Dietary patterns in North and South India: a comparison with EAT-Lancet dietary guidelines

Key words: Indian diets, EAT-Lancet, adults

Authors' contributions:

AG- Conducted research, designed and wrote the paper; MD- Analysed data and performed statistical analysis; HP- Assisted in data management, analysis and developing the manuscript; RG- Reviewed the paper and helped in designing and developing the manuscript; KAB- Reviewed the paper and helped in designing and developing the manuscript; NSV- Designed and conducted research; PJ- Designed and conducted research; DP- Got funding, helped in designing the study; SM- Got funding, helped in designing the study; all authors read and approved the final manuscript.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Abstract:

Background: Environmentally sustainable diets are represented in the global planetary health guidelines developed by the EAT-Lancet Commission in 2019. Very few studies have compared Indian diets with the EAT-Lancet guidelines, and we did this using primary dietary data on adults from north and south India.

Methodology: Data from 8762 adults (52.4±11.7 years) of the UDAY cohort from Sonipat and Vizag India, were collected on socio-demographic characteristics, wealth index (calculated using household assets), and dietary intake. The quantity consumed and energy from each food group was compared with EAT-Lancet guidelines. We studied the likelihood of having inadequate and excess consumption was studied by different socio-demographic factors controlling for age.

Results: Half of the study participants were women and half resided in rural areas. Food groups like fruits and vegetables were consumed inadequately while dairy and added fats were consumed in excess amounts when compared with the EAT-Lancet recommendations. For fruits and vegetables, those belonging to the poorest wealth index and residing in rural areas had a higher likelihood to fall into the deficient or no consumption category; while rural place of residence and poor wealth index were found to be associated with excess consumption of dairy and added fats ($p<0.05$, all).

Conclusion: The diets of the study participants were mainly plant-based, high in dairy but lacking in nutrient-rich foods like fruits and vegetables. Considering widespread malnutrition in India, urgent policy actions for making healthy sustainable diets and micronutrient-rich foods available and affordable, especially for rural and disadvantaged populations are essential.

Introduction: Providing a growing global population with healthy diets from sustainable food systems is an immediate challenge. In 2010, the FAO defined sustainable and healthy diets as those with "low environmental impacts that contribute to healthy life for present and future generations and are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy" ([1]). In considering these, the Sustainable Development Goals (SDG), promise to ensure food security and nutrition within sustainable food systems ([2]). The global trends of diets and the food systems which produce those diets, however, suggest that they are neither healthy nor sustainable. This has implications for achieving SDGs by 2030, as it is acknowledged globally the disease burden due to dietary risks is alarmingly high and we are unlikely to universally meet the SDG 2 Zero Hunger ([3,4]).

Large-scale and coordinated efforts are required to transform the global food systems and achieve the SDG goals. Studies show that foods differ greatly in their environmental impacts ([5]). Animal-sourced foods tend to have higher environmental impacts than plant-based foods, and within a food group there can be considerable variation dependent on the environmental indices used (greenhouse gas emissions, water use etc.), how, where, and when a food was produced, and its level of processing ([6]). The EAT-Lancet guidelines consider the environmental and health impacts of foods and set universal scientific targets for global diets where the food system would be healthy (safe and nutritious) and environmentally sustainable (operate within planetary boundaries) ([7]). It provides quantitative scientific targets or ranges for different food groups that will enable 10 billion people to consume a healthy diet within safe planetary boundaries by 2050, citing shifts in dietary patterns around the world are both possible (in theory) and necessary. The EAT-Lancet diet includes reference ranges and absolute amounts, in grams per day and kcal per day, for eight food groups: whole grains, tubers and starchy vegetables, fruits, other vegetables, dairy foods,

protein sources, added fats, and added sugars. These guidelines provide a way to compare the health and sustainability of diets around the world. For example, the EAT-Lancet diet has been associated with a lower risk of ischaemic heart disease and diabetes ([8]) and overall mortality ([9]). Meeting the dietary guidelines has also been related to achieving higher micronutrient adequacy of diets in rural women of reproductive age from LMICs ([10]).

India needs a greater push to achieve SDG 2 zero hunger as ensuring universal food as well as nutrition security remain a challenge ([11, 12]). The burden of non-communicable diseases related to diets is also increasing following "nutrition transitions," as dietary patterns change to incorporate those observed in many high-income countries ([13]). In this context, few studies have compared Indian diets against the EAT-Lancet recommendations. For example, a study using the household Consumption Expenditure Survey (CES) conducted by the National Sample Survey Organization (NSSO) of India in 2011–12, showed that Indian food expenditures for different food groups were much lower than the EAT-Lancet recommendations ([14]). Another study using primary data on food prices and household food purchases, and secondary data on food expenditures for a period of 12 months in 2018–19 indicated similar results ([15]). These studies, however, were based on proxy data and lacked while comparison using consumption data from a primary source. The current analysis using primary data is necessary as diets vary across India and the resulting information can inform context-specific targeted action. We provide a comparison using primary data in two diverse Indian populations, which include adults from both rural and urban regions and across different socio-economic strata. This study aimed to identify dietary gaps by comparing Indian diets with EAT-Lancet recommended diets and study the differences by state (north or south), place of residence (rural or urban), sex and socioeconomic status.

Materials and methods:

Study design: The analysis presented in this paper is based on data from the UDAY cohort study's baseline follow-up survey conducted during October 2018-February 2019 among 9005 adults aged $\geq$ 30 years from urban and rural households in Sonipat (north India) and Vizag (south India). The UDAY methodology has been published elsewhere ([16]). Briefly, the study was established to improve the prevention, detection and management of diabetes and hypertension among adults.

Ethics: Ethics approval was obtained from the Institutional Ethics Committee (IEC) of the Public Health Foundation of India (IRB No: IRB00006330). Participants willing to participate and who provided informed written consent were included in the study.

Measurements: All the measurements were carried out by trained field staff by using globally acceptable instruments, entered in a computer-assisted personal interview (CAPI) platform, and were closely supervised and evaluated by the research staff for quality control.

Demographics: Information on residence (urban or rural), site and state (Sonipat, Haryana or Vizag, Andhra Pradesh), age, sex, and employment status were collected through a pre-tested questionnaire.

Wealth index: The wealth index was constructed using principal component analysis (PCA) based on household facilities and asset data, separately for rural and urban households ([17]). It was based on the ownership of 12 household assets (radio, television, computer, phone, refrigerator, bicycle, scooter, car, washing machine, sewing machine, house, and land), and 5 key housing characteristics (water supply, type of toilet and whether it is shared, cooking fuel, housing material, and source of lighting). The first component in the PCA was extracted and divided into quintiles- the first quintile being the poorest and the fifth being the richest.

Dietary food groups: In this study, the dietary intakes were measured using a food frequency questionnaire containing 23 groups. For the EAT-Lancet comparison the above food groups were merged into the eight food groups according to their nutritional content as shown in **Table 1**. Further we divided the protein sources food group into two categories: vegetarian and non-vegetarian as half of the participants were vegetarian (consumed no egg, meat or fish). The EAT-Lancet has no separate group for recording the snack consumption patterns. Hence, we created a separate group of refined products including white rice and refined flours.

Quantity (grams/day) and energy (kcal/day) calculation: In the UDAY questionnaire the participants were initially asked to report the consumption of various foods in four frequency categories: daily, weekly, monthly, and rarely (never or less than once a month). Further, they were asked about the portion size of servings per day or the amount eaten each sitting, using standardized food models (bowls, cups, spoons, etc). Using the above information and standardized recipe manual ([18]) the daily raw quantity of various foods consumed by the participants was calculated. Based on quantity (grams/day) the daily calories consumed were calculated using reference values for raw food from the ([19, 20]).

Statistical analysis: Continuous variables were summarised as means (standard deviation [SD]) and categorical variables as frequencies (percent). We compared daily quantity and calorie consumption of the participants with the EAT-Lancet recommendations. The EAT-Lancet pattern provides ranges in addition to single values for most of its recommendations to account for uncertainty and accommodate diverse eating patterns according to individual preferences and cultural contexts. The mean UDAY diet patterns were compared with the ranges or single values as provided by EAT-Lancet. We also compared the diets across places of residence (urban and rural) and states (north and south). Further, we studied the likelihood of having inadequate

consumption (none or deficient) for whole grains, vegetables and fruits and the likelihood of having excess consumption for dairy and added fats by sex, wealth index categories and rural-urban place of residence controlling for age. The statistical analysis was completed using Stata 16.1 (Stata Corp)/ SPSS 22 (IBM, India).

Results:

Consumption data was available for 8762 (97.3%) out of 9005 recruited participants. Out of 8762 participants, 50% were women and resided in rural areas. The mean ± SD age of the participants was 52.4±11.7 years.

Proportion of participants following EAT-Lancet: Out of 8762 participants, more than 80% of the participants consumed all nine adapted EAT-Lancet food groups, except for the non-vegetarian protein group, which was consumed by half of the participants. Participants from Sonipat were mainly vegetarians (no consumption of eggs, meat, and fish) (**see Table 2**).

Comparison of quantity as compared to EAT-Lancet: When we compared the quantity of the foods consumed, except for dairy, all foods were consumed in lower quantities than the mean EAT-Lancet recommendations. Consumption of all food groups, apart from fruit and vegetables, was within the target ranges (e.g., dairy consumption was above the recommended single value of 250 g/d, although within the upper bound of the range of 0-500 g/d). Vegetable and fruit consumption was substantially less, on average, than the lower bound of the EAT-Lancet range. The mean quantity consumed of whole grains, all vegetables, fruits, dairy, and added fats was higher in Vizag than in Sonipat (**Supplementary Table 1).** However, the mean quantity consumption of starchy vegetables and added sugars were higher in Sonipat than in Vizag (p <0.01 for all). When compared by urban/ rural residence, quantity consumption of starchy vegetables, all vegetables, fruits, and protein-rich foods were higher in urban areas. Whereas, the consumption of

whole grains and dairy products was higher in rural areas (p <0.01 for all). Consumption of starchy vegetables and all vegetables were higher among women; while consumption of non-vegetarian protein sources was higher among men. Consumption of whole grains and added fats were higher among participants belonging to the poorest wealth index category; while consumption of vegetables, fruits, and dairy was highest among participants belonging to the richest wealth index category.

Comparison of energy: Corresponding as well as additional information was identified by looking at the contribution of each food group to daily energy (kcal) intake (see **Figure 2**). Dairy and added fats contributed remarkably higher calories to daily diets than recommended by the EAT-Lancet. On the other hand, fruits and protein sources contributed remarkably lower calories than recommended by EAT-Lancet. The average energy intake of the participants was 1560 kcal/day. Only 0.5% of the participants consumed ≥2500kcal/day as recommended by EAT-Lancet guidelines (results not shown).

Comparison with EAT-Lancet ranges: Using the ranges suggested by EAT-Lancet we classified the participants from the two states and, urban and rural places of residence into no consumption, below, in and above range categories (**Figure 1**). For starchy vegetables, dairy, protein sources (vegetarian and non-vegetarian), added fats, and sugar there are no lower-range recommendations provided by EAT-Lancet, thus we could not classify participants into a below-range category. Most of the participants belonged to the deficient or no consumption categories for whole grains, vegetables, and fruits. Participants from Sonipat did not consume non-vegetarian protein sources, while dairy was consumed in the above range mainly by participants from rural Sonipat and Vizag (both urban and rural). Added fats were consumed in the above range mainly by participants from Vizag.

Socio-demographic factors associated with deficient or excess consumption of different EAT-Lancet groups: We studied socio-demographic factors like age, sex, wealth index and residence that may be related to the likelihood (see **Table 3**) of belonging to the deficient or no consumption groups relating to foods that were least consumed i.e., whole grains, all vegetables and fruits (as shown in **Figure 1**). For whole grains, female participants (OR 2.69 95% CI 1.67, 4.33) and those belonging to the poorest wealth index (OR 3.50 95% CI: 1.50, 8.16) had a higher likelihood to fall into the deficient or no consumption category than their counterparts. For all vegetables and fruits, those belonging to the poorest wealth index (OR 4.49 95% CI: 3.53, 5.70; OR 6.01 95% CI: 4.03, 8.94 respectively) and those residing in rural areas (OR 2.94 95% CI: 2.55, 3.38; OR 2.30 95% CI: 1.86, 2.86 respectively had a higher likelihood to fall into the deficient or no consumption category than their counterparts (p<0.05, all). For all three food groups increasing age made participants more likely to fall into the deficient or no consumption category.

Dairy and added fats were two food groups consumed in higher quantity than recommended by some of the participants (**Table 4**). For dairy those residing in rural areas (OR 1.60 95% CI: 1.47, 1.76); and for added fats, those residing in rural areas (OR 1.20 95% CI: 1.08, 1.33) had a higher likelihood of falling into the excess consumption category than the counterparts (p<0.05, all).

Discussion:

This study compares food consumption patterns among adult males and females from North and South India with the EAT-Lancet recommendations. Indian diets lack both in quantity and quality for many food groups; it was grossly low for fruits and vegetables. Correspondingly there were substantial differences in the contribution of each food group to daily calorie intake than recommended; those contributed by dairy and added fats were very high and that of fruits and protein sources were remarkably lower than recommended by EAT-Lancet. Place of residence,

wealth index, and sex were the major factors influencing consumption patterns. Especially those residing in rural areas and belonging to poor wealth index were found to be having most inadequate diets in nutrient rich foods like fruits and vegetables. All these results are discussed in further detail below.

Lower fruit and vegetable consumption in India is a concern considering widespread micronutrient deficiencies and related non-communicable diseases [21]. These low levels do not comply with national dietary guidelines from the ICMR which recommends 5-7 serves (400g) of fruits and vegetables in a day. A study analysing national data of the food expenditure survey conducted a decade back shows that Indian diets lack in fruits and vegetables and they have shifted away from cereals to higher consumption of dairy [14]. Our study shows these trends have continued as dairy was the prominent food group consumed in adequate or excess quantity in rural and urban places and in north and south India. Apart from dairy, added fats was another adequately or excessively consumed food group especially in participants from Vizag and those belonging to the poor wealth index. Considering the magnitude of metabolic risk in India consumption of foods with high fat is a concern [22]. As the above results show that these dietary patterns are far away from the EAT-Lancet recommendations, there is an urgent need to modify them to achieve healthier and sustainable diets.

When we looked at the ICMR dietary guidelines in comparison with the EAT-Lancet recommendations, we found that the daily quantity recommended for consumption by the EAT-Lancet is higher for fruits, legumes, non-vegetarian foods, added fats and sugars and is lower for whole grains, vegetables, and dairy foods than ICMR [23]. Considering the body composition of Indians with low lean mass, the protein quantity recommended by ICMR is lower [24]. Though the total calorie recommended by EAT-Lacet and ICMR is similar (up to 2500kcal) the contributions

recommended by different food groups vary. For Indians to follow the EAT-Lancet guidelines there is a need to consider dietary guidelines for Indians and modify them to match with the EAT-Lancet.

While computing and comparing our diets according to the EAT-Lancet recommendations we faced certain limitations. Considering the socio-cultural and regional differences worldwide, the lower range for certain food groups like whole grains, starchy vegetables, and protein groups is zero for EAT-Lancet, hence we could not estimate the gaps in diets for these foods. Considering that the global population consume both vegetarian and non-vegetarian sources of protein, the EAT-Lancet has given combined guidelines for the protein sources. However, half of the study population from Sonipat did not consume non-vegetarian protein sources, hence we had to separate out the vegetarian and non-vegetarian protein sources in our results. The EAT-Lancet did not specify the type of food under each category for example, type of rice (brown or polished), which whole grains can be considered, etc., so we had to compute the groups according to our understanding. We suggest that EAT-Lancet needs to provide separate guidelines for micronutrient-rich foods considering inadequate dietary patterns in LMICs. Considering the heavy burden of diet-related metabolic disorders in India and other LMICs such guidelines are of tremendous importance.

The EAT-Lancet Commission recommends the consumption of limited amounts of refined food and the 2500-calorie guidelines of EAT-Lancet recommended diets are without processed food as a separate group. However, snacks and processed foods are now part of everyday diets in India and contributed ~15% of daily calories as shown in our recent analysis of snack consumption in the same population ([23]). It is necessary to incorporate guidelines related to these foods as they have a high metabolic risk impact.

There are various actions required at different stages of the value chain starting from consumers to farmers to gear up the food system according to the EAT-Lancet recommendations. In this context, the government has been taking certain initiatives. At the consumer level, EAT Right India has provided guidelines to ensure safe, healthy, and sustainable food for all [25]. Additionally, efforts are needed to generate awareness among consumers regarding a sustainable diet. Also, culinary skills related to cleaning, freezing, drying, storing, and preparing vegetables in a tasty way need to be improved. This will help the consumers to adapt to the EAT-Lancet diet.

India is facing issues related to affordability and availability of fruits and vegetables. Even our study findings show that those belonging to poor wealth index and residing in rural areas had issues related to accessibility, availability, and affordability of fruits and vegetables. Apart from affordability, the availability of fruits and vegetables is important. India is the second largest producer of fruits and vegetables in the world after China. But the country accounts for the post-harvest losses of 30-40% for fruits and vegetables. The losses are 10-25% for perishable foods like milk, fish, and eggs [26]. The country is the largest pulse producer globally, accounting for 27% of the world's total production however it has to import 14% of pulses globally being the largest consumer [27]. There is a need for policies addressing post-harvest losses [28]. The analysis of the affordability of EAT-Lancet recommendations shows that they are not affordable to the world's poor [29]. The comparison to Indian diets using data on prices and expenditures shows that the cost of the EAT-Lancet dietary recommendations for rural India ranges between Rs 244.5-407.4 per person per day as compared to the actual dietary intake which at present is valued at around Rs 81.5 per person per day. In order to get to the EAT-Lancet recommendations individuals will have to spend nearly Rs 81.5 per person per day more on meat, fish, dairy foods, and fruit [15]. Thus, Indian policymakers need to accelerate food-system-wide efforts by planning policies to reduce

post-harvest losses by improving cold chain storages to further improve the accessibility of fruits and vegetables.

Conclusion:

The diets of the study participants were mainly plant-based, high in dairy but lacking in nutrient-rich foods like fruits and vegetables. Thus, diets of our study participants are far away from those recommended by EAT-Lancet. Unlike developed countries consumption of red meat and foods high in carbon footprint is not an issue in Indian diets, India needs micronutrient-rich foods recommendations. Similar is the need for other LMICS. Regional-level applicability and adaptability of sustainable and environmentally friendly diets need to be considered.

Table 1: Distribution of EAT-Lancet and UDAY food groups

EAT-Lancet food groups	UDAY food groups
Whole grains	Rice, whole wheat, refined flour
Starchy vegetables	Starchy vegetables
All vegetables	Green leafy vegetables, other vegetables, uncooked raw vegetables
Fruits	Sweet fruits, other fruits
Dairy foods	Milk, milk products
Protein vegetarian: Legumes, nuts, soy food, peanuts	Legumes
Protein non-vegetarian: Chicken, other poultry, eggs, fish, beef, lamb, and pork	Poultry, eggs, fish, shell fish, meat, trimmed meat, organ meats
Added fats	Deep fried (2 groups), Desserts (2 groups)
Added sugar	Calculated from mixed food groups: daily foods plus fried foods plus desserts

Table 2: Average raw mean quantity of different foods consumed by the participants

Eat-Lancet food groups	Recommended quantity, g/day	% Consumers (N=8762)	Daily quantity consumed (g) Mean ± SD
Whole grains	232	99.8	123.5±66.5
Starchy vegetables	50 (0-100)	79.9	36.2±28.2
All vegetables	300 (200-600)	99.8	117.8±70.6
Fruits	200 (100-300)	91.0	38.6±31.5
Dairy foods	250 (0-500)	95.9	458.6±242.5
Total protein	209 (0-197)	99.2	29.8±19.3
Protein vegetarian	125 (0-175)	98.4	20.8±14.3
Protein non-vegetarian	84 (0-197)	45.5	9.1±12.1
Added fats	52(0-80)	100.0	38.9±16.4
Added sugar	31(0-31)	98.4	14.8±7.4

Grey highlighted rows shows significantly lower consumption

Table 3: Likelihood of having deficient consumption by socio-demographic characteristics

Sociodemographic factors	Categories	Exp(B) Adjusted for all factors	95% CI for Exp(B)		p value
			Lower Bound	Upper Bound	
Whole grains					
Age		1.03	1.01	1.05	0.01
Sex (Male as reference)	Female	**2.69**	**1.67**	**4.33**	**0.00**
Wealth index (Richest as reference)	1 Poorest	**3.50**	**1.50**	**8.16**	**0.00**
	2	3.00	1.38	6.50	0.01
	3	1.69	0.89	3.20	0.11
	4 Rich	1.29	0.71	2.35	0.41
Residence (Urban as reference)	Rural	0.16	0.08	0.32	0.00
All vegetables					
Age		**1.01**	**1.01**	**1.02**	**0.00**
Sex (Male as reference)	Female	**1.31**	**1.14**	**1.50**	**0.00**
Wealth index (Richest as reference)	1 Poorest	**4.49**	**3.53**	**5.70**	**0.00**
	2	4.22	3.34	5.32	0.00
	3	2.14	1.77	2.59	0.00
	4 Rich	1.49	1.24	1.78	0.00
Residence (Urban as reference)	Rural	**2.94**	**2.55**	**3.38**	**0.00**
Fruits					
Age		1.01	1.00	1.02	0.00
Sex (Male as reference)	Female	1.11	0.90	1.37	0.32
Wealth index (Richest as reference)	1 Poorest	6.00	4.03	8.94	0.00
	2	4.26	3.01	6.03	0.00
	3	3.25	2.39	4.41	0.00
	4 Rich	2.14	1.62	2.81	0.00
Residence (Urban as reference)	Rural	2.30	1.85	2.86	0.00

Table 4: Likelihood of having excess consumption by socio-demographic characteristics

| Socio demographic factors	Categories	Exp(B) Adjusted for all factors	95% CI for Exp(B)		p value
			Lower Bound	Upper Bound	
Dairy					
Age		1.00	1.00	1.00	0.77
Sex (Male as reference)	Female	0.94	0.86	1.03	0.17
Wealth index (Richest as reference)	1 Poorest	0.72	0.62	0.83	0.00
	2	1.22	1.06	1.40	0.01
	3	1.26	1.09	1.44	0.00
	4 Rich	1.09	0.95	1.25	0.23
Residence (Urban as reference)	Rural	1.60	1.47	1.76	0.00
Added fats					
Age		0.99	0.98	0.99	0.00
Sex (Male as reference)	Female	0.92	0.83	1.02	0.10
Wealth index (Richest as reference)	1 Poorest	5.25	4.30	6.41	0.00
	2	6.70	5.49	8.16	0.00
	3	4.45	3.65	5.44	0.00
	4 Rich	2.37	1.92	2.93	0.00
Residence (Urban as reference)	Rural	1.20	1.08	1.33	0.00

Figure 1: Consumption patterns (no, below, within or above the EAT-Lancet recommendation) of various food groups by the study participants
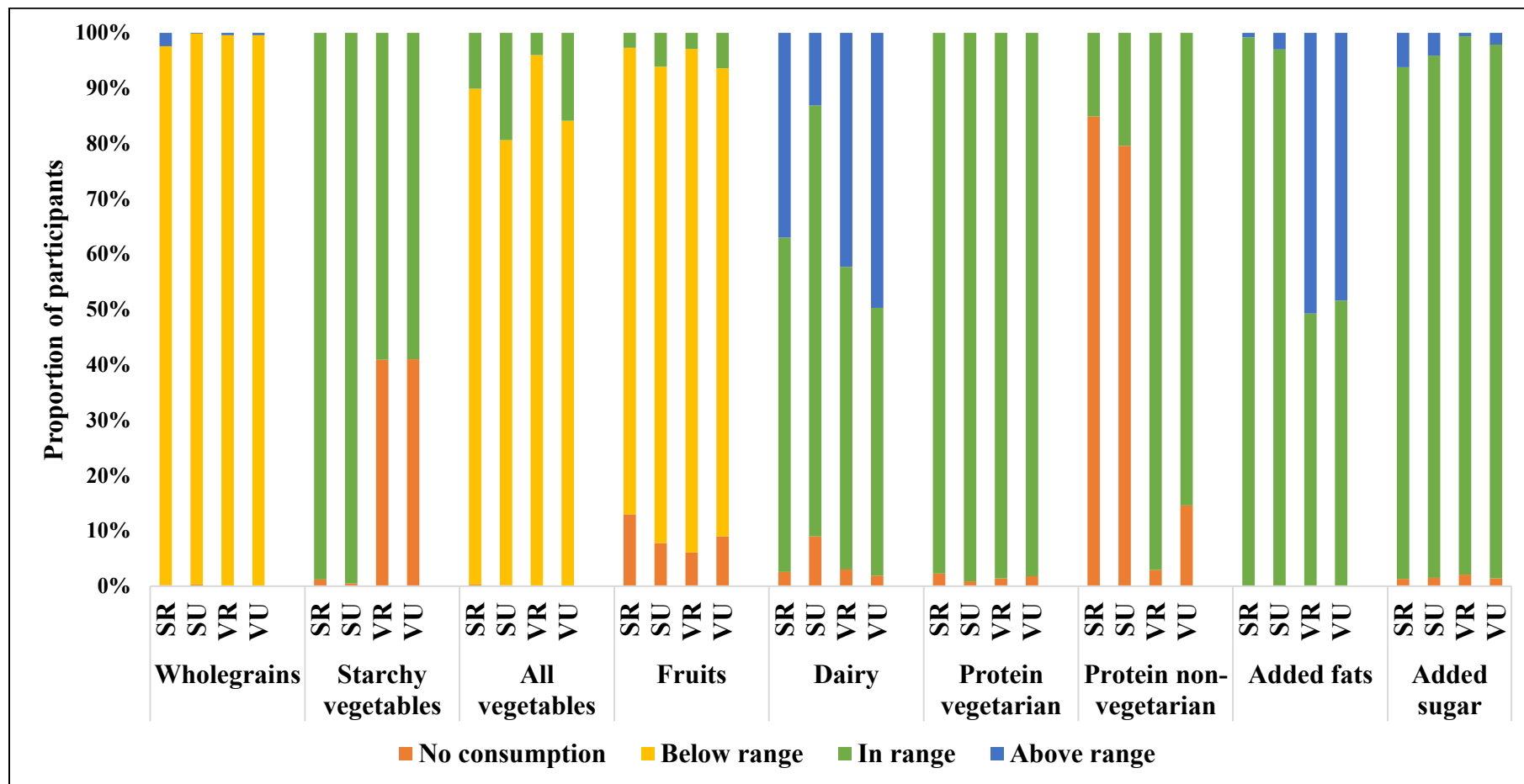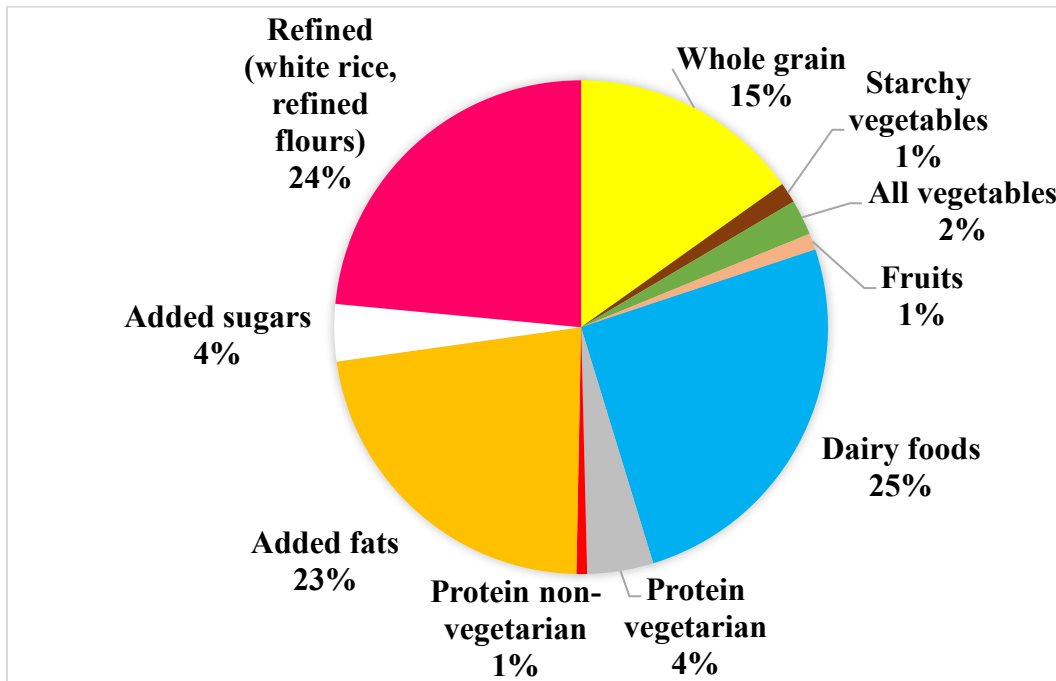

SR: Sonipat rural, SU: Sonipat urban, VR: Vizag rural, VU: Vizag urban

Figure 2: Daily calorie consumption of the study participants compared with EAT-Lancet recommendations

EAT-Lancet recommendations (2500kcal/d)
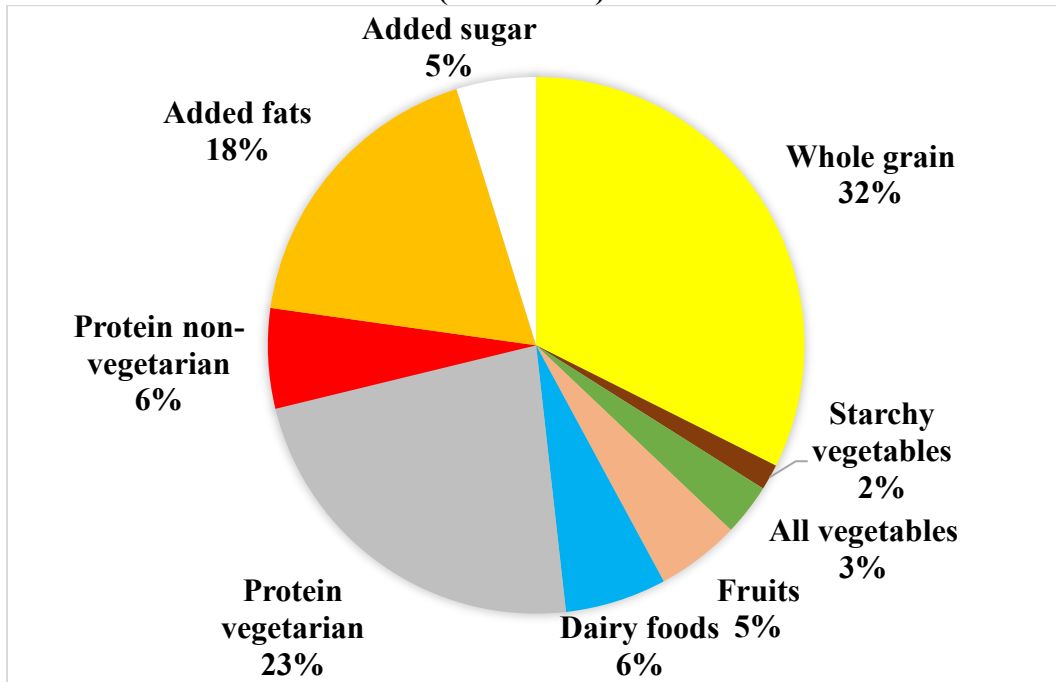
Consumption of the study participants (1560kcal/d)

Refined food group was an additional food group created in this study

Biographies:

Dr Anjali Ganpule-Rao is a Senior Research Associate at Centre for Chronic Disease Control, New Delhi. Her research focuses on maternal and child health, public health nutrition, sustainable food systems.

Manisha Dubey (PhD) is a Senior Research Associate at Centre for Chronic Disease Control, New Delhi. Her area of interest are health and mortality analysis, food security and human longevity.

Himanshi Pandey is a research assistant at the Centre for Chronic Disease Control, New Delhi. She has a Master's degree in Applied Nutrition and her research focuses on food systems.

Rosemary Green is a Professor of Food, Climate and Health at LSHTM. Her research focuses on the interactions between environmental change, agriculture and diets, and human health.

Dr Kerry Ann Brown is a Senior Lecturer at the University of Exeter. Dr Brown is an expert in public health nutrition, with a research interest in sustainable diets.

Nikhil Srinivasapura Venkateshmurthy is an MD in Community Medicine, currently working as Senior Research Scientist at Centre for Chronic Disease Control. His research interest is in implementation science.

Dr. Prashant Jarhyan (MBBS, MD, Ph.D.) is a Public Health Specialist at the Public Health Foundation of India. His research is focused on epidemiology, translational and health systems research.

Rajesh Khatkar is a research associate at Public Health Foundation of India. His research is related to non-communicable disease and their association with nutrition, health systems, and behavioural risk factors.

Dr. Avinav Prasad Maddury, BPT, MPH is an Associate Consultant at Bridge Medicals. His research interests are non-communicable diseases epidemiology, operational and outcomes research.

Professor D. Prabhakaran is a globally reputed cardiologist and epidemiologist. He is Distinguished Professor, Public Health Foundation of India, and Executive Director, Centre for Chronic Disease Control, New Delhi, India.

Professor Sailesh Mohan is a public health researcher. He is the Joint Director, Public Health Foundation of India and Centre for Chronic Disease Control, New Delhi, India.

References:

1. Lang T. Sustainable diets and biodiversity: The challenge for policy, evidence and behaviour change. Rome *Food Agric Organ* UN. 2012.

2. Sustainable Development Goals. United Nations Development Programme. https://sdgs.un.org/goals (accessed January 2023).

3. Fanzo J. Healthy and sustainable diets and food systems: the key to achieving Sustainable Development Goal 2? *Food ethics,* 2019; 4:159–74.

4. Benson T. Making the achievement of zero hunger and malnutrition a policy priority: A critical assessment of recent national Zero Hunger Strategic Reviews from Asia and the Pacific. *Asia Pac J Clin Nutr,* 2021; 30(2): 316–28.

5. Clark M, Macdiarmid J, Jones AD, et al. The role of healthy diets in environmentally sustainable food systems. *Food Nutr Bull*, 2020; 41(2_suppl):31S-58S.

6. Espinosa-Marron A, Adams K, Sinno L, et al. Environmental impact of animal-based food production and the feasibility of a shift toward sustainable plant-based diets in the United States. *Front Sustain,* 2022;19.

7. Willett W, Rockström J, Loken B, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet*, 2019; 393(10170): 447–92.

8. Knuppel A, Papier K, Key TJ, et al. EAT-Lancet score and major health outcomes: the EPIC-Oxford study. *Lancet*, 2019; 394(10194):213–4.

9. Stubbendorff A, Sonestedt E, Ramne S, et al. Development of an EAT-Lancet index and its relation to mortality in a Swedish population. *Am J Clin Nutr,* 2022; 115(3): 705–16.

10. Hanley-Cook GT, Argaw AA, de Kok BP, et al. EAT–Lancet diet score requires minimum intake values to predict higher micronutrient adequacy of diets in rural women of reproductive age from five low-and middle-income countries. *Br J Nutr,* 2021; 126(1):92–100.

11. International Institute of Population Sciences (2019-21) National Family Health Survey-5. http://rchiips.org/nfhs/# (accessed January 2023).

12. Index GH. 2022-Global Hunger Index-Food Systems Transformation And Local Governance. 2022.

13. Joy EJM, Green R, Agrawal S, et al. Dietary patterns and non-communicable disease risk in Indian adults: secondary analysis of Indian Migration Study data. *Public Health Nutr*. 2017; 20(11):1963–72.

14. Sharma M, Kishore A, Roy D, et al. A comparison of the Indian diet with the EAT-Lancet reference diet. *BMC Public Health,* 2020; 20: 1–13.

15. Gupta S, Vemireddy V, Singh DK, et al. Ground truthing the cost of achieving the EAT lancet recommended diets: Evidence from rural India. *Glob Food Sec,* 2021; 28:100498.

16. Mohan S, Jarhyan P, Ghosh S, Venkateshmurthy NS, Gupta R, Rana R et al. UDAY: A comprehensive diabetes and hypertension prevention and management program in India. BMJ Open. 2018;8:e015919.

17. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data—or tears: an application to educational enrollments in states of India. *Demography*. 2001; 38:115–32.

18. National Institute of Nutrition. Some common Indian recipes and their nutritive values.

19. Longvah T, Anantan I, Bhaskarachary K, et al. Indian food composition tables. National Institute of Nutrition, Indian Council of Medical Research Hyderabad; 2017.

20. Rao S. Nutritive Values of Some Indian Food Preparations. Pune, Maharashtra: Agharkar Research Institute, 1992.

21. Tak M, Shankar B, Kadiyala S. Dietary transition in India: temporal and regional trends, 1993 to 2012. *Food Nutr Bull,* 2019; 40(2): 254–70.

22. Ganpule A, Dubey M, Pandey H, et al. Snacking behavior and association with metabolic risk factors in adults from north and south India. *J Nutr,* 2023.

23. Manual A. Dietary guidelines for Indians. Nat Inst Nutr. 2011;2:89–117.

24. Pomeroy E, Mushrif-Tripathy V, Cole TJ, et al. Ancient origins of low lean mass among South Asians and implications for modern type 2 diabetes susceptibility. *Sci Rep,* 2019; 9(1):1–12.

25. Food Safety and Standards Authority of India. Eat Right India. 2018. https://eatrightindia.gov.in/ (accessed January 2023).

26. Hegazy R. Post-harvest situation and losses in India. High Court Karnataka-Bengaluru *Bench WP,* 2013; 24739.

27. Ahlawat IPS, Sharma P, Singh U. Production, demand and import of pulses in India. 2016.

28. Muroyiwa B, Shokopa L, Likoetla P, et al. Integration of post-harvest management in agricultural policy and strategies to minimise post-harvest losses in Lesotho. *J Dev Agric Econ,* 2020; 12(2):84-94.

29. Hirvonen K, Bai Y, Headey D, et al. Affordability of the EAT–Lancet reference diet: a global analysis. *Lancet Glob Heal,* 2020; 8(1):e59–66.