



## Food subsidies, nutrition transition, and dietary patterns in a remote Indian district

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### ABSTRACT

We examined food subsidies and dietary intake in a remote district of India in the context of globalizing food environments. We used bespoke quantitative instruments to collect data on frequency of intake of 69 foods and a dietary variety score among 937 adults. We compared frequency of intake between urban and rural people receiving and not receiving subsidies. Subsidy recipients, who live in poverty, had slightly less varied diets and less frequent consumption of expensive foods, especially fruits and dairy, than non-recipients. However, there were no differences between poor and non-poor in frequency of intake of rice and pulses, both of which are provided through the subsidies to the poor.

### 1. Introduction

India continues to experience high levels of under-nutrition, together with increasing levels of overweight and obesity. In nationally representative estimates, underweight was higher than 10% across all age groups and sexes; overweight was above 10% for those above age 30. (Patel et al., 2015). Changes in food supplies occurring with globalization and economic expansion can offer new means of addressing malnutrition in the form of under-nutrition but may also promote malnutrition in the form of obesity. Indeed, foods supplies are changing even in remote parts of the Global South, introducing new goods in places that have largely relied on locally grown foods until recently. These new items may increase the stability of food supplies and increase diversity of foods, but many of the newly introduced goods are non-perishable, pre-prepared foods, with low nutritional quality and high caloric, fat, and sugar content (Meshram et al., 2016). Several research programs are in place to understand how these foods enter local diets, with a focus on their widespread penetration due to increasing availability, competitive prices, and prominence in advertisements and the media.

The goal of this study was to examine how a program aimed at

preventing hunger is nested in this changing food environment. Specifically, we examine how the use of India's Public Distribution System (PDS), which provides rice, pulses, and a few other basic cooking supplies to poor families, is associated with food consumption, including the presence of non-local items in people's diets. We assess the role of the PDS as a driver of food choice by comparing the intake of foods and dietary variety in households that do and do not use PDS benefits. We examine food intake and dietary variety in rural and urban households, which experience differing levels of access to non-local foods.

### 2. India's Public Distribution System

The PDS is India's food security system, providing food and cooking items to the neediest households. PDS bundles provide free or subsidized rice and subsidized pulses; they frequently also include subsidized oil, salt, and kerosene, and in some states wheat and traditional grains. These goods are provided free or at highly subsidized prices for households living below or near the poverty line. The foundations of the PDS are in the rationing systems put in place during and immediately after World War II and subsequently adapted to address food insecurity across India. The PDS is run in collaboration between the national and state

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governments. The program was revamped from a universal system to a selective, targeted system during the 1990s, aimed at preventing malnutrition among India's poor. The national government is responsible for procurement, storage, and transportation of materials, while the state government is responsible for distribution. Food and materials are distributed through a network of Fair Price Shops run by the government-owned Food Corporation of India or by authorized private Cooperative Societies licensed by State food and civil supplies departments. The PDS categorizes households as *priority* and *non-priority*, with eligibility determined at the state level ([Government of Karnataka](#)). Beneficiaries receive or purchase items from Fair Price Shops according to their income.<sup>12</sup> Priority households are the 25 million poorest households in India, which hold Antyodaya Anna Yojana (AAY) cards and other families living in poverty, which hold Below the Poverty Line (BPL) cards. In the state of Karnataka in Southern India, where our study is set, households are eligible for a BPL card if they have a yearly household income less than 120,000 Indian National Rupees (INR) (~1632 USD), living space of less than 1000 square feet, and no members earning a taxable income. Non-priority households, those not meeting the conditions defined as living in poverty, do not qualify for the PDS. Still, if they feel they are food-insecure, they can register to receive an Above the Poverty Line (APL) card, which entitles them to buy up to 10 kg of rice monthly at a subsidized price of 15 INR per kg.

The goods supplied to beneficiaries of the PDS vary across states and sometimes across districts within states. In Karnataka state, the AAY households receive 35 kg of free rice monthly, contributed jointly by national and state governments ([Ministry of Consumer Affairs - Department of Food & Public Distribution - Government of India, 2020](#)). BPL households receive 7 kg of free rice per person monthly. Additionally, AAY and BPL card-holders can buy 1 kg of toor dal (split pigeon peas) at the subsidized price of 38 INR per kg; 1 kg of salt is also available at 2 INR monthly. Additional subsidized items, such as oil and wheat, are intermittently but not regularly provided as part of the PDS ([Food Civil Supplies And Consumer Affairs Department, 2020](#)).

### 3. Changing food environments, food subsidies, and eating patterns

The economic expansion and globalization of markets in recent decades is changing eating patterns around the world. For food availability in India, these changes have entailed the expansion of food markets to include perishable and non-perishable foods and beverages from other countries. These items, which we call "global foods", include energy-dense and nutrient-poor foods, especially ready-made meals and snacks such as pizza and noodles. They have contributed to diversifying diets in the most connected and metropolitan parts of India, though it has been suggested that they may be linked with the increase in diet-related health conditions such as obesity and diabetes in India ([Popkin et al., 2001](#); [Shaikh et al., 2016](#); [Shetty, 2002](#); [Singh et al., 2014](#)). Global food markets also expand the variety of fruits and vegetables and may reduce risks associated with crop failures and supply chain break-downs ([Prabhu Pingali, 2007](#); [PK Pingali and Khwaja, 2004](#); [Shaikh et al., 2016](#)). Rural and remote parts of India have been isolated in terms of their access to global foods, though this isolation is beginning to dissipate ([Kapil and Sachdev, 2012](#); [Shaikh et al., 2016](#); [Swaminathan et al., 2007](#)).

Ease of transportation and migration patterns within India are also disseminating foods from some parts of India to others; we call these non-local Indian foods. They include grains and vegetables that are grown in other regions of the country and are beginning to appear in supermarkets, as well as fried savory snacks such as samosas and *panipuri* and non-vegetarian snacks, such as "chicken 65" and "egg rice", sold on streets by migrant vendors. These non-local Indian foods are expanding the variety and quantity of healthy and unhealthy foods available to consumers even in remote parts of the country.

As new food items become available, it is often the wealthiest

consumers who learn about them first. For example, through globally-connected social networks, travel, and advertisement they are often the ones who can afford to purchase them ([Maxfield et al., 2016](#); [PK Pingali and Khwaja, 2004](#)). With time, both knowledge and supply of new items often increase, making these items known, accessible, and desirable to poorer consumers as well. In India, smaller packages and knock-off versions of global brands often make these goods available for the general public.

There are several ways in which the PDS may contribute to changing food choices. One is through the items that are provided to users. PDS supplies consist primarily of rice; however, rice has not been the principal staple throughout India. The staple grains in Northern Karnataka have historically been sorghum (locally, *jowar*), pearl millet (locally, *bajra*) and wheat. While the provision of rice may contribute to preventing hunger, it may compel poor households to change their diets and to replace these local grains, which are higher in protein and fiber and lower in glycemic load, with rice ([Food Civil Supplies And Consumer Affairs Department, 2020](#)).

Access to global foods may also differ for people whose diets are supported in part by the PDS. On one hand, PDS users are poor, so their purchasing power may be limited to only purchasing the basics needed to meet caloric requirements; as such, their consumption of non-local goods other than rice may be lower than those of people not relying on PDS. On the other hand, PDS users already have some of the very basic needs met through the PDS provision of rice and pulses, and may thus be able to use even their limited discretionary income to make other purchases. In fact, some global and non-local foods are calorie-dense and cheap, and could offer inexpensive, albeit unhealthy items to complement the PDS supplies. Their taste is also appealing and strong, with tangy, salty and spicy flavors, which can satisfy quickly. As such, the consumption of non-local goods by PDS users could be higher than that of people not relying on PDS.

As noted above, people living in urban and rural areas have access to different food environments, with urban dwellers having more access to global and non-local Indian foods. There may be additional differences in dietary patterns among rural and urban people according to their use of the PDS, in that PDS users are additionally constrained in their purchasing power by very limited budgets. For example, in urban areas, PDS users may be able to afford fewer global and non-local foods than people who are not eligible for the PDS, even though many such goods are easily available in urban shops. On the other hand, rural PDS non-users, who have some disposable income, may be able to afford trips to the city or special deliveries of global and non-local foods from urban shops, even though those items are not available in their villages. PDS users in rural areas may be the most isolated from non-local foods, having limited or no access to them, nor the resources to seek them out.

### 4. Study setting

The study was conducted in Vijayapura district, in Karnataka State, India. This is a remote district, located in the northwestern region of the state, at 580 km from the State capital of Bangalore and considered socio-economically underdeveloped. The district has a balanced sex ratio (960) and 67% of adults are literate. The population is predominantly Hindu (82%), but is diverse, with substantial populations of Muslims (17%), as well as some Christians, Jains, and Buddhists ([Census 2011](#); [2020a](#); [Government of India Ministry of MSME, 2011](#)). Agriculture is the main occupation in the district, with the main crops grown being sorghum, pearl millet, toor dal and maize. Growers are largely reliant on the monsoon, seen typically between June–September, and are frequently affected by drought, as only 17% of the cultivated area is irrigated.

Vijayapura City is the administrative headquarters of the district and is a mid-size city with population of approximately 330,000 inhabitants. It is urbanizing as a result of the major economic growth of universities, agriculture, and a thermal power plant ([Census 2011](#); [2020a](#);

Government of India Ministry of MSME, 2011). This was the setting of the study's urban component.

The rural site was the village of Ukkali, situated 25 km from Vijayapur City, with a population of approximately 8519 individuals in 1759 families. The major occupation in Ukkali is farm labour. The sex ratio is higher and the literacy level is lower than the state average, but the village and its surroundings benefit from two well-established health centers (Census 2011, 2020b).

In Vijayapura city, as in other urban areas, the food environment consists of long-standing food sources, including *kiraana* (small local grocery stores) and street-side fruit and vegetable vendors, as well as new supermarkets, street food eateries, and bakeries (Barooah, 2012; Goenka, S, 2007; Panda, 2013). Many food outlets increasingly stock processed and packaged foods and beverages, which are shelf-stable and ready-to-eat. They cater to local tastes and, for people on limited budgets, unbranded varieties are available (Gupta et al., 2016; P. K. Pingali, Y., 2004).

Diets and eating preferences in the district are centered around foods typical to this region, but, especially in urban areas, also include goods from other regions of India and some foods from other countries, which were unknown until recently (International Institute for Population Sciences (IIPS) and ICF, 2017; Shaikh et al., 2016). Previous research has shown socio-economic differences in eating patterns, which may be relevant as we examine the role of the PDS in diets. For example, youth from wealthier families consumed expensive foods, such as fruits, dairy and homemade sweets, more frequently, while those from poorer families consumed tea, coffee, eggs and ready-made snacks and street foods more frequently (Shaikh et al., 2016). The diets and eating preferences in northern Karnataka villages have not been documented previously.

Typical meals in northern Karnataka consist of flatbreads – *roti*, made from sorghum or pearl millet, and *chapatis*, made from wheat - accompanying pulses, like red gram, horse gram, green gram, and often eaten with vegetable curries, including brinjal (lady fingers), ridge gourd and green leafy vegetables like amaranth and sorrel leaves. Yogurt, or *curd* is frequently eaten with meals, as are dry peanut or flax seed chutneys (Mallick, 2017). Banana, papaya and *sapota* are fruit available throughout the year; seasonal fruits are ber (Indian plum), grapes, pomegranate, mango, and melons. About half of the population is vegetarian; others eat eggs, chicken, mutton and fish. Rice is not central to local diets as it is in other parts of Southern India, though, given its easy and cheap availability through the PDS, it has recently become incorporated into regular meals, including as a course in the main meal, as a flour in snacks and breakfast items such as *idli*, *dosa*, and *paddu*, or as replacement for millets in the flour used for local dishes. The major beverages consumed are coffee or tea, prepared with sugar and milk; sugar cane juice and fresh fruit juices made from seasonal fruits are sold by street vendors commonly. Local sweet dishes are *holige/pooran poli* (gram and jaggery mixture stuffed into wheat dough), and *laddos* (peanut-jaggery-gram flour balls).

## 5. Data and methods

### 5.1. Data collection

The data presented here are part of a larger study focused on the drivers of food choice in one urban and one rural community in Vijayapura district. The urban households were sampled for this study from an existing cohort, representative of households with a school-going adolescent ages 10–19 years in Vijayapura City. Children were sampled from school rosters in 2012 and their families have been followed since with periodic in-home data collection. For this study, we sampled households that were still based in Vijayapura City and still had at least one household member between ages 10 and 21 years in 2019. The rural households were newly sampled in 2019 to be representative of households with a school-going adolescent in Ukkali village. Children ages 10–19 years were sampled from rosters of all schools in the village;

adults in the sampled children's households were then interviewed in their homes. Based on sample size calculations, we drew probability samples of 273 urban and 225 rural households, with one adult man and one adult woman interviewed in each household. The final sample consisted of 265 urban households, after 97% response, and 222 rural households, after 99% response, for a total of 937 men and women. There were 37 households that had only 1 adult man or 1 adult woman in residence.

Quantitative survey instruments included a socio-demographic module and a Food Frequency Questionnaire (FFQ) developed to capture multiple factors relevant to food choice. The socio-demographic module included information on the household, its assets, receipt of PDS benefits, and characteristics of each household member. The module was answered by the head of the household or his spouse. The FFQ asked about the intake of 69 foods and beverages categorized, based on previous research, as local, non-local Indian, and global. We conceptualized foods, based on exploratory data, into four broad categories – i) staples and local foods, including PDS- and non-PDS-supported staples, produce and local snacks; ii) animal source foods; iii) non-local Indian and global foods; and iv) drinks. FFQ data were collected from one man and one woman in each household; where available, the parents of an adolescent were selected. Participants were asked, "How often in a month do you eat or drink the following foods and beverages?" The eight response categories were 'daily', 'few times per week', 'once per week', '2–3 times per month', 'once per month', 'sometimes', 'never', and 'don't know'.

The study was approved by the Institutional Review Board at Emory University, the Institutional Ethics Committee at BLDE University, and the Indian Council of Medical Research (ICMR). Instruments were pre-tested, pilot-tested, and adapted before fielding. Interviewers were selected and trained in survey methodology and on the study instruments. Household interviews lasted 45–60 min and were conducted after each respondent was informed about the study and granted informed consent. We conducted up to 4 re-visits to ensure that the sampled respondents were interviewed at times convenient for them. Data collection with rural and urban households was conducted in January to September 2019.

### 5.2. Analysis

Data were analyzed using Stata 13 and Statistical Analysis Software (SAS® version 9.4; SAS Institute, Cary, NC). Socio-demographic variables were created to describe the study population in terms of gender, religion and caste.

Food frequency data were transformed into weekly intake (times/week). The frequencies of consumption were coded as follows: daily = 7; few times per week = 3.5; once per week = 1, 2–3 times per month = 0.58; once per month = 0.23; sometimes = 0.12; never = 0; and don't know = 0. The 69 foods and beverages in the FFQ were collapsed into 20 meaningful food groups, as shown in (Supplementary Table 1). For all foods and food groups, we calculated the percent who ever consumed items from that food group, weekly intake (times/week) among all (extensive margin), and weekly intake for those who ever consumed items from the food group (intensive margins). A person may answer "don't know" because they do not know the item at all or because they know the item but do not know the frequency with which they consume it. Formative research locally suggested that it is more commonly used by respondents to indicate lack of recognition of a new food, and it was primarily selected in response to prompts about foods that are not commonly found in the area. Therefore, we clubbed these responses together with "never", as indicators of the reach or familiarity of a food. Still, in supplementary analyses, we treated "don't know" responses as missing values (Supplementary Table 2).

We also created a Food Variety Score (range 0–69) by summing the number of foods consumed.

Analyses were conducted for users and non-users of the means-tested

PDS, where PDS users were adults in households that held an AAY or BPL ration card and had used the card in the previous three months (coded as yes, no). We compared frequency of intake and diet variety for PDS users and non-users. We compared these indicators for urban and rural residents, and in supplementary analyses, for men and women (Supplementary Table 3). In robustness checks, we also calculated these on a subsample with only one randomly-selected respondent per household (Supplementary Table 4). We calculated the difference in weekly intake between the groups using Student *t*-tests and chi-square tests.

## 6. Results

### 6.1. Population characteristics

Table 1 shows the characteristics of respondents. Participants were adult women and men, on average 45 years old. By design, they were

**Table 1**  
Demographic and socio-economic profile of adults in Vijayapura district, India.

Characteristic	Overall %, mean (n = 937)	PDS users %, mean (n = 588)	PDS non-users %, mean (n = 349)
Age (years)	45.0 ± 9.9	42.9 ± 10.1	48.6 ± 8.5 ***
Men	48.5 (45.2, 51.7)	48.5 (44.4, 52.5)	48.4 (43.2, 53.7)
Religion			
Hindu	72.2 (70.4, 76.1)	68.0 (64.3, 71.8)	81.9 (77.9, 86.0)
Muslim	23.6 (20.9, 26.3)	31.6 (27.9, 35.4)	10.0 (6.9, 13.2)
Jain	3.0 (1.9, 4.1)	.	8.0 (5.2, 10.9)
Christian	0.2 (0.0, 0.5)	0.3 (0.0, 0.8)	.
Caste <sup>a</sup>			
Other Backward Class	58.0 (54.8, 61.1)	61.6 (57.6, 65.5)	51.9 (46.6, 57.1) ***
General	23.7 (21.0, 26.4)	15.5 (12.5, 18.4)	37.5 (32.4, 42.6)
Scheduled Caste and Scheduled Tribe	18.4 (15.9, 20.8)	23.0 (19.6, 26.4)	10.6 (7.4, 13.8)
Relationship to household head			
Head	45.1 (42.0, 48.3)	44.4 (40.4, 48.4)	46.4 (41.2, 51.7)
Spouse	38.6 (35.5, 41.8)	37.6 (33.7, 41.5)	40.4 (35.2, 45.6)
Child, child in-law, grandchild, niece	13.2 (11.1, 15.4)	15.0 (12.1, 17.9)	10.3 (7.1, 13.5)
Parent, parent-in-law, sibling, siblings-in-law	3.0 (1.9, 4.1)	3.1 (1.7, 4.5)	2.9 (1.1, 4.6)
Schooling			
Never attended	31.7 (28.7, 34.7)	44.6 (40.5, 48.6)	10.0 (6.9, 13.2) ***
Primary	29.2 (26.3, 32.2)	12.6 (9.9, 15.3)	57.3 (52.1, 62.5)
Secondary	22.5 (19.8, 25.2)	28.1 (24.4, 31.7)	13.2 (9.6, 16.7)
Post-secondary	16.5 (14.2, 18.9)	14.8 (11.9, 17.7)	19.5 (15.3, 23.6)
Occupation			
Agriculture	28.4 (25.5, 31.3)	37.8 (33.8, 41.7)	12.6 (9.1, 16.1) ***
Non-agriculture	41.2 (38.0, 44.4)	38.3 (34.3, 42.2)	46.1 (40.9, 51.4)
Not working outside the home	30.4 (27.5, 33.4)	24.0 (20.5, 27.4)	41.3 (36.1, 46.4)
Residence			
Urban	54.4 (51.2, 57.6)	38.8 (34.8, 42.7)	80.8 (76.7, 84.9) ***
Rural	45.6 (42.4, 48.8)	61.2 (57.3, 65.2)	19.2 (15.1, 23.3)
Household members (number)	5.8 ± 2.4	6.1 ± 2.6	5.4 ± 2.1 ***

\*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001.

<sup>a</sup> Other Backward Class, Scheduled Class and Scheduled Tribe are terms used by the Government of India to classify socially and educationally disadvantaged sections of the population.

approximately equally distributed by gender and by urban and rural residence. The majority of respondents were either the head of the household or the spouse of the head. Educational levels were diverse: a third had never attended school, while another third had post-secondary education. About a third were involved in agricultural occupations, and about another third did not work outside the home. On average, participants lived in households with close to six members. The majority identified as Hindu, and the largest proportion belonged to socially disadvantaged groups.

Compared with adults in households not using the PDS, adults who were using the PDS were younger, had less education, and were more likely to be working in agriculture. They were more often living in larger households in rural areas and were more often from a disadvantaged social group.

### 6.2. Overall diet patterns

Table 2 shows average frequency of intake per week for all respondents, and for PDS users and non-users. Among all respondents, rice, pulses, wheat, pearl millet, and sorghum were eaten universally (Supplementary Table 2) and were consumed on average more than once per day (Table 2). While rice is not traditionally eaten in this population, the high frequency of rice consumption shown in our data is likely due to the availability of free rice through the PDS. Fruits and vegetables, as well as local savory foods and snacks, were also consumed universally (Supplementary Table 1) and more than once per day (Table 2). Over 95% of the population consumed nuts and sweets, though these were eaten less frequently, 1–4 times per week.

Among animal-source products, dairy was consumed most frequently, usually in the form of yogurt, almost twice per day on average. Other animal products were consumed infrequently, with eggs 1–2 times per week and meat less than once per week. Almost half of the population has never consumed meat (Supplementary Table 2).

The majority of the population had consumed non-local foods at some time (Supplementary Table 2), though the frequency of eating these items was generally low (Table 2). Savory snacks, such as samosas and other fried items that are not typically a part of the local diet but have been introduced from other parts of India, were consumed on average almost 4 times per week. Non-local Indian sweets, such as *gulab jamun*, were eaten less frequently than local sweets. Global breads and cereals that have been available in India for decades, such as white bread, noodles and biscuits, were consumed on average twice per week, while more newly introduced global foods, such as vegetarian burgers and pizzas were consumed infrequently (<2 times per week).

Among drinks, tea and coffee were consumed almost daily on average. Fruit juices were less common, at 1.5 times per week on average, and sodas and energy drinks were even less common (0.3 times per week).

### 6.3. Diet patterns by PDS use

The Food Variety Score was significantly higher among PDS non-users than users, though the difference was only about 1 item (51.7 vs. 50.6) (Table 2). There were substantial differences in frequency of intake of specific foods. The largest differences were in the intake of fruits and of dairy products. These items are expensive locally, and indeed, we see that PDS users, who are poor, consumed these much less frequently than PDS non-users: fruit, 13 vs. 19 times per week; dairy, 12 vs. 17 times per week; vegetables, 9 vs. 10.5 times per week. However, there were no differences in the intake of rice and pulses, both of which are supplied through the PDS. Nor were there differences in the frequency of local staples. It could be that the PDS permits the poor to consume as many of these food items as those who are not poor. In terms of other typical local foods, including snacks, nuts, and sweeteners, PDS non-users consumed significantly more. This pattern may reflect differences in discretionary consumption between the poor and non-poor

**Table 2**  
Food consumption patterns (times, week) and food variety score among PDS users and PDS non-users in Karnataka, India.

	Overall (n = 937)	PDS users (n = 588)	PDS non- users (n = 349)	Difference (PDS Users-PDS non- users)
<b>Staples and local foods</b>				
<i>PDS-supported staples</i>				
Rice and rice- based dishes <sup>a</sup>	8.5 ± 2.2	8.4 ± 2.0	8.7 ± 2.5	-0.3
Pulses <sup>b</sup>	10.0 ± 2.3	10.1 ± 2.1	9.9 ± 2.5	0.2
<i>Non-PDS-supported staples</i>				
Wheat, pearl millet, and sorghum <sup>c</sup>	7.8 ± 0.9	7.8 ± 0.9	7.8 ± 0.9	0.0
<i>Produce</i>				
Fruits <sup>d</sup>	15.1 ± 9.8	12.9 ± 8.1	18.8 ± 11.2	-5.9***
Vegetables <sup>e</sup>	9.7 ± 3.2	9.2 ± 2.9	10.5 ± 3.5	-1.3***
<i>Snacks, sweets and condiments</i>				
Savory foods and snacks <sup>f</sup>	8.8 ± 4.4	8.5 ± 4.4	9.2 ± 4.5	-0.7*
Nuts	3.8 ± 2.5	3.6 ± 2.5	4.2 ± 2.5	-0.6**
Local sweets <sup>g</sup>	1.2 ± 1.5	1.2 ± 1.6	1.2 ± 1.5	0.0
Sweeteners <sup>h</sup>	2.6 ± 3.0	2.3 ± 2.6	3.1 ± 3.4	-0.8***
<b>Animal-source foods</b>				
Mutton	0.4 ± 0.7	0.4 ± 0.8	0.2 ± 0.6	0.2***
Chicken and fish	0.7 ± 1.2	0.9 ± 1.2	0.4 ± 1.1	0.5***
Eggs	1.7 ± 1.9	2.1 ± 2.0	1.1 ± 1.7	1.0***
Dairy <sup>k</sup>	13.9 ± 8.1	11.8 ± 7.3	17.4 ± 8.1	-5.6***
<b>Non-local foods: Global and Indian</b>				
Global breads and cereals <sup>l</sup>	2.0 ± 2.5	2.2 ± 2.5	1.8 ± 2.5	0.4*
Global savory foods and snacks <sup>m</sup>	1.5 ± 2.0	1.6 ± 2.2	1.2 ± 1.6	0.4**
Global sweets <sup>n</sup>	3.6 ± 3.4	3.3 ± 3.3	3.9 ± 3.5	-0.6**
Non-local Indian savory snacks <sup>o</sup>	3.7 ± 3.7	4.0 ± 3.9	3.1 ± 3.2	0.9***
Non-local Indian sweets <sup>p</sup>	0.5 ± 0.8	0.6 ± 0.9	0.4 ± 0.6	0.2**
<b>Drinks</b>				
Tea and coffee	6.4 ± 1.8	6.5 ± 1.7	6.3 ± 2.0	0.2
Fruit juices <sup>q</sup>	1.5 ± 1.7	1.3 ± 1.6	1.8 ± 1.9	-0.5***
Soda and energy drinks	0.3 ± 0.9	0.4 ± 1.0	0.3 ± 0.8	0.1*
<b>Food Variety Score</b>				
mean ± SD (min- max)	51.0 ± 5.8 (19–67)	50.6 ± 6.0 (19–67)	51.7 ± 5.6 (33–63)	-1.1**

Values are mean ± SD.

\*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001.

<sup>a</sup> Rice, curd rice, veg pulao, idli, dosa, uttapa.

<sup>b</sup> Dal, sambar, peas, chana, soybean, sprouts.

<sup>c</sup> Chapati, roti, poori, paratha, puran poli.

<sup>d</sup> Bananas, apples, citrus, pomegranate, gooseberries, watermelon, grapes, mango, custard apple.

<sup>e</sup> Green leafy vegetables, potatoes, yams, and other vegetables.

<sup>f</sup> Wadas, bhajji, bonda, papad, poha, upma, chooda.

<sup>g</sup> Pedas, barfi, laddoo, halwa, kheer, shrinkhand.

<sup>h</sup> Sugar, jaggery, honey, and sweeteners.

<sup>k</sup> Curd, raita, paneer, cheese, butter, ghee, milk, lassi, milkshake, flavored milk, buttermilk.

<sup>l</sup> Bread, multigrain biscuits, cereal, muesli, oats, masala oats.

<sup>m</sup> Burgers, pizzas, pasta, noodles, potato chips, popcorn, puffs.

<sup>n</sup> Chocolate, chocolate spreads, pancakes, waffles, biscuits, and ice cream.

<sup>o</sup> Samosa, wada pav, gobi manchurian, chaat, pav bhaji, khaari, rusk.

<sup>p</sup> Cakes, pastries, kulfi, gulab jumun.

<sup>q</sup> Fresh and packaged.

families.

Turning to food items that have not been part of the typical local diet, PDS users tended to consume non-local savory foods more frequently than PDS non-users. Specifically, they had more frequent consumption of Western-style bread, fried Indian snacks, packaged western-style foods such as chips and noodles, as well as sodas and energy drinks. These patterns reflect selection of lower-cost, energy-dense items by PDS users. PDS users had less frequent intake of sweets, such as ice cream and fruit juices, which are relatively expensive luxury goods.

PDS users also more frequently ate non-vegetarian items: they consumed eggs and meat twice as frequently as PDS non-users. This pattern likely relates to cultural and religious norms, as PDS users are more often from non-vegetarian social groups. Qualitative informants also indicated that people who do hard manual labor sometimes opt to take some meat in their meals for energy.

#### 6.4. Urban and rural dietary patterns among PDS users and non-users

Table 3 shows weekly food frequency among PDS users and PDS non-users, by urban or rural place of residence. There were no differences in Food Variety Scores between PDS users and PDS non-users in urban areas and no differences among them within rural areas, though people living in rural areas, both PDS users or non-users, had lower food variety scores than urban people. Among PDS users, those living in the urban area more frequently consumed all food groups than those living in the rural area. Differences were significant for most items. Slightly lower frequency of rice among rural dwellers could be due to distribution problems in rural areas, which were mentioned in qualitative data.

Among PDS non-users also, those living in urban areas consumed most foods more frequently than rural residents. The differences were most marked for fruit, nuts, and dairy.

Within urban areas, there were differences in frequency of consumption of most food groups between PDS users and non-users. PDS users had slightly higher intake of PDS supply items – rice and pulses. They had much more frequent intake of eggs and meats and of non-local savory snacks. Urban residents not using the PDS had higher intake of fruit, vegetables and dairy – all of which are expensive foods.

Within rural areas, there was very small difference in frequency of intake between PDS users and non-users. The patterns between PDS users and non-users were similar to those in urban areas, but the only significant difference was in the higher intake of eggs among PDS users.

Across groups, the most frequent consumers of rice were urban PDS users. They were also the most frequent consumers of local, Indian and global, savory snacks and sweets and by far the most frequent consumers of eggs and meat. The frequency of meat intake was highest among urban PDS users, but was overall low for all groups, reaching no more than once per week in any groups. Frequency of egg intake was also highest among urban residents, but still under 2.5 times per week.

Local staples, fruit, and vegetables were most frequently eaten by urban PDS non-users, as were some less healthy items such as sweeteners and global sweets. In urban areas, for wealthier people, the unhealthy items would seem to be consumed as desserts and treats, while for poorer people the unhealthy items were savory snacks, which may be supplementing or replacing meals.

As described above, for a more complete picture, we conducted several supplementary analyses: examining gender differences in food intake; treating responses of “don’t know” as missing values; and restricting analysis to one randomly selected respondent per household. Men had a slightly higher Food Variety Score, but not necessarily more nutritious (Supplementary Table 3). Women more frequently ate fruit, nuts and dairy, while men more frequently ate pulses, local staples, and meat. Women more frequently had sweeteners and global sweets, while men more frequently had fruit juice, sodas, and energy drinks.

When we treat responses of “don’t know” as missing values, rather than as an indication that the respondent was not familiar with the item named, staples and local items, meats, and tea and coffee are not

**Table 3**

Frequency of food consumption (times, week), with comparison between PDS users and PDS non-users within and across rural and urban residence Karnataka, India.

	PDS user n = 588		Urban v. rural	PDS non-user n = 349		Urban v. rural	Urban PDS users v. non-users	Rural PDS users v. non-users
	Urban n = 228	Rural n = 360		Urban n = 282	Rural n = 67			
<b>Staples and local foods</b>								
<i>PDS-supported staples</i>								
Rice and rice-based dishes <sup>a</sup>	8.9 ± 1.8	8.1 ± 2.0	***	8.7 ± 2.6	8.4 ± 2.1			
Pulses <sup>b</sup>	10.2 ± 2.2	10.0 ± 2.1		9.7 ± 2.5	10.4 ± 2.1		*	
<i>Non-PDS-supported staples</i>								
Wheat, pearl millet, and sorghum <sup>c</sup>	7.8 ± 0.8	7.8 ± 0.9		7.9 ± 1.0	7.8 ± 0.5			
<i>Produce</i>								
Fruits <sup>d</sup>	14.2 ± 8.7	12.1 ± 7.6	**	20.6 ± 11.4	11.5 ± 6.7	***	***	
Vegetables <sup>e</sup>	9.9 ± 3.0	8.8 ± 2.8	***	10.8 ± 3.6	9.5 ± 2.9	**	**	
<i>Snacks, sweets and condiments</i>								
Savory foods and snacks <sup>f</sup>	9.4 ± 4.8	8.0 ± 4.1	***	9.3 ± 4.6	9.0 ± 3.8			
Nuts	3.7 ± 2.5	3.6 ± 2.5		4.5 ± 2.5	3.1 ± 2.5	***	**	
Local sweets <sup>g</sup>	1.5 ± 1.8	1.0 ± 1.3	**	1.2 ± 1.5	1.0 ± 1.2	**		
Sweeteners <sup>h</sup>	2.5 ± 2.9	2.2 ± 2.4		3.4 ± 3.6	2.2 ± 2.3		*	
<b>Animal-source foods</b>								
Mutton	0.5 ± 0.8	0.3 ± 0.8	**	0.2 ± 0.6	0.2 ± 0.6		***	
Chicken and fish	1.0 ± 1.2	0.9 ± 1.2		0.4 ± 1.1	0.6 ± 1.2		***	
Eggs	2.4 ± 2.0	1.9 ± 2.0	**	1.1 ± 1.7	1.3 ± 1.8		***	*
Dairy <sup>k</sup>	13.5 ± 7.7	10.8 ± 6.9	***	18.7 ± 7.6	11.9 ± 7.6	***	***	
<b>Non-local foods: Global and Indian</b>								
Global breads and cereals <sup>l</sup>	2.1 ± 2.7	2.2 ± 2.4		1.7 ± 2.5	2.2 ± 2.2			
Global savory foods and snacks <sup>m</sup>	2.1 ± 2.6	1.3 ± 1.8	***	1.2 ± 1.6	1.2 ± 1.5		***	
Global sweets <sup>n</sup>	3.7 ± 3.3	3.1 ± 3.3		3.5 ± 3.2	2.9 ± 2.5			
Non-local Indian savory snacks <sup>o</sup>	1.4 ± 1.9	0.9 ± 1.4	***	1.0 ± 1.3	0.8 ± 1.0		***	
Non-local Indian sweets <sup>p</sup>	0.8 ± 1.2	0.5 ± 0.6	***	3.1 ± 3.2	3.2 ± 2.9		***	
<b>Drinks</b>								
Tea and coffee	6.5 ± 1.7	6.5 ± 1.7	***	6.3 ± 2.0	6.5 ± 1.7			
Fruit juices	1.7 ± 1.9	1.1 ± 1.4		1.9 ± 1.9	1.3 ± 1.7	*		
Soda and energy drinks	0.6 ± 1.2	0.3 ± 0.7	***	0.3 ± 0.9	0.3 ± 0.6		**	
<b>Food Variety Score</b>								
Mean ± SD (min-max)	52.3 ± 6.6 (19–67)	49.5 ± 5.3 (30–62)	***	52.3 ± 5.6 (33–63)	49.3 ± 4.8 (39–60)	***		

Values are mean ± SD.

P &lt; 0.05, \*\*P &lt; 0.01, \*\*\*P &lt; 0.001.

Comparing different consumption patterns between urban and rural of PDS users and non-users.

'Differences in food consumption between urban and rural PDS users and PDS non-users were tested using Students *t* tests'.<sup>a</sup> Rice, curd rice, veg pulao, idli, dosa, uttapa.<sup>b</sup> Dal, sambar, peas, chana, soybean, sprouts.<sup>c</sup> Chapati, roti, poori, paratha, puran poli.<sup>d</sup> Bananas, apples, citrus, pomegranate, gooseberries, watermelon, grapes, mango, custard apple.<sup>e</sup> Green leafy vegetables, potatoes, yams, and other vegetables.<sup>f</sup> Wadas, bhajji, bonda, papad, poha, upma, chooda.<sup>g</sup> Peda, barfi, laddoo, halwa, kheer, shrinkhand.<sup>h</sup> Sugar, jaggery, honey, and sweeteners.<sup>k</sup> Curd, raita, paneer, cheese, butter, ghee, milk, lassi, milkshake, flavored milk, buttermilk.<sup>l</sup> Bread, multigrain biscuits, cereal, muesli, oats, masala oats.<sup>m</sup> Burgers, pizzas, pasta, noodles, potato chips, popcorn, puffs.<sup>n</sup> Chocolate, chocolate spreads, pancakes, waffles, biscuits, ice cream.

<sup>o</sup> Samosa, wada pav, gobi manchurian, chaat, pav bhaji, khaari, rusk.

<sup>p</sup> Cakes, pastries, kulfi, gulab jumun.

affected, as all respondents were familiar with those items (Supplementary Table 4). “Don’t know” was sometimes used by respondents for global foods, for Indian savory snacks, and for sweeteners and dairy. The estimated frequency of intake of these items increased only slightly; the patterns, including the comparisons between PDS users and PDS non-users, remained consistent.

In a robustness analysis that only randomly selected one of the respondents in each household (Supplementary Table 4), patterns of consumption remained the same, as did most of the differences between PDS users and non-users. For three food groups, differences between PDS users and non-users became non-significant: local savory snacks, sweeteners, and global sweets.

## 7. Discussion

The food environment in India, as elsewhere, is changing in many ways, with many forces operating in tandem to shape food choices. In India, the Public Distribution System is one of these forces. It is one of the world’s largest and most impactful food subsidy programs. The program is constantly in flux in attempts to improve its reach and impact, while often facing challenges in terms of costs, supplies, and distribution; these short-comings are not unexpected given the grand challenge of reaching India’s 276 million people living in poverty.

India’s PDS provides free rice in large quantities and subsidized pulses, oil, salt, and kerosene to households living in poverty; in some districts, wheat and other local grains are also provided. These supplies are intended to prevent hunger. They may also change the types and quantities of foods consumed; for example, for PDS recipients, free rice may replace other grains, such as millets and sorghum, which are not free and thus have to be purchased. Even the diets of families not eligible for the PDS may be affected, as leakage from the system and re-selling on the black market can expand the availability of cheap rice to wealthier segments of the population. The PDS may also expand the food choices available to poor households by providing for some of their most basic food needs; as such, poor families may use their limited discretionary income to purchase other items, be it more vegetables or non-perishable energy-dense items, which satisfy hunger for a relatively low price. Previous work exploring the introduction of pulses into the PDS in other states reported only small increases in households’ consumption of pulses (Chakrabarti et al., 2018); the authors point out that some of the subsidized goods may have replaced similar items that households would have otherwise purchased, freeing up household budgets for other spending.

The goal of this study was to quantify how PDS use is associated with food consumption. We examined dietary patterns among PDS users and PDS non-users living in an urban and a rural area in Northern Karnataka state. We found that PDS non-users, who were typically wealthier and therefore not eligible for the PDS, had slightly more varied diets. PDS users, who were eligible for the PDS because they were poor, had less frequent consumption of expensive foods, especially fruits and dairy. However, there were no differences among the PDS users and non-users in the intake of rice and pulses, both of which are provided through the PDS. This pattern is consistent with the proposition that the PDS may enable the poor to consume basic food items as frequently as do the non-poor.

Consistent with the proposition that poor families use their limited discretionary food budgets to purchase lower-cost, energy-dense, non-perishable foods, we found that PDS users had more frequent consumption of savory snacks, both local and non-local. In qualitative discussions, some agricultural families indicated that meat was also seen as an energy-dense, less-perishable food.

Among both PDS users and non-users, urban residents had higher frequency of intake of most foods. These differences are to be expected,

as rural food markets have limited selections and operate only weekly. Given the more limited variety of foods available in remote rural areas, there were few significant differences between PDS users and non-users in the village. At the same time, as the majority of rural people are PDS users, our sample may be insufficient to detect differences.

There were, however, differences in intake among urban residents, who have access to more diverse markets and therefore can more easily diversify their purchases. These differences in frequency of staples were minimal, but wealthier households more frequently ate fruit, vegetables, dairy and sweets, while poorer households more frequently ate meat and savory snacks. Both PDS users and PDS non-users consumed energy-dense global and non-local foods, though consumption was generally more frequent among PDS users; thus, these items have broad appeal and their prices are also within the reach of people living in poverty. These patterns indicate that, even in a remote urban center, there is plentiful access to non-local foods. Access to global foods is limited in rural areas, as even those who may be able to afford them consumed them less frequently than urban residents.

The similarity in frequency of intake of rice and pulses between those who were and were not eligible for PDS may result from the free supply of rice to the poor. In this region, we hypothesize that local staples would be eaten more frequently in the absence of a rice subsidy because those staples are typical in local dishes and because the price of rice would be higher than the price of millets, sorghum, or wheat. For example, the market price of rice ranges from 40 to 130 INR per kg, depending on quality; the price of millets is 15–20 INR per kg, sorghum is 30–40 INR per kg, and wheat is 35–38 INR per kg. Free and subsidized rice provisions change the price of rice relative to local grains for the recipients; the artificially low price of rice may lead to substitution away from local grains.

Our study has some limitations. One is that we did not collect quantities of intake of each food item, nor information on ingredients and preparation methods - only frequency. As a result, we cannot compare differences in amounts consumed, or caloric intake. It may be that poor and non-poor families eat rice, pulses, or vegetables, but that wealthier families have larger portions and that poor families have insufficient intake. It may also be that the quality of the items consumed by wealthier families is higher, and that the types of items, for example, vegetables, are more varied. Thus, our approach of examining frequency of intake may underestimate the differences between PDS users and non-users. Two, the findings may not be generalizable to other communities. Our study focused on only one rural and one urban community in Northern Karnataka. Three, the analyses were cross-sectional and descriptive, so we are not able to draw causal inferences or observe changes in dietary patterns over time. The study design does not allow us to track changes in food consumption following the introduction of or changes in PDS provisions.

While we have focused here on the PDS, there are other considerations driving consumption, including the changing availability of foods, introduction of new foods, advertisement, and social pressure. Previous research in the urban population showed that the main reasons for selecting food is often not price, but taste, accessibility and perceptions of prestige and of healthfulness (Maxfield et al., 2016; Shaikh et al., 2017). Indeed, qualitative research has shown that even poor people can afford a special meal once per week, and that their preference is for items perceived to provide high energy and not to spoil easily, especially snacks and meat, and less so fruit and vegetables.

The study design does not allow us to fully capture the complexity of changing food environments and food choice. We have provided possible interpretations of the observed patterns, pointing to explanations that we judged as particularly relevant to the local context. Longitudinal analyses and qualitative research can add more nuances to these interpretations. As there is variability in the foods provided

through the PDS across time and across states in India, future research can build on these findings by examining how *changes* in supplies within a state and *differences* across states relate to dietary patterns. This approach would make it possible to advance causal inferences about the links between PDS supplies, changing food environments, and dietary intake.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gfs.2021.100506>.

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