Consumption of fortified foods

Fortified Product Category	Participants consuming Fortified Variant	Percentage
Rice	149	42.5%
Oil	204	58.1%
Milk	31	8.8%
Wheat Flour	25	7.1%
Iodised salt	351	100%

DISCUSSION

In India, the fortified food landscape is expanding, but consumer awareness and market penetration remain low. Statistics from India have reported that there are over 157 brands of

five major fortified staples namely oil, milk, wheat flour, rice and DFS currently available (FSSAI, 2020). Apart from staples, majority of packaged products available are unfortified. Only 15.6% packaged foods available in the Indian market were fortified or enriched with one/more micronutrients (Access to Nutrition Initiative [ATNI], 2023). This gap indicates a key policy challenge. Fortification efforts have increased at the level of regulation and licensing, but market penetration remains limited.

The availability of fortified staples is often influenced by supply chain. According to government reports, more than 21,000 rice mills have been outfitted with blending or extrusion equipment to create fortified rice kernels, primarily in order to satisfy the demands of public food programs (Press Information Bureau [PIB], 2024). Fortified rice has little traction in open retail markets and is still mostly restricted to government procurement channels despite this capability. This maybe because lower-income households consume locally milled or loosely sold unfortified rice that is not covered by centralized fortification systems. On the other hand, about 30 cooperative dairy farms provide fortified milk across 23 states in India (International Dairy Federation, 2021).

Another supply chain challenge is the complete absence of DFS in all the retail stores. Other Indian studies have also reported low availability of DFS (Duggal et al., 2022; Reddy & Nair, 2016). Hence, there is a need for approaches that focus on distribution and retail-level adoption.

Additionally, demand-side dynamics continue to be a limitation. Consumer awareness and practices related to fortified foods varied across metropolitan cities. While a study in Mumbai reported relatively high awareness and consumption of fortified foods, research from urban Delhi identified gaps in knowledge, recognition of fortification logos, and consumption practices (Battalwar & Chavan, 2017; Premkumar & Garg, 2020). Although this study reported that 78.9% women were consuming at least one fortified food. This could possibly be due to two reasons – free fortified rice supplied in the PDS outlets and brand value of/loyalty to the edible oil companies.

Another important but underutilized policy lever was retailer awareness. Shopkeepers in this study had low awareness of fortification and identification markers like the +F logo. The last-mile efficacy of fortification policies is weakened by retailers' limited involvement. In low-income urban areas, shopkeepers' awareness can directly influence the fortified food environment as they are crucial in determining what foods are stocked, displayed and promoted.

PDS serves as an example of what can be accomplished with strong policy alignment as it reaches out to about 81.35 crore beneficiaries nationwide (PIB, 2023). This study was conducted during the times when the distribution of fortified rice was mandated by the Government. It has been discontinued from 2026. A formative study reported dissatisfaction with respect to the fortified rice available via PDS outlets as 68% households said that rice floats while washing and 27% reported throwing away the floating kernels (ICMR-National Institute of Nutrition, 2024). Although, the widespread availability of fortified rice via PDS outlets demonstrates the efficacy of mandatory procurement and centralized distribution, but lack of consumer's knowledge about fortification made them reject the food.

Limitations

The study covered only selected slum clusters, restricting generalizability to other settings. Self-reported data from participants may have introduced a bias. The cross-sectional nature of the study reflects observations from a single point in time.

Author's Contribution

SM conceptualized the research, conducted the literature review, and drafted the manuscript. PM provided supervision, edited and approved the manuscript. KY provided supervision and inputs for refining the manuscript.

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Ethics approval and consent to participate

Ethical approvals were taken from Institutional Ethics Committee, Lady Irwin College. Consent was taken from participants before enrollment.

Conflicts of interest

There are no conflicts of interest.

Data Availability Statement

Data sharing is available upon request to the authors.

CONCLUSION

Food environment plays a crucial role in dietary choices. Penetration of fortified foods in markets serving lower SES remains limited. While India's fortification agenda has achieved regulatory scale and public-sector reach, its population-level impact will depend on deeper integration with private markets, stronger retailer engagement, and demand-generation strategies aligned with consumer behavior. Addressing these policy gaps is essential to

ensure that fortification moves beyond programmatic success towards sustained improvements in everyday diets.

Hence, in order to improve availability and demand for fortified foods, both supply assurance and consumer awareness should be prioritized.

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