Availability, healthiness, and price of packaged and unpackaged foods in India: A cross-sectional study

Elizabeth K Dunford^{1,4}, Clare Farrand¹, Mark D Huffman^{1,2}, Thout Sudhir Raj³, Maria Shahid¹, Cliona Ni Mhurchu^{1,5}, Bruce Neal^{1,6}, Claire Johnson¹.

¹ Food Policy Division, The George Institute for Global Health, University of New South Wales, Sydney, Australia

² Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

³ George Institute for Global Health India, Hyderabad, India

⁴ Department of Nutrition, Gillings Global School of Public Health, The University of North Carolina at Chapel Hill, USA

⁵ National Institute for Health Innovation, University of Auckland, New Zealand

⁶ School of Public Health, Imperial College London, UK

Corresponding author: Elizabeth Dunford, PhD, The George Institute for Global Health, PO Box M201 Missenden Rd, NSW 2050 Australia: +1-919-903-7863; edunford@georgeinstitute.org.au

Short title: The healthiness and cost of food in India

ABSTRACT

Background: Vulnerable populations are the most prone to diet-related disease. The availability, healthiness, and price of foods have established associations with diet-related disease in communities. However, data describing this in India are sparse, particularly in urban slums and rural areas.

Aim: To quantify and compare availability, healthiness, and price of packaged and unpackaged foods and beverages in India, and to identify opportunities to improve diets and health of vulnerable populations.

Methods: Nutrition data and price were collected on foods and beverages available at 44 stores in urban, urban slum, and rural areas in four states in India between May and August 2018. Healthiness was assessed using the Australasian Health Star Rating system and product retail prices were examined. Comparisons in the findings were made across state, community area type, and adherence to current and draft Indian food labeling regulations was determined.

Results: Packaged foods and beverages (n=1,443, 89%) were more prevalent than unpackaged (n=172, 11%). Unpackaged products were healthier than packaged (mean HSR = 3.5 vs 2.0; $p<0.001$) and lower in price (median price per 100g/mL: 13.42 Indian rupees vs 25.70 Indian rupees; $p<0.001$), a pattern observed across most community area types and states. 96% of packaged products were compliant with current Indian labeling regulations but only 23% were compliant with proposed labelling regulations.

Conclusions: Unpackaged products were on average much healthier and lower in price than packaged foods and beverages. Food policies that support greater availability, accessibility and consumption of unpackaged foods, while limiting consumption of packaged foods, have enormous potential for sustaining the health of the Indian population.

Keywords: Food system surveillance, India, healthiness, price, packaged food, unprocessed food

INTRODUCTION

Vulnerable populations around the world are the most prone to diet-related ill health, micronutrient deficiencies, and inadequate energy consumption, which have long been associated with poverty and disadvantage (Newton, 2017). Obesity and its related health problems were historically restricted to the most affluent members of society; however, obesity-related ill health is increasingly affecting lower-socio economic populations (Newton, 2017). There has been a significant national effort in India since the 1950s to address micronutrient deficiency disorders, such as iodine deficiencies, with strong evidence of success (Swaminathan, 2019). Over the same period, health problems caused by excess consumption of adverse dietary components have risen by approximately 80% (Corsi, 2019). India now experiences a double-burden of diet-related ill health, characterised by the joint effects of nutritional deficiencies and the over-supply of adverse dietary components such as harmful fats, salt, added sugars, and energy (Popkin, 2012).

The 2015 Global Burden of Disease Study estimated that for India there were 40 million disability adjusted life years attributable to child and maternal malnutrition (Swaminathan, 2019), which largely consist of nutritional deficiencies. There were also 48 million disability adjusted life years attributable to other dietary risks (Kassebaum, 2016) such as excess intake of harmful fats, sodium, and added sugar. These two risks ranked 3rd and 2nd, respectively, behind only air pollution, as the leading health risks in India (Dandona, 2017). An integrated and coherent policy agenda that addresses both under- and over-nutrition, as well as the intersection with climate change, is increasingly recognized as an essential strategy to improve individual, population, and planetary health as outlined in the 2019 Lancet Commission Report on Global Syndemic of Obesity, Undernutrition, and Climate Change (Willett, 2019).

The wide availability and heavy marketing of unhealthy food, mainly packaged food and beverage products—typically energy dense and high in harmful fats, sugar and salt—is a key driver of unhealthy diets globally (Moodie et al., 2013), with the packaged food and beverage sector growing rapidly in India. The availability, healthiness, and price of foods all have established associations with the types and levels of diet-related ill health in communities. Given the size of India's population, the Indian food and grocery market measured by sales is the world's sixth largest, with retail contributing to 70% of the total sales (Rajesh S., 2015). On average, Indians spend 31% of their total earnings on food and

groceries. In contrast, consumers in the US spend 9%, while in Brazil and China, the expenditure on food is 17% and 25%, respectively (Ali, 2010). With rising levels of income, per capita fat consumption has been growing rapidly in India (Golait, 2006), coupled with steady increases in consumption of processed food due to increasing per capita income, a large young population (60% below 35 years of age), deeper retail penetration, and a growing number of nuclear families, India's demand for processed foods and beverages is projected to increase (Rajesh S., 2015).

Recent research has shown that packaged food and beverages available in India are generally unhealthy, with less than 20% of products meeting thresholds for "healthiness" (Jones et al., 2017). Similarly, research comparing the healthiness of packaged foods and beverages from 12 countries found that western countries such as the USA, Australia and the UK had generally healthier product portfolios compared to developing countries such as India, with India ranked consistently in the least healthy third of all countries (Dunford et al., 2019). One previous study also showed that adherence to labelling regulations of packaged food and beverages in India was low, with less than 50% product compliance (Johnson et al., 2017). Data describing the price of foods in India are sparse, particularly in urban slums and rural areas of India. The objective of this study was therefore to quantify and compare availability, healthiness, and price of packaged and unpackaged foods and beverages in India, and to identify opportunities to improve the diets and health of vulnerable populations.

METHODS

States, community area types and retail outlets surveyed

Data were collected using a standardized protocol (described in further detail in the data collection section below) and survey done by trained study personnel between May and August 2018 in four states across India: Andhra Pradesh, Bihar, Delhi, and Uttar Pradesh. These states were selected to represent a broad range of socioeconomic development and geography across India. Within each of the four states, three community area types were identified to include a broadly representative population sample: 1) urban areas, 2) urban slum areas, and 3) rural areas.

The cross-sectional survey encompassed three types of retail outlets (stores) from which most foods are purchased in India: (Johnson, 2017; Jones, 2017) 1) small corner stores (kirana shops), 2) medium-sized

outlets, and 3) larger supermarkets. Data were collected from a total of 44 stores across the three community area types in the four states. Data were collected for all available packaged and unpackaged foods and beverages in selected stores. Permission to collect data was obtained from each store manager or owner.

Data collection

For packaged foods and beverages, The George Institute's *Data Collector App* (Android platform) was used according to standard protocols developed by the Global Food Monitoring Group. This app utilizes a smartphone camera to capture information on the barcode, package label, ingredient list, nutrition information, and price. Products were also geo-tagged using the app. Images were uploaded to the FoodSwitch Content Management System (Dunford et al., 2014), and data from the photographs were doubly entered into this system using a quality control process that included taking a 10% sample of the entered data and re-checking against the original images. All quantitative data for packaged food and beverages underwent range checks to identify outliers, both overall and according to each food and beverage category. Variables entered included: brand name, product name, package size, servings per package, serving size, nutrient information per serve and per 100g, ingredient list, and retail price (in Indian rupees (INR)). Products were excluded if the image quality was too poor to extract the required data or if nutrition information was missing.

For unpackaged foods and beverages, a smartphone camera was used to capture photos of the products including the name of the product, if displayed, and the retail price. Data quality checks were again carried out on 10% of products.

Categorization of foods and beverages

Foods and beverages were categorized using the system established by the Global Food Monitoring Group (Dunford, 2012). This system uses a tree structure to group foods and beverages into major and minor subcategories. Primary analyses were conducted at the major category level, which defines 17 categories of foods and beverages, of which 14 were included for this survey: 1) *bread and bakery products*, 2) *cereal and grain products*, 3) *confectionery*, 4) *convenience foods*, 5) *dairy and dairy alternatives*, 6) *eggs*, 7) *edible oils and oil emulsions*, 8) *seafood and seafood products*, 9) *fruits, vegetables, nuts, and legumes*, 10) *meat and meat alternatives*, 11) *non-alcoholic beverages*, 12) *sauces, dressings, dips, and spreads*, 13) *snack foods*, and 14) *sugars, honey, and related products*.

The categories *special foods* (which includes *foods for specific dietary use* and *vitamins and minerals*), *alcoholic beverages*, and *herbs and spices* were excluded from the analyses due to limited nutritional content.

Measure of healthiness

The Australasian Health Star Rating (HSR) front-of-pack labelling system (Health Star Rating Advisory Committee, 2014) was used to examine the healthiness of food and beverage products. The HSR assigns products a rating between 0.5 (least healthy), and 5.0 stars (healthiest) in 10 half-star increments based on the nutritional composition of the products (Department of Health Commonwealth of Australia, 2016). Products were further classified into two HSR categories: ‘unhealthy’ if the product had an HSR <3.5, and ‘healthy’ if the product had an HSR ≥3.5. The cut-off of 3.5 is based on previous research showing this cut-off to align with Australian dietary guidelines (Dunford et al., 2018; Jones et al., 2017).

For packaged food and beverage products that displayed a nutrition label, nutrient data per 100g or 100mL were used to calculate the HSR. If nutritional components required to calculate an HSR were absent for these products (e.g. the product displayed energy, saturated fat, and sodium but did not display total sugar), then proxy values (Jones et al., 2017) were used in the calculation. Proxy values for saturated fat, total sugar, sodium, fibre, and fruit, vegetable, nut, and legume (FVNL) content were imputed based on mean levels from available data for 515 food categories and more than 10,000 products in The George Institute’s FoodSwitch India database using methods previously described (Johnson, 2017).

For unpackaged food and beverage products, nutrient information was derived from Indian Food Composition Table (Longvah, 2017). The Indian Food Composition Tables (Longvah, 2017) were used to extract food composition data for fresh produce that do not normally display NIP information (e.g. fresh produce). For each collected unpackaged product, its best match in the Indian Food Composition Tables was identified. Each unpackaged product was matched to one of 541 items for which data were available in these tables. An HSR was then calculated based on these data. Where no category for the collected product was identified in the Indian Food Composition Tables, the product was assigned to a category within the FoodSwitch India database, and mean values for all nutrients and HSR values were assigned to that product.

Measure of price

Price was recorded in INR per 100g, per 100mL or per piece for each product at the time the image was captured, depending upon what pricing information was available. For products which only had a price per piece, price per 100g or per 100mL was either calculated using the displayed serving and package size, or if this was not available, products were assigned proxy weights using values from the FoodSwitch India database. Where different prices were recorded for the same product present in more than one store across all stores sampled (for each state and community area type combination), the median price [IQR] was calculated and used to compare between states, community area types, and food categories.

Assessment of compliance with Indian Food Labelling Regulations

In 2011, the Food Safety and Standards Authority of India introduced national nutrition labelling regulations that require core information describing the nutritional content of packaged foods to include energy (kilocalories), protein (g), carbohydrate (g) and total fat (g) per 100g or 100mL serving of the product (Food Safety and Standards Authority of India, 2011). In 2018, amendments to this regulation were proposed recommending total sugars, saturated fat, trans fat, and sodium content also be mandatorily displayed. Compliance with both the 2011 and the draft 2018 regulations was assessed by calculating the proportion of packaged foods displaying each regulation's mandatory nutrient information overall and by food category.

Data analysis

Packaged and unpackaged food and beverage product counts were reported overall and for each state and community area type: urban, urban slum, and rural. Analysis was limited to unique products. A unique product was defined as the same product available in different package sizes. For example, one brand of cola might be available in 6 different package sizes, however its nutritional information remains the same, and so only one product was included in analysis. Primary analyses were performed and reported overall, by state, by community area type, and by major food and beverage categories. Outputs were reported for: 1) mean HSR, 2), median price per 100g or per 100mL in INR, and 3) proportions of packaged food and beverage products meeting contemporary (2011) (Food Safety and Standards Authority of India, 2011) and proposed (2018) (Food Standards and Safety Authority of India, 2018) legislated minimum nutrition labelling information.

Mean HSRs across states and community area types were compared using analysis of variance (ANOVA) with post-testing adjustment conducted using Tukey's honestly significant difference (HSD). Median prices in INR were compared using the Kruskal-Wallis equality-of-populations rank test with post testing adjustment done using the Dunn-Bonferroni method. A two-sided p-value <0.05 defined statistical significance. Analyses were performed using Stata version 15.1.

RESULTS

Supplementary Figure 1 shows the flowchart of products surveyed and analyzed. Data were collected for 6,325 food and beverage products. Products were excluded if they were an ineligible product type (n=979), had poor image quality (n=64), or were duplicate products (n=1,615), leaving 1,443 unique packaged foods and beverages (90%) and 172 unpackaged foods and beverages (10%) distributed across states and community area types (**Table 1**). The greatest number of unique packaged products were in urban areas (n=1,006 products), and the greatest number of unique unpackaged products were in urban slum areas (n=132 products). The results for healthiness and price are presented in the following sections.

Table 1: Total packaged and unpackaged food and beverage products available by state and community area type.

Package type and State	Urban	Urban Slum	Rural	All
Unpackaged				
Andhra Pradesh	108	105	81	152
Bihar	34	48	29	68
Delhi	18	25	3	31
Uttar Pradesh	29	28	33	50
All States	122	132	102	172
Packaged				
Andhra Pradesh	319	200	151	508
Bihar	347	231	110	523
Delhi/NCR	328	159	152	527
Uttar Pradesh	353	133	75	463
All States	1,006	586	396	1443

Total packaged or unpackaged	1,128	718	498	1,615
-------------------------------------	-------	-----	-----	-------

Healthiness of foods

Table 2 describes the healthiness of packaged and unpackaged food and beverage products by state and community area type. Unpackaged foods and beverages were healthier than packaged products overall (mean [SD] HSR = 3.5 [1.7] versus 2.0 [1.3]; $p < 0.001$). This pattern was broadly consistent across states

and community area types. There was evidence that packaged foods and beverages in rural Delhi were healthier than packaged foods and beverages in urban slum and urban areas (mean HSR = 2.5 [1.4] versus 1.7 [1.1] and 1.9 [1.2], respectively; $p < 0.001$). Conversely packaged products in Uttar Pradesh were healthier in urban areas compared to rural areas (mean HSR = 1.9 [1.1] versus 1.6 [1.1]; $p = 0.05$). Mean HSRs for unpackaged products were similar across community area types and states.

Table 2. Healthiness of packaged and unpackaged food and beverage products measured by mean (SD) Health Star Rating (HSR) by state and community area type.

	Urban		Urban Slum		Rural		p-value	Total	
	Mean HSR		Mean HSR		Mean HSR			n	Mean HSR (SD)
	n	(SD)	n	(SD)	n	(SD)			
Unpackaged									
Andhra Pradesh	101	3.6 (1.7)	94	3.6 (1.6)	73	3.9 (1.5)	0.4	139	3.5 (1.7)
Bihar	33	3.6 (1.7)	46	4.0 (1.5)	29	3.4 (1.6)	0.3	65	3.7 (1.5)
Delhi	18	4.1 (1.4)	25	3.1 (1.8)	3	3.3 (1.8)	0.1	31	3.2 (1.8)
Uttar Pradesh	28	3.6 (1.5)	27	2.9 (1.6)	31	3.4 (1.5)	0.2	47	3.3 (1.6)
All states	114	3.5 (1.7)	119	3.6 (1.6)	93	3.7 (1.5)	0.7	158	3.5 (1.7)
Packaged									
Andhra Pradesh	259	1.9 (1.3)	165	1.8 (1.3)	118	1.8 (1.4)	0.7	416	1.9 (1.3)
Bihar	311	1.7 (1.3)	197	2.0 (1.4)	95	1.9 (1.1)	0.2	458	1.9 (1.3)
Delhi	296	1.9 (1.2)*	145	1.7 (1.1)†	126	2.5 (1.4)*†	<0.001	468	2.0 (1.3)
Uttar Pradesh	320	1.9 (1.1)*	117	1.7 (1.0)	61	1.6 (1.1)*	0.02	410	1.8 (1.1)
All states	872	1.9 (1.3)	505	1.9 (1.3)	328	2.1 (1.4)	0.1	1,238	2.0 (1.3)

P-values represent global tests of differences between the three groups. Superscript characters indicate statistically significant differences: ^Urban vs Urban Slum, *Urban vs Rural, and †Urban Slum vs Rural.

n = number of products with nutrition information sufficient to calculate HSR

Supplementary Table 1 describes the healthiness of packaged and unpackaged products in each food category by state and community area type. Mean HSR varied markedly between major food and beverage categories, however there were no differences observed between state or community area type ($p>0.05$ for all). The category with the highest mean HSR was *fruit, vegetables, nuts and legumes* (mean [SD] HSR = 4.4 [1.3]). The category with the lowest HSR was *confectionery* (mean HSR = 0.9 [0.6]).

Price of foods

Table 3 describes the price (INR) of products overall and by state and community area type. **Figure 1** shows the price (INR) for packaged versus unpackaged products by HSR category (“unhealthy” <3.5 versus “healthy” ≥ 3.5). Packaged food and beverage products were more costly than unpackaged products (median price per 100g/100mL = 25.66 [27.21] INR vs 13.42 [24.59] INR; $p<0.001$) with a similar pattern observed across all states and community area types and when stratified by healthiness (**Supplementary Figure 2**).

There were clear differences in packaged food and beverage prices across community area types, with consistently lower prices in rural areas compared to urban slum areas (median [IQR] INR 20.02 [15.11] versus 24.72 [28.17]; $p=0.02$) and rural compared to urban areas (median [IQR] price = 20.02 [15.11] INR versus 27.24 [26.91] INR; $p<0.001$). Urban slum and urban areas had similar prices. Differences in price between urban and rural communities were observed in Andhra Pradesh, Bihar and Delhi, but no difference was detected in Uttar Pradesh. There was no evidence of price differences for unpackaged food and beverage products across community area types or states.

Supplementary Table 2 shows the wide variation in price of products between major food and beverage categories. *Convenience foods* had the highest median [IQR] price in urban areas (69.45 [22.34] INR) and urban slum areas (70.83 [14.43] INR), and *eggs* had the lowest median [IQR] price in all area types. *Confectionery* was significantly lower in price in rural areas (29.31 [20.89] compared to urban (49.61 [41.70] INR) and urban slum (30.99 [26.79] INR) areas ($p<0.001$). *Cereal and grain products* and *Bread and bakery products* were also significantly higher in price in urban versus rural areas ($p=0.01$ for both).

Table 3. Price of packaged and unpackaged food and beverage products measured by median (IQR) Indian rupee (INR) per 100g

	Urban		Urban Slum		Rural		p-value	Total	
	Median INR		Median INR		Median INR			Median INR	
	n	(IQR)	n	(IQR)	n	(IQR)		n	(IQR)
Unpackaged									
Andhra Pradesh	108	14.3 (17.9)	105	14.9 (22.1)	80	14.0 (18.1)	0.9	152	12.1 (17.7)
Bihar	34	23.9 (53.5)	48	20.3 (37.2)	29	9.9 (9.1)	0.3	68	19.1 (32.8)
Delhi	18	8.6 (5.1)	25	11.0 (12.2)	3	1.2 (0.9)	0.2	31	10.5 (11.6)
Uttar Pradesh	29	9.1 (6.5)	28	11.8 (12.1)	33	24.8 (85.7)	0.5	50	10.7 (10.7)
All states	122	13.9 (17.5)	132	16.5 (28.3)	101	17.5 (51.3)	0.7	172	13.4 (24.6)
Packaged									
Andhra Pradesh	306	30.8 (30.4)^*	192	23.1 (19.9)^	144	21.2 (17.6)*	<0.001	485	26.8 (26.3)
Bihar	334	30.5 (33.9)*	221	28.6 (39.2)	102	20.1 (11.9)*	0.02	497	28.8 (34.9)
Delhi	309	25.5 (21.5)*	148	23.8 (17.4)	145	20.6 (13.8)*	0.03	492	23.8 (18.6)
Uttar Pradesh	339	23.6 (20.4)	124	24.6 (25.3)	71	20.8 (19.7)	0.5	439	24.0 (23.0)
All states	958	27.2 (26.9)*	555	24.7 (28.2)†	373	20.0 (15.1)*†	<0.001	1,358	25.7 (27.2)

P-values represent global tests of differences between the three groups. Superscript characters indicate statistically significant differences: [^]Urban vs Urban Slum, ^{*}Urban vs

Rural, and [†]Urban Slum vs Rural. NCR=National Capital Region

Compliance with labelling regulations

Overall, 96% of packaged products met the criteria for the 2011 Food Safety and Standards Authority of India (FSSAI) legislated minimum nutritional information, including 100% compliance for *convenience foods*, 98% for *snack foods*, and 99% for *bread and bakery products*. The food category with the lowest proportion of products complying was *edible oils and oil emulsions* (83%). On the other hand, only 23% of products overall met the FSSAI 2018 draft labelling regulation standards, which stipulate the mandatory reporting of sugars, sodium, saturated fat and trans-fat in addition to energy (kilocalories), protein, carbohydrate and fat mandated in the 2011 version. Specifically, there was 50% compliance of *convenience foods*, 39% compliance of *snack foods*, and 0% of *meat and meat alternatives* with the updated draft standards (**Supplementary Table 3**).

DISCUSSION

This study found that, overall, packaged food and beverage products available in India were more prevalent, less healthy, and more expensive than unpackaged food and beverage products. Unpackaged foods and beverages had a higher mean HSR (3.5 vs 2.0 out of 5.0), a pattern which was observed consistently across most community area types in all four states. The general unhealthiness of Indian packaged food and beverage products in this study is in line with previous research which showed that the mean HSR for the largest 11 food and beverage manufacturers in India was 1.8 out of 5.0 (Jones, 2017), and that India consistently ranked poorly in terms of nutritional quality of processed foods when compared to western countries (Dunford et al., 2019). Interestingly, the current study showed varying results in the healthiness of packaged food and beverages by community area type in each state. Delhi, for example, had significantly healthier packaged foods and beverages available for purchase in rural compared to urban and urban slum areas with Uttar Pradesh having significantly less healthy packaged food and beverage products in rural areas. Rural India is home to almost 70% of the Indian population (Ministry of Home Affairs Government of India, 2011) and is known to have significantly lower food security and income compared to urban and urban slum areas (Joshi et al., 2019; Mberu et al., 2016), highlighting the importance of capturing information in each community area type and not only products available from large metropolitan supermarkets.

Packaged food and beverage products were more costly than unpackaged food products overall in this study and in all community area types and states. There were consistently lower prices for packaged

food in rural compared to urban slum and urban areas. Nutrition surveys in recent decades have shown a change in consumption patterns in India from a traditional diet high in fruits, vegetables and pulses towards more processed foods. Interestingly, the trend of healthy foods being lower in price in the current study is contradictory to previous research undertaken in western countries such as the US, New Zealand and Australia (Darmon and Drewnowski, 2015), where packaged/processed foods are generally found to be lower in price compared to fresh produce. One study from Brazil examined changes over time in the relative prices of unhealthy and healthy foods and forecast that although in 1995 processed foods were more expensive than unprocessed foods, that by 2026 unhealthy foods would be more expensive than healthy foods (Maia et al., 2020). India may follow a similar path over time as the packaged food market increases over time.

Overall, 96% of Indian packaged foods and beverages were compliant with current 2011 Indian labeling regulations with only 23% compliant under the draft 2018 labelling regulations which require additional information about total sugars, sodium, dietary fibre and trans-fat content to be displayed. This is in line with previous research from 2014 which found that the proportion of foods meeting the draft 2018 labelling regulations was less than half of what was available for sale in Indian supermarkets, making it difficult for consumers to make informed food purchasing decisions (Johnson, 2017). The current 2011 Indian labelling regulations do not meet all the requirements of the international body governing food labelling, Codex Alimentarius. Global guidelines set by Codex suggest the reporting of saturated fat and sodium, both which are not currently required to be labelled on packaged food and beverage products in India. For consumers to make fully informed choices about the healthiness of products they want to purchase, the Indian government should at a minimum adopt the Codex guidance on sodium and saturated fat labelling. Previous research in India has shown that many large global food companies meet the current 2011 Indian labelling regulations, but none meet the draft 2018 regulations, despite many of these large global companies operating in other countries which do require the additional labelling of saturated fat and sodium (Dunford et al., 2015). It is therefore reasonable to suggest that at a minimum, large global food companies operating and selling products in India should provide saturated fat and sodium information on the label so that consumers can make a more informed choice.

This study had some limitations. Data collection was undertaken at only one time point, so seasonal variation in unpackaged product availability and pricing could not be assessed. A limited number of stores and states were sampled, and the results may not be generalizable across all Indian states and

communities. The number of food and beverage products may also have been underestimated due to the limited number of stores and states sampled. Previous studies on packaged food and beverages in India have found upwards of 5,000 unique products for sale in surveys that were conducted in large retail chain stores, such as Hypercity and More Supermarket (Johnson, 2017). Due to the smaller sample size compared to other studies conducted primarily in large retail stores, differences in healthiness and price between states and across community types may be the result of chance rather than reflecting real, systematic differences. Whilst these larger chain stores have a wider variety of products, many communities in the urban, rural, and urban slum localities generally do not shop in these types of stores for everyday purposes but instead frequent the smaller local stores in their locality (Johnson, 2017; Johnson, 2019).

The study findings support the implementation of intervention programs that encourage the wider production, distribution, marketing, sale, purchase, and consumption of minimally processed and unpackaged foods and beverages in India. Programs and policies targeting reformulation of packaged food and beverage products can complement those focused on changing consumer behavior (Vandevijvere, 2019). These might include adoption of standards for sodium in packaged foods as shown in Brazil and the UK (He, 2014; Nilson, 2017), sugar-sweetened beverage taxes (Scarborough, 2020), artificial trans-fat bans (World Health Organization, 2018), unhealthy food marketing restrictions, and warning labels to indicate foods that are high in certain nutrients of concern.

CONCLUSIONS

This study showed that the overall healthiness of packaged food and beverage products in India was low, and that differences exist in product availability, healthiness and price between urban, urban slum and rural areas. Food policies that support the greater availability, accessibility and consumption of unpackaged foods, while limiting consumption of packaged foods, have enormous potential for sustaining the health of the Indian population. Novel interventions and policies that address both the under- and over-supply of dietary components are urgently required to address the enormous burden of diet-related disease in India.

Acknowledgements: Not applicable.

Funding: This work was supported by The Bill and Melinda Gates Foundation. The funders had no role in the design, analysis or writing of this article. CJ is supported by a National Heart Foundation Postdoctoral Fellowship (HF101945).

Availability of data and materials: The authors can be contacted with any questions regarding the data used in analysis.

Conflict of Interest: MDH has received grant support from the World Heart Federation to serve as its senior program advisor for the Emerging Leaders program, which has been supported by unrestricted educational grants from Boehringer Ingelheim and Novartis with previous support from Bupa. MDH has also received support from the American Heart Association, Verily, and AstraZeneca and the American Medical Association for work unrelated to this project.

Author's contributions: BN and CJ designed the study. CF and ED wrote the first draft of this research paper with primary responsibility for the final content with oversight and input from MDH. TS supervised data collection. MS carried out data analysis. All authors reviewed and provided written comments upon subsequent iterations.

Ethical Approval: Not applicable.

REFERENCES

- Ali J, Kapoor, S., Moorthy, J.,. (2010) Buying behaviour of consumers for food products in an emerging economy. *British Food Journal*.
- Corsi DJ, Subramanian, S.V. (2019) Socioeconomic gradients and distribution of diabetes, hypertension, and obesity in India. *JAMA network open* 2: e190411-e190411.
- Dandona L, Dandona, R., Kumar, G.A., Shukla, D.K., Paul, V.K., Balakrishnan, K., et al. (2017) Nations within a nation: variations in epidemiological transition across the states of India, 1990–2016 in the Global Burden of Disease Study. *The Lancet* 390: 2437-2460.
- Darmon N and Drewnowski A. (2015) Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis. *Nutrition reviews* 73: 643-660.
- Department of Health Commonwealth of Australia. (2016) Guide for industry to the Health Star Rating Calculator.
- Dunford E, Trevena H, Goodsell C, et al. (2014) FoodSwitch: A Mobile Phone App to Enable Consumers to Make Healthier Food Choices and Crowdsourcing of National Food Composition Data. *JMIR Mhealth Uhealth* 2: e37.
- Dunford E, Webster, J., Metzler, A. B., Czernichow, S., Ni Mhurchu, C., Wolmarans, P., et al. (2012) International collaborative project to compare and monitor the nutritional composition of processed foods. *Eur J Prev Cardiol* 19: 1326-1332.
- Dunford EK, Guggilla RK, Ratneswaren A, et al. (2015) The adherence of packaged food products in Hyderabad, India with nutritional labelling guidelines. *Asia Pac J Clin Nutr* 24: 540-545.
- Dunford EK, Huang L, Peters SAE, et al. (2018) Evaluation of Alignment between the Health Claims Nutrient Profiling Scoring Criterion (NPSC) and the Health Star Rating (HSR) Nutrient Profiling Models. *Nutrients* 10.
- Dunford EK, Ni Mhurchu C, Huang L, et al. (2019) A comparison of the healthiness of packaged foods and beverages from 12 countries using the Health Star Rating nutrient profiling system, 2013-2018. *Obes Rev* 20 Suppl 2: 107-115.
- Food Safety and Standards Authority of India. (2011) Food Safety and Standards (Packaging and Labelling) Regulations.
- Food Standards and Safety Authority of India. (2018) Notice calling for suggestions, views, comments etc from stakeholders on the draft Food Safety and Standards (Labelling and Display) Regulations, 2018.
- Golait R, Pradhan, N., . (2006) Changing food consumption pattern in rural India: Implication on food and nutrition security. *Ind. Jn. of Agri. Econ* 61.
- He FJ, Brinsden, H.C., MacGregor, G.A. (2014) Salt reduction in the United Kingdom: a successful experiment in public health. *Journal of human hypertension* 28: 345-352.
- Health Star Rating Advisory Committee. (2014) About Health Star Ratings.
<http://healthstarrating.gov.au/internet/healthstarrating/publishing.nsf/content/About-health-stars>.
- Johnson C, Santos, J.A., Sparks, E., Thout., S.R., Mohan, S., Garg, V. et al. (2019) Sources of dietary salt in north and south India estimated from 24 hour dietary recall. *Nutrients* 11: 318.
- Johnson C, Thout SR, Mohan S, et al. (2017) Labelling completeness and sodium content of packaged foods in India. *Public Health Nutrition* 20: 2839-2846.
- Johnson C, Thout, S.R., Mohan, S., Dunford, E., Farrand, C., Wu, J.H.Y., et al. (2017) Labelling completeness and sodium content of packaged foods in India. *Public health nutrition* 20: 2839-2846.
- Jones A, Dunford E, Crossley R, et al. (2017) An Evaluation of the Healthiness of the Indian Packaged Food and Beverage Supply. *Nutrients* 9.
- Jones A, Dunford, E., Crossley, R., Thout, S.R., Rayner, M., Neal, B. (2017) An evaluation of the healthiness of the Indian packaged food and beverage supply. *Nutrients* 9: 1103.

-
- Joshi A, Arora A, Amadi-Mgbenka C, et al. (2019) Burden of household food insecurity in urban slum settings. *PloS one* 14: e0214461-e0214461.
- Kassebaum NJ, Arora, M., Barber, R.M., Bhutta, Z.A., Brown, J., Carter, A., et al. (2016) Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet* 388: 1603-1658.
- Longvah T, Anantan, I., Bhaskarachary, K., Venkaiah, K. (2017) Indian food composition tables. National Institute of Nutrition, Indian Council of Medical Research Hyderabad.
- Maia EG, Dos Passos CM, Levy RB, et al. (2020) What to expect from the price of healthy and unhealthy foods over time? The case from Brazil. *Public health nutrition* 23: 579-588.
- Mberu BU, Haregu TN, Kyobutungi C, et al. (2016) Health and health-related indicators in slum, rural, and urban communities: a comparative analysis. *Global health action* 9: 33163-33163.
- Ministry of Home Affairs Government of India. (2011) India Household Census. In: Commissioner OotRGC (ed). New Delhi, India.
- Moodie R, Stuckler D, Monteiro C, et al. (2013) Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. *Lancet* 381: 670-679.
- Newton S, Braithwaite, D., Akinyemiju, T.F. (2017) Socio-economic status over the life course and obesity: Systematic review and meta-analysis. *PloS one* 12.
- Nilson EAF, Spaniol, A.M., Gonçalves, V.S.S., Moura, I., Silva, S.A., L'Abbé, M., et al. (2017) Sodium reduction in processed foods in Brazil: analysis of food categories and voluntary targets from 2011 to 2017. *Nutrients* 9: 742.
- Popkin BM, Adair, L.S., Ng, S.W. (2012) Global nutrition transition and the pandemic of obesity in developing countries. *Nutrition Reviews* 70: 3-21.
- Rajesh S. M, B. (2015) Indian Consumer Market 2020: Structure, Size, Growth and Intensity. People Research on India's Consumer Economy (PRICE).
- Scarborough P, Adhikari, V., Harrington, R.A., Elhoussein, A., Briggs, A., Rayner, M., et al. (2020) Impact of the announcement and implementation of the UK Soft Drinks Industry Levy on sugar content, price, product size and number of available soft drinks in the UK, 2015-19: A controlled interrupted time series analysis. *PLoS medicine* 17: e1003025.
- Swaminathan S, Hemalatha, R., Pandey, A., Kassebaum, N.J., Laxmaiah, A., Longvah, T., et al. (2019) The burden of child and maternal malnutrition and trends in its indicators in the states of India: the Global Burden of Disease Study 1990–2017. *The Lancet Child & Adolescent Health* 3: 855-870.
- Vandevijvere S, Vanderlee, L. (2019) Effect of formulation, labelling, and taxation policies on the nutritional quality of the food supply. *Current nutrition reports* 8: 240-249.
- Willett W, Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., et al. (2019) Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet* 393: 447-492.
- World Health Organization. (2018) REPLACE: An action package to eliminate industrially-produced trans fat from the global food supply.
-

Figure Legend:

Figure 1. Median (interquartile range) price of foods per 100 grams or 100 milliliters in Indian rupees (INR) and healthiness measured by Health Star Rating < 3.5 and Health Star Rating ≥ 3.5 overall and by packaged vs unpackaged products.