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A Direct Assessment of the External Domain of Food Environments in the National Capital Region of India

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Data on food environments in India and other low- and middle-income countries are scarce. The objective of this study was to assess the four dimensions of the external domain of food environments (availability, price, vendor and product properties, and marketing) in food establishments in the National Capital Region of India. The assessment focused on fruits, vegetables, and ultra-processed foods. The 60 food establishments surveyed were categorized as stores, restaurants, or mobile food vendors. Only 13.3% of food establishments sold fruits and vegetables. Stores were more likely to sell vegetables than mobile food vendors (14.8 vs. 6.2%, respectively) and sold a greater variety of both fruits and vegetables as compared to mobile food vendors [mean (SD) of 8.6 (3.2) fruits and 18.6 (9.2) vegetables available at stores vs. 5.5 (5.7) fruits and 25 vegetables available at the one mobile food vendor who sold vegetables]. However, these healthy food items were more expensive at stores. The availability (100% of stores, 12.5% of mobile food vendors, and 12.5% of restaurants) and variety (156 types) of ultra-processed foods across food establishments were higher than fruits and vegetables. A greater percentage of food establishments displayed advertisements for ultra-processed foods as compared to unprocessed or minimally processed foods such as fruits and vegetables. The National Capital Region of India has an unhealthy food environment. Regulations that limit the availability of ultra-processed foods and improve the availability and affordability of fruits and vegetables are needed to reverse the rising tide of chronic non-communicable diseases in this setting.

Keywords: nutrition, food supply, food acquisition, fruits and vegetables, ultra-processed food, food price, built environment, nutrition transition

INTRODUCTION

Healthy dietary changes, including increasing consumption of fruits, vegetables, legumes, and nuts, and reducing consumption of added sugars and red meat, could prevent an estimated 19% of deaths globally (EAT-Lancet Commission on Healthy Diets From Sustainable Food Systems, 2019). However, global dietary patterns are trending in the opposite direction, especially in many low- and middle-income countries (LMICs) such as India (Ronto et al., 2018). As a result of these unhealthy dietary patterns, while undernutrition has declined over the past decade in India, overweight has increased and is emerging as a significant public health challenge (Ministry of Health and Family Welfare Government of India, 2017).

Detailed, nationally representative dietary intake data in India and elsewhere are scarce (Green et al., 2016). Nonetheless, available data suggest that the Indian diet is becoming more calorically dense with a larger share of calories coming from unhealthy foods high in fat and sugar (Shetty, 2002; Green et al., 2016). While carbohydrates still constitute 64% of total energy intake (Ramachandran and Kalaivani, 2018), the proportion of cereals that are coarse cereals has declined from 23 to 6% in rural areas over the past 30 years (Defries et al., 2018). There has also been an increase in dietary salt intake to an average of 11 g per day, far exceeding the World Health Organization's 5 g per day upper limit (Johnson et al., 2017).

Even less is known about the factors influencing these consumption patterns. Given that a majority of food (>80%) is purchased from market sources in India (National Sample Survey Office, 2014), the food environment is likely to play a key role. Turner et al. define the food environment as "the interface that mediates people's food acquisition and consumption within the wider food system" (Turner et al., 2018). They divide the food environment into two domains: external and personal. The personal domain includes the accessibility, affordability, convenience, and desirability of food. The external domain includes the availability, price, vendor and product properties, and marketing of food. Changes in these external food environment characteristics in particular have been implicated as primary drivers of unhealthy dietary patterns in LMICs (Popkin et al., 2012; Ronto et al., 2018). The current paper, therefore, focuses on the external domain of the food environment, specifically market food sources in and around Delhi.

Research on food environments has been conducted in only 22 of 136 LMICs (Turner et al., 2020). Turner et al.'s systematic review of food environment research in LMICs identified six studies from India (Turner et al., 2020). Four of these six studies used qualitative methods (Finzer et al., 2013; Maxfield et al., 2016; Rathi et al., 2016, 2017) and two of the six used quantitative methods (Gupta et al., 2016; Patel et al., 2018). With regards to the latter, one of the studies found high levels of saturated fat in items sold by mobile food vendors in Delhi (Gupta et al., 2016). The other found that adults in Delhi who lived closer to full-service and fast-food restaurants were less likely to consume fruit and more likely to consume refined grains than those who lived further away from these restaurants (Patel et al., 2018).

Since Turner et al.'s systematic review was conducted, four additional studies on food environments in India have been published (Li et al., 2019; Bassi et al., 2020; Ganpule-Rao et al., 2020; Surendran et al., 2020). A cross-sectional study of adolescents in rural Pune found that those living in villages with the highest density of food vendors had a higher body mass index (BMI), waist circumference, and percent body fat (Ganpule-Rao et al., 2020). Similarly, a cross-sectional study of adults living in peri-urban villages of Hyderabad in south India found that adults who lived in neighborhoods with a higher density of highly processed/takeaway food vendors had a higher BMI, waist circumference, and blood pressure (Li et al., 2019). They also found that adults who lived in neighborhoods with a higher density of fruit/vegetable vendors had lower blood pressure (Li et al., 2019). A qualitative study in that same population found

that affordability and availability were the most important drivers of fruit and vegetable intake (Surendran et al., 2020). Finally, a study in Delhi found that there is a greater density of unhealthy food vendors outside private schools and colleges compared to public schools and that marketing of foods high in fat, sugar, and salt is more common around private schools compared to public schools (Bassi et al., 2020).

In summary, most previous research on the external food environment in India has focused on availability. However, other aspects including price, vendor and product properties, and marketing are likely to play a role in food choice. The aim of this research was to pilot a more comprehensive assessment of the external food environment including availability, price, vendor and product properties, and marketing. We focused on the capital city region of India and market sources of food given this was a highly urbanized area where own-production and wild harvesting of food are uncommon.

MATERIALS AND METHODS

Study Setting

The study was conducted in Delhi National Capital Region (NCR) India, which is an inter-state region comprised of the entire National Capital Territory of Delhi and adjoining districts from the surrounding states of Haryana, Rajasthan, and Uttar Pradesh (National Capital Regional Planning Board, 2014). The NCR's total population is about 46 million which is spread over an area of 53,817 km^2 (National Capital Region Planning Board Government of India, 2017). Data from the National Family Health Surveys have highlighted a rise in the double burden of malnutrition not only in India but also the National Capital Territory of Delhi where the prevalence of underweight is 17.7% for men and 14.9% for women and the prevalence of overweight is 24.6% for men and 33.5% for women (Ministry of Health and Family Welfare Government of India, 2016). Four NCR areas were selected per convenience for this study: two from Delhi and two from Gurugram in Haryana.

Sampling

The catchment area for survey administration was defined as the circle surrounding the central market with a 1-km radius. For each of the four catchment areas, a comprehensive list of food establishments was generated using Google and other online platforms available for ordering and delivery (Swiggy, https://www.swiggy.com/; Zomato, https://www.zomato.com/; and Food Panda, https://www.foodpanda.com/), and was updated via physical verification. The process of physical verification involved field investigator visits to the four catchment areas to confirm the location and functionality of the food establishments listed online.

Food establishments for this study were defined as facilities that sell food directly to consumers. Food establishments not having any food items, located in access-restricted or inaccessible areas, and those falling outside the selected radius for the respective catchment area were excluded from the list (**Figure 1**). The total number of food establishments in the final lists (one for each of the four areas) ranged from 146 to 274. Of these,

FIGURE 1 | Study sampling. *Online order platforms included Swiggy, Zomato, and Food Panda.
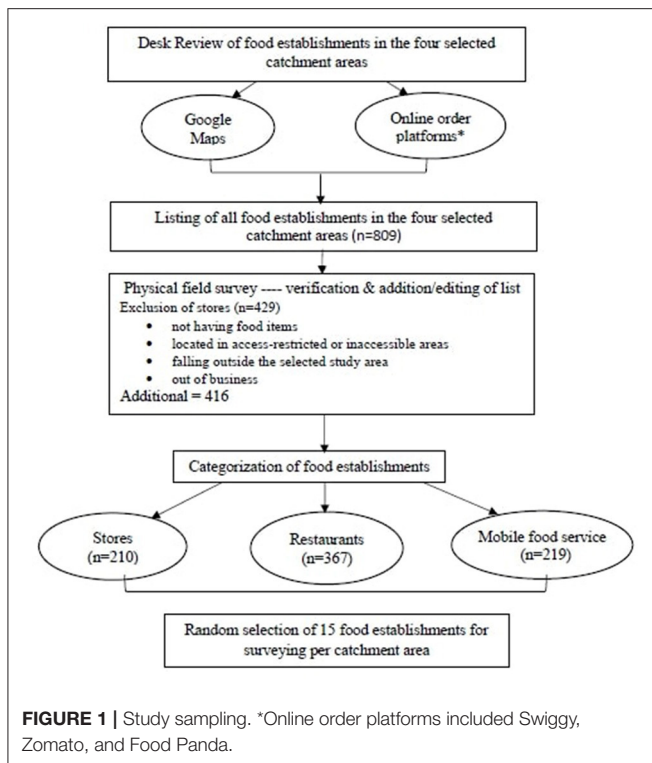
15 total food establishments were selected from each area via simple random sampling. This sampling was stratified according to the type of food establishment (e.g., stores, restaurants, and mobile food vendors). Given the increased frequency of eating out and consumption of street food from mobile food vendors and convenience food from stores in Asia (Winarno and Allain, 1991), we selected a sample of seven stores, four restaurants, and four mobile food vendors in each area. Thus, 60 food establishments (28 stores, 16 restaurants, and 16 mobile food vendors) out of a total of 796 were selected for surveying across the four areas. The surveying was completed around the monsoon season over a period of 3 months (June, July, and August, 2018).

Food establishments surveyed were categorized as stores, restaurants, or mobile food vendors based on a modified version of definitions from the 1997 North American Industrial Classification System (Classification Development Branch, 1997) and the World Bank (International Comparison Program, 2011) (**Table 1**). Stores were further classified as supermarket chains, large grocery stores, convenience stores, dairies, or pharmacies. Restaurants were further classified as full-service or limited-service.

Audit Tool

The development of the audit tool involved reviewing the literature on audit tools used to assess the external domain of the food environment. We found no audit tools that had been adapted for use in India. Thus, we started by adapting the most commonly used tool, Glanz et al.'s (2007) Nutrition Environment Measures Survey in Stores, to measure the external

food environment factors proposed by Turner et al. (2018) in stores, restaurants, and mobile food vendors in India. Additional questions were taken from other studies conducted by Glanz et al. (2005) and Hua et al. (2014). It took approximately 15 min to complete the survey for small-scale convenience stores, limited-service restaurants, and mobile food vendors, and 25–30 min for supermarket chains, large grocery stores, and full-service restaurants.

Table 2 describes the components of the final version of the audit tool. The first section of the form recorded details on vendor properties, namely, the type of store, and days and timings of operation. The content of the second section differed for stores vs. restaurants and mobile food vendors. For stores and restaurants, we collected information on marketing and promotional messages used outside and inside the food establishment. These included any advertising of food items in the form of images, posters, banners, or paintings displayed outside near the entrance of the establishment or anywhere inside near the cash counter, on the floor, or hanging from the ceiling; the type of foods and beverages near the cash counters in stores and billing area in self-service restaurants; and any promotional offers on foods and beverages.

We assessed the level of processing for different foods and categorized them into three groups as defined by Monteiro et al. (2018): (1) unprocessed and minimally processed foods, (2) processed foods, and (3) ultra-processed foods (**Table 3**). According to Monteiro et al. (2018), "Methods used in the culinary preparation of food at home or in restaurant kitchens are not industrial, by definition." Thus, for example, a package of frozen samosas produced by industrial processes and purchased from a store was classified as "ultra-processed" but a samosa made from culinary ingredients in a restaurant kitchen was classified as "processed." Pre-packaged, industrially produced paneer was classified as "ultra-processed" whereas paneer made from scratch was classified as "processed." Restaurants and mobile food vendors were asked about the preparation technique for cooked items in order to appropriately classify them as "ultra-processed" or "processed." For all food establishments, we collected availability and price of fruits, vegetables, and ultra-processed foods. In addition, for restaurants and mobile food vendors, we collected the availability and price of processed foods.

Field Testing

The initial questionnaire was pilot tested in food establishments located around each study area by four trained field investigators (one for each of the four areas). These field investigators were interns with a college education in nutrition, who were trained to record these data as a part of the study. The field testing was carried out in eight stores (in two stores by each field investigator). The testing identified missing details in the survey, the need for correction of wording and content, survey scheduling issues, and concerns raised by clerks at stores during observations. These findings helped in revising the study protocol, the audit tool, and the training materials. The data collected during piloting was not included in the analysis.

TABLE 1 | Categorization and definition of surveyed food establishments (adapted from North American Industrial Classification System and the World Bank).

Stores	Mobile food vendors	Restaurants
Supermarket chain A large store that sells food and other items, including canned and frozen foods, fresh fruits and vegetables, and fresh (raw) and prepared meats, fish, and poultry. It is owned by a company that has a chain. **Large grocery store** A large store that sells food and other items, including canned and frozen foods, fresh fruits and vegetables, and fresh (raw) and prepared meats, fish, and poultry. It may be part of a small regional chain of fewer stores. **Convenience store** A store that sells convenience items only, including bread, milk, soda, and snacks. These stores do not sell fresh (raw) meat. These stores also are known as food marts. **Pharmacies** Establishments engaged in the retail sale of prescription drugs, proprietary drugs, and non-prescription medicines, and which may also carry a number of other product lines, such as cosmetics, toiletries, tobacco, novelty merchandise, and a limited selection of grocery items including snacks, refrigerated and frozen foods. **Dairies** Establishments primarily engaged in the sale of dairy products.	Establishments primarily engaged in preparing and serving meals and snacks for immediate consumption from motorized vehicles or non-motorized carts. These included establishments primarily engaged in providing food services from vehicles, such as hot dog cart, snack stands, food trucks, and ice cream truck.	**Full service restaurants** Establishments primarily engaged in providing food services to patrons who order and are served while seated (i.e., waiter/waitress service) and pay after eating. **Limited service restaurants** Establishments primarily engaged in providing food services where patrons generally order or select items and pay before eating. Most establishments do not have waiter/waitress service, but some provide limited service, such as cooking to order (i.e., per special request), bringing food to seated customers, or providing off-site delivery. These include cafeterias, fast-food restaurants, non-alcoholic beverage bars, pizza delivery establishments, and takeout eating places.

Ethical Considerations

Ethical clearance to conduct the study was obtained from the Institutional Ethics Committee of the Public Health Foundation of India (TRC-IEC-375/18). Since the research team only surveyed via direct observation (e.g., no interaction with human subjects), consent was not obtained. However, in situations where items were not on display in stores and menus were not available in restaurants, a letter was presented to the manager of the food establishment to explain the purpose of the study, and his/her verbal consent was obtained.

Statistical Analysis

Descriptive statistics were used to summarize the availability, price, vendor and product properties, and marketing of food items according to food establishment type. All statistics were calculated using SPSS version 21 (IBM Corp, Armonk, NY).

RESULTS

Availability

Only 13.3% of sampled food establishments sold fruits and vegetables (excluding pharmacies because they do not sell fruits and vegetables in Delhi). Fruits were available in only 11.1% of stores and 25.0% of mobile food vendors whereas vegetables were available in 14.8% of stores and 6.2% (only 1) of mobile food vendors (**Table 4**). Cumulatively, 27 types of fruits (27 in stores, 14 in mobile food vendors) and 43 types of vegetables (35 in stores, 24 in mobile food vendors) were available with a mean (SD) of 8.6 (3.2) fruits and 18.6 (9.2) vegetables available at stores and 5.5 (5.7) fruits and 25 vegetables available at the

one mobile food vendor who sold vegetables. The types of fruits and vegetables available varied between stores and mobile food vendors (**Supplementary Table 1**).

Price

Watermelon was the cheapest fruit available in stores [9.9 INR (~0.14 USD) per 500 g] and cherries the most expensive [125 INR (~1.70 USD) per 500 g] (**Supplementary Table 1**). At mobile food vendors, mango was the cheapest fruit available [19 INR (~0.26 USD) per 500 g] and green apple the most expensive [100 INR (~1.36 USD) per 500 g]. There was substantial variability in price between the stores and mobile food vendors for certain fruits and vegetables with the price being higher in stores for a majority of the items.

The price of ultra-processed food items ranged from 1 INR (~0.014 USD) for candy to 745 INR (~10.16 USD) for desserts such as red velvet cake (**Supplementary Table 2**). In terms of comparison of price between ultra-processed foods and fruits and vegetables, it was observed that the relative prices between the two varied with the type of item. For instance, an apple (100 g) costing 17.5 INR (~0.25 USD) was found to be cheaper than a 100 g bag of chips (average cost, 36.7 INR, ~0.53 USD) but more expensive than cookies, which cost, on average, 13.6 INR (~0.1 USD) for the same amount (100 g).

Vendor Properties

Of the 60 food establishments surveyed, 46.6% were stores, 26.7% were restaurants, and 26.7% were mobile food vendors. Within the category of stores, the majority were classified as large grocery stores and convenience stores (39.3% each), followed by dairies (14.2%), one supermarket chain, and one pharmacy. Full-service

TABLE 2 | Items captured by the survey instrument.

Item	Details
Data collection details	Date; Survey start and end time; Food establishment name and address; Days and hours of operation
Type of food establishment	Store (Supermarket chain, Large grocery store, Convenience Store, Pharmacy, and Dairy); Restaurant (Full-Service Restaurant, Limited-Service Restaurant); Mobile Food Vendor
Distance from nearest public transportation	Is the facility <0.5 km from public transportation?–Recorded as Yes/No
Exterior marketing	- Information on advertising of products (banners, posters, temporary signs, painted murals, etc.) outside the food establishment (doors, windows, fences, garbage cans) - Number and size of the advertisements along with information on the product advertised: images of food (e.g., tomato, apple, hamburger, hot dog) and/or beverages (e.g., milk, soda, shake, smoothie)
Stores	
Interior marketing	- Marketing of foods and beverages next to the main check-out area and categorization of these products as ultra-processed, unprocessed or minimally processed foods - Presence of ads or promotions on/near the reception/check-out area, on the floor, hanging from the ceiling
General questions on food items	- What does this store mostly sell? - What options for sweetening agents are available?
Availability, display, and storage of fruits and vegetables	- Availability of fresh fruits and vegetables - Types of fresh fruits and vegetables available and their price - Any health promotion items around the fruit and vegetable display - Are the fruits/vegetables refrigerated?
Quality of fruits and vegetables	Recorded under categories: Good Quality; Wilting (leaves or stems are limp); Decay (mold or blackening); Shrivel (skin has wrinkles); Brown stems/dry stem cuts; Color changes (yellowing when item should be dark green)
Milk and other dairy products	Types of dairy products and their price
Other items available	Recorded under the following categories along with their price: Breads and cereals; snacks; ready to eat/instant mixes; beverages, and; Sauces/Spreads & dressings.
Restaurants	
Type of restaurant	Recorded under categories: Fast food chain (global/country/local); Non-Fast food chain; Mixed (fast food and fresh); Restaurant chain (global/country/local); Non-chain restaurant
Cuisine type	Recorded under categories: North Indian; South Indian; Asian (Chinese, Thai, Japanese); Italian; American (hamburgers, wings, steaks); Other
Size of restaurant	Measured as seating capacity
Nutritional information on the menu	Posting of calories for every dish
Promotion of healthier option or portion sizes	- Section of healthier options on the menu; Reduced size portions offered on menu; Low-carb promotion; Diet options for fountain drinks; Salad bar at the restaurant; Healthy cooking options available (baked, boiled, steamed); Choice of healthy side menus available (salad, fruits, steamed/boiled veggies) - Signs/tables/displays highlight healthy menu options; Non-fried vegetable/fruit or salad offered free of charge with the main dish
Promotion of unhealthy eating	Signs/table tents/display encouraging unhealthy eating or overeating (all-you-can-eat, super-size, jumbo, grande, supreme, king size, feast descriptors on menu, or signage); Free fountain drinks refill
Menu review	Name, price, ingredients, and availability with combo meal for all items mentioned on the menu
Mobile food vendors	
Types of foods available	Categorized under Fresh fruits; Fresh vegetables; Fried fruits and/or vegetables; Sugar-sweetened beverages; Fast food; North Indian food; South Indian food; Eggs
Menu review	Name, price, ingredients, and availability with combo meal for all items mentioned on the menu

and limited-service restaurants comprised 37.5 and 62.5% of all restaurants, respectively. Stores were open for a mean (SD) of 13.1 (2.6) hours per day. The opening hours for restaurants and mobile food vendors were 11.4 (2.2) and 9.8 (3.1) hours per day, respectively. A majority of the food establishments (96.4% of stores, 100% of restaurants, and 88.8% of mobile food vendors) were open 7 days a week.

Product Properties

The quality of fruits and vegetables at stores (where available) was reported to be "Good." Processed food items were sold at 75.0% of mobile food vendors and 81.2% of restaurants. A total of 104 different types of processed foods were available in restaurants and 53 in mobile food vendors (**Supplementary Table 3**). Ultra-processed food items were sold at 100% of stores, 12.5% of

TABLE 3 | Categorization of foods according to level of processing (adapted from Monteiro et al., 2018).

Definition	Stores	Mobile food vendors	Restaurants
Ultra-processed foods: • "Processing of a mix of unprocessed and processed foodstuffs in order to create durable, accessible, convenient, and palatable ready-to-eat or to-heat food products liable to be consumed as snacks or desserts or to replace home-prepared dishes"	• Packaged snacks (chips, breads, biscuits) • Instant noodles and frozen meals • Ready-to-eat items • Beverages • Sauces/spreads/dressings/syrups • Cakes and pastries, ice cream • Breakfast cereals • Fruit and milk drinks, soda • Frozen pizza • Prepared meat • Canned or dehydrated soups, stews and pot noodle • Ready-to-eat mix	• Kulcha (ultra-processed Indian bread) • Dishes including pre-packaged paneer as an ingredient • Fruit and milk drinks, soda	• Ready-to-eat items that used pre-packaged paneer or gravies • Fruit and milk drinks, soda
Processed foods: • "Extraction and purification of components of single whole foods, resulting in producing ingredients used in the preparation and cooking of dishes and meals made up from unprocessed or minimally processed foods in homes or traditional restaurants, or else in the formulation by manufacturers of ultra-processed foods"		• Dishes made from culinary ingredients in a kitchen such as momos (dumplings) and samosas	• Dishes made from culinary ingredients in a kitchen such as momos (dumplings), dosas, and curries
Unprocessed or minimally processed: • "No processing, or mostly physical processes used to make single whole foods more durable, accessible, convenient, palatable, or safe"	• Dried fruits • Fruits and vegetables (including frozen and vacuum-packed) • Unsweetened fruit juices • Fresh and pasteurized milk • Fermented milk such as plain yogurt • Tea, coffee	• Fruits and vegetables	• Fruit-based dishes with no additives (sugar or salt) • Tea, coffee

mobile food vendors, and 12.5% of restaurants. A total of 156 different types of ultra-processed food items were recorded across all food establishments (105 in stores, 36 in restaurants, and 17 in mobile food vendors) (**Supplementary Table 2**). Candy, chocolate, cookies, potato chips, namkeen (a savory snack), and fruit juice were the most commonly found ultra-processed food items in stores whereas pizza was the most common in mobile food vendors. There was greater variability in the number of different types of ultra-processed foods available in stores compared to mobile food vendors and restaurants, with greater availability of flavored drinks, packaged snacks, ready-to-eat mixes, and syrups/sauces.

Marketing

Nearly half of all food establishments displayed advertisements as a part of external marketing (42.8% of stores, 50.0% of restaurants, and 43.7% of mobile food vendors, **Table 5**). Only 7.1% of stores and 6.2% of restaurants had painted murals of healthy foods and beverages. 39.2% of stores had processed food products near the checkout counter. **Table 6** depicts the greater advertising of processed and ultra-processed food items than unprocessed or minimally processed foods across the three types of food establishments surveyed. None of the restaurants mentioned nutritional information or total calories for the dishes on the menu. Also, the menus did not promote any low-carb

dishes. Non-fried vegetables or salad were not offered free of charge with the main dish in any of the restaurants. However, 62.5% of restaurants provided reduced portion sizes and 25% had healthier options on their menu. Only 12.5% of restaurants had a salad bar and only 18.7% had healthier cooking options (baked, steamed, boiled) available.

DISCUSSION

Few studies have evaluated food environments in LMICs (Turner et al., 2020). Up-to-date descriptive studies of food environments such as the one presented herein for urban India provide an important benchmark against which future programs and policies can be measured. We found that stores were more likely to sell vegetables and sold a greater variety of both fruits and vegetables as compared to mobile food vendors, but that these healthy food items were generally more expensive at stores. In addition, the availability and variety of ultra-processed foods across all food establishments were higher than that for fruits and vegetables. Similar findings have been reported in Brazil– where university food services offer limited fruit and vegetable options, but starchy vegetables, sugary beverages, desserts, and candies are widely available (Pulz et al., 2017). And also in South Africa, where less than half of surveyed schools in one study served fruits and vegetables (Faber et al., 2013), and Ghana, where

TABLE 4 | Availability and variety of food items according to level of processing across surveyed food establishments (n = 60) of Delhi National Capital Region, India.

Availability of food categories	Stores (n = 28)	Mobile food vendors (n = 16)	Restaurants (n = 16)
Fruits available (% yes)	3 (11.1%)*	4 (25.0%)	0
If yes, how many types (mean ± SD)	8.6 ± 3.2	5.5 ± 5.7	–
Min–max	5–11	2–14	
Vegetables available (% yes)	4 (14.8%)*	1 (6.2%)	0
If yes, how many types (mean ± SD)	18.6 ± 9.2	25.0 ± 0.0	–
Min–max	2–28	0–25	
Processed foods (% yes)		12 (75.0%)	13 (81.2%)
If yes, how many types (mean ± SD)		4.4 ± 3.4	8.7 ± 4.9
Min–max		2–14	1–18
Ultra-processed foods (% yes)	28 (100%)	2 (12.5%)	2 (12.5%)
If yes, how many types (mean ± SD)	20.6 ± 10.6	10.0 ± 7.0	19.0 ± 8.0
Min–max	5–39	3–17	11–27
Vegetarian item available (% yes)		16 (100%)	16 (100%)
Non-vegetarian item available (% yes)		3 (18.7%)	7 (43.7%)

*Excludes pharmacies.

fruits and vegetables were found to be the least common type of food in one study of urban poor communities (Dake et al., 2016). Research conducted in 12 cities in China also found that a majority of food stores did not sell fresh/frozen vegetables or fruits (Liao et al., 2016). Regulations that limit the availability of cheap, ultra-processed foods and increase the availability of cheap, high-quality fruits, and vegetables are needed to improve food environments in urban LMICs.

The Food Safety and Standards Authority of India (FSSAI) has recently introduced regulations that prohibit the sale and advertising of foods high in saturated fats, trans fats, added sugar, or sodium in schools (FSSAI, 2020). However, such regulations have not been implemented in market areas where most people procure their food. In this study, a majority of the food establishments advertised unhealthy food items in the form of posters and painted murals. Similar findings were reported in Guatemala, where 37% of the advertisements in food stores around preschools and schools promoted sugary beverages (Chacon et al., 2015). With regards to providing nutrition information, a study at a Brazilian university found <20% of restaurants provided such information (Pulz et al., 2017), similar to our study in India wherein none of the restaurants provided nutritional information on their menus.

India has great horticultural diversity (Ministry of Statistics and Program Implementation, 2017). Statistics on Indian horticulture report the production of more than 25 species of fruits and 40 species of vegetables and spices (Horticulture Statistics Division, 2017). This was close to the findings from

our market-based survey, which identified 23 species of fruits and 48 species of vegetables for sale in NCR. This diversity of fruits and vegetables was not uniformly available across food establishments. For example, only one mobile food vendor sold vegetables and only 15% of stores sold vegetables. The Government of India has taken a number of measures to increase access to fruits and vegetables including investment in production, infrastructure for storage, marketing reforms, and increased distribution and surveillance (Khandelwal et al., 2019). However, a study conducted in south Delhi found that affordability, not accessibility, is the main barrier to increasing fruit and vegetable intake (Finzer et al., 2013). Affordability was also reported as the primary barrier to increasing fruit and vegetable intake in a study conducted in peri-urban villages of Telangana, a state in south India (Surendran et al., 2020). Repeated market-based surveys of the food environment can be used to evaluate the long-term impact of government initiatives on availability, affordability, and marketing of fruits and vegetables.

A major barrier to increasing the availability and affordability of fruits and vegetables, particularly in dense, urban areas such as NCR, is the high price of transportation and lack of cold chain systems in India–which contribute to food waste. The involvement of intermediaries in the supply chain makes this even more difficult for the people involved in agriculture (Biswas, 2016; Thow et al., 2018; Khandelwal et al., 2019). It has been estimated that 35–40% of India's total fruit production perishes before reaching consumers (Bung, 2012; Kumar et al., 2017). In contrast, ultra-processed foods have long shelf lives and do not require expensive, cold transport, or storage. This may be one reason that ultra-processed foods are more commonly available than fruits and vegetables.

Increased sales of ultra-processed foods accompanied with the expansion of modern grocery retails is occurring rapidly in Asia's middle-income countries (Baker and Friel, 2016). In the current study, 100% of the stores had ultra-processed foods available and mobile food vendors were more likely to sell processed foods than fruits and vegetables. Variability in the availability of healthy foods has also been assessed in other LMICs such as Brazil, which measured the food environment using a healthy food store index and a healthy restaurant index. That study revealed greater availability of healthy food items at open-air food markets compared to local grocery stores and convenience stores (Duran et al., 2008).

A few studies have been conducted in India for assessment of the food environment. Three of these studies assessed the food environment surrounding private schools and colleges (Rathi et al., 2016, 2017; Bassi et al., 2020). Another two assessed the opinions of adolescents toward different categories of foods (Maxfield et al., 2016; Rathi et al., 2018) and the effect of the rural food environment and access to food on their nutritional status (Ganpule-Rao et al., 2020). The fat content of mobile food vendors in rural areas and urban slums of NCR has also been previously described, supporting that food prepared by mobile food vendors is high in saturated fats (Gupta et al., 2016), consistent with our study, which found fried snacks (e.g., samosa, kachodi, bhatura, bread pakoda, and golgappe) were

TABLE 5 | Types of advertisement used for marketing and promotion of food across surveyed food establishments ($n = 60$) of Delhi National Capital Region, India.

Food establishment type	Advertising on the roof, walls, fences or parking lot	Food images painted on the doors or windows of the store	Any painted murals of healthy foods and/or beverages anywhere on the building walls	% ultra-processed ads near the checkout area	% ultra-processed foods available next to the checkout area
Stores	42.8%	7.1%	7.1%	39.2%	42.8%
Restaurants	50.0%	31.2%	6.2%	–	–
Mobile Food Vendors	43.7%	6.2%	0%	–	–

TABLE 6 | Percentage advertisements displayed according to category of processing of the food item on display across surveyed food establishments ($n = 60$) of Delhi National Capital Region, India.

Food establishment type	Unprocessed food	Processed food	Ultra-processed food
Stores	4 (14.2%)	5 (17.8%)	7 (25.0%)
Restaurants	–	4 (25.0%)	5 (31.5%)
Mobile Food Vendors	–	6 (37.5%)	3 (18.7%)

available at 87.5% of mobile food vendors. Finzer et al. (2013) found that mobile food vendors and markets are the dominant sources of fruits and vegetables in South Delhi. Another study that assessed the food environment in Delhi found that people with higher socioeconomic statuses live in neighborhoods that have a higher density of unhealthy foods (fast food and full-service restaurants), and are less likely to consume fruits and more likely to consume refined grains (Patel et al., 2018).

In the current study, only 14.2% of stores advertised unprocessed or minimally processed foods. Advertisements and promotional messages play a crucial role in influencing consumers' food choices. In a controlled experiment with 351 adult participants in the United States, Zimmerman and Shimoga (2014) found that food advertising resulted in an increase of 84% in the number of unhealthy snacks chosen. Children and adolescents are especially vulnerable to advertising of ultra-processed foods and beverages (Mallarino et al., 2013). In the Indian scenario, food marketing has been found to have a significant impact on the food choices made by adolescents (Sivathanu, 2017). Apart from regulating the nutritional content of foods, governments should consider regulating the food environment at schools. A study conducted in Kolkata found that the food environment in schools was characterized by an oversupply of unhealthy foods and relatively inadequate availability of healthy foods (Rathi et al., 2017). The food environment at home was found to be much more conducive to healthy eating wherein fruits and vegetables were always available in 91.6 and 95.7% of homes, respectively (Rathi et al., 2018).

Over the past few years, the Government of India has taken steps to improve the food environment by introducing various mandates. In 2016, it set a regulation limit of 5% on trans fats in partially hydrogenated vegetable oils. The recent release of Food Safety and Standards (Labeling and Display) Regulations in 2018 by FSSAI is a step toward better labeling of food (especially packaged foods including most ultra-processed foods) with the introduction of "high fat, sugar, salt food" labels along with other nutritional information (FSSAI, 2018). However, mobile food vendors who sell unpackaged food directly to consumers, which is usually higher in trans fat (Gupta et al., 2016), are exempt from this regulation, as are small-scale local sweet shops. Filling these regulatory gaps will require innovative approaches unique to the LMIC context.

The studies conducted on the food environment in LMICs so far have focused on two domains: external and personal food environment. The assessment of the external food environment domain has predominantly involved the evaluation of availability, vendors and their products, prices, and marketing. The assessment of personal food environment on the other hand involves accessibility, desirability, convenience, and affordability. While more than 60% of the studies conducted in LMIC settings have included multiple dimensions as described above, less than half of these have assessed both the external and personal food environment domains (Turner et al., 2020). The current study covers all domains of the external food environment, however, the personal food environment was not evaluated. Moreover, the sample size of food establishments was too small to conduct multivariate analyses to understand the complex interactions between dimensions of the external food environment domain. This is one of the key limitations of this study: we did not collect data on purchasing and consumption patterns that were prevalent at the study site or the profile of the consumers at the surveyed food establishments. To the best of our knowledge, there is no up-to-date data on where people in cities such as Delhi get their food. For example, in the United States in 2003–2006, children (2–18 years) got 69% of their calories from stores, 5% from full-service restaurants, 13% from fast food restaurants, 8% from schools, and 5% from other sources (Poti and Popkin, 2011). Similar information will be necessary to improve upon future food environment surveys. Also, seasonality plays an important role in the availability and affordability of fruits and vegetables, but we collected data at a single time point, in July-August, which is monsoon season in India, and it was unusually warm in the year of collection and thus mango was the most widely available seasonal fruit at that point in time. While food environment audits based on direct observation as conducted in our study are considered the "gold standard" against which other sources of data on the food environment are validated–for example, government data or commercially available business data–it would have been informative to assess the convergent validity of our tool with other food environment audit tools. We also did not assess inter-rater or test-retest reliability due to

similar resource constraints. These are important next steps for future research.

The current study highlights not only the low availability of fruits and vegetables in food establishments but also their limited promotion. It also contributes to growing evidence on the pervasiveness of ultra-processed foods. To our knowledge, this is the first food environment survey that focuses on the assessment of the external food environment factors including food availability, price, vendor and product properties, and marketing in India. Continued monitoring of the external food environment in India is needed to assess the nutrition transition and to examine the longitudinal association of these changes with nutrition and health outcomes.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available upon request by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Ethics Committee of the Public Health Foundation of India (TRC-IEC-375/18). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MC analyzed the data and wrote the first draft. LJ helped in writing the draft and provided critical feedback. MB, PM, and AS collected data. SK designed and supervised the study and provided feedback in revising the manuscript draft. All authors have read and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2021.726819/full#supplementary-material

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