An investigation of the sources and patterns of free sugars intake by younger people in India and Australia

Doctoral Thesis

Submitted to fulfil the requirements to obtain the degree of
Doctor of Philosophy (PhD) from
The University of Adelaide

By

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September 2023

Adelaide, Australia

Thesis declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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I acknowledge the support I have received for my research through the provision of The University of Adelaide Colgate-Betty Fanning Scholarship.

Sincerely,

Signed

Anupama Ivaturi

Dear *Naanna,*

I dedicate this work to you.

I still cannot fathom the impact of your absence. I am trying my best to hold on to good memories but I must admit- it is really difficult. Thank you for instilling the values of resilience and perseverance in me. Perhaps only these kept me going.

I miss you.

Acknowledgements

First of all, I would like to acknowledge the skilful teaching, invaluable scientific input and constructive feedback provided by my mentors Paula Moynihan, Lynne Giles and, Loc Do which has led to the successful accomplishment of this doctoral research project.

I extend my sincere thanks to Professor Paula for the successful funding opportunity which made my PhD dream come true. Through Paula's mentorship, I have found the love for scientific writing and developed an interest in nutrition research. I also learnt to reflect, stay in the present and be determined. Paula's aptitude and approach to respond to challenges are virtues I look up to and hope to emulate.

I honestly had 'math anxiety' until I met Lynne. I owe many thanks to Lynne for the inimitable teaching and advice during all our interactions. This doctoral project provided vast experience in data analysis and Lynne's approach to statistical analyses and data management has helped me gain confidence and understand biostatistics like never before!

I am grateful to Professor Loc for kindly agreeing to provide access to dietary data from the SMILE cohort study on Australian children. This was timely and provided a unique learning opportunity during 2020-21 when the COVID-19 pandemic impacted the research timelines. Many thanks also go to the SMILE team for the valuable inputs on the manuscript.

I acknowledge the support I have received for my research through the provision of The University of Adelaide Colgate-Betty Fanning Scholarship.

I am grateful to the Intake24 team at Cambridge University for setting up the South Asia Locale for applying this as the dietary assessment tool for the first time in the Indian context.

I acknowledge the support extended by Professor Monika Arora and Dr Tina from HRIDAY, New Delhi for facilitating ethics approval in India and enabling initial contact with school teachers.

Beyond studies, my mentors were like family to me and I am grateful for the consistent support and encouragement remotely and in-person. My father's passing in 2021 remains a huge personal setback and I am truly indebted to my supervisory team for the understanding and empathy.

A big hug and many thanks to my little fur-baby *Miles* for being with me and showing me that it's the bigger things that matter*!*

Pratheek, amma and, *akka*: thanks for bearing with me.

Sandeep, I miss you a lot *ra*. I thank you for all the wonderful memories.

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Abstract

There are no reliable data on individual dietary behaviours and none on free sugars intake despite the triple nutrition burden in young Indian populations. The original research project aimed to quantify sugars intake and determine the sources and pattern of free sugars intake in 11-13-year-olds in Delhi and qualitatively study the barriers and facilitators to sugars reduction. Travel restrictions and school closures due to the pandemic affected this plan; qualitative study was abandoned. A secondary analysis of the data sourced from the Australian Study of Mothers' and Infants' Life Events affecting oral health (SMILE) cohort was included to gain experience in the methods of analysis of dietary data. The aim was to identify intake, sources and determinants of free sugars by 5-year-old children. Results showed that 5-year-olds in the SMILE cohort obtained an average of 60% free sugars from three food groups - Cakes, Biscuits and Cereal Bars, Sweetened Yoghurts and Desserts. Experience gained in food group analysis, validation of energy intake and statistical methods (e.g. Multinomial logistic regression) were then applied to the primary doctoral study on sugars intake in India.

Subsequent to ethics approval, a statistician external to the research team generated a random sample of 150 private schools stratified by 11 Delhi districts. Recruitment continued until 10 schools had consented. Teachers shared study information with parents who were invited to complete an online consent form; child assent was obtained before data collection. Participants recorded all food and drink consumed over three consecutive days, including one weekend day, in a food diary. Information recorded was entered into an online dietary assessment tool, Intake24 (South Asia Locale) during a researcher-participant interview; portion size was ascertained with reference to the Intake24 integrated food photographs. Intake24 converted food and drink reported into nutrient intake through integrated food compositional tables.

A total of 514 pupils provided consent and 393 participants (76.5%) (169 Girls, 224 boys) completed the study. The median energy (E) intake was 11.6 (9.9- 14.1) MJ/day; percent E from fat was above the recommended range in nearly 75% participants with saturated fat contributing a median 16.3 (13.9 - 18.5) % E. Less than 40% girls achieved the India Estimated Average Requirement for iron intake. The median daily intake of free and total sugars were 48.0 (31.1 – 72.9) g and 98.0 (75.6 - 129.1) g respectively, contributing 7.1 (IQR 4.8-10.1) % and 14.9 (IQR 11.4-18.1) % E. The WHO recommended threshold to limit free sugars intake to <5% E was achieved by 27.2%. Sugar, Preserves and Syrups, Cakes and Biscuits and Desserts were the principal sources. More free sugars was consumed as snacks compared with meals ($P<0.001$) and intake was significantly lower on weekdays ($P=0.01$).

The intake of free sugars as well as saturated fat was above the recommended thresholds, implying that this population is at risk of obesity and other diet-related conditions. These results

are expected to underpin the next stages of research to address risk of unhealthy diet in young adolescents living in urban areas in India.

Based on the findings, the forthcoming plans include research on a whole of school approach to reduce exposure of young adolescents to unhealthy diet, including restricting the sale of foods containing high-saturated fat, added salt and free sugars around schools.

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List of abbreviations

ABS	Australian Bureau of Statistics
AUSNUT	Australian Food and Nutrient Database
E	Energy Intake
EAR	Estimated Average Requirement
EER	Estimated Energy Requirement
FAO	Food and Agriculture Organization
FoPL	Front of Pack Labelling
FSSAI	Food Safety and Standards Authority of India
HFSS	High Fat, Sugar and, Salt
HSR	Health Star Ratings
ICMR	Indian Council for Medical Research
IRSAD	Index for Relative Socioeconomic Advantage and Disadvantage
NCDs	Noncommunicable diseases
NIN	National Institute of Nutrition
NNMB	National Nutrition Monitoring Bureau
RDA	Recommended Dietary Allowance
SES	Socio Economic Status
SMILE	Study of Mothers' and Children's Life Events affecting oral health
SSB	Sugar Sweetened Beverages
UK-NDNS	United Kingdom National Diet and Nutrition Survey
UNICEF	United Nations Children's Fund
USA	United States of America
WHO	World Health Organization

The original thesis plan and impact of COVID-19

The original research plan included quantitative and qualitative studies to assess the intake of free sugars by young adolescent schoolchildren in Government and private schools and to identify the barriers and facilitators for sugars reduction in the school environments in Delhi. However, the COVID-19 pandemic prevented this.

After COVID-19 was declared a global public health emergency in March 2020, schools in Delhi were closed indefinitely, Australia closed borders and this created uncertainty over the planned travel to India. It was likely that only one visit to India was possible instead of the two visits planned originally. Therefore, a decision was made to abandon the qualitative study and supplement this study by conducting a secondary data analysis to report the free sugars intake by Australia children by using existing dietary data. It was decided that the qualitative component could be re-visited in post-doctoral research. The dataset on sugars intake by 5-year-old children in Australia from an ongoing birth cohort study - Study of Mothers' and Infants' Life Events affecting oral health (SMILE) was accessed and analysed to report the amount, sources and determinants of free sugars intake.

Ethical approval was obtained for the India component of the PhD project in February 2021. However, the pandemic continued to disrupt school functioning in Delhi and schools remained closed. Based on anecdotal evidence provided by the Health-Related Information Dissemination Amongst Youth (HRIDAY) based in India, digital learning continued and private school children were able access to the Internet and e-learning resources. HRIDAY team shared that majority of the Government school children had emigrated from Delhi and were not approachable through telephone or email communication.

In view of this, the project was amended again which meant that the ethics applications had to be amended once again, after obtaining original approval. This led to considerable delays and the loss of nearly 210 working days. In the final research plan, only private schoolchildren were included in the sample, and a digital (editable PDF) version of the food diary was used instead of paper-based diaries for the children to record food and drink intake. Online survey tools were used to obtain consent, assent and collect demographic information. An encrypted online video conferencing program was used to interview participants.

Despite the challenges and delays, data were collected from approximately 400 schoolchildren and the original recruitment target was achieved.

Chapter 1

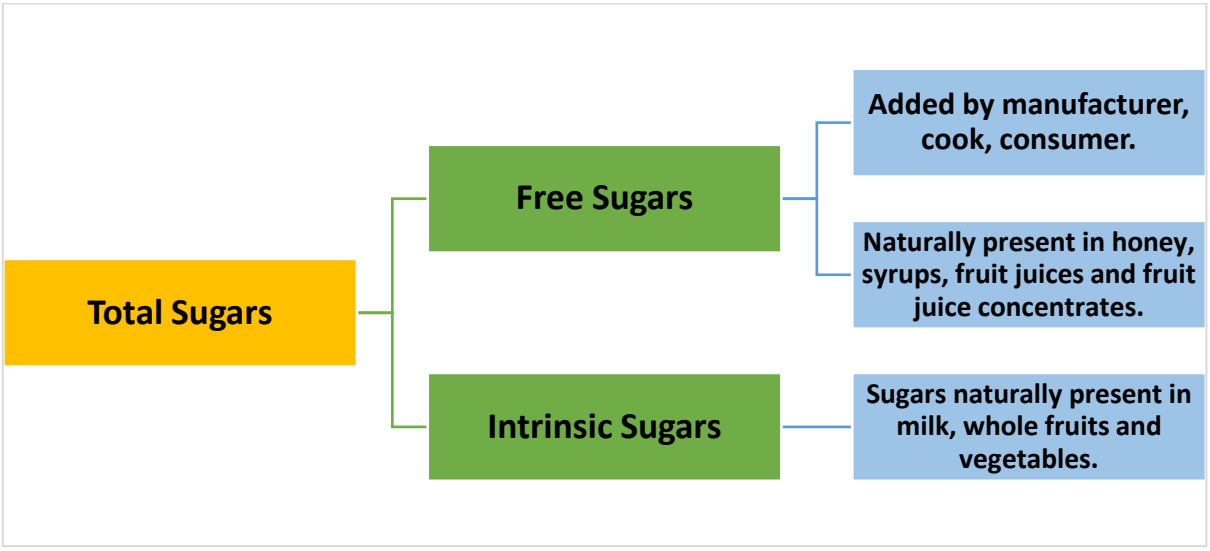
Chapter 1: Introduction and Literature Review

1.1 Preface

Growing urbanisation and change in living conditions have led to an increase in the prevalence of preventable diseases across the globe [1]. Children and adults are exposed to multiple risk factors that can lead to noncommunicable diseases (NCDs) [2]. An unhealthy diet is one of the major risk factors creating an adverse impact on the health of both young and old, especially in lower-middle-income-countries (LMICs) [2]

The term 'Sugars' refers to a range of biochemical components which include mono-, di- and oligosaccharides like glucose, fructose, maltose, lactose, sucrose and galactose which are contained in different items of the human diet. White, brown or table sugar refers to sucrose, a disaccharide [3]. The classification of dietary sugars is illustrated in Figure 1.1.

Figure 1.1: Classification of dietary sugars



The availability and affordability of food with high free sugars content is one of the primary reasons for the rapid increase in NCDs including oral disease burden that has been observed in both LMICs and high-income countries (HICs) [2, 4]. The transition from traditional staple foods which include a combination of cereals, pulses and vegetables [5, 6] to a diet with processed and packaged food that contains added salt, fat and free sugars contributes to unhealthy weight gain, dyslipidaemia and hypertension [7, 8].

Sugars intake: global recommendations and the situation in India

In the Guideline on Sugars Intake for Adults and Children, 2015 [3] the World Health Organization (WHO), strongly recommends a reduced intake of free sugars throughout the life course and limiting the intake of free sugars to less than 10% of the total energy (E) intake in

both adults and children. The WHO also suggests limiting the intake of free sugars to less than 5% E with a target to reduce dental caries, especially in poor populations. As a result, governments and other authoritative agencies with international remits have proposed national recommendations on sugars intake [9-12]. The Indian Council of Medical Research recommends limiting the intake of 'sugar' to < 30 g/day. Although the recommendation of the WHO is referred to in the 2019 report on consumption of added sugars, there are no data that assess the intake of free sugars as a percentage of E or compare the intake of free sugars to the WHO recommended thresholds for intake.

India is one of the largest producers and the largest consumer of sucrose in the world [13]. Sucrose is available for consumption in the form of raw sugar, brown sugar, white or table sugar and, a crude lump sugar called 'gur' or jaggery [13]. The per capita consumption of sucrose in the available forms in India is approximately 20 kg per person per year, based on the most recent estimates [14]. This amounts to an intake of approximately 55 grams/day, equivalent to 220 calories per day or approximately 12% contribution to E. This is an estimated intake of only sucrose and does not include other free sugars that are present in the diet. The latest national survey of dental diseases in India [15] showed that more than half (52.5%) of young adolescents in India are affected by dental caries with an average Decayed, Missing, Filled Teeth (DMFT) index of 1.7 [15, 16]

Adolescents in India: the role of schools in exposure to free sugars

Adolescence is a stage of transition between childhood and adulthood, encompassing the ages between 10 to 19 years. It is a unique stage marked by rapid growth and an increased requirement for E and nutrients. Therefore, there is a high chance of deficiencies. Adolescence provides a window of opportunity to promote good health and establish patterns of behaviour including consumption of a balanced diet and physical activity [17, 18]. With age, adolescents have increasing autonomy in making food choices and are also influenced by peer pressure [19]. Around the age of 11-13 years, almost all the permanent teeth are erupted [20]. LMICs, including India, are impacted by targeted campaigns from food and beverage producers. Some authors have contended that the sugar industry has found a vulnerable, new market for high-sugars foods and beverages in young populations [6]. Further, the 2018 nationwide nutrition survey [21] has reported an alarming increase in the prevalence of overweight (12.3%) and obesity (3.6%) in 10-19-year-olds in Delhi when compared with earlier estimates. Evidence shows that the combined prevalence of childhood obesity and overweight in India increased from 16.3% reported for 2001-2005 to 19.3% in 2010 [22]. The most recent national surveys of the metabolic

parameters including cholesterol and plasma glucose have also shown that urban populations of all age groups in India are susceptible to NCDs [23].

Published and anecdotal evidence from India shows that food sources of free sugars are readily available for young populations around schools, in shops and near recreation places in cities. For instance, in Delhi it was found that young adolescents attending private educational institutions are exposed to foods containing high free sugars, added salt and fat (HFSS), and exposure to such foods has been linked to dietary related NCDs early in life [24]. Processed and pre-packaged HFSS foods are inexpensive and widely advertised, making them attractive to young adolescents [5].

The WHO has highlighted the important role schools play in free sugars reduction and oral health promotion. The Global School Health Initiative [25] provides evidence that school-based approaches are cost-effective. In order to inform interventions to promote intake of a healthy and balanced diet, a understanding the intake of HFSS foods, including sources of free sugars, is critical.

In India, children from the lower socio-economic status (SES) groups typically attend Government schools and those from middle- and higher-income families attend private schools [26]. Despite school feeding programs actively operating in Government and Government-aided schools [27], children from lower income groups are disproportionately impacted by the unhealthy city food environments in close proximity to schools with the offer and sale of HFSS food. On the other hand, children from middle- and high-income groups attending private schools have access to disposable income and are exposed to HFSS foods in school cafeterias and through the location of outlets of multinational fast-food chains in the environment around school. Therefore, children and adolescents in India, irrespective of the SES status are at risk of exposure to high free sugars intake.

Actions to tackle sugars intake in India

In 2020, the Food Safety and Standards Authority of India (FSSAI) notified draft guidelines to promote the intake of a balanced diet by schoolchildren [28]. In view of the triple burden of malnutrition in India (i.e. overnutrition, micronutrient deficiencies and undernutrition [29, 30]), integrated approaches are being developed. Moving away from previous isolated approaches [31-33], holistic programs for example, the centrally sponsored schemes for nutrition and food security [27], with an aim to promote the intake of a healthier diet that provides E and essential

micronutrients and that is low in sodium, free sugars and fat is being encouraged. The initiative calls for collaboration of food business operators, school administration and the city authorities to discourage the sale and availability of processed and pre-packaged HFSS food [27, 28, 34]. These efforts are promising but it is vital that the level of intake of E, along with intakes of macronutrients (including dietary sugars) and micronutrients, is assessed to understand diets of schoolchildren in India and to help target intervention strategies to promote healthier diets. Policymakers and stakeholders working on designing specific nutrition interventions for adolescent schoolchildren will benefit from a robust assessment of dietary intake using well-validated methods.

Available data on intake of nutrients including sugars intake

In existing reports based on urban and rural populations in India, dietary intake was estimated using 24h recall and food frequency questionnaire (FFQ) and compared with the 2010 dietary guidelines to report the nutritional status [35]. Diet and nutrition surveys of rural [36] and urban [37] populations in ten states of India were conducted in 2012 and 2017 respectively. It was reported that the mean intakes of protein and E (at the household level) and the mean intakes of calcium, iron, folate, B12 and vitamin A in young adolescents did not meet the Recommended Dietary Allowance (RDA). Revised dietary reference values were issued in 2020 and Estimated Average Requirements (EAR) for E, macro and micronutrients were defined for the first time. There are no data on the dietary behaviour in comparison with these EARs.

In 2019, an assessment of the intake of added sugars by an urban population subset was conducted and it reported that the average intake of added sugars by 12-17-year-old adolescents was 19.9 grams/day which, when compared with the per capita sugar intake in India (55 g per day) [14] is considerably less and probably not a reliable value. To estimate added sugars intake, the India –National Institute of Nutrition (NIN) conducted a secondary analysis of existing dietary data from an urban population subset [38]. An exact food compositional analysis was not used to report intake of free sugars from all dietary sources and it is not clear if the reported results reflect only added 'sucrose' from the listed recipes. There are reports from local surveys in India on the frequency and pattern of intake of common sucrose-containing foods and beverages [39]. Further, there are available data on the impact on dental caries and Body Mass Index, of frequent intake of these foods as snacks, in-between meals [40-42].

Global research on nutritional status and sugars intake indicates that it is feasible to generate data on sugars intake by using well-tested methods [43] (detailed further in Section 1.5) and yet these data do not exist for India.

The studies of dietary intake in India have relied on existing food composition databases and required researchers to manually analyze data [44] for the estimation of intake of nutrients from reported food intakes, and these were usually collected using 24 hour recalls or food frequency questionnaires [36, 37]. However, there are no comprehensive local food and recipe databases. Further, the challenge posed by the lack of software to link the intakes to national food compositional tables has been identified [44]. Open-source and low-cost applications that facilitate assessment of dietary intake through the creation of a digital record of the food and drink intake are commonly used in high-income countries HIC [45, 46]. The application of such tools for dietary assessment in lower-middle-income-countries (LMIC) is limited or, as is the case with India, non-existent. The validity and reliability of one such tool 'Intake24' (https://intake24.org) has been tested [46] and used in the national dietary surveys in other countries (e.g. the UK National Diet and Nutrition Survey) [46-48]. An English Language South Asia Locale (2022 version) of this application has recently been developed (https://intake24.co.uk/info/localisation) but it has not previously been applied to populations in India.

It is this paucity of relevant data from Indian adolescents that this doctoral project was originally designed to address. To gain a deeper understanding of how the amount and sources of free sugars are ascertained in epidemiological studies, a secondary analysis of data from an existing cohort study – the SMILE study - that assessed dietary intake in children was undertaken as a preparatory step for the study of Indian adolescents.

1.2 SMILE Cohort study and the assessment of free sugars intake in children living in Adelaide

In Australia, approximately one quarter of children aged 5-9 years are overweight (17%) or obese (7%) [49] and nearly half (42%) of children experience dental caries [50, 51]. Reducing the intake of free sugars is important for the prevention of dental caries and excess weight gain [52-54]. In order to develop dietary interventions to lower the intake of free sugars, information on the amount, sources and social determinants of free sugars intake in children is essential. The SMILE (Study of Mothers' and Infants' Life Events Affecting Oral Health) cohort includes 2181 infants recruited at birth in Adelaide, South Australia.

The SMILE cohort study aims to understand the critical factors that influence oral health and to gain knowledge on the link between diet, sociodemographic factors and oral health in early life. Participants were followed up at 3 and 6 months and at 1, 2 and 5 years of age [55]. The analysis of the free sugars intake to understand its impact on the dental caries status in the Australian children is central to this study.

Previous analysis [55-58], based on the Food Standards Australia and New Zealand Australian Food and Nutrient database (AUSNUT) [59] showed that infant foods and cereal-based snacks like biscuits were the leading sources of free sugars intake at 12-14 months [57] and beverages, cakes and biscuits at two years of age [56]. At one year of age, free sugars contributed 3.6% of the Estimated Energy Requirement (EER) and 8% EER at 2 years of age. By age five years, children begin to explore wider food and drink choices and the amount, sources and social determinants of free sugars may therefore change. Dietary information from children at age 5 years had also been collected in the SMILE study but had not been analysed.

In order to understand the methods applied to derive data on the amount, sources and determinants of free sugars intake in children and gain experience in the statistical analysis of dietary data, the objective to analyse the pre-existing dietary data collected from 5-year-old children of the SMILE cohort was introduced in the PhD research project. This SMILE cohort sub-study served as a precursor to inform development of a reliable and valid method for the primary doctoral study on sugars intake in Indian young adolescents.

The primary aim of this research was to quantify the intake of E, nutrients and free sugars in 11-13-year-old school children in India and determine for the first time, the data on the amount and pattern of intake and the principal dietary sources of free sugars using a three-day dietary diary. The secondary aim was to learn and apply statistical methods to the analysis of dietary data drawn from a pre-existing database on free sugars intake by 5-year-old children in Australia.

1.3 Research hypotheses

Primary research hypotheses

- The free sugars intake in 11-13 -year-old school children in India exceeds the <5% E WHO threshold for the intake of free sugars
- The sources of free sugars intake will be similar to those observed for young adolescent school children in HIC
- The intake of E and nutrients in a population of 11-13 -year old schoolchildren in India does not meet the new dietary reference values (Estimated Average Requirement).

Research Questions

1. What are the current intakes of E, macronutrients and micronutrients (vitamins A, B12, Folate and, D and iron, calcium, iodine, zinc and selenium) in 11-13-year-old school children in India?
2. What is the current amount (g/day and %E) and pattern (based on eating occasion; weekday vs. weekend day) of intake of free sugars in 11-13-year-old school children in India?
3. What are the principal dietary sources of free sugars in 11-13-year-old school children in India?

SMILE Cohort Study sub-study on sugars intake at age 5 years to learn sugars data analysis methods research hypothesis

- The percent contribution of free sugars to E in the 5-year-old children of the SMILE cohort study is above the <5% E WHO threshold for the intake of free sugars.
- The principal dietary sources of free sugars in 5-year-old Australian children are different from the sources in 2-year old children in the SMILE Cohort.
- The total free sugars intake in 5-year-old Australian children is above the WHO recommended threshold for intake.

In conducting this analysis, the following questions will be answered, and objectives achieved:

SMILE Cohort Study sub-study Research Questions

1. What is the amount of free sugars intake by 5-year-old Australian children?
2. What are the principal dietary sources of free sugars in 5-year-old Australian children?
3. What are the determinants of achieving the WHO recommended thresholds for the intake of free sugars in Australian 5-year-olds?

1.4 Aims and Objectives

Primary Aim

Determine the data on the level of intake, principal dietary sources and patterns of free sugars consumption by 11-13-year-old school children in India.

This study population was chosen because young adolescents of this age are vulnerable to dental caries because permanent molars are newly erupted. Data from other LMICs also showed high free sugars intake for this age group. In Delhi, private schoolchildren are vulnerable due to exposure to HFSS foods in school canteens and through the environments outside the school gates.

Objectives of the primary study:

1. To determine the intake of E (mega joules/day), macronutrients (in grams and percent E) and micronutrients and to compare intake with the India National Institute of Nutrition Estimated Average Requirement (NIN-EAR) (Answers Research Question 1).
2. To quantify the intake of total and free sugars (grams/day) consumed by a sample of 11-13-year-old school children in Delhi, India. (Answers Research Question 2).
3. To identify the principal dietary sources and the pattern (weekday versus weekend day, main meal versus snacks) of free sugars in the diets of 11-13-year-old school children. (Answers Research Question 3).
4. Use a 3-day food diary with a validated online dietary assessment tool 'Intake24' to achieve the above objectives.

Aim of the SMILE Cohort Study sub-study on sugars intake at age 5 years

Explore and apply dietary data statistical analysis methods to a pre-existing database on sugars intake by 5-year-old Australian children, sourced from the nutritional survey of the SMILE Cohort.

Objectives of the Sub-study:

1. Determine total sugars and free sugars intake by 5-year-old Australian children. (Answers sub-study Q1).
2. Identify the sources of sugars and the percentage contribution of the various dietary sources to free sugars intake of Australian children at age 5 years. (Answers sub-study Q2).

1.5 Literature Review

A review of literature on the nutritional status and sugars intake research illustrates the use of a number of approaches to assess and report sugars intake. There are published scientific works sourced from data generated in the national surveys in the countries of interest- India and Australia as well as from HICs Europe, the U.K. and the USA. Sugars data are also available from local surveys of specific population groups of interest in middle and LMICs.

From a few selected national dietary and nutrition surveys, information on the amount of free sugars intake, main dietary sources of free sugars, added sugars and total sugars and the methods used to collect dietary information have been tabulated in Table 1.1. Similar findings from a few exemplar local surveys have been tabulated in Table 1.2, followed by a review of information on the amount, sources and pattern of free sugars intake.

As illustrated in the Tables 1.1 and 1.2, the information on sugars intake reported in literature can be broadly categorised into resources on: i) amount of intake of either total, free, added sugars; ii) sources of sugars categorized into foods or food groups; iii) trends and patterns of intake.

Comparison of free sugars intake to the WHO recommended threshold for intake

Free sugars intake in children exceeds the WHO recommended thresholds in many countries. For instance, in the United Kingdom (UK) and Lebanon, free sugars contributed to an average 12% of E in children aged < 10 years [60, 61], 14% E in 2-5-year-old children in the USA [62] and Japan [63], 16% in French [64] 3-6-year-old children and 27% in German pre-school children [65]. The most recent national survey in Australia in 2012 showed that children (4-8-year-old) obtained 14% E from free sugars [66].

Published quantitative data on amount of sugars intake

Data on amount of sugars consumed are presented as total, free and or added sugars intake, measured as grams per day (g/d), kilograms per year, or as percent E.

The mean daily intake of total sugars for 424 adolescents aged 11-12 years in Northumberland, UK [67] was 108.4 g (105.1-111.6) which contributed to 21.6% of energy (21.2-22.0) and of which free sugars constituted 81.0g/day. In European children participating in a multi- city cohort study [65, 68] the mean total sugars intake ranged from 77.0 g/d in children in Estonia to 114g/d in Germany. Contribution of total sugars to energy intake was highest in Germany, at 30% and lowest at 19% in Estonia. In the Healthy lifestyle in Europe through nutrition in adolescence (HELENA) study on 1,630 adolescents [69], aged 12.5-17.5 years, the mean intake

of total sugars was 137.5 g/d, contributing to 23.6% of total energy intake and the mean intake of free sugars was 110.1 g/d, contributing to 19% E, which is above the recommended threshold for the intake of free sugars.

Research from other high-income countries like Canada, and a few European countries reports sugars intake as a part of the national nutrition surveys. A recent survey [70] based on data from the Canadian Community Health Survey-Nutrition reported that the average daily total sugars intake in age group of 9-18-year-old Canadians was 115 g/d. Similarly, in a household survey of 1250 individuals of different age groups in Brazil [71], researchers reported in that in adolescents, added sugars accounted for 12.4 percent (11.1-12.9) of E. In a different multi-centre cohort study conducted in eight Latin American countries [72], it was found that the median intake of total sugars in the 15-19-year-old age group was 109.2 g/day, (IQR 79.9-131.1) and that of added sugars was 73.9 grams/day, (IQR 49.9-91.2), with the highest mean intake of added sugars reported in Argentina (106.9 g/d) and the lowest in Chile (58.2 g/d). These data demonstrate that the reported intake was above the WHO recommended threshold for the intake of free sugars.

Table 1.1: Summary of sugars intake data from National surveys in different countries

Authors, Year, Title of study	Main dietary outcome variables	Amount of free sugars quantified	Sources and percentage contribution to E	Added Sugars	Total Sugars	Method used
Data Source: National Health and Nutrition Examination Survey (NHANES), USA Bailey et al. (2018). Sources of Added Sugars in Young Children, Adolescents and Adults with low and high intakes of added sugars [73].	Added sugars intake and contribution from various food groups across 16,806 individuals in different age groups.	-	The percent E contributed by added sugars in 9-18-year-old children was 16.2±0.2 Sweetened beverages (53.3%), sweet bakery products (11.4%) and candy (5.6%) were highest ranked foods.	Usual added sugars intake ranged from 59.9 to 110.9 g/d. Highest intakes were noticed in 9-18-year-old individuals.	-	Repeat 24 h recall, first in person, second over telephone, using an automated multiple pass method.
Data Source: National Diet and Nutrition Survey, UK Amoutzopoulos. et al (2020) Free and added sugar consumption and adherence to guidelines: The U.K. National Diet and Nutrition Survey (2014/15-2015/16) [60].	Dietary sources of free and added sugars in 2138 U.K. individuals, aged 1.5-64 years. Percentage contribution of added and free sugars to total energy intake.	Median intake of free sugars in age group of 11-18 Years age group was 58.7 (IQR 37.5-79.3) g/day,	Free sugars contributed a median 13 (IQR 9-17) % to E in the 4–10-year-old children and in adolescents aged 11-18 years. Cereal and cereal products including breakfast cereals. Biscuits, buns pastries were the top contributors (29.4%) followed by soft drinks (22.9%) and sugar, preserves and confectionery (22.3%) were the top contributors to free sugars	Median intake of added sugars in 11-18-year-old adolescents was 49.9 (IQR 30.1-72.4) g/d.	-	4-day estimated food diary.

Data source: Australian National Children Nutrition and Physical Activity Survey, Australia 2007. Louie JCY et al (2016). Intake and sources of added sugars among Australian children and adolescents (n=4140; 2-16-year old) [74]	Total, added and free sugars intake in Australian children and adolescents at different ages; Percent contribution of macronutrients and sugars to E;	59.7(29.3) g/day in 4–8-year-olds and 78.5 (37.4) g/day in 9-13-year olds	In 4–8-year-olds Free Sugars contributed 13.7% and 9-13-year-olds obtained 14.6% from free sugars. Sugar-Sweetened Beverages were the leading contributors to free sugars 16.7 (17.2) % in 4-8 year olds and 22.9 (19.8)% in 9-13 year olds; Cakes, biscuits, pastries and batter-based products; Chocolate and confectionary	4–8-year-olds: Mean (SD) 49.8 (26.2) g/day. 9-13-year-olds: Mean (SD) 68.0 (35.1)	Mean (SD) 111.6 (34.9) g/day in 4-8-year-old children and 130.3 (46.2) g/day in 9-13-year olds	Repeat 24-hour recall
Data Sources: National Nutrition Monitoring Bureau, Indian Council of Medical Research-National institute of Nutrition (ICMR-NIN) [38, 75] using the 2016 data collected on 5127 individuals.	Sugar and added sugars intake. Added sugars intake from listed recipes determined through a secondary data analysis of pre-existing data	-	-	12-17-year-old adolescents consumed 19.9g/day added sugar	-	24h recall

Table 1.2: Summary of sugars intake data from local surveys in different HICs and LMICs

Authors, Year, Title of study	Main dietary outcome variables	Amount of free sugars quantified	Sources and percentage contribution to E	Added Sugars	Total Sugars	Method used
United Kingdom Rugg-Gunn et al. (1986) Dietary intake of added and natural sugars in 405 English adolescents.	Amount and sources of added and natural sugars in the diet. Contribution of added sugars to total sugars and E in the diet.	-	Confectionery (28%), sucrose (24%), soft drinks (17%), biscuits and cakes (12%), sweet puddings (9%), syrups and preserves, breakfast cereals, milk cheese and butter, fruit were the nine food groups.	The mean (SD) of added sugars intake in grams/day was 81.3 (23.6), contributing to 15% of total energy and 69% of total sugars intake in 405 adolescents.	The mean (SD) of total sugars intake in grams/day was 118 (29).	3-day diary with interview, repeated on five different occasions.
Libya Huew et al. (2013) [76] Nutrient intake and dietary patterns of relevance to dental health of 12-year old Libyan children (n=180).	Amount of intake and percentage contribution to total energy from total sugars, free sugars, intrinsic and milk sugars.	Mean intake of free sugars was 56 g/d, the 95% CI was 52.1, 59.6.	Sources of free sugars were listed which included acidic items consumed as meals or snacks. The median intake of acidic items was 145.5g/d, IQR 67-267, confectionery 11.4g/d, IQR 6.1-18.9, fruits 10.2 g/d, IQR 4.5-15 Free sugars provided 12.6% and intrinsic milk sugars provided 7.8% of daily energy intake	-	Yes Mean intake of total sugars was 90.3 g/d, 95% CI was 85.4, 94.8 and total sugars provided 20.4% of daily energy intake.	3-day estimated food diary followed by interview.
Australia Devenish et al. (2019).	Median usual free sugars intake,	Median free sugars intake at 2 years was	Food group contributions to free sugars intake were- cereal based products and	-	Median total sugars intake was	Customised Food Frequency Questionnaire

Free sugars intake, sources and determinants of high consumption among Australian 2-year old children in the SMILE Cohort (n=1043).	contribution of free sugars to energy based on Estimated Energy Requirement.	22.5 grams per day (IQR 12.8-37.7). In more than 70% children, free sugars intake exceeded 5% of the estimated energy requirement and free sugars contributed to 8% of the estimated energy requirement (IQR 4.6-13.2).	dishes like cakes, biscuits, doughnuts, scones, sweet breads (18.8%), milk products and dishes likes custards, flavoured milk (16.4%), non-alcoholic beverages like fruit and vegetable juices (15.9%), infant formula and foods (14.9%), sugar products and dishes like table sugar, honey, syrups, jams, chocolate spreads (11.7%), confectionery including chocolate, ,muesli and cereal bars (9.4%).		77.5 grams/day (IQR 56-105.3).	linked to food groups in Australian Food and Nutrient (AUSNUT) database.
India National Nutrition Monitoring Bureau, Indian Council of Medical Research-National institute of Nutrition (ICMR-NIN 2019) [38, 75] using the 2016 data collected on 5127 individuals.	Sugar and added sugars intake Added sugars intake determined from listed recipes in individuals determined through a secondary data analysis of existing data	-	Sweets, SSBs, fruit-based recipes, juices and milk-based recipes were the reported 'recipe-groups' contributing to added sugar.	12-17-year-old adolescents consumed an average 19.9g/day added sugar	-	24h recall
Lebanon Jomaa et al.	Amount, sources and determinants	The average daily intake of free sugars in	SSBs, biscuits, chocolate confectionery, cereal-based products were the	-	In < 5-year-old children the median total	24h recall

Dietary intakes, sources, and determinants of free sugars amongst Lebanese children and adolescents: findings from two national surveys [61] in a population of children under 5 years (n=899) and 5-18 years (n=1133)	of free sugars intake	children less than 5 years was 26.5 (43.9); the median intake in the 5-18 years age group was 49.5g/day	principal food groups contributing to free sugars intake.		sugars intake was 69.0 g/day and that in 5-18 year old children was 71.6 g/day	
Portugal Marinho et al (2020) [77]. Total, added and free sugar intakes, dietary sources and determinants of consumption in Portugal: the National Food, Nutrition and Physical Activity Survey (IAN-AF 2015-2016) [77] in Portuguese population 3 months to 84 years (n=5811).	Total, added and free sugars intake intakes, dietary sources, adherence to recommendations and determinants of consumption in	The mean free sugars intake was 49.7 g/day in 5-9 year old and 52.9 g/day in 10-17 year old; free sugars contributed a median 9.8% to E in 5-9 year old and 10-17-year-olds	Soft drinks, confectionery, cereals and cereal-based products were the principal sources of free sugars in adolescents. Confectionery, soft drinks and yoghurts contributed the largest proportion to free sugars in 5-9-year-old.	The median IQR of added sugars intake was 42.6 (28.4 – 61.3) g/day in 10-17-year old and 39.6 (26.4 – 57.6) g/day in 5-9-year-old children	Median IQR of total sugars was 96.2 (76.1 – 119.7) g/day in 5-9-year-old children and 96.0 (75.9 – 119.6) g/day in 10-17-year-old adolescents	The eAT24 (Electronic Assessment Tool for 24-hours recall) software was used to collect detailed consumption data by 24 h recall or food diaries.
Europe (multi country study). Graffe MM et al (2019). Dietary sources of free sugars in the diet of European children: the IDEFICS Study [65]	Dietary sugars and food groups contributing to free sugars	Mean (SD) of free sugars intake was 79 (48) g/day and free sugars contributed 18% E	Fruit juices and soft drinks contributed nearly 50% of free sugars. Dairy products and confectionery were other top contributors to free sugars	-	Mean (SD) total sugars intake was 96 (51) g/day	Computer-assisted 24-h dietary recalls called SACINA: 'Self-Administered Children and Infant Nutrition Assessment'

Existing data on sources of sugars

There are available data from a number of countries (primarily high-income countries) on the principal dietary sources of free sugars and the contribution of these sources to total energy intake. The sources of free sugars intake are diverse and change rapidly as children age. Information on the sources of free sugars intake is important for informing dietary intervention. For dental caries prevention, it is important to restrict the foods and drinks containing free sugars, especially those that tend to be consumed between meals, when salivary flow is relatively low (e.g. sugar-sweetened beverages (SSB), confectionery, biscuits, cakes and cereal bars, and dried fruits) [54]. The sources broadly include sugar sweetened beverages (SSBs) and foods to which sugars, most commonly sucrose, were added during manufacture, cooking or consumption like sweets, confectionery and chocolates.

The percent contribution of sources in foods or as food groups to the total sugars, free sugars and total energy intake were reported. The sources remained similar in the diets of adolescents of the HIC, and included, but were not limited to sweetened beverages and sweet bakery products. In the UK [60], USA [62], European countries [65] and Mexico [78] recent studies have shown that children obtain a large proportion of free sugars from SSBs including sweetened juices. Further, cakes, biscuits, cereal based products and confectionery were the leading contributors of free sugars intake by children in Portugal [77], Lebanon [61] and China [78].

The 2012 national data on the dietary sources of sugars in Australian 2-17-year-olds showed that added sugars were sourced from soft drinks, confectionery and cakes [66]. However, as diet in early childhood impacts on the longer-term risk of dental caries [79] it is important to have specific data on the level of intake, sources and determinants of free sugars intake to guide early intervention for caries prevention. Previous analysis [55-58], based on the food codes in the Food Standards Australia New Zealand: Australian Food and Nutrient database (AUSNUT) [59] showed that infant foods and cereal-based snacks like biscuits were the leading sources of free sugars intake at 12-14 months [57] and beverages, cakes and biscuits at two years of age [56]. At one year of age, free sugars contributed 3.6% of EER and 8% EER at 2 years of age.

In the United States NHANES, in adolescents [73], ready-to-eat cereals contributed to 12.5 (±2.4) percent in the lower-intake decile, whereas in the high intake deciles, sugar-sweetened beverages, sweet bakery products, candy, desserts like ice-cream were contributors to total added sugars intake. Sugar added to tea and coffee contributed to high intake of added sugars in adults. In the UK [52, 67], among various sources of added sugars in the diet of adolescents at

12-13 years, soft drinks contributed the highest (38%), followed by confectionery (23%), biscuits and cakes (12.3%). Table sugar, confectionery and soft drinks contributed 69% of the mean daily intake of added sugars in adolescents. Other sources were sweet puddings, breakfast cereals, syrups and preservatives. Free sugars in adolescents in Brazil [71] were sourced from beverages (54.8%), cookies (12.8%), sweets (12.4%), cakes/breads, table sugar, honey and other sources like chips.

Although there is no clarity on the contribution of foods to free sugars in India, available information in Current Trends in Consumption of Fat, Salt and Sugar in India shows that table sugar, jaggery, sweetened milk, confectionery and sweet baked products are commonly consumed. In a distinct survey on the consumption of added sugar [38], it was found that addition of sugar was the highest in recipes labelled as *Sweets, Carbonated Beverages, Fruit-based recipes. Processed Fruit Juices and Milk based recipe*s. However, the actual intake of free sugars from these foods and their relative contribution to daily free sugars intake by different population groups is unknown.

Available data on pattern of intake

Local surveys have also reported on the frequency of intake, as the number of times sources of free/added/natural sugars were consumed as a meal or as snacks in-between meals [80], from breakfast to post-dinner [71, 72]. In a multi-centre cohort study in Europe, it was found that the intake of added and total sugars was higher on Fridays and weekend days than weekdays, in adolescents in Germany, Hungary, Sweden, Italy and Spain [68].

Pattern of free sugars intake was also described as intake during main meals i.e. breakfast, lunch and dinner versus intake as a part of snacks. Snacks were specifically defined in these research studies. For instance, free sugars as snacks contributed to 22.7 % of daily energy intake and free sugars in meals contributed 7.5% of daily energy intake in 12-year old children in Libya [76]. In Iceland, soft drinks contributed to 30% of added sugars intake [81] when consumed within meals and 38% as snacks in between meals.

Existing data on sugars intake from national or nationally representative surveys in India

What is known about sugars intake in India, is based largely on observational studies and local cross-sectional surveys using convenience samples in specific provinces in India. Researchers have analysed the intake of sucrose-containing foods in children and adolescents, broadly with the objective to assess the impact on dental caries, prevalence of obesity and the association of

eating behaviour with the changes in the Body Mass Index and anthropometric measurements [40-42, 82].

There are no available data on free sugars intake in children and adolescents. The mean intake of sugars was reported as 19.9 g/d, contributing to 5.1% of daily energy intake in 12-17-year-old adolescents [38]. It is unclear as to what this value exactly indicates and what methods were used to assess the 'added sugars' intake. For example, this low value suggests that it may refer to added table sugar. Additionally, the sources of 'sugar' as listed refer to the amount of sucrose added to the food items and not the contribution of the food item to individuals' daily sugars intake. These data therefore do not provide information on the daily amount of total or free sugars consumed by people in India and cannot be used for comparison with WHO thresholds. The sources of sucrose in the diet of individuals were reported in a household survey [37] by comparing the reported intakes with recommended daily intakes using the Food Composition tables in the Nutritive Value of Indian foods. Sucrose intake was reported separately as white sugar and jaggery and it was found that 52.3% individuals complied with the recommended levels of table sugar and jaggery intake set by the National Institute of Nutrition, India in 2011. Soft drinks consumption, referred to as 'carbonated beverages' was seen in more than half of the surveyed population. However, the frequency of consumption or the percent contribution of soft drinks to total sugars or total E were not reported and thus, it does not give an account of exposure to sugars.

In addition to crude estimates [83] that report per-capita sucrose intake, independent surveys on sugar production and consumption by industries and households in India, show that the per-capita consumption of low-income segments is nearly half that of high-income segments. The problem with this kind of approach is that it fails to take age group variations, household waste and sources of free sugars other than table sugar and jaggery into account.

Existing data on sugars from specific population groups in India

In the table 1.3, the information from a few local surveys in India that assessed intake of foods that contain sucrose is summarised [40-42, 82, 84]. As illustrated, unlike the global surveys reported earlier, none of the studies reported quantitative data on free sugars intake or contribution of various dietary sources of free sugars to daily energy intake, added sugars or total sugars intake. Local surveys in India have assessed the relationship between prevalence of dental caries and frequent intake of sucrose-containing foods like sweets, cakes, biscuits and chocolates. For example, in a specific population of 12-18-year-old adolescents [39] in a province in North India,

it was found that 78% of the study population consumed a sucrose-containing food at least once a day and about 22% consumed more than one item among chips, bakery products, soft drinks, chocolate. The most common time of consumption was after school hours and the source was shops outside schools.

Frequency of intake of a researcher determined list of foods has been widely reported in local surveys in India. In a cross-sectional study on 1800 children aged 9-18 years [80], it was reported that among the high consumers of foods containing sugars (≥ 4 times a week), 90% consumed white sugar or sucrose and more than half of the children consumed sweetened fruit juices and intake of acidic beverages was seen in 21%. Other sources of free sugars were biscuits and cookies (63%), chocolates (39%), cakes (10%), ice cream (19.5%). Although these data provide information on which sources of sugars are consumed, they do not provide information on the amount of sugars provided by these foods or the percent contribution of these food sources to overall free sugars intake. This information is important as it informs the health education i.e. outlines the important food groups to focus on and contributes to improving the content of dietary advice in dental practice.

Several other local surveys listed similar food sources but did not report amount of intake or percent contribution to total intake. The purpose of many of these studies was to look at the association between frequency of the intake of sugar-containing foods and dental caries and/or health.

From the perspective of sugars intake in India, there seems to be data on outcomes relevant to intake of sucrose or sucrose-containing sources and the proportion of population that consumed these sources, but no validated quantitative data on the amount of sugars intake or of different categories of sugars, the daily pattern of intake or the place of obtaining the free sugars Moreover, data on sugars when reported in the context of dental caries or other NCDs and which call for policies for reducing intakes in India, should be validated, reliable and achieved after all the confounders are controlled for including socioeconomic indicators, oral hygiene habits and access to sources of free sugars, particularly in school-aged children.

In the aforementioned SMILE Cohort study, comprehensive data on sugars consumption was obtained including data on total and free sugars intake, main dietary sources of free sugars the percent contribution of each source to total sugars intake. Dietary data have also been collected

from the children at age 5 years, but as yet these data have not been analysed. There is a need to collect similar reliable quantitative data on sugars intake from school children in India.

Nutrient intake and dietary assessment

As demonstrated by several global research studies on sugars intake, a validated and robust method of dietary assessment, is an essential pre-requisite to obtain accurate information on amount, sources and percent contribution of sugars to total daily energy intake. For instance, a 24-hour recall may be appropriate to report average sugars intake of a population or a specific age group while a Food Frequency Questionnaire would help a researcher classify individuals into bands of intake.

When the objective is to elicit in-depth information in which amount, pattern, timing and place of intake are needed and when the researcher aims to list the sources of free sugars and the individual variations in sugars intake, to differentiate between intake variations and within person variations (E.g. school vs. non-school days), methods that address all these aspects and help in distinguishing these outcomes are essential. A dietary diary that records all the food consumed on consecutive days or a repeat 24-hour recall accounts for all the sources of free sugars and does not limit assessment to a researcher pre-determined list of items. Hence, this research will be carried out by using three-day food diary.

Previous studies of dietary intake in India have relied on existing food composition databases and required researchers to manually analyze data [(44)] for the estimation of intake of nutrients from reported food intakes, and these were usually collected using 24 hour recalls or food frequency questionnaires [(36, 37)]. However, there are no comprehensive local food and recipe databases. Further, the challenge posed by the lack of software to link the intakes to national food compositional tables has been identified [(44)]. Open-source and low-cost applications that facilitate assessment of dietary intake through the creation of a digital record of the food and drink intake are commonly used in high-income countries HIC [(45, 46)]. The application of such tools for dietary assessment in lower-middle-income-countries (LMIC) is limited or, as is the case with India, non-existent. The validity and reliability of one such tool 'Intake24' (https://intake24.org) has been tested [(46)] and used in the national dietary surveys in other countries (e.g. the UK National Diet and Nutrition Survey) [(46-48)]. An English Language South Asia Locale (2022 version) of this application has recently been developed (https://intake24.co.uk/info/localisation) but it has not previously been applied to populations in India.

Previous surveys of ten states of India of diet and nutrition status of rural [36] and urban [37] populations conducted in 2012 and 2017 respectively reported that the mean intakes of calcium, iron, folate, B12 and, vitamin A in young adolescents did not meet the Recommended Dietary Allowance (the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals). Since the publication of these reports, the reference values have been updated [35] and Estimated Average Requirement (EAR) values proposed.

For a given nutrient, the EAR represents the nutrient intake value that is estimated to meet the requirement of 50 percent of the healthy individuals. The EAR was suggested for the first time as the appropriate reference value for assessing requirements and adequacy in healthy individuals. Since the update of dietary reference values in 2020, no data of dietary behavior have been collected and compared with the initial EARs for E and nutrients.

This doctoral project will report the data on the E, macronutrient and micronutrient intake in the sample of Indian young adolescents from Delhi. This is expected to set the context for the detailed report on sugars intake.

Table 1.4 provides a summary of some of the national surveys that reported the intake of macronutrients, E and micronutrients. In these diet and nutrition status surveys in HICs including the UK and Australia, the intake of nutrients and E were quantified and compared with the national dietary guidelines.

Table 1.3: Summary of Data on sugars intake from specific populations in India

Authors, Year, Title of the study	Dietary outcome variables	Amount of free sugars (Yes/No)	Sources and percentage contribution to E (Yes/No)	Added Sugars (Yes/No)	Total Sugars (Yes/No)	Method used
Honne et al (2012) [82]. Relationship between obesity⁄ overweight status, sugar consumption and dental caries among adolescents in South India. 2012	Frequency of sucrose consumption from soft drinks, fruit juices, sweets, ice cream and biscuits.	No	No	No	No	Unclear. Closed-ended questionnaire.
Gupta et al. (2014) [40]. Prevalence of dental caries in relation to daily sugar intake and oral hygiene status in 12-year old school children in Mathura city- A pilot study.	Daily intake of sucrose containing foods and drinks categorised based on 'sugar sweet score.' Anthropometric measurements and BMI.	No	No	No	No	24-hour recall. Data presented based on Sugar Sweet Score.
Gulati et al (2016) [80]. Dietary Intakes and Familial Correlates of overweight/obesity: A Four-Cities Study in India	Frequency of consumption of various foods and drinks from a list of foods and drinks. Pattern of intake. Perceptions of mothers and children about dietary intake. Body Mass Index and anthropometric measurements.	No	No	No	No	Food Frequency Questionnaire
Wilson et al (2018) [41]. Dental Caries and Co-Relation with Sugar Intake in 12-Year-Old School Children Coorg, India. Open	Frequency and timing of intake of sucrose containing foods including sucrose in milk, fruit juice with honey, biscuits, sweets, jams and jaggery.	No	No	No	No	Unclear. Authors report use of 24 hour recall method but data presented using

Access Journal of Public Health.						items in a questionnaire.
Naik et al. (2018) [42]. Caries Risk Assessment of 12-13-year-old Government and Private School Going Children of Mysore City Using Cariogram: A Comparative Study	Frequency of intake of sucrose containing foods and drinks to match with the components of Cariogram [1](a tool to screen for risk of dental caries).	No	No	No	No	3-day dietary diary.
Gurunathan and Priyadarshini. (2020) [84]. Role of diet in ECC [2]affected South Indian children assessed by the HEI-2005: A pilot study.	Healthy Eating Index (HEI, 2005) component scores and total scores. Components included: Total fruit, whole fruit, total vegetables, dark green, orange vegetables, legumes, milk, Calories from Solid Fats, Meat, Beans, Oil, Saturated fats, Sodium and Solid fats, Alcoholic Beverages, and Added Sugars	No	No	No	No	24 h recall and 3-day dietary record followed by telephonic interview.

[1] Cariogram is a tool that illustrates the individuals' risk for developing new dental caries in the future by analyzing the etiological factors like the diet, bacterial load, past caries experience and susceptibility based on fluoride program, saliva secretion and salivary buffer capacity.

[2] ECC: Early Childhood Caries

Table 1.4: Summary of E and nutrient intake data National surveys in different countries

Authors, Year, Title of study	Main dietary outcome variables	E intake	Carbohydrate and Percent E from Carbohydrate	Protein and Percent E from Protein	Fat and Percent E from fat	Micronutrient intake	Method used
National Nutrition Monitoring Bureau rural and urban nutrition surveys in 2012 and 2017 [36, 37] N=1654	Nutrient intake status of a sample from ten states in India. Results of the 10-12-year-old children reported in this table.	6.2 (2.2) MJ/day for boys and 5.9 (2.2) MJ/day for girls	74.5% E	40.3 (18.6) g/day and 38.6 (18.7) g/day in boys and girls respectively	21.9 (15.4) g/ day and 20.7 (14.4) g/day in boys and girls respectively	Vitamin A and iron deficiency in boys; vitamin A, calcium, iron and riboflavin deficiency in girls	24h recall
Louie JCY et al (2016). Intake and sources of added sugars among Australian children and adolescents N=4140; 2-16-year-old [74]	Total, added and free sugars intake in Australian children and adolescents at different ages; Percent contribution of macronutrients and sugars to E;	8.9 (2.1) MJ/day in 9-13-year old	51.6 (6.5)	16.7 (3.6)	30.8 (5.4)	-	Repeat 24 h recall
UK National Diet and Nutrition Survey [85] results from 2016/17 – 2018-19 rolling program. Data for 11-18 year old children	Diet and nutrient intake status of UK population of different ages	7.3 MJ/day for boys and 6.5 MJ/day for girls		15.4% E	34.4 % E; saturated fat contributed 12.6% to E	49% Girls reported iron intake below the Lower Recommended Nutrient Intake	Digital dietary assessment tool 'Intake24' to analyse information reported in 4d food diary

1.6 Thesis Outline

The remainder of this thesis is organised in the following way.

First, the study methods and statistical methods are elaborated on in Chapter 2, to give additional detail to that presented in the subsequent chapters. In Chapter 3, results pertaining to the analysis of the SMILE data are summarised, and presented in the format of a submitted journal article. In Chapters 4 and 5, the primary aim of this thesis is addressed. In Chapter 4, energy and nutrient intake by young adolescents living in Delhi, India are described. Chapter 5 presents a detailed analysis of free sugars intake young adolescents living in Delhi. Finally, a general discussion of the overall findings, conclusions and forthcoming research plans are presented in Chapter 6.

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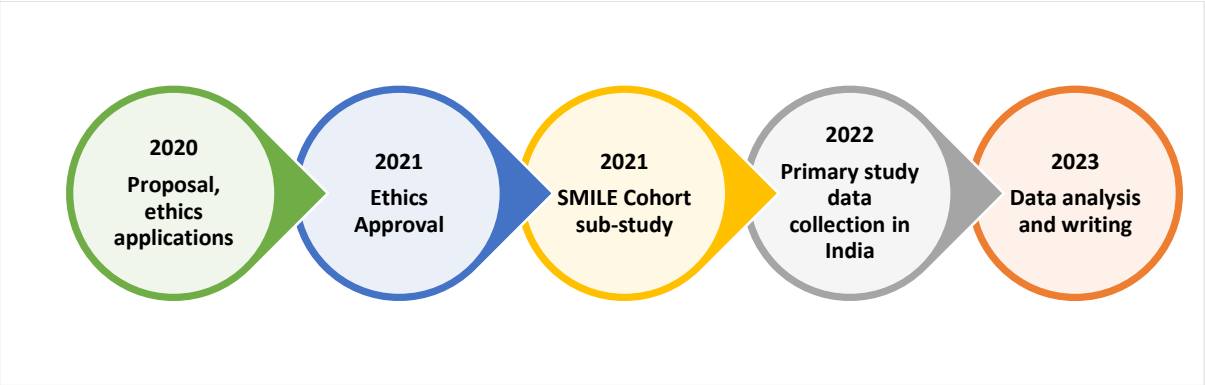
Chapter 2

Chapter 2: Methods

2.1 Preface

In this chapter, the focus is the methods and procedures relating to the primary study conducted in India. Additionally, relevant aspects of the SMILE study are described. The methods used to derive free sugars and nutrient intakes in the two studies are outlined. Finally, the statistical methods used to address the overall thesis aims are outlined. Figure 2.1 presents a schema showing the timeline of activities related to the doctoral project.

Figure 2.1: Timeline of the project activities



The secondary analysis as a part of the SMILE cohort sub-study was conducted during March - October 2021 before the data collection for the primary study commenced. This chapter will therefore start with the steps in the secondary analysis with a brief note on the learnings.

2.2 Secondary analysis of the dietary data from the SMILE Cohort sub-study

Secondary analysis of the dietary data collected from participants at age 5 years in the SMILE Birth cohort study was used to investigate the sources and determinants of free sugars intake by five-year-old Australian children. Details of the SMILE birth cohort have been described previously [1-4]. In brief, 2181 mother and newborn dyads were recruited in Adelaide, South Australia in 2013/2014. Sociodemographic data were collected at baseline. Dietary data were collected for the children at ages 1, 2 and 5 years.

Collection of dietary data from children-aged 5 years

In 2019, dietary data were collected from 733 participants at child age five years using the 98 item SMILE Food Frequency Questionnaire (SMILE-FFQ) [5]. SMILE-FFQ was designed to capture information on sugars intake and does not assess dietary intake.

Data generated from the SMILE-FFQ does not provide information on total energy intake (E) and so the percent contribution of free sugars to E could not be derived. However, as height and weight were measured, energy requirements could be estimated and the percent of energy requirement from sugars was derived.

In this questionnaire, six options were provided to answer the question on frequency of intake of each listed item- ranging from 'never/rarely' to 'once every two weeks', 'once per week', '2-3 times/week', '4-6 times/week', '1-2 times/day' and 'three times per day'. For the question on portion sizes, options were provided to report the weight/volume along with the appropriate household measures (tablespoons, teaspoons, cups, scoops etc.). For each participant, the responses to the SMILE-FFQ were exported into a Microsoft Access database containing food composition tables adapted from the Australian Food, Supplement and Nutrient (AUSNUT) database [6]. The AUSNUT database provides information on the amount in grams of total and free sugars per 100-gram edible portion of different foods and drinks. The participant responses to the SMILE-FFQ were matched with the foods in the AUSNUT database in order to derive an estimate of usual total and free sugars intake per participant in grams per day.

Calculation of the percentage of energy requirement obtained from sugars by 5-year-old children in the SMILE cohort

The height and weight of each child were measured at age five years during a study visit. These data were used to estimate the energy requirement of each child using the US Institute of Medicine (IOM) equation [7]. A Physical Activity Level (PAL) of 1.6 (light activity) was assigned to all participants in accordance with previous analyses [1]. This was based on the median value for PAL calculated from activity data reported by approximately 27% of the SMILE sample [8]. Children with no available anthropometric data were split by gender and the median Estimated Energy Requirement (EER) of the study group for the corresponding gender was assigned [8, 9].

The percentage contribution of food sources to free sugars intake

The intention of this analysis was to determine the sources of free sugars intake from the perspective of dental health. Thus, although the grouping of foods for this analysis was informed by the AUSNUT food grouping classification system [6], the cariogenic potential of food items/groups informed modifications to the food group categories and labels. For example, distinguishing foods which tend to be consumed between meals from those consumed with meals, distinguishing dried fruits (cariogenic) from nuts (non-cariogenic). For dental caries prevention, it is important to restrict the foods and drinks containing free sugars, especially those that tend to be consumed between meals, when salivary flow is relatively low (e.g. sugar-sweetened beverages (SSB), confectionery, biscuits, cakes and cereal bars, and dried fruits) [10].

Sociodemographic data

Sociodemographic data collected at baseline included child age and sex, maternal age, maternal education, mother's country of birth, number of children in the family and family composition (one-parent or two-parent) and postcode from which the Index of Relative Socioeconomic Advantage or Disadvantage (IRSAD) was derived [(1)].

Statistical Analysis

The distribution of total and free sugars intake was assessed. In line with earlier assessments at two years of age [(1)], those individuals with total or free sugars values that exceeded the 95th percentile were excluded from subsequent analysis. For each participant, E from total and free sugars (grams of intake x 16.7 Kilojoules) was calculated and this figure was divided by EER and multiplied by 100 to give the percentage of EER provided by total and free sugars [(9)]. For each participant, the grams of free sugars obtained from each food source was calculated as a percentage of their overall free sugars intake. Subsequently, the percent contribution of each food source to free sugars intake were derived for the study population as a whole and for 'consumers only'. 'Consumers' of a food group were defined as those participants who reported any valid response other than "never or rarely" in the SMILE-FFQ, for at least one item within the food group.

Descriptive statistics (frequencies, percentages, mean, standard deviation (SD), median, interquartile range (IQR)) were derived for sociodemographic variables, total and free sugars intake, as appropriate. Children were classified according to their percentage EER obtained from free sugars intake into the following categories: (1) <5% EER, (2) 5-<10% EER (children meeting the WHO recommended thresholds), or (3) ≥10% EER (children exceeding the WHO recommended thresholds).

Multinomial logistic regression

The sociodemographic factors were investigated as determinants of lower free sugars intake (<5% EER, and 5-<10% EER) through multinomial logistic regression. All sociodemographic variables were included in the initial logistic regression model as explanatory variables, and retained in the final model if the corresponding overall P-value was <0.2. The reference group was children with a free sugars intake ≥10% EER. The results were expressed as relative risk ratios (RRR) with associated 95% Confidence Intervals (CI). Mother's age, education, country of birth, family size and family composition (single-parent or dual parent) were retained as the explanatory variables.

Key takeaways from the secondary analysis

The secondary analysis of pre-existing SMILE cohort data provided the chance to appraise the characteristics of dietary data collected using a food frequency questionnaire. The analyses conducted to elicit information on sources of free sugars and identify the determinants of intake provided a learning experience on dietary data statistical methods, specifically, logistic regression. Knowledge on food group validation served as a roadmap for the methods to report sources of free sugars in the Indian young adolescents.

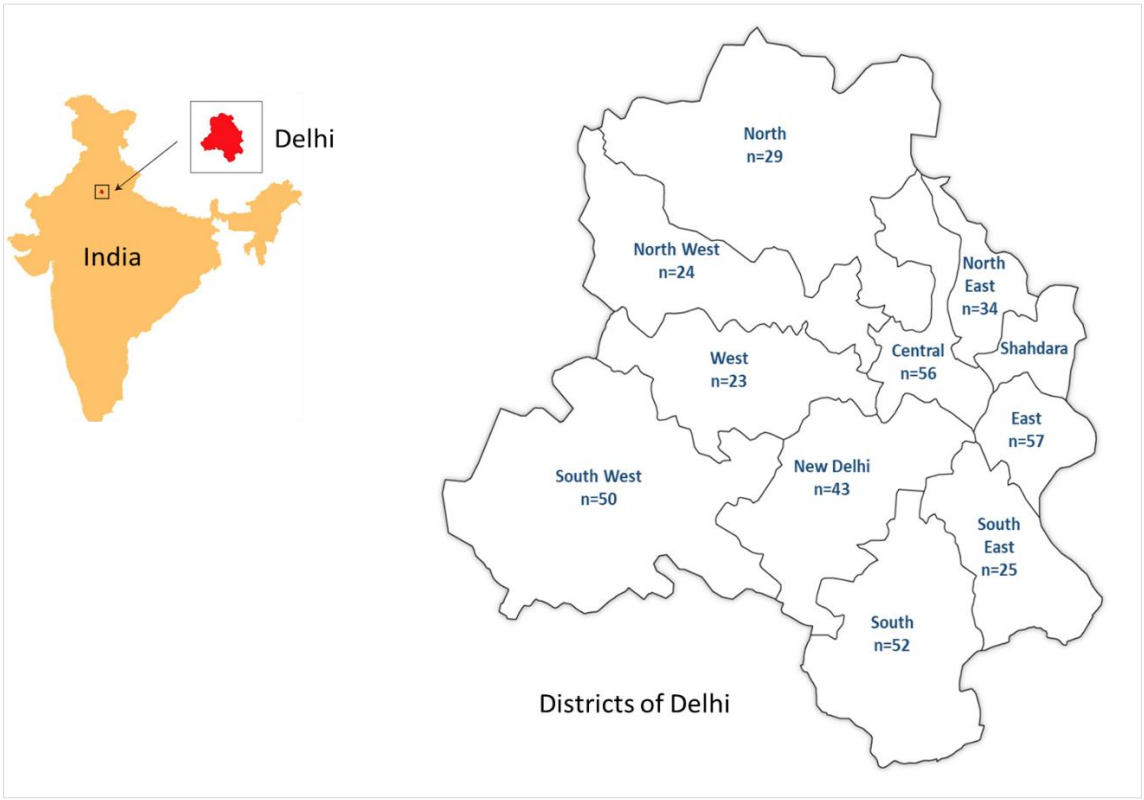
2.3 Methods to investigate the dietary intake of 11-13-year-old young adolescents living in Delhi, India

The data for the primary study were collected during May - October 2022. The next few pages provided the details about the study location and participants and the methods used for dietary data collection, data management and statistical analyses.

Study site

Delhi is a Union Territory located in North India with a diverse population of 20.2 million people from different socio-economic, cultural and ethnic backgrounds. Delhi is the largest metropolitan area in India and the second largest in the world and New Delhi, the capital of India is located here. Delhi is divided into 11 civic administrative districts (Appendix A). There are rural and urban sectors in Delhi. The 112 villages in the rural sector are not limited to any specific district. The municipal corporations of North, East, South and New Delhi constitute the urban sector.

Figure 2.2: Map showing the location of Delhi, Delhi districts and the number of study participants from each district



Government, government-aided and private schools constitute the school education system in Delhi. Private schools were chosen for the sampling frame because recent research [11] indicated that young adolescents especially those attending private schools in Delhi are vulnerable due to the exposure HFSS foods and beverages through school canteens within schools and also through the location and concentration of shops, mobile food carts and fast-food outlets in the city environment of schools. Although Government and aided schools do not have canteens, the children and adolescents there is anecdotal evidence to show that Government schools are exposed to HFSS through concentration of mobile food carts during lunch break and school leaving time.

At the time of planning this study, the private schools constituted 40% of the total school enrolment and approximately 1.8 million children attended private schools at primary, middle, secondary and senior secondary levels. Nearly all (95%) of the 11-14 age demographic attended classes across 6^{th} - 8^{th} years at the middle /secondary school level. There are 804 private middle and secondary schools and the distribution of schools is not uniform across the 11 Delhi districts.

Ethics Approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki. The Human Research Ethics Committee (HREC) at The University of Adelaide approved this study in 2021 and the amendments were approved in 2022 (*H-2021-027*, Date: 8 March 2022). Approval by an Independent Ethics Committee in India was essential and therefore, the India collaborator (HRIDAY- Health Related Information Dissemination Amongst Youth) facilitated the application to the Independent Ethics Committee at the Centre for Chronic Disease Control in New Delhi. That Committee provided approval in 2021 (*CCDC-IEC_14_2021* Date: 9 December 2021).

The inclusion and exclusion criteria for selection of participants are provided below-

Inclusion criteria

- Young adolescents in the age group of 11-13-years attending private schools in Delhi
- Absence of chronic diseases (other than obesity, dental caries and type 2 diabetes mellitus)

Exclusion criteria

- Children on therapeutic diet
- Children whose parents do not provide consent
- Children diagnosed with renal disease, phenylketonuria, type 1 diabetes mellitus, metabolic diseases and cystic fibrosis

Sample size calculation

The sample size calculations were performed using three previous studies [9, 12, 13] as a guide to the expected total sugars intake for 12-year-old children. The sample size calculations were based on the number of participants needed to estimate the total sugars intake in grams per day with a margin of error of ± 5 g / day. The calculations assumed 80% power to estimate mean total sugar intake and two-sided α of 0.05. The resulting sample size was inflated to allow for 20% attrition. The sex ratio of 11-13-year-old adolescents in Delhi is 58.3% boys and 41.7% girls which was the basis for the gender distribution.

School selection and consent

The website of the Delhi Directorate of Education provides the district-wise list of all the private unaided schools [14]. Private schools constituted 40% of the total school enrolment in 2022 and 95% of the 11-14 age demographic attended a school in Delhi. The number of private schools and students is not uniform across the 11 districts in Delhi. Using this complete list of 1374 private schools, a statistician external to the research team generated a random sample of 150 schools, stratified by district from across the 11 districts of Delhi. Using the random schedule, the researcher contacted the principal / teacher of each school through email (Appendix A) and on telephone and explained the purpose of the study in plain language. The researcher shared information about the study through email with those schools that expressed interest to take part in the study (Appendix B: School Information Sheet).

Once a school agreed to participate, a link to the school consent form was sent by email. A digital version of the school consent form (Appendix C) was created on an online survey platform called Qualtrics (*Qualtrics XM* experience management software, Sydney, NSW; www.qualtrics.com. This application provides options to create a survey and disseminate it by generating a unique survey link. The data aggregation tools allow the user to download data in a Microsoft Excel Spreadsheet format upon completion of the survey).

To connect with a school, the researcher made a minimum of three attempts. If no response was obtained or if the school declined to take part, the researched moved to the next school on the list for that specific district. Upon obtaining consent, the process for recruitment of participants was initiated. The HRIDAY team assisted the researcher in establishing initial contact with the principals of schools where the contact numbers or email IDs were not available. HRIDAY is a nongovernmental network of researchers and stakeholders based in New Delhi which works towards prevention and management of NCDs with a priority to inform health promotion strategies through research and advocacy (www.hriday.org.in).

Parent consent and participant assent

A template letter for inviting parents of the 11-13-year-old students to take part in the study was prepared by the researcher and provided to the school (Appendix D). Within each school, a dedicated teacher provided study information (prepared in plain language by the researcher: Appendix E) to the parents of the 11-13-year-old students through the school network on social media applications (WhatsApp) or through emails. Parents who were interested for their child to take part in the study communicated their interest to the teachers. The teacher then created a list of all interested participants. Next, the teacher asked the parents to fill-in and sign the online parent consent form (Appendix F) by sharing a link to this form through the school social media network. Some schools requested the researcher to provide a brief orientation about the research to the group of participants who were selected by the school. This talk was organised by the school and held in the school's auditorium or in a classroom. During this interaction, the researcher explained in detail the purpose of the study and the expected level of involvement of the participants. The researcher requested participants to share the study information with parents. Only after the researcher received a completely filled in and signed consent form from the parent(s), the pupil was recruited as a participant in the study. A child information sheet was shared by the researcher for the participants to further understand the purpose of the study and the level of their involvement (Appendix G). Participants provided assent online (Appendix H) before data collection commenced. The numbers of participating students from each school varied. This was based on the total number of 11-13-year-old students in the school and the number of participants for whom parental consent has been obtained.

Data collection

Demographic, height and weight data

Participant demographic data were collected using the online survey form hosted on Qualtrics. Demographic variables included participant name, age and, date of birth; parent name and age and the area of residence. Parents were asked to record at home, or provide from previous records, their weight (in kilograms) and height (in inches or centimetres). The researcher provided instructions in plain language to assist the parents in the measurement of height and weight at home.

Dietary data collection using a 3-day food diary and Intake24

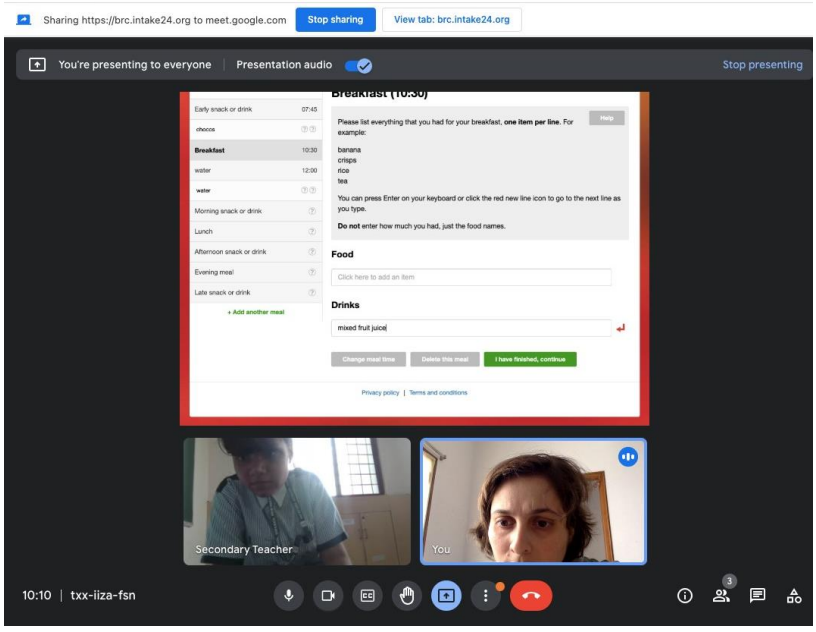
Information on the dietary intake of each participating child was collected over three consecutive days in a purpose-designed food diary (Appendix I). Participants recorded intake on Friday, Saturday and Sunday or on Sunday, Monday and Tuesday. This allowed estimation

of the dietary intake during school days (i.e. Monday, Tuesday, Friday, and Saturday) and non-school days (Sunday). Participants were asked to report their dietary intake using a paper-based or editable electronic purpose-designed three-day food diary. After the participants completed recording their dietary intake, the researcher transferred the reported food and drink intake of each day into the Intake24 South Asia Locale, 2022 version (https://intake24.org). This was done during a one-on-one interview with each participant to discuss, clarify and enlarge on the information provided and confirm the portion size of foods and drinks consumed using the database of portion size photographs on Intake24. The entries for each day of the food diary were entered online as one 24-hour recall. Thus, a total of 3 days recording for each participant was obtained.

One-on-one interviews and data transfer

An end-to-end encrypted and fully-licensed version of the Zoom video conferencing application (https://zoom.us) was used for the online one-on-one interviews. The researcher shared the schedule of interviews and the link to the zoom meeting with each school's liaison teacher. The researcher created a distinct user ID and a password for each participant. This was used to log on and complete the transfer of the reported food and drink intake onto Intake24. After a participant logged on to the zoom meeting, the researcher shared the screen with the child and logged into the Intake24 system. Thereafter, the researcher transferred all the information written by the child in the diary including the time of intake and then requested the child to confirm the portion sizes of the foods consumed.

Figure 2.3: Screenshot of the participant-researcher online interview to transfer information from the food diary to Intake24



This was facilitated by the Intake24 database of 2500 portion sizes of more than 100 foods. The amount of water and other beverages (e.g. coffee, tea, juice, milk etc.) consumed was confirmed by using the interactive feature of the system where the level of the drink could be selected after choosing the type and size of the glass or mug. Intake24 then converted the reported intake of foods and drink into average daily intake of nutrients (e.g. sugars, protein, fat, vitamins etc.) through integrated food composition tables.

Figure 2.4. Screenshot to illustrate portion size images. Courtesy: https://intake24.com

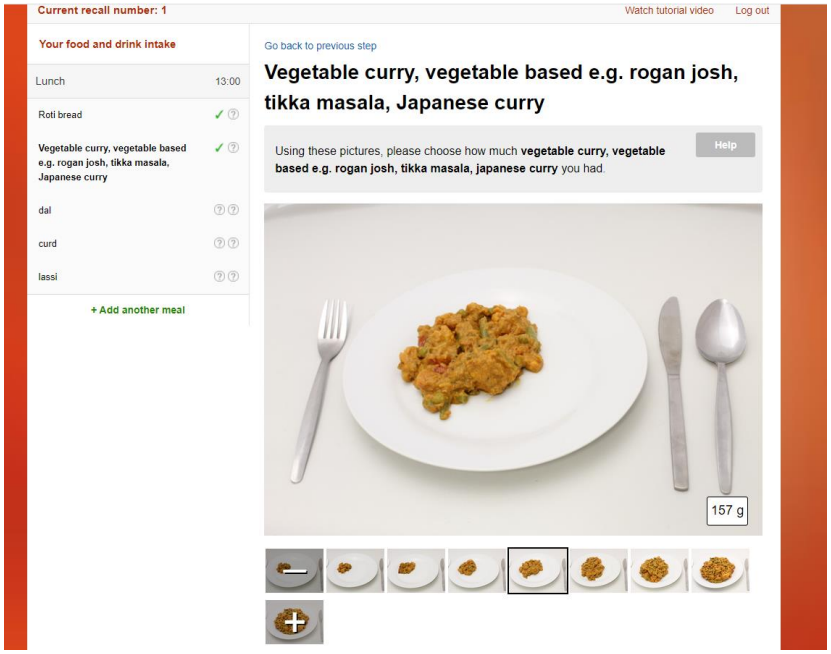
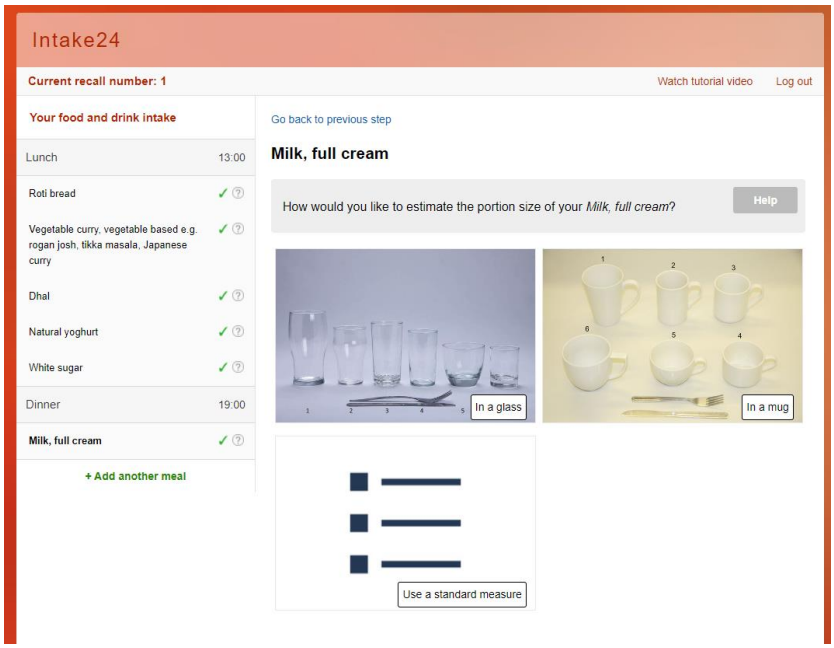


Figure 2.5: Screenshot to illustrate the portion size options for reporting amount of intake of beverages. Courtesy: https://intake24.com



Data Management

Following completion of all interviews, the resulting data file was downloaded from Intake24. The dietary data were accessed in a Comma Separated Values (.csv) format and imported into STATA 17.0 (Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC).

Initial manipulation

In the dataset, the daily food and drink intake reported by each participant for each of the three days, was organised into meals. The predefined list of meals in Intake24 are: (1) early snack or drink; (2) breakfast; (3) morning snack or drink; (4) lunch; (5) afternoon snack or drink; (6) evening meal and (7) late snack or drink. The first step in the initial manipulation of the dataset on STATA was creation of global and index variables. The purpose of these variables was to enable organization of the data and the derivation of daily intakes for participants for the various nutrients. Table 2.1 provides the list of outcome variables reported in this study.

Derivation of nutrient intakes

Intake24 converts each reported food and drink into nutrients. The nutrients of interest in this study included carbohydrate, protein, fat, saturated fat, free sugars, total sugars, vitamins A, B12, folate, D, iron, zinc, calcium, selenium and iodine. The daily total across all of the reported foods and drinks was calculated for each nutrient. The daily total intakes were then averaged across the three days for each child, so as to derive average daily intake of nutrients. Each gram of carbohydrate, sugars and protein provides 4 kcal E and each gram of fat/ saturated fat provides 9 kcal E, so that daily E obtained from the nutrients of interest were derived, and the average E intake across the 3 days then calculated.

- E obtained from carbohydrate, sugars and protein = grams of intake x 4
- E obtained from fat, saturated fat = grams of intake x 9

Following this, the average daily percent contribution of macronutrients to E was derived.

- Percent contribution of nutrients to E = Average E from nutrients x 100/ Average E intake

Table 2.1: Dietary outcome variables and units of measurement

Dietary Variables	Unit of measurement
Energy intake (E)	kcal/MJ /day
Carbohydrates	grams/day and % contribution to E
Protein	grams/day and % contribution to E
Fat	grams/day and % contribution to E
Saturated fat	grams/day and % contribution to E
Vitamin A	Micrograms (µg) /day
Vitamin B12	Micrograms (µg) /day
Vitamin D	Micrograms (µg) /day
Folate	Micrograms (µg) /day
Iron	Milligrams (mg) /day
Calcium	Milligrams (mg) /day
Zinc	Milligrams (mg) / day
Iodine	Micrograms (µg) /day
Selenium	Micrograms (µg) /day
Free Sugars	grams/day and % contribution to E
Total Sugars	grams/day and % contribution to E

Sources of free sugars

The sources of food groups presented in the current study as sources of free sugars were based on an earlier report by the India National Nutrition Monitoring Bureau (NNMB) [(15)]. The observations with non-zero values under the 'Free Sugars' variable in the data output were filtered as a first step. This yielded a list of 408 foods and beverages with unique food codes. Using the reference list of food groupings [(15)], the 408 foods were categorised into 19 main groups with sub-groups in each. Table 2.2 provides the detailed list of main groups and subgroups. The detailed list of the foods and beverages within each sub-group is provided in Appendix J.

Table 2.2 Main and sub-group categories analysed as sources contributing to free sugars intake in 11-13-year-old adolescents living in Delhi

Main Group	Sub-group
Sugar, preserves and syrups	Table Sugar
	Honey and syrups
Beverages	100% fruit and / or vegetable juices
	Sugar Sweetened Beverages
Bread and bread-based savouries	Bread with fillings
	Bread and bread rolls
Cakes and biscuits	Cakes
	Sweet and savoury biscuits
Confectionery	Candies/Sugar confectionery
	Chocolate confectionery
Sweetened Milk Products	Milk-based drinks
	Yoghurt(lassi)
Desserts	Frozen milk-based desserts
	Frozen non-milk desserts
	Non-frozen milk-based desserts
	Non-frozen non-milk desserts
Spreads and sauces	Savoury sauces
	Sweet spreads
Breakfast foods	Breakfast cereals
	Savoury breakfast foods
Cereal-based savouries	Cereal-based savouries
	Spring rolls
	Dumplings
Chicken/Meat dishes	Chicken/Meat dishes
	Kebab/tikka
Savoury snacks	Crisps and savoury snacks
Chutney and condiments	Chutney and condiments
Curry	Vegetarian curry dishes
	Non-vegetarian curry dishes
Noodles and noodle dishes	
Pizza	
Pulse-based dishes	
Savoury rice dishes	
Other sources	

The grams of free sugars from each food/drink within a given subgroup were added together to create a subgroup total. The subgroup totals were then summed to generate free sugars (grams) from the 19 main groups. The daily and average intake from each main group and subgroup were derived. For each participant, the grams of free sugars obtained from each food group was calculated as a percentage of their daily free sugars intake.

For each participant, E from free sugars (grams of free sugars x 4 kcal) was calculated and divided by E and multiplied by 100 to give the percentage of E provided by free sugars. Participants were classified according to their percentage E obtained from free sugars intake into the following categories: (1) <5% E, (2) 5-<10% E, or (3) ≥10% E. Children in (3) were those who exceeded the WHO recommended thresholds).

Statistical Analysis

The distribution of the daily intake of macronutrients and micronutrients for the group and the percent contribution to E was assessed and the appropriate measures of central tendency were used to summarize the data i.e. median with the interquartile range (IQR) for variables with a non-Gaussian distribution and mean and standard deviation (SD) for those with a normal distribution. The percentage contribution of main and sub-groups to free sugars intake was derived for the study population as a whole and for 'consumers only'.

Comparison with the NIN-EAR

The derived intakes of macro and micronutrients were compared with the India-NIN Estimated Average Requirements (EAR). The percentage of study population with daily intakes of E and macronutrients above the NIN-EAR and percentage of the study population with daily intake of micronutrients below the NIN-EAR was reported.

Validation of energy intake

Physical Activity Level (PAL) was used to validate the reported E intake and identify the proportion of participants who may have over-or under-reported E intake. The PAL was calculated by dividing the reported E intake by the Basal Metabolic Rate (BMR). The Schofield equation [16] was used to predict the BMR of both the boys and girls in the sample from the weight information provided by the participants. The equations used were:

- BMR=17.686 x Weight(kgs) + 658.2 (Boys)
- BMR=13.38 x Weight(kgs) + 692.6 (Girls)

Analyses to study the effect of demographic variables on free sugars intake

Multivariable mixed effects linear regression models were used to explore the effect of age and gender on daily free sugars intake, with school treated as a random effect in these models. In a second set of models, differences in daily intake of free sugars intake according to eating occasion (i.e. main meals versus snacks) were investigated, with a random effect for meal type included in the models to account for the correlation between repeated measurements within a child. Finally, differences in daily free sugars intake on weekdays versus weekends were considered, with age and gender included in the model. Variables were retained in the final models if the corresponding overall P value was <0.2.

Multivariable logistic regression models were also fit to explore the association of the demographic variables with children achieving the WHO recommended thresholds for free sugars intake. The results were expressed as odds ratios. The daily free sugars (g/day) and the amount of free sugars at meals (g/day) and snacks (g/day) were the outcome variables.

A reflection on challenges during the PhD

The pandemic affected the PhD project unfavourably. The timelines, research plan and the data collection were impacted. Since the research plan was amended multiple times, it led to a doubling of the effort to obtain ethics committee approvals both in India and Australia for each amendment. The rapid increase in fatalities and cases in Delhi in 2021 created a sense of confusion about the project plan and timeframe. Schools remained closed all through 2021 until mid-2022. This led to the loss of nearly 210 days of candidature. However, the researcher used the available time judiciously and focused on the secondary study which helped learn and apply dietary data analysis methods to report free sugars intake in the Indian schoolchildren.

During early 2022, the researcher communicated with the team at HRIDAY (the India collaborator) to seek updates on the plans around reopening of private schools. The digital literacy of pupils, teachers and parents, perhaps a positive outcome of two years of online school, worked in favour of the researcher. The study participants were highly familiar with use of online video conferencing applications and survey platforms which were applied for data collection in this project. Teachers and students found the entire project, especially completing the dietary recall on Intake24, very exciting. The PhD not only contributed to the academic advancement for the researcher but also helped her build the resilience to work in challenging circumstances.

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Chapter 3

Chapter 3: Sources and determinants of free sugars intake by five-year-old Australian children in the SMILE Cohort

3.1 Preface

This chapter describes the results of the secondary analysis of the dietary data collected on the five-year-old Australian children in the SMILE Cohort which provides information on the sources and determinants of free sugars intake at age five years. The research work and the references are written in the journal format.

The analysis is a continuation in the series of reports on sugars intake by children of the SMILE cohort. This research work is unique in two aspects: i) the findings from this analysis outline the socioeconomic determinants associated with children achieving the WHO recommended threshold for free sugars intake, in contrast to the earlier reports which described the factors associated with an intake that exceeded WHO thresholds; and ii) the percentage contribution to free sugars intake of groups of foods known to contribute to dental caries (e.g. foods high in free sugars that tend to be consumed between meals) are reported with the intention to determine information on sources of free sugars from the perspective of oral health.

Highlights

Children in Australia have some way to go to reach the WHO recommendation to limit the intake of free sugars to less than 5% E. Cakes, Biscuits and Cereal Bars, Sweetened Milk Products and Desserts were the principal contributors to free sugars intake. Nutrition interventions are needed to support priority populations such as migrants and those with lower education.

This chapter is formatted according to the author guidelines for Public Health Nutrition. The manuscript has been submitted and is currently under review.

Manuscript ID: PHN-2023-0596

3.2 Statement of Authorship

Title of Paper	Sources and determinants of free sugars intake by Australian 5-year-old children
Publication Status	Submitted for Publication
Publication Details	The paper has been submitted to the journal 'Public Health Nutrition' and is currently under review.

Principal Author

Name of Principal Author (Candidate)	Anupama Ivaturi		
Contribution to the Paper	Dietary data analysis and statistical analysis Manuscript original draft, review and editing		
Overall percentage (%)	60%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	July 2023

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);
ii. permission is granted for the candidate in include the publication in the thesis; and
iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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3.3 Manuscript on Sources and determinants of free sugars intake by five-year-old Australian children in the SMILE Cohort

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Short title: Free Sugars intake in SMILE cohort at 5 Years

Acknowledgements: The authors thank all the children and mothers in the cohort for their cooperation with the study. The authors also acknowledge the South Australian Dental Services for support during the fieldwork, and Drs Le and Vu for the use of their clinics. The SMILE research support staff are gratefully acknowledged.

Financial Support: The SMILE study was supported by a National Health and Medical Research Council Project Grant # 1046219 (2013-2017) and #1144595 (2018-2022).

Conflict of Interest: There are no conflicts of interest to declare.

Authorship: The study was conceptualized by the SMILE team (G.D, L.D, D.H, J.A.S, R.G, and LKB); Data collection, initial analysis, software, methodology, validation: G.D, L.D, L.B, R.G, D.H, J.A.S; Funding acquisition, D.H., L.D. and J.A.S; Supervision, P.M, L.D, L.G.; Statistical analyses of the age 5 data: L.G, A.I; Writing—original draft, A.I as a part of her PhD studies with substantial contributions from, P.M, L.G. L.D, Writing- review and editing: P.M, L.D, L.G, G.D., R.G., D.H, L.B and J.A.S.

Ethical Standards Disclosure: This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by The Southern Adelaide Clinical Human Research Ethics Committee (HREC/50.13, approval date: 28 Feb 2013) and the South Australian Women and Children Health Network (HREC/13/WCHN/69, approval date: 7 August 2013). Written informed consent was obtained from all participants.

Abstract

Objectives: Reducing free sugars intake is important for the prevention of dental caries and obesity in children. This study aimed to determine the amount and sources, and identify sociodemographic determinants, of free sugars intake by children aged 5 years.

Design: Cross-sectional analysis of dietary data from a cohort study, collected using a customized food frequency questionnaire. Free sugars intake was calculated as grams/day and percentage contribution to Estimated Energy Requirement (EER). The percent contribution of food sources to free sugars intake was derived. Sociodemographic determinants of achieving intakes within WHO thresholds (i.e. <5% and <10% EER) were explored with multinomial logistic regression.

Setting: Australia.

Participants Children aged five years

Results: Complete data were available for 641 children (347 boys, 294 girls). Median (IQR) free sugars intake (g/day) was 31.6 (21.3 - 47.6) in boys and 28.1 (19.6 - 47.9) in girls. The median (IQR) percentage contribution to EER was 7.9 (5.4- 12.7); 21% and 42% of children had intakes <5% EER and between 5-<10% respectively. The main sources of free sugars were: (1) Cakes, Biscuits and Cereal Bars; (2) Sweetened Milk Products and (3) Desserts. Maternal university education, single-parent household, and maternal place of birth being Australia or New Zealand were associated with free sugars intake <5% EER.

Conclusions: Less than a quarter of children achieved free sugars intake <5% EER. Cakes, Biscuits and Cereal Bars, and Sweetened Milk Products were the leading sources. Strategies to lower free sugars intake should target priority populations such migrants and populations with lower levels of education or health literacy.

Keywords: free sugars intake; food frequency questionnaire; food sources; sociodemographic determinants; early childhood

Introduction

There is evidence that intake of free sugars is a risk factors for overweight and obesity and is a direct cause of dental caries (i.e. tooth decay) [1-3]. In 5-9-year-olds, in Australia, approximately one quarter of children are overweight (17%) or obese (7%) [4] and nearly half (42%) children experience dental caries [5, 6]. Reducing the intake of free sugars is important for the prevention of dental caries and excess weight gain [2, 7, 8]. In order to develop dietary interventions to lower the intake of free sugars, information on the amount, sources and social determinants of free sugars intake in children is essential.

The World Health Organization (WHO) recommends limiting the intake of free sugars to less than 10% energy intake (EI) and preferably to below 5% to protect oral health throughout the life course [9]. Free sugars include all monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, fruit juices and fruit juice concentrates [9]. Free sugars make a sizeable contribution to total dietary sugars [10]. Total sugars include free sugars and the sugars naturally present in whole fruits, vegetables and milk [10]. Free sugars intake in children exceeds the WHO recommended thresholds in many countries. For instance, in the United Kingdom (UK) and Lebanon, free sugars contributed to an average 12% of EI in children aged < 10 years [11, 12], 14% EI in 2-5 year old children in the USA[13] and Japan [14], 16% in French[15] 3-6 year old children and 27% in German pre-school children [16]. The most recent national survey in Australia in 2012 showed that children (4-8-year-old) obtained 14% EI from free sugars [17].

Socio-demographic factors have been shown to influence food intake, including intake of free sugars. Data on the specific sociodemographic factors that determine amount and sources of free sugars intake are available from UK [11], Japan [14], some European Countries [16, 18], Canada [19] and Latin American countries [20] showing that education, income and family composition are key determinants of free sugars intake in children. Data are also available from the 2012 Australian national survey, showing that children from families living with disadvantage consumed greater amounts of free sugars [17]. However, these data do not provide information on sociodemographic factors associated with achieving intakes of free sugars within the WHO recommended thresholds. The sources of free sugars intake are diverse and change rapidly as children age. Information on the sources of free sugars intake is important for informing dietary intervention. For dental caries prevention, it is important to restrict the foods and drinks containing free sugars, especially those that tend to be consumed between meals, when salivary flow is relatively low (e.g. sugar-sweetened beverages (SSB), confectionery, biscuits, cakes and cereal bars, and dried fruits) [8]. In the UK [11], USA [13], European countries [16] and Mexico [21]

recent studies have shown that children obtain a large proportion of free sugars from SSBs including sweetened juices. Further, cakes, biscuits, cereal based products and confectionery were the leading contributors of free sugars intake by children in Portugal [18], Lebanon [12] and China [21]. The 2012 national data on the dietary sources of sugars in Australian 2-17-year-olds showed that added sugars were sourced from soft drinks, confectionery and cakes [17]. However, as diet in early childhood impacts on the longer-term risk of dental caries [22] it is important to have specific data on the level of intake, sources and determinants of free sugars intake to guide early intervention for caries prevention.

The SMILE (Study of Mothers' and Infants' Life Events Affecting Oral Health) cohort includes 2181 infants recruited at birth in Adelaide, South Australia. The SMILE cohort study aims to understand the critical factors that influence oral health and to gain knowledge on the link between diet, sociodemographic factors and oral health in early life. Participants were followed up at 3 and 6 months and at 1, 2 and 5 years of age [23]. Previous analysis [23-26], based on the Food Standards Australia and New Zealand Nutrient (AUSNUT) database codes [27] showed that infant foods and cereal-based snacks like biscuits were the leading sources of free sugars intake at 12-14 months [25] and beverages, cakes and biscuits at two years of age [24]. At one year of age, free sugars contributed 3.6% of the Estimated Energy Requirement (EER) and 8% EER at 2 years of age. Household disadvantage and low income were associated with exceeding the WHO recommended threshold for free sugars intake at both one and two years [23-26]. Furthermore, at two years, maternal place of birth, maternal age and number of siblings were determinants of free sugars above the WHO recommended thresholds [24]. By age five years, children begin to explore wider food and drink choices and the amount, sources and social determinants of free sugars may therefore change.

The aim of this paper is to report the amount, sources and determinants of free sugars intake by the SMILE study participants at age five years. The objectives were to: (1) estimate the amount of total and free sugars intake; (2) determine the percentage contribution to free sugars intake of groups of foods known to contribute to dental caries (e.g. foods high in free sugars that tend to be consumed between meals); and (3) identify the key sociodemographic factors associated with intakes of free sugars within the WHO recommended thresholds.

Methods

Details of the SMILE birth cohort have been described previously [23-26]. In brief, 2181 mother and newborn dyads were recruited in Adelaide, South Australia in 2013/2014. Sociodemographic data were collected at baseline. Dietary data were collected for the children at ages 1, 2 and 5 years.

Collection of dietary data at age 5 years

Dietary data were collected from 733 participants in 2019 at child age five years using the 98 item SMILE Food Frequency Questionnaire (SMILE-FFQ) [28]. In this questionnaire, six options were provided to answer the question on frequency of intake of each listed item- ranging from 'never/rarely' to 'once every two weeks', 'once per week', '2-3 times/week', '4-6 times/week', '1-2 times/day' and 'three times per day'. For the question on portion sizes, options were provided to report the weight/volume along with the appropriate household measures (tablespoons, teaspoons, cups, scoops etc.).For each participant, the responses to the SMILE-FFQ were exported into a Microsoft Access database containing food composition tables adapted from the Australian Food, Supplement and Nutrient (AUSNUT) database [27]. The AUSNUT database provides information on the amount in grams of total and free sugars per 100-gram edible portion of different foods and drinks. The participant responses to the SMILE-FFQ were matched with the foods in the AUSNUT database in order to derive an estimate of usual total and free sugars intake per participant in grams per day.

Calculation of the percentage of energy requirement obtained from dietary sugars

The height and weight of each child were measured at age five years during a study visit to collect dental data. These data were used to estimate the energy requirement of each child using the US Institute of Medicine (IOM) equation [29]. A Physical Activity Level (PAL) of 1.6 (light activity) was assigned to all participants in accordance with previous analyses [24]. This was based on the median value for PAL calculated from activity data reported by approximately 27% of the SMILE sample [30]. Children with no available anthropometric data were split by gender and the median EER of the study group for the corresponding gender was assigned [30, 31] . For each child, EI from total and free sugars (grams of intake x 16.7 Kilojoules) was calculated and this figure was divided by EER and multiplied by 100 to give the percentage of EER provided by total and free sugars [31].

The percentage contribution of food sources to free sugars intake

The intention of this study was to determine the sources of free sugars intake from the perspective of dental health. Thus, although the grouping of foods for these analyses was informed by the AUSNUT food grouping classification system (reference), the cariogenic potential of food items/groups informed modifications to the food group categories and labels. For example, distinguishing foods which tend to be consumed between meals from those consumed with meals, distinguishing dried fruits (cariogenic) from nuts (non-cariogenic). Table 3.3 defines the food groups used in this analysis and how these differed from the AUSNUT food codes used in Australia. For each child, the grams of free sugars obtained from each food source was calculated as a percentage of their overall usual free sugars intake. Subsequently, the percentage contribution of each food source to free sugars intake were derived for the study population as a whole and for 'consumers only'. 'Consumers' of a food group were defined as those participants who reported any valid response other than "never or rarely" in the SMILE-FFQ, for at least one item within the food group.

Sociodemographic data

Sociodemographic data collected at baseline included child age and sex, maternal age, maternal education, mother's country of birth, number of children in the family and family composition (one-parent or two-parent) and postcode from which the Index of Relative Socioeconomic Advantage or Disadvantage (IRSAD) was derived [(24)].

Statistical analyses

The distribution of total and free sugars intake was assessed as a first step. In line with earlier assessments at two years of age [(24)], those individuals with total or free sugars values that exceeded the 95th percentile were excluded from subsequent analysis which resulted in a dataset of 688 participants. Of these, sociodemographic data were available for 641 participants. Descriptive statistics (frequencies, percentages, mean, standard deviation (SD), median, interquartile range (IQR)) were derived for sociodemographic variables, total and free sugars intake, as appropriate. Children were classified according to their percentage EER obtained from free sugars intake into the following categories: (1) <5% EER, (2) 5-<10% EER (children meeting the WHO recommended thresholds), or (3) ≥10% EER (children exceeding the WHO recommended thresholds).

The sociodemographic factors were investigated as determinants of lower free sugars intake (<5% EER, and 5-<10% EER) through multinomial logistic regression models that were fit using STATA 17.0 (Stata Statistical Software: Release 17. College Station, TX: StataCorp

LLC). An analysis dataset (n=641) with complete data for all variables of interest was used for statistical analyses for these statistical models. All sociodemographic variables were included in the initial logistic regression model as explanatory variables, and retained in the final model if the corresponding overall P-value was <0.2. The reference group was children with a free sugars intake ≥10% EER. The results were expressed as relative risk ratios (RRR) with associated 95% Confidence Intervals (CI). Mother's age, education, country of birth, family size and family composition (single-parent or dual parent) were retained as the explanatory variables.

Results

Participant characteristics

The baseline participant characteristics (n=688) are presented in Table 3.1. A large proportion of the mothers were in the 25-34 years age group and two-thirds of the mothers in this cohort attained University education or above. About half of the children had no siblings and less than 5% children belonged to single-parent households at the time of their birth.

Data on Sugars Intake

Data for intake of total and free sugars were not normally distributed (Table 3.2). The median total and free sugars intake were 72.6 g/day and 29.5 g/day respectively. Children obtained a median 7.9% EER from free sugars. The data showed no statistically significant differences between boys and girls for intake of sugars and the percentage contribution of total and free sugars to the EER. About one fifth of children (21%) achieved the WHO recommendation for the lower threshold of free sugars intake (<5% EI), 42% had free sugars intake between 5 and <10% EI, and 37% children exceeded the WHO recommendation to limit free sugars intake to less than 10% EI.

The contribution of food sources to free sugars intake

The percentage contribution from each food group and sub-group to free sugars intake for the study population as a whole and for consumers only is presented in Table 3.4. The principal food sources were: (1) Cakes, Biscuits and Cereal Bars, (2) Sweetened Milk Products (Milk-based drinks, and yoghurts), and (3) Desserts. Collectively these food groups accounted for 52% of all free sugars intake (based on the medians for the group).

Sociodemographic determinants of free sugars intake within the WHO recommended thresholds

Complete data for the regression analyses were available for 641 participants. The results of the multinomial regression analyses (Table 3.5) showed that children belonging to single parent households were more likely to have a free sugars intake < 5% EER compared with children from two-parent households. Children born to mothers who attended university were more likely to have free sugars intake < 5% EER or between 5-<10% EER than children born to mothers who did not have higher education. Relative to Australian and New Zealand born mothers, children born to mothers who immigrated from India, other Asian countries, and other countries were less likely to consume <10% EER from free sugars. Children belonging to families with more than three children were less likely to consume <5% from free sugars compared with single-child families.

Discussion

This study aimed to determine the amount and sources of free sugars intake in 5-year-old children belonging to the SMILE cohort, and to identify the key sociodemographic determinants of achieving the recommended WHO thresholds for intake of free sugars. It was found that the median free sugars intake was 29.5 grams/day and the median percentage contribution to EER was 7.9%. In this study, 21% and 42% of children had free sugars intake less than 5% EI and 5-<10% respectively. The principal sources of free sugars intake were: (1) Cakes, Biscuits and Cereal Bars, (2) Sweetened Milk Products (predominantly yoghurts) and (3) Desserts. Mother's level of education (University level), family composition (single parent households) and mother's ethnicity (being born in Australia and New Zealand) were the factors associated with a lower intake of free sugars intake by children.

The median percent contribution of free sugars to EER (7.9%) in the current (2019) study is lower than that reported for older 4-8-year-old Australian children (14%) in 2007 [32], 2-6 year old European children in 2007/8 (18%) [16], and 3-6 year old French children in 2019 (16%) [15]. The absolute intake of free sugars (29.5 grams/day) in the current study is lower than the intakes reported for 2-6-year-old children in Europe [16] and 5-9 year old children in Portugal (44 grams/day) [18]. In the current study, 63% children achieved the WHO recommended threshold to limit free sugars to <10% EI. This is higher when compared to findings from an analysis of the data from the 2007 Australian National Children Nutrition and Physical Activity Survey which showed that more than 80% of 4-8-year-old Australian children exceeded this threshold [32]. This difference in intake of free sugars may be explained by differences in study

methodology or temporal trends as a result of increased public awareness about the harmful effects associated with the intake of sugars [17] and product reformulation efforts that have received media attention in recent years [33].

Results from the present analysis showed that Cakes, Biscuits and Cereal Bars were the leading contributors (median 23.5%) to free sugars intake. This figure is higher when compared with the reported proportion of free sugars obtained from cakes, muffins, scones and cake-type desserts (11.3%) and sweet biscuits (5.6%) by 4-8-year-old Australian children, in the 2011-12 national survey [32]. However, the inclusion of cereal bars in this food grouping in the current analysis may account for the difference. The current data are, however, similar to the reported intake of free sugars from biscuits, cakes and pies in American 2–5-year-old children (20%) [34] and the UK 4–10-year-old children (23.5%) [11]. In the current study Sweetened Milk Products, predominantly yoghurts, contributed a median 12% to free sugars. This is similar to the results from a survey of 5-9-Year-old Portuguese children (12% from sweetened yoghurts) [18] and 2-5-year-old American children (12.3% from sweetened milk) [34]. In the present analysis breakfast cereals contributed a median of only 0.2% to free sugars. This is considerably lower than the proportion of free sugars from ready to eat breakfast cereals (3.8%) by 4-8-year-old Australian children reported in the earlier survey [17, 32] however, cereal and breakfast bars were included in this food category in this survey. The current value is also much lower than that for UK 4-10-year-old children (34%) [11], and Portuguese 5-9-year-old children (10.3%) [18]. The current study results indicate that children are exposed to hidden free sugars in baked goods and sweetened yoghurts at an early age.

The contribution of beverages (median 6.7%) to free sugars in the current study is very low when compared with the proportion of free sugars contributed by beverages (34%) in 4-8-year-old Australian children, reported in the 2011-12 survey [17, 32]. Sugar sweetened beverages (SSBs) including cordials, soft drinks, frozen drinks, flavoured water and juices contributed a median 1.5% to free sugars in the present analysis. In contrast, SSBs were the leading contributors to free sugars in, 2-5 year old children in Lebanon (36%) [12], Europe (51%)[16] and the USA (20%) [34]. When compared with the results from the 2011-12 National survey, the findings may suggest that there is a decline in the consumption of SSBs in Australia. It has been suggested that the public in Australia are more health conscious and therefore avoid SSB intake [17]. In the present study, intake from SSBs could have been underreported by the mothers as they were aware of the upcoming dental survey. Moreover, the data from the 2011-12 National survey are more than 10 years old.

In line with the current findings, the results from a meta-analysis on SSB intake in countries with high dietary-related burden of disease showed that the SSB intake in 2-18-year olds in Australia was the lowest in the world [35]. The policies in Australia around limiting the marketing of SSBs to children and increasing access to drinking water [36] may help explain the results on the low contribution of beverages to free sugars intake. Wider adoption of such strategies in other countries where SSB intake is higher may lead to significant reductions in free sugars intake. In recent years, there has been a global focus on SSB taxation as a means of reducing sugars intake. Based on the current information on the main contributors to sugars intake at age 5, targeting the intake of biscuits, cakes and sweetened milk products through reformulation efforts and health education may have more impact on lowering free sugars intake. Recent data from the UK [37] on the progress of sugars reduction and product reformulation show that there was an overall 3.5% reduction in the total sugar per 100g (sales weighted average) in products sold between 2015 and 2020, with larger reductions in specific products like yoghurts (14%) among other foods, These data support the efficacy of reformulation programmes in lowering intake from specific food sources known to contain high free sugars.

The finding from the present study that maternal education was a significant determinant of free sugars intake within the WHO thresholds in children concurs with previous finding from a study of Lebanese children [12] which showed children of mothers who attained a higher level of education consumed less free sugars. These findings also align with the results from a systematic review on determinants of beverage intake, which showed that lower parental education is associated with higher intake of SSBs in children [35, 38]. The current study finding that children of mothers classified as being born in *India*, or *Other Asian Countries* were less likely to achieve the WHO recommended thresholds for intake compared to children of mothers born in Australia and New Zealand confirms the findings observed for the study cohort at aged 2 years [24]. Cultural influences, feeding practices by mothers from different ethnic backgrounds, and a shift in dietary patterns after migration to a different country possibly explain the results of the present analysis [39]. Furthermore, this finding from the present study aligns with the results of studies on changes in diet after migration which reported an increase in intake of SSBs, refined foods and a substantial increase in energy intake in South Asians [39]. However, an improved understanding of the ethnic and cultural factors affecting the food and drink intake by children from families who migrate from India and other Asian countries to Australia will help provide more support to such families with respect to health education and provision of healthy environments to live in.

In the present analysis, despite the finding that higher maternal education, often considered a proxy for socioeconomic status (SES), was associated with children achieving the threshold of free sugars intake, there was no difference between sugars intake based on the IRSAD classification. In alignment with this observation, data from the UK [10, 11] show sugars intake not to vary by social groups based on income and occupation. However, several other countries do report SES differences [13-16, 24]. The finding from the present analysis is suggestive of an early exposure of children belonging to all SES groups to free sugars, and therefore highlights the need for an early nutrition intervention for all children.

It was found that children born into single-parent households (4.7%), were more likely to achieve the WHO recommended thresholds in the present study. This finding contrasts with earlier data from Australia, which showed being in a single-parent environment was associated with increased intake of SSB by children [40, 41]. The Labour Force Status of Families in Australia reports a growing number of single-parent households. More than half of one-parent families (51.5%) had a youngest dependent aged 0–9 years and 72% had an employed mother at dependent age 5-9 years [42]. These data are suggestive of a changing population dynamic. Perhaps being in a single parent family is no longer a proxy for a lower socioeconomic status [41]. Though from a small sub-sample, the finding from the present study is suggestive of the need to explore further about the factors that influence eating habits of children belonging to one-parent families.

Limitations

There are several limitations to the study which are acknowledged. First, a retrospective questionnaire was used to collect dietary data, therefore recall bias cannot be ruled out [43, 44]. However, the SMILE-FFQ was previously validated as a tool to assess sugars intake against the multiple pass 24-h method with acceptable comparability [28]. Second, mothers were aware about the follow up investigations including oral examinations which were conducted as a part of the wider study. Therefore, it is possible data were subject to bias of social desirability [45] resulting in an over or underreporting of the intake of certain foods and drinks. Third, as EI could not be derived from the dietary assessment instrument, the analysis used the estimated EER of the child and not their EI to estimate the contribution of sugars to EI which will affect the accuracy of the data. The median EER was attributed to participants with missing anthropometric data (7.5%) which could have resulted in an over or underestimation of contribution of free sugars intake to EER in these participants. However, use of EER is a recognised proxy for EI to apply in situations where EI cannot be derived [24, 25] and EER was derived using well-established methods [30, 46-48]. The observed attrition rates from the SMILE Cohort study are comparable with other research studies and during recruitment, participants

from the socially disadvantaged areas were oversampled to address a possible loss to follow up [23].

Future directions

The current study has shown that the intake of free sugars in this cohort study of 5-year-old children remains higher than the WHO lower threshold for the majority of children, indicating that while intervention efforts to lower intake may be having a positive impact, sustaining and enhancing interventions remain a priority. The findings of the current analysis contribute to disentangling the factors that are associated with achieving recommended thresholds on sugars intake. Such information is useful in informing health promotion and public health nutrition interventions. In addition, future research should develop and evaluate interventions to lower sugars consumption provided by the hidden sugars in baked goods, sweetened milk products, and desserts, for example through exploring impacts of product reformulation [33] and through targeted health promotion [49]. Qualitative research including focus group discussions with parents, especially mothers, of young immigrant children could lead to the generation of an evidence-base on the factors that inform dietary choices in this specific community.

Conclusion

The WHO conditional recommendation to limit free sugars to below 5% EI aims to protect dental health throughout the life course. From the current findings, it can be concluded that Australia has some way to go to reach this recommendation. Cakes, Biscuits and Cereal Bars, Sweetened Milk Products and Desserts were the principal contributors to free sugars intake. The current findings would support interventions that work with priority populations such as migrants and those with lower education or health literacy.

Table 3.1: Characteristics of the SMILE study participants

Characteristic	Mean	SD	n	%	Range
Child age (years)	5.4	0.3	688		4.0-6.9
Gender					
Boys			380	55.2	
Girls			308	44.8	
Mother education					
School/vocational education			258	37.5	
University education and higher			423	61.5	
Missing			7	1.0	
Mother age (years)	30.8	5.0			
Mother age					
< 25 years			55	8.0	
25-34 years			461	67.0	
≥ 35 years			153	22.2	
Missing			19	2.8	
Number of children in the family					
1 child			338	49.1	
2 children			242	35.2	
>= 3 children			86	12.5	
Missing			22	3.2	
Family composition					
Single parent household			32	4.7	
Two parent household			650	94.5	
Missing			6	0.9	
Mother country of birth					
Australia or NZ and UK			510	74.1	
Asia except India			67	9.7	
India			56	8.1	
Other Countries			47	6.8	
Missing			6	0.9	
Index of Relative Socio-economic Advantage or Disadvantage (IRSAD)					
Quintile 1 (most disadvantaged)			99	14.4	
Quintile 2			132	19.2	
Quintile 3			149	21.7	
Quintile 4			127	18.5	
Quintile 5 (least disadvantaged)			173	25.1	
Missing			8	1.2	

Table 3.2: Total and Free Sugars Intake (grams/day) and percentage contribution of total and free sugars to EER (n=68

Variable	Median	IQR	Mean	SD
Total Sugars (g/d)	**72.6**	**53.8-100.9**	**79.0**	**34.3**
Boys	72.1	55.3-100.4	79.7	33.4
Girls	74.2	51.0-105.0	78.0	35.4
Free Sugars (g/d)	**29.5**	**20.3-48.0**	**35.7**	**21.5**
Boys	31.6	21.3-47.6	36.4	21.0
Girls	28.1	19.6-48.0	34.9	22.0
Percentage Contribution of Total Sugars to EER (%)	**19.3**	**14.0-27.2**	**21.0**	**9.3**
Boys	18.7	14.0-26.0	20.5	8.7
Girls	20.0	14.1-28.8	21.6	9.9
Percentage Contribution of Free Sugars to EER (%)	**7.9**	**5.4-12.7**	**9.5**	**5.8**
Boys	8.0	5.4-11.9	9.3	5.4
Girls	7.8	5.3-13.2	9.7	6.2

Table 3.3: Cariogenic food groups defined in the present analysis, variation from AUSNUT food groups and rationale for food grouping

Cariogenic food group	Sub-groups	Food items included in each Group/sub-group, with the AUSNUT Item ID	Variation from AUSNUT food Groups used in National Food Surveys[17]	Rationale for food grouping
Cakes, biscuits and cereal bars	Cakes and pastries	Cakes, Muffins, Slices, Doughnuts and Puddings (133) Sweet Bread and Pancakes (136) Sweet Pastry (134)	None	-
	Biscuits	Plain, Sweet Biscuits and Wafers (131) All Other Sweet Biscuits and Cookies (131) Meringue or Honeycomb (273)	In AUSNUT national surveys, savoury biscuits are included in 'Biscuits'. In this analysis only sweet biscuits were included in this group.	To enable the contribution of savoury foods to free sugars intake to be determined as a distinct group. This was to provide information on the contribution of savoury foods, including savoury biscuits, to free sugars intake. This will inform on hidden sugars in savoury foods.
	Cereal bars	Cereal bars (283) Cake or Muffin Bars and Muesli Bars (283)	In AUSNUT national surveys, cereal bars are included in 'Confectionery'. Here, Cereal bars included with Cakes, Biscuits to create a cariogenic food group comprising sweet baked foods.	To create a group comprising cereal-based foods that contain free sugars and tend to be eaten in-between meals. Important to look at sources of sugars consumed in-between meals (when more cariogenic) distinctly.
Sweetened Milk Products	Milk based drinks and alternatives	Condensed Milk (191) Evaporated Milk (191) Flavoured Milk (198) Flavoured Milk Alternatives (202) Regular Milk Alternatives (plain, unflavoured) (201) Junior Formula (321) Drink Powder: fortified (118) Drink Powder: Regular (118)	Named the group 'Sweetened milk products'. In AUSNUT national surveys these foods were grouped in 'Milk products and dishes'	To enable the contribution of sweetened milk products like yoghurts and flavoured milk to be determined as a distinct group. This will inform on hidden free sugars.
	Sweetened Yoghurts	Children's Yoghurt: (32303) Fruit Flavoured Yoghurts: regular and reduced fat (192) Any Other Flavoured Yoghurt: regular and reduced fat (192) Probiotic Yoghurt Drinks (192) Yoghurt Alternatives: Flavoured and plain (205)		
Desserts	Non-frozen desserts	Regular Custard: Plain or Vanilla in pouches/home cooked (196/197) All Other Kinds of Flavoured Custard and Custard-like Desserts Other milk-based desserts e.g. pudding (273) Jelly (195)	Created a food group called 'Desserts' (which does not exist in AUSNUT national surveys).	Desserts are potentially a major contributor to free sugars intake. Distinct group enables estimation of impact of limiting desserts on free sugars intake.

	Frozen, milk-based desserts	Ice cream and frozen yoghurt (204) Ice Cream Alternatives and Other Frozen Milk Alternatives (273)		
	Frozen, non-milk desserts	Icy Poles and Sorbet (273)		
Beverages	Sugar-sweetened beverages (SSB)	Soft Drinks (115) Frozen Drinks (117) Water: Lightly Flavoured, Clear (32401) Junior Juice (113) All Other Fruit Juice or Fruit Juice Drinks and Vegetable juice (114) Cordial: All Other Types (113)	SSB formed a distinct sub-group of beverages. In AUSNUT national surveys SSB are grouped with other non-alcoholic beverages.	To enable comparison with internationally published data on sugars from SSB.
	100% Fruit Juice	No added sugar:100% fruit juice (111)	100% fruit juice was assessed as a distinct sub-group. In AUSNUT national surveys 100% fruit juice is grouped with other non-alcoholic beverages	To enable the contribution to free sugars from 100% fruit juice to be assessed separately to highlight the contribution to free sugars intake. Some food-based dietary guidelines permit one portion of 100% juice to contribute to fruit and vegetable goals. Therefore, important to determine the impact of this advice on free sugars intake.
	Tea and Coffee	Tea: From Leaves (111) Tea: Powder/Syrup/Pre-made (112) Coffee (114)	Tea and coffee assessed as a distinct group. In AUSNUT national surveys tea and coffee are grouped in non-alcoholic beverages.	To enable the contribution of sugars/syrups added to tea, coffee to be determined.
	No added sugar beverages	Sugar free cordials and soft drinks (115)	No added sugars drinks assessed as a distinct sub-group. In AUSNUT national survey sugar free beverages are grouped in non-alcoholic beverages	'No added sugar' drinks may contain free sugars (from juice fruit). A distinct sub-group enables contribution of 'no added sugar' drinks to free sugars intake to be determined. Defining this group is helpful in educating parents that such beverages contain free sugars and are cariogenic.
Confectionery	Chocolate confectionery	Chocolate or Carob: All Types (284)	This group excludes 'muesli/ cereal style bars' which are included in the group 'Cakes, biscuits and cereal bars' group. In AUSNUT national surveys cereal bars are grouped with confectionery	To enable the distinct contribution of chocolate confectionery and candies (lollies, sweets) to be determined and compared with international data
	Candies	Lollipops, mints, toffees, candies, liquorice, marshmallows, gummies (284)		
Breakfast cereals		Porridge or Other Hot Cereal (125) Wheat Biscuits (breakfast cereals in 'biscuit' shapes): Plain (125) Puffed, Unflavoured Cereal (125) Muesli, toasted/ untoasted (125) Cereal Flakes (125) Flavoured Breakfast Cereal (125)	Named this group 'Breakfast cereals'. In AUSNUT Breakfast cereals are grouped in 'Cereals and cereal products' group along with 'English-style muffins, flat breads, savoury and sweet breads'; 'pasta', 'plain bread', 'flours and other cereal grains and starches'.	From a cariogenicity perspective it is important to determine the overall contribution of breakfast cereals to free sugars intake

Sugar and syrups	Table sugar	Sugar: Solid or Granulated - regular table sugar, white, brown, raw, palm and date sugar (271)	Excludes jam, lemon and chocolate spreads	To distinguish sweeteners that are added to foods by consumer (i.e. table sugar, honey and sugar syrups) from spreads that tend to be consumed on bread. Dietary advice for dental health would be distinct for these two categories of sweet food.
	Honey and sugar syrups	Honey (271) Sugar: Syrups Other Than Honey. E.g. agave, maple, golden syrup, corn or rice syrup (271) Dessert Toppings (271)		
Savoury Snacks and Crackers		Plain Savoury Biscuits or Crackers (132) Flavoured Savoury Biscuits or Crackers (132) Savoury Snack Foods (26)	Created this food group which is not included in AUSNUT national surveys	To enable the contribution of savoury foods to free sugars intake to be determined as a distinct group. This was to provide information on the contribution of savoury foods, including savoury biscuits, to free sugars intake. This will inform on hidden sugars
Spreads and sauces	Sweet spreads	Nut Paste: peanut butter, almond spread, cashew paste etc. (222) Chocolate or Carob Spread-With or without nuts (272) Jam, Marmalade and Other Fruit Spreads (272)	Created the food group Spreads and sauces, and the sub-categories 'sweet spreads' and 'savoury sauces and condiments'. Sweet spreads include Jam and lemon spreads, chocolate spreads, sauces. In the AUSNUT national surveys, jam, lemon and chocolate spreads are included in the 'Sugar products and dishes' group and savoury sauces and condiments are included in the 'Sauces, dips and condiments' group.	Spreads contain free sugars and tend to be consumed with bread, increasing cariogenicity. Savoury sauces and condiments contain hidden sugars. Information on contribution of these distinct categories to free sugars intake will inform dietary advice for caries prevention.
	Savoury sauces and condiments	Tomato or Barbecue Sauce (231) Sweet Marinades and Sauces (231) Mayonnaise (233) Chutney or Relish (232)		
Processed fruits and nuts	Processed fruit	Coated dried fruit (281) Tinned, stewed and pureed fruit (16) Fruit Flavoured Snacks (282)	Created the group 'Processed fruits and nuts' and the sub-categories 'processed fruit' and 'coated nuts'. In AUSNUT national surveys processed fruit is included in the 'fruit products and dishes' group and coated nuts is included in 'nuts and nut products' group.	To create a category of cariogenic foods that tend to be consumed by children between meals. The subgroups enable the distinct contribution of 'coated nuts' and 'processed dried fruit' to free sugars to be determined. Processed dried fruit is potentially cariogenic, whereas nut consumption (through salivary stimulation) may protect against caries.
	Coated nuts	Coated nuts (281)		

Table 3.4: Percent contribution of food sources to free sugars intake by five-year-old children in the SMILE study (whole sample, n=688, and in consumers only)

	All Participants (n=688)				Consumers Only				
Food sources	**Median%**	**IQR**	**Mean%**	**SD**	**Median%**	**IQR**	**Mean%**	**SD**	**n**
Cakes, biscuits, cereal bars	**23.0**	**12.6 – 3.4**	**24.9**	**15.7**	**7.0**	**3.9 – 12.3**	**25.9**	**15.1**	**660**
Cakes and pastries	11.8	4.3 – 21.1	14.3	12.4	4.1	1.9 – 8.3	16.8	11.8	583
Biscuits	4.1	1.4 – 9.0	6.6	6.5	1.8	0.7 – 3.6	7.9	7.3	582
Cereal bars	0.8	0.0 – 5.4	3.9	6.4	1.6	0.8 – 3.3	7.5	7.3	356
Confectionery (Candies and chocolates)	**6.4**	**2.9 – 12.3**	**9.0**	**9.5**	**7.5**	**4.2 – 13.3**	**10.3**	**9.5**	**603**
Chocolates	3.1	0.8 – 6.6	5.1	7.1	4.5	2.3 – 8.1	6.6	7.4	531
Candies	2.0	0.0 – 5.4	3.9	5.7	4.5	2.5 – 8.2	6.4	6.0	427
Sugar and syrups	**3.2**	**0.0 – 11.6**	**8.0**	**11.7**	**7.1**	**2.8 – 15.8**	**11.7**	**12.5**	**472**
Table sugar	0.0	0.0 - 0.7	1.4	4.0	3.0	1.4 – 6.5	5.1	6.1	197
Honey and sugar syrups	1.4	0.0 – 8.6	6.5	11.0	6.6	2.4 – 15.1	11.0	12.5	409
Desserts	**8.1**	**3.2 – 15.0**	**10.5**	**16.1**	**9.0**	**4.6 – 15.9**	**11.9**	**9.9**	**606**
Non-frozen milk-based desserts	0.0	0.0 – 2.4	2.2	5.6	3.2	1.5 – 5.8	5.4	7.6	286
Frozen, milk-based desserts	3.3	1.2 – 7.2	5.4	6.5	4.7	2.5 – 8.7	6.9	6.5	539
Frozen, non-milk desserts	0.0	0.0 – 4.0	2.9	5.1	4.9	2.3 – 6.8	5.8	5.9	342
Spreads and sauces	**6.6**	**2.4 – 13**	**9.6**	**10.4**	**7.2**	**3.0 – 13.7**	**10.2**	**10.5**	**647**
Spreads	2.6	0.3 – 7.3	5.2	7.4	3.8	1.3 – 8.8	6.5	7.8	559
Sweet sauces	0.0	0.0	0.3	1.4	1.1	0.6 – 2.0	2.1	3.0	110
Savoury sauces and condiments	1.8	0.5 – 5.0	4.0	6.9	2.5	1.0 – 5.7	4.6	7.1	597
Sweetened Milk Products	**12.0**	**4.1 – 24.4**	**16.5**	**16.1**	**13.7**	**6.0 – 26.8**	**18.5**	**16.0**	**615**
Milk based drinks and alternatives	0.5	0.0 – 2.9	2.8	6.6	2.7	1.2 – 5.3	5.2	8.3	373
Yoghurt	9.2	1.4 – 20.7	13.7	15.1	12.5	5.8 – 24.4	17.4	15.1	544
Beverages	**6.7**	**0.0 – 15.5**	**10.8**	**12.8**	**10.9**	**5.6 – 20.5**	**14.8**	**12.9**	**503**
Sugar sweetened beverages	1.5	0.0 – 9.1	6.4	10.1	8.5	4.6 - 15.9	12.3	11.1	357
100% Fruit juices	0.0	0.0 – 4.4	4.2	9.0	6.9	3.8 - 15.7	11.6	11.8	247
Tea and coffee	0.0	0.0	0.2	1.6	7.5	3.4 - 11.8	9.4	8.8	12
No added sugar beverages	0.0	0.0	0.1	1.8	0.3	0.1 - 0.6	2.0	8.2	33
Savoury snacks and crackers	**0.9**	**0.4 – 1.6**	**1.3**	**1.9**	**1.0**	**0.5 - 1.8**	**1.4**	**1.5**	**652**
Breakfast cereals	**0.2**	**0.0 – 1.1**	**1.1**	**2.4**	**0.9**	**0.35 - 2.1**	**1.8**	**2.8**	**419**
Processed fruits and nuts	**0.0**	**0.0 – 4.3**	**0.9**	**2.5**	**1.0**	**0.8 – 4.0**	**3.1**	**3.9**	**188**
Processed fruit	0.0	0.0	0.7	2.1	1.5	0.7 - 3.5	2.8	3.6	166
Coated nuts	0.0	0.0	0.2	1.0	1.5	0.7 - 3.5	2.9	3.1	45

Table 3.5: Participant characteristics associated with child achieving the recommended threshold of free sugars intake (<5% EER and 5- <10% EER)

Variable	Free Sugars <5% EER RRR [3](95% CI)	Free Sugars 5- <10% EER RRR (95% CI)
Mother age[4]	0.99 (0.95, 1.04)	0.97 (0.94, 1.01)
Mother education		
School/vocational education (referent)	1	1
University education and higher	1.50 (0.94, 2.42)	1.60 (1.07 , 2.31)
Family size (Number of children in the family)		
1 child (referent)	1	1
2 children	0.69 (0.43, 1.12)	0.84 (0.57, 1.25)
>3 children	0.55 (0.27, 1.13)	0.67 (0.38, 1.19)
Family composition		
Two parent household (referent)	1	1
Single parent household	3.00 (1.11, 8.68)	1.43 (0.55, 3.76)
Mother's Country of Birth		
Australia and NZ (referent)	1	1
Asia except India	0.81 (0.39, 1.68)	0.57 (0.30, 1.08)
India	0.87 (0.41, 1.84)	0.47 (0.24, 0.92)
Other countries	0.61 (0.27, 1.40)	0.38 (0.19, 0.79)

[3] Results expressed as relative risk ratios (RRR) relative to free sugars >10% EER.
Statistical models fit to n=641 complete cases.
This model was adjusted for child age and child gender. As indicated, one category for each variable was taken as the referent category. The relative risk of lower free sugars intake in the other categories of a sociodemographic variable are shown compared to those in the more than 10% energy requirement category.
[4] RRR shows effect of each additional year of age

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Chapter 4

Chapter 4: Energy and nutrient intake by 11-13-year-old young adolescents living in Delhi, India

4.1 Preface

This chapter reports the first of the results from the primary study conducted in Delhi, India. As described in Chapter 2, the integrated food compositional tables in Intake24 converted the reported food and drink intake into nutrient intakes. The key learnings from the analysis of the SMILE data, described in Chapter 3, informed the decisions for the research work outlined in this chapter, specifically the choice of the dietary data collection tools.

With an intention to provide a comprehensive report on the dietary intake in this population, the data on daily E, macronutrient and micronutrient intake were analysed as a first step. The current chapter sets the context for the detailed report on the sugars intake (Chapter 5). Some of the distinctive features of this research work are: (i) the comparison of the nutrition status with the newly defined reference values: the 2020 National institute of Nutrition- Estimated Average Requirement (NIN-EAR); (ii) the use of integrated food compositional tables within the South Asia Locale of Intake24 to convert the participant-reported local foods and beverages into nutrients and thus determine the exact intake of carbohydrate, protein, fat, and saturated fat and, selected micronutrients and, (iii) the confirmation of the portion size with the help of the library of photographs on Intake24.

Highlights

The E, carbohydrate and, saturated fat intake in 11-13year-olds exceeded the WHO Food and Agriculture Organization (FAO) recommended ranges. Fewer than 40% of the girls achieved the NIN-EAR for iron intake. Interventions are needed to lower the E and saturated fat intake and improve iron intake in girls.

This chapter is formatted for submission to British Journal of Nutrition and is a draft prepared for submission.

4.2 Statement of Authorship

Title of Paper	Energy and nutrient intake by 11-13-year-old young adolescents living in Delhi, India
Publication Status	Unpublished work written in manuscript style.
Publication Details	This chapter is written in the format for submission to the British Journal of Nutrition

Principal Author

Name of Principal Author (Candidate)	Anupama Ivaturi		
Contribution to the Paper	Conceptualisation, design, data acquisition, initial analysis, application of dietary assessment and analysis software on field, methodology, and interpretation of statistical analyses and dietary data Manuscript writing and editing		
Overall percentage (%)	80%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	September 2023

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

iv. the candidate's stated contribution to the publication is accurate (as detailed above);
v. permission is granted for the candidate in include the publication in the thesis; and
vi. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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5.3 Manuscript: Energy and nutrient intake by 11-13-year-old young adolescents living in Delhi, India

Title page

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Short title: Dietary intake in young adolescents in India

Keywords: eating, nutrients, saturated fatty acids, dietary fats, dietary reference intakes, nutrition status

Abstract

There are no high-quality data on individual dietary behavior of young adolescents in India. The objectives of this study were to: (1) assess the intake of energy (E) and selected nutrients and (2) determine the contribution of macronutrients to E intake in a random sample of 11–13-year-old schoolchildren in Delhi, India. Participants from ten randomly selected schools recorded food and drink consumed over three consecutive days in a food diary. Information was entered into an online dietary assessment tool, Intake24 South Asia Locale (2022), to ascertain portion size and convert reported intake into nutrient intake through integrated food compositional tables. The intake of E, macronutrients, vitamins A, D, B12, folate, iron, calcium, zinc, iodine, and selenium were summarized using descriptive statistics and compared with the Estimated Average Requirements (EAR) proposed by the India-National Institute of Nutrition (NIN). Of the 514 schoolchildren providing consent, 393 participants (76.4%) (169 girls, 224 boys) with a mean age of 11.4 (SD 1.8) years completed the study. The median E intake was 11.6 (9.9- 14.1) MJ/day and that of carbohydrates was 360.2 (300.1- 441.9) grams/day; nearly all the participants exceeded the NIN EAR for carbohydrate intake and percent E from fat was above the Food and Agricultural Organization (FAO) recommended ranges in >74% participants with saturated fat contributing a median 16.3 (13.9 - 18.5) percent. The median intake of girls was slightly lower than that of boys for % E from saturated fat ($P<0.05$). Less than 40% girls achieved the NIN-EAR for iron intake. In conclusion, the E intake is high and fewer girls achieved the NIN-EAR for iron. Strategies to optimize dietary behaviors in young adolescents in India should focus on preventing excess energy intakes, reducing the intake of saturated fat, and improving iron intake in girls.

Introduction

India has the largest adolescent population (>253 million) in the world [1]. Early adolescence is a period of rapid development and growth [2]. Requirements of energy (E) peak as does the requirements for micronutrients and therefore adolescence is a period during which there is an increased risk of deficiency [3]. The results of the Comprehensive National Nutrition Survey (CNNS 2016-18) [4] show that a 'triple burden' of undernutrition, micronutrient deficiency [5, 6] and overnutrition exists in the young Indian population [6-8]. Dietary preferences and habits that form in adolescence may last lifelong and therefore it is an appropriate time to encourage and build healthy eating habits [9].

The transition of the traditional Indian diet towards a more 'westernized' diet that includes prepackaged and processed food has been reported previously [10, 11]. Existing food environments in lower-middle-income-countries (LMICs) like India negatively impact dietary intake [12]. Adolescents attending private educational institutions in Delhi are exposed to processed foods in school food environments which is concerning as this contributes to a high risk of noncommunicable diseases (NCDs) [13]. Evidence shows that the combined prevalence of childhood obesity and overweight in India increased from 16.3% reported for 2001-2005 to 19.3% in 2010 [14]. The prevalence of overweight (12.3%) and obesity (3.6%) in adolescents in Delhi in 2018 is higher than previous estimates of 1998 [4]. Despite these concerning reports, there are no data on the individual dietary behavior of this population.

Addressing undernutrition and ensuring food security remains the priority of the Government of India [15]. Food fortification and vitamin supplementation were implemented as stopgap measures to address micronutrient deficiency in vulnerable groups, specifically deficiencies of vitamin A, B12, folate, iron and iodine [16]. However, these approaches have been criticized for the lack of sustainability [17]. The results of hematologic investigations in the CNNS 2016-18 [4] showed that iron deficiency anemia was still prevalent in some 40% of adolescent girls in India [18], and 24% of adolescents were vitamin D deficient. The Government of India has now evolved its strategies to tackle the triple nutrition burden in adolescents through a package of interventions in the National Adolescent Health Program to be delivered in collaboration with other health agencies [1, 19]. In addition to supply of fortified food in school lunches, approaches for adolescents to build an understanding of nutritious diet, make healthier choices and avoid processed food are being implemented. Policy-level action has been initiated to prohibit sale and marketing of unhealthy foods within and around schools [20]. There are, however, no high-quality data on the level of intake of nutrients from the local foods and the existing reports are

limited to intake of food groups [17] by adolescents. It is important to generate sub-national and national data on dietary intake to identify the level of any problem and inform the efforts to optimize eating behaviors.

Previous surveys of ten states of India of diet and nutrition status of rural [21] and urban [22] populations conducted in 2012 and 2017 respectively reported that the mean intakes of calcium, iron, folate, B12 and, vitamin A in young adolescents did not meet the Recommended Dietary Allowance (the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) of healthy individuals. Since the publication of these reports, the reference values have been updated [23] and Estimated Average Requirement No it is not per (EAR) values proposed. For a given nutrient, the EAR represents the nutrient intake value that is estimated to meet the requirement of 50 percent of the healthy individuals. The EAR was suggested for the first time as the appropriate reference value for assessing requirements and adequacy in healthy individuals. Since the update of dietary reference values in 2020, no data of dietary behavior have been collected and compared with the initial EARs for E and nutrients.

Research shows that lockdown during the COVID-19 pandemic had a significant impact on diet and physical activity [24-27]. In adolescents, compared to pre-pandemic period, screen time and intake of all food groups increased with a notable decline in physical activity [28, 29]. In a study on young adolescents living in Mumbai, an increase in the intake of staple food and fruit, as well as foods high in sugar, fried food, sugar-sweetened beverages with a marked rise in snacking in between meals was reported [30]. In Delhi, schools remained closed for two years due to the pandemic and reopened in 2022. In this post-pandemic context, an update on the nutrient intake would be useful to understand adolescent dietary behaviors.

Previous studies of dietary intake in India have relied on existing food composition databases and required researchers to manually analyze data [17] for the estimation of intake of nutrients from reported food intakes, and these were usually collected using 24 hour recalls or food frequency questionnaires [21, 22]. However, there are no comprehensive local food and recipe databases. Further, the challenge posed by the lack of software to link the intakes to national food compositional tables has been identified [17]. Open-source and low-cost applications that facilitate assessment of dietary intake through the creation of a digital record of the food and drink intake are commonly used in high-income countries HIC [31, 32]. The application of such tools for dietary assessment in lower-middle-income-countries (LMIC) is limited or, as is the

case with India, non-existent. The validity and reliability of one such tool 'Intake24' (https://intake24.org) has been tested [32] and used in the national dietary surveys in other countries (e.g. the UK National Diet and Nutrition Survey) [32-34]. An English Language South Asia Locale (2022 version) of this application has recently been developed (https://intake24.co.uk/info/localisation) but it has not previously been applied to populations in India.

The aim of this study was to determine the intake of E and nutrients in 11-13-year-old young adolescents in Delhi using the South Asia locale of Intake24. The specific objectives were to: (i) estimate the intake of E and macronutrients and the contribution of macronutrients to E, (ii) to estimate the intake of vitamins A, D, B12 and, folate, and iron, calcium, zinc, iodine and, (iii) compare the intakes with the NIN-EARs.

Methods

Ethical Approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by The Human Research Ethics Committee (HREC) at The University of Adelaide (*H-2021-027*, Date: 8 March 2022) and by the Independent Ethics Committee, Centre for Chronic Disease Control, New Delhi, India (*CCDC-IEC_14_2021* Date: 9 December 2021.

Study location

Delhi is a Union Territory located in North India with a population of 20.2 million people from different socio-economic, cultural and ethnic backgrounds. New Delhi, the capital city of India is located within Delhi. Delhi is the largest metropolitan area in India and the second largest in the world. It is divided into 11 civic administrative districts (Figure 1) and three municipalities. There are rural and urban sectors in Delhi. The 112 villages in the rural sector are not limited to any specific district. The municipal corporations of North, East, South and New Delhi constitute the urban sector [35].

Sample size and school selection

Young adolescents in the age group of interest (11-13 years) attend middle schools in Delhi i.e. class 6th to 8th Grade. The sample size calculations were based on the number of participants needed to estimate the total sugars intake in grams per day with a margin of error of ± 5 g / day. The calculations assumed 80% power to estimate mean total sugar intake and two-sided α of

0.05. The resulting sample size was inflated to allow for 20% attrition. Private schools constituted 40% of the total school enrolment in 2022 and 95% of the 11-14 age demographic attended a school in Delhi. The number of private schools and students is not uniform across the 11 districts in Delhi. Using the complete list of 1374 private schools provided by the Directorate of Education, a statistician external to the research team generated a random sample of 150 schools, stratified by district from across the 11 districts of Delhi. Using this schedule, schools were invited to participate, and recruitment continued until 10 schools had consented. Figure 2.2 in Chapter 2 illustrates the districts of Delhi.

School consent

Using the list of schools, a researcher (AI) contacted the principal of each school through email and on telephone and explained the purpose of the study in plain language. The researcher made three attempts to connect with the school and explain the study information. If no response was obtained or if the school declined to take part, the researched moved to the next school on the list for that specific district. This process was repeated until the researcher recruited at least one school from each district. Researchers collaborated with Health-Related Information Dissemination Amongst Youth (HRIDAY), a nongovernmental organization based in Delhi, in establishing initial contact with the principals of private schools. The researcher shared information about the study with those schools that expressed interest to take part in the research through email. Once a school agreed, a link to the school consent form was sent by email (Qualtrics XM Experience Management, North Sydney, Australia). Upon obtaining consent, the process for recruitment of participants was initiated.

Parent consent and participant assent

A dedicated teacher in each school shared study information (prepared in plain language by the researcher) with the parents of the 11-13-year-old pupils through the school network on social media applications (WhatsApp) or through emails. Parents who were interested in their child taking part communicated their interest to the teacher. The teacher then created a list of all participants interested in study participation. Next, the teacher asked the parents to complete the online parent consent form hosted on Qualtrics. Schools were given the opportunity for the researcher to visit the school and explain the purpose of the study to pupils and provide information on the expected level of involvement to potential participants. Data collection commenced only after the researcher received a completely filled in and signed consent from the parent, and an online assent form from the participant.

Collection of demographic data

Demographic data on participants were collected from their parents using an online questionnaire, using the Qualtrics survey tool. The variables included name, age and date of birth of the child, name and age of the parent and the area of residence. As part of this questionnaire, parents were asked to record at home, or provide from previous records, the weight (in kilograms) and height (in inches or centimeters) of their child.

Dietary data collection

Dietary data were collected between May and October 2022. Participants recorded all foods and drinks consumed over three consecutive days in paper based or online version of a purpose-designed food diary. Recording included two weekdays and one weekend day. This allowed estimation of the dietary intake during school days (Fridays, Saturday, Mondays and Tuesdays) and non-school days (Sunday). Participants were asked to report all food and drink consumed including the time of consumption and the amount that was consumed using household measures (cups, bowls, spoons, glasses and plates etc.) After completing the diary, the researcher met each participant in a one-on-one interview to discuss, clarify and enlarge on the information provided and to confirm the portion size of foods and drinks consumed using the library of 2500 food portion sizes available in the online dietary assessment tool Intake24 (South Asia Locale 2022 version) [32, 33]. During the interview the researcher entered the dietary information into Intake24 which enabled the daily intake of E and sugars to be derived through integrated food composition tables.

Following the completion of all interviews, the resulting data file was downloaded as an Excel spreadsheet from Intake24. The dietary data were imported into STATA 17.0 (Stata Statistical Software: Release 17. College Station, TX: Stata Corp LLC). In the dataset, the daily dietary data for each participant for each of the three days, were organised into eating occasions. The pre-defined eating occasions in Intake24 included: (1) early snack or drink; (2) breakfast; (3) morning snack or drink; (4) lunch; (5) afternoon snack or drink; (6) evening meal and (7) late snack or drink. Water intake was recorded at the end of each day as daily water intake. In the spreadsheet, the data were identified through user IDs which included name of the school and the numeric participant ID (1 to n for each school). Indexing variables were created for the school, the participant, the day and eating occasion. The total intake of E (mega joules), grams of carbohydrates, protein, fat, saturated fat and fibre and vitamins A, B12, folate, and D, and minerals iron, calcium, zinc, iodine and selenium for each of the three days of recording was derived and then averaged to get the daily intake of E and nutrients for each participant.

Validation of energy intake

The estimation of Physical Activity Level (PAL) was used to validate the reported E and identify the proportion of participants who may have over-or under-reported E. The PAL was calculated by dividing the reported E by the Basal Metabolic Rate (BMR). Schofield equation [36] was used to predict the BMR from gender, age, height and, weight information provided by the participants.

Statistical Analyses

The distribution of variables was assessed. Descriptive statistics for continuous variables that were normally distributed included mean, standard deviation and 95 % confidence interval (CI) and for variables with non-Gaussian distribution median and interquartile range (IQR) were reported. Between gender differences for E, macronutrient and micronutrient intake and percent E obtained from macronutrients were explored through Wilcoxon rank-sum tests. A two-sided significance level of 0.05 was used in all analyses.

Results

Participation rate

During the school recruitment process, 27 schools declined to participate, and 15 schools could not be contacted. In total 52 schools were approached before the required sample of ten was achieved. Between June and October 2022 students from each school consented. Of the 514 participants in total who provided consent, 393 (169 girls, 224 boys) completed the diary on all three days and attended the interview (76.4%) (Table 4.1). The mean age of the participants was 11.4 (SD 1.8) years.

Table 4.1: Participation rate from ten private schools in Delhi, India

	Number	Percentage of total
Target Sample size	360	-
Number. consented	514	100
Withdrew before data collection	110	21.4
Filled in the food diary	404	78.6
Incomplete diary	4	0.8
Completed diary on all 3 days	400	77.8
Declined interview	7	1.4
Completed interview	393	76.4

Energy intake and PAL ratios

The distribution of the E, macronutrient and micronutrient intake data was skewed and therefore the data have been summarized as medians and interquartile range (IQR). The median daily E

intake was 10.8 (IQR 9.0 -12.5) MJ for girls, and 12.3 (IQR 10.3; 15.2) MJ for boys (Table 4.2). The PAL ratios derived for those 241 participants who provided height and weight were 2.0 for girls and 2.1 for boys. The median weight of the 97 (57.4%) girls who provided anthropometric data was 45 (IQR 38; 51) kg and of the 144 (67.3%) boys who provided data was 44.1 (IQR 37; 52.5) kg. The median weight for the study population was above the reference weight for 10-12-year-old Indian young adolescents of 34.9 kg for boys and 36.4 kg for girls [23].

Macronutrient intakes

The information on the median daily intakes of carbohydrate, fat, saturated fat and, protein are detailed in Table 2. There were no significant between-gender differences in percent E from protein: median 10.2 (IQR 9.2 - 11.4); boys 10.1 (9.2 – 11.4) versus girls 10.4 (IQR 9.2 – 11.5), or carbohydrate: median 52.4 (IQR 48.7 - 56.7); boys 51.9 (48.4- 56.3) versus girls 52.9 (49.5-57.5). A comparison of the percent E from macronutrients with NIN-EAR and the FAO recommended ranges for percent E from macronutrients is also presented in Table 4.2.

Table 4.2: Energy, macronutrient intake and percent contributions of macronutrients to energy for 393 11-13-year-old young adolescents (224 boys and 169 girls) attending private schools in Delhi, India

	All participants		Boys (n=224)			Girls (n=169)		
Variable	**Median**	**IQR**	**Median**	**IQR**	**% > EAR[5]**	**Median**	**IQR**	**% > EAR**
E intake								
MJ/day	11.6	9.9- 14.1	12.3	10.3-15.2	80.4	10.8	8.9- 12.5	81.7
kcal/day	2761	2348- 3358	2941	2467- 3599		2580	2139-2989	
Carbohydrate								
grams/day	360	300- 442	380	318- 462	99.6	336	285- 394	99.4
% E	52.4	48.7- 56.7	51.9	48.4- 56.3		52.9	49.5- 57.5	
Protein								
grams/day	70	59- 86	74	61- 89		65	55- 79	
% E	10.2	9.2- 11.4	10.1	9.2- 11.4	52.7	10.4	9.2- 11.5	53.8
Fat								
grams/day	125	99- 156	129	106- 166		114	90- 139	
% E	40.4	36.1 - 44.2	40.8	36.7 - 44.5	74.1	40.1	35.1 - 43.3	65.1
Saturated Fat								
grams/day	52	37 - 63.0	55	42 – 69		46	35 - 58	
% E	16.3	13.9 - 18.5	16.3	14.2 - 19.1	90.2	16.1	11.0 - 18.2	90.5

[5] Estimated Average Requirements for Indians [23]
Source: National Institute of Nutrition (2020).www.nin.res.in.
Appendix L provides the summary of the EAR for 10-12-year-old boys and girls used for comparison.

The absolute intakes of macronutrient intakes (g/day) were above the India NIN-EAR for 10-12-year-old population. The percent E contributed by carbohydrate and protein were within the recommended FAO ranges but the contribution of saturated fat to E was considerably above the recommended threshold of no more than 10% [37]. The median intake of girls (16.1% (IQR 11.0-18.2) was slightly lower than that of boys 16.3% (IQR 14.2 - 19.1) ($P<0.05$) for percent E from saturated fat

Micronutrient intakes

The median intakes of micronutrients are summarized in Table 4.3, along with the percentage of participants achieving NIN-EAR for the intake of micronutrients.

Nearly all the participants (95%) achieved the EAR for daily vitamin A intake. In contrast, only 7% boys and 4% girls achieved the NIN-EAR for Vitamin D. The median daily intakes of Iodine in girls iron, selenium and vitamin D in both girls and boys were below the NIN-EAR. Less than 40% of girls achieved the NIN-EAR for daily iron intake.

Table 4.3: Micronutrient intake by 393 11-13-year-old young adolescents (224 boys and 169 girls) attending private schools in Delhi, India

	All participants		Boys (n=224)			Girls (n=169)		
Variable	**Median**	**IQR**	**Median**	**IQR**	**% achieving EAR[6] [23]**	**Median**	**IQR**	**% achieving EAR**
Vitamin A (µg)	1083	839.4 - 1346.4	1132.9	918.1 - 1406.4	96.4	953.2	767.7 - 1246.6	94.7
Vitamin D (µg)	1.7	0.9 - 3.6	1.9	1.0 - 4.0	7.1	1.4	0.7 - 3.0	4.1
Vitamin B12 (µg)	3.2	1.8 - 4.6	3.3	2.0 - 5.0	73.2	2.9	1.6 - 4.2	63.3
Folate (µg)	261.5	204.0 - 315.3	267.8	205.7 - 321.7	72.8	253.6	203.0 - 303.8	72.2
Calcium (mg)	1105.1	797.4 - 1551.7	1183	836.6 - 1646.3	84.4	1033.5	778.6 - 1406.7	75.7
Iron (mg)	15.1	12.4 - 18.4	15.7	13.3 - 19.0	72.8	14	11.6 - 17.0	37.9
Zinc (mg)	9.4	7.8 - 11.8	9.9	8.2 - 12.7	81.7	8.6	7.3 - 10.6	72.2
Iodine (µg)	157	108.7 - 216.6	168.6	116.1 - 223.4	78.6	142.5	102.8 - 209.8	72.8
Selenium (µg)	34.2	27.2 - 43.0	35.9	28.4 - 44.1	37.1	31.6	26.7 - 41.7	30.2

[6] Estimated Average Requirements for Indians [23]
Source: National Institute of Nutrition (2020). www.nin.res.in
Appendix L provides the summary of the EAR for 10-12-year-old boys and girls used for comparison.

Discussion

In this sample of young adolescents living in Delhi, the intakes (g/day) of protein, carbohydrate and fat were above the NIN EAR. The median E intake (11.6 (9.9- 14.1) MJ/day) was higher than that previously reported for similar aged adolescents living in some high-income countries (HICs) in the WHO European [38], American [3, 39], Eastern Mediterranean [40], Western Pacific Regions [41] and lower-middle-income-countries (LMICs) like Libya [42] but is similar to intakes reported for adolescents in the African and South East Asian regions; e.g. 9.7 MJ /day in Cameroon [43] and approximately 12.3 MJ/day in Bangladesh [44]. The E intake in the current study was validated against the estimation of PAL using data provided by a sub-sample (n=241). The PAL obtained correlates with the values associated with vigorous activity, however, the higher than desirable median weight (45kgs) and high median E intake is suggestive of overeating. Hence, there is a need to control E intake in order to prevent obesity. However, it is possible that participants may have overestimated portion sizes for social desirability. Moreover, the Intake24 sometimes relies on best match foods from the UK food compositional database when data on the composition of local foods are unavailable. Further development of the SE Asian version of Intake24 to include more specific compositional data is desirable for future surveys.

Macronutrient intake

Of concern is the percent contribution of saturated fat to E (median 16.3%), which is above the 10% E threshold for intake of saturated fats recommended by the WHO FAO and other authoritative agencies [23, 37]. More than 90% of the current study sample consumed above 10% E as saturated fat and dietary fat contributed more than 35% to total E in 75% of the boys and 65% girls. This figure is higher than the reported contribution of saturated fat to E in the diets of adolescents living in the UK (median 12.6%) [45], Europe (14.0%) [38] and, the Middle East (15.0%) [40]. Due to the known association between a diet high in saturated fat and risk for NCDs [46], strategies to lower the intake of saturated fat to less than 10% E in adolescents need consideration. The intake of the ready-to-eat and prepackaged foods reported by the current study sample as ‘snacks’ probably contributed to the high fat intake [47]. Such foods are widely available within private schools in the cafeteria and also in school food environments [48].

It is important to find means to and strategies to support and promote the intake of nutrient-dense food and reduce the consumption of high fat energy-dense food. The percent E from carbohydrates and fat in the current study was lower than that in diets of adolescents in the UK [45] and many HICs in Europe [38] and Middle East [40] and also in LMICs such as Lebanon,

Libya, and Morocco [40]. The median percent E contributed by protein in the current study sample (10%) is lower than the contribution of protein (approximately 15%) in the diets of adolescents in the UK [45], Europe [49] and, Middle East [40] but is similar to the reported intake of protein for adolescents in LMICs, for instance Cameroon (10%) [43] and Bangladesh (9%) [44]. The 2017 survey on urban populations in India has reported that the intake of protein is low when compared with the RDA [22]. Further, results from a survey that compared Indian diet with the Lancet EAT-reference diet indicate that the intake of plant and animal-based protein is lower across all sectors, regions and income groups in India [50].

Micronutrient intake

The intake of micronutrients was compared with the NIN-EARs, except for selenium. The India-NIN provides the RDA for daily selenium intake but no EAR. Median intakes below the NIN-EARs were observed for the intake of vitamin D, folate, iron and zinc.

The finding that the intake of Vitamin A was above the NIN-EAR in nearly all participants (95%), contrasts with the findings for school-age adolescents in developing countries which have reported the status of Vitamin A to be inadequate in > 85% school-age adolescents in Ethiopia and > 80% adolescents in Cameroon and Uganda [51]. The current study figure is also unlike the 2012 and 2017 survey findings [21] which showed that vitamin A intake was inadequate in 52-85% adolescents. However, these previous reports compared the intake with the RDA for vitamin A (600 µg/d). In addition to the difference in methodology to report the adequacy of intake, it is also likely that the results are different due to the reported change in diet with a shift towards intake of raw vegetables and in some participants, supplementation (unpublished data). The data on supplementation were not analysed in this research project as the intake of nutrients from foods was of interest.

The low intake of Vitamin D in the current study population is similar to that reported for adolescents in UK (1.8 µg/d) [45]. Dietary sources of Vitamin D are few, however, it is likely that the study population benefited from subcutaneous synthesis of vitamin D. According to the serologic investigations conducted as a part of the recent CNNS survey [4] nearly half of the (47.1%) adolescents in Delhi were found to be deficient in Vitamin D. Information of the serum concentrations of 25(OH)D (25-hydroxy cholecalciferol) would provide more comprehensive information on Vitamin D status. Possible changes in the exposure to sunlight due the confinement of participants indoors as a result of the pandemic may have affected the vitamin D status.

The median daily intake of folate by girls in the present study (254 µg/day (IQR 203 – 304)) is considerably higher than the previously reported intake (165 µg/day) for south Indian adolescent girls [52]. Of concern, however, are the relatively low intakes of iron by girls found in the current study. Inadequate status of iron in adolescent girls has previously been reported for several developing countries in Africa, South East Asia and Middle East [51, 53]. More than 60% of the girls in the current study did not achieve the NIN-EAR for iron intake. Information on menarche was not collected in the current study which may have provided clarity on the demand for iron and folate in girls. More than half of anemia cases are estimated to be due to iron deficiency [54]. In India, anemia is a recognized public health problem. One priority of the National Adolescent Health Program [19] is weekly micronutrient supplementation through the provision of iron and folic acid tablets. However, only adolescent in government, government-aided and municipal schools are covered. The current study results suggest the need to improve iron intake by girls. The fact that the adolescents in private schools do not have access to the fortified food supply through school lunches suggest that there is a need to explore the feasibility of expanding the weekly supplementation to all adolescent girls.

Compared with intakes reported for adolescents in previous studies conducted in LMICs in Africa [51, 53] and Middle East [51], median zinc intake (8.6mg/day) was high with 72% girls achieving the NIN-EAR. Participants in the present study reported intake of zinc-containing foods as a part of main meals e.g. *dal*, and pulses like chick peas, soybeans, rajma beans etc. which may have contributed to adequate zinc intake. Compared with previously reported intake for adolescent girls in India [52, 55, 56] the zinc intake is high.

The proportion of the study population which achieved the NIN-EAR for iodine (75%) is higher compared with previous estimates [57]. Salt fortification with iodine was a crucial component of a national program that aimed to prevent and control the endemic Iodine deficiency disorders (IDD) in India which also lead to a ban on the sale of non-iodized salt. Although information on the intake of iodized salt was not specifically obtained in the current study, this is likely to have contributed to adequacy of iodine intake. Thirty percent of girls and 37% boys achieved the NIN-RDA for selenium intake (40 µg/day, EAR not defined). There are few comparative data on selenium intake available although the intake was comparable with that reported for UK adolescents [45]. However, recently available data from the estimation of serum selenium levels showed that 10% of urban young adolescents in India and a majority of adolescents in LMICs in Africa have inadequate serum selenium [55, 58].

Strengths and limitations

Revised nutrient recommendations for intake of E and nutrients in the Indian population at different ages were proposed in the year 2020. To the authors' knowledge, this is the first assessment of dietary intake reported since then. Moreover, the data on nutrient intake are the first to be collected using the Intake24 SE Asian version. Nonetheless, there are some limitations which need to be acknowledged. First, participant-reported and not researcher measured height and weight were used to derive PAL. The height and weight data were available for only 61.3% of the sample which may have impacted the accuracy of the PAL ratios. Second, Intake24 is designed to be a self-completed multiple pass 24 hour recall dietary analysis tool. However, the South Asia locale version is available only in the English language which was not be the first language for many participants. Therefore, the food and drink intake data were collected using a 3d dietary diary and the researcher transferred this information to Intake24 which was used to ascertain the portion size (during a participant-researcher interview), and to translate recorded food intake into the intake of nutrients. Although the participants did not directly enter dietary data, the library of portion size photographs enabled portion size estimation. Third, despite Intake24South Asia locale being the most comprehensive dietary assessment tool designed to be used in all the Southeast Asian countries, the nutrient composition of every Southeast Asian food and drink items is not available. Therefore, the system finds a best match from the UK food composition tables which may introduce some inaccuracies. Fourth, the study was conducted between May and December 2022, a time during which participants were transitioning back into in-person learning at schools after the COVID-19 lockdown led to school closures. The changes to diet reported by participants i.e. vitamin supplementation, increase in the intake of raw vegetables, citrus fruit juices and whole fruits (unpublished data) [25, 27] which persisted even after schools reopened, could have influenced the nutrient intakes. Finally, it is possible that the data were subject to bias of social desirability so that unhealthy food or drink items may have been under-reported.

Future directions

The results show that it is possible to obtain individual and population level data including the daily intake of E and nutrients through the use of Intake24. The capture of data using Intake24 reduced research burden by translating reported food intake into daily intake of nutrients. Intake24 should be further developed into local languages and expanded to include a more comprehensive coverage of foods and dishes that are part of the food culture of India.

The findings of this study pertaining to the intake of E and macronutrients suggest that measures are needed to prevent excess energy intake particularly that provided by fat, especially saturated fat. The results relating to the intake of iron in girls suggest targeted strategies to reduce the risk of anaemia in adolescence by improving dietary intake through measures such as food fortification may be required.

Conclusion

The E intake in this sample of young adolescents attending private schools in Delhi, India was above the level recommended by FAO and the India NIN-EAR. The intake of saturated fat was above the <10% E threshold, with slightly high median intake in boys compared with girls for percent E from saturated fat. The majority of the girls did not achieve the NIN EAR for iron. Strategies to optimize dietary behaviors in young adolescents attending private schools in India should focus on preventing excess energy intakes, reducing the intake of saturated fat, and promoting increased intake of iron in girls.

Acknowledgements

The authors thank the school principals, teachers, participants and, parents for their cooperation for the study. The authors thank the Intake24 team for setting up Intake24-South Asia Locale 2022 version for use in this study to analyse the dietary data. Intake24 is an open-source web-based dietary assessment research tool based on the 24-hour recall method, primarily designed for self-completion. Intake24 was created by Newcastle University (UK), funded by Food Standards Agency, Scotland and is now maintained and developed through a collaboration between Cambridge University (UK), Monash University (Australia) and Newcastle University (UK). The authors are thankful to the Health-Related Information Dissemination Amongst Youth (HRIDAY) team for support during the fieldwork.

Financial Support

AI's Ph.D. was funded through the University of Adelaide-Colgate-Betty Fanning Scholarship,

Conflict of Interest

The authors have declared no competing interests

Authorship

The study was conceptualized by P.M, A.I, L.G, L.D, funding acquisition: P.M. Data acquisition, initial analysis, software, methodology, and interpretation: A.I, P.M, L.G and L.D. Statistical analyses: L.G, A.I, P.M, and L.D. Writing: original draft: A.I as a part of her PhD studies with contributions from, P.M, L.G. L.D. Writing- review and editing: all authors.

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Chapter 5

Chapter 5: Intake of free sugars by 11-13-year-old young adolescents living in Delhi, India

5.1 Preface

This chapter describes the results of the data analyses conducted to capture information on total and free sugars intake and the sources and pattern of intake of free sugars by the 11-13-year-old young Indian adolescents.

This is the first research study that reports the intake of free sugars in young Indian adolescents using Intake24- a novel dietary assessment and analysis tool. The sources of free sugars presented in this chapter are expected to inform the development of food-based dietary guidelines in India. Data on the pattern of free sugars intake including: (i) the comparison of free sugars consumption in main meals versus snacks and; (ii) the intake of free sugars on weekdays versus weekends are presented. Further, information on the trends in the intake of free sugars and the percent contribution of free sugars to E, based on the school district is included.

Highlights

In the 11-13-year-old young Indian adolescents, forms of sugar added to foods and drinks by consumers made the largest contribution to free sugars. Greater amounts of free sugars were consumed as snacks and the intake on weekdays was lower than weekends.

This chapter is formatted for submission to Public Health Nutrition and is a draft prepared for submission.

5.2 Statement of Authorship

Title of Paper	Intake of free sugars by 11-13-year-old young adolescents living in Delhi, India
Publication Status	Unpublished work written in manuscript style.
Publication Details	This chapter is written in the format for submission to Public Health Nutrition

Principal Author

Name of Principal Author (Candidate)	Anupama Ivaturi		
Contribution to the Paper	Conceptualisation, design, data acquisition, initial analysis, application of dietary assessment and analysis software on field, methodology, and interpretation of statistical analyses and dietary data Manuscript writing, editing and revisions		
Overall percentage (%)	70%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
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By signing the Statement of Authorship, each author certifies that:

vii. the candidate's stated contribution to the publication is accurate (as detailed above);

viii. permission is granted for the candidate in include the publication in the thesis; and

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5.3 Manuscript: Intake of free sugars by 11-13-year-old young adolescents living in Delhi, India

Title page

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Short title: Free Sugars intake by young adolescents in India

Keywords: diet survey, snack foods, meals, diet, food intake

Abstract

Objectives: There is a dearth of data on free sugars intake by Indian young adolescents. The objectives were to determine (1) sugars intake and (2) the main contributing food sources and (3) the pattern of intake in a random sample of 11–13-year-olds in Delhi, India.

Design: Dietary information was obtained from 11-13-year-olds in ten randomly selected schools using an estimated 3d food diary and entered into Intake24, an online diet assessment tool which was used to ascertain portion size and to convert food and drink reported into nutrient intake through integrated food compositional tables. Energy (E) and sugars intake, sources of free sugars, the amount consumed as meals vs. snacks, and weekdays vs. weekend days were summarized using descriptive analyses and generalized linear mixed-model regression.

Setting: Delhi, India

Participants: Young adolescents aged 11-13-years.

Results: Of the 514 consenting participants, 393 (224 boys and 169 girls) (76.4%) with a mean age of 11.4 (SD 1.8) years completed the study. The median daily intake of free and total sugars were 48.0 (31.1 – 72.9) g and 98.0 (75.6 - 129.1) g respectively, contributing 7.1 (IQR 4.8-10.1) % and 14.9 (IQR 11.4-18.1) % E. The WHO recommended threshold to limit free sugars intake to <5% E was achieved by 27.2%. The principal sources of free sugars were Sugars Preserves and Syrups (31.2% (IQR. 9.6-51.7%)); Cakes and Biscuits (13.7% (IQR 0-26.4%)); and Desserts (5.4% (IQR 0-17.5%)). More free sugars was consumed snacks compared with meals (P<0.001) and intake was significantly lower on weekdays (P=0.01).

Conclusions: The intake of free sugars was above the <5% E threshold recommended by WHO. Strategies to reduce free sugars should include reducing free sugars added to the diet by consumers.

Introduction

An unhealthy diet high in free sugars is a risk factor for non-communicable diseases (NCDs) including undesirable weight gain and dental caries [1]. Evidence shows a role of free sugars in the development of overweight [2], obesity [3], type-2 diabetes mellitus [4] and, dental caries [5, 6]. While total sugars include all mono and disaccharides in food, free sugars include those added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, fruit juices and fruit juice concentrates [7].

The World Health Organization (WHO) Guideline on Sugars Intake for Adults and Children, recommended that children limit the intake of free sugars to less than 10% of energy intake (E) and to preferably below 5% E to protect oral health throughout the life course [7]. As a result, the governments in many countries have initiated action on sugars and have recommended limiting the intake of foods and beverages containing free sugars [8-10]. Available data show that high proportions of young adolescent school children obtained >10% E from free sugars [10] for instance- Europe (19%) [11], Brazil (25%) [12], the United Kingdom (UK) (13%) [8], Libya (12.6%) [13], and Australia (14.6%) [14]. In many lower-middle-income countries (LMICs), urbanization, improved agricultural technology and mass media access have led to nutrition transition towards intake of a 'westernized diet' that is high in fats, free sugars, and added sodium [15, 16]. The intake of traditional and staple diets is on the decline [15].

India is a LMIC undergoing a nutrition transition, Young adolescents in India are impacted by targeted campaigns and the sugar industry has found a vulnerable, new market for foods and beverages containing free sugars in these populations [15, 17, 18]. A recent national survey of metabolic diseases has shown that there has been an increase in the prevalence of type 2 diabetes mellitus, hypertension and obesity in younger Indians, with urban populations at a greater risk [19]. The most recent national survey of dental diseases indicated that more than half (52.5%) of children aged 11-13 years were affected by dental caries [20]. In Delhi, the prevalence of overweight (12.3%) and obesity (3.6%) in 10-19-year-olds is higher when compared with previous estimates and is currently the third highest in India [21].

However, there is a dearth of national or sub-national high-quality data from India on dietary behavior of young adolescents and none with respect to free sugars intake. Moreover, with age, adolescents have increasing autonomy in making food choices and are also influenced by peer pressure [22]. Around the age of 11-13 years, almost all the permanent teeth are erupted [23] and data from other countries shows that free sugars intake is the highest among adolescents [10]. It

is therefore crucial to make free sugars accountable through high-quality data on dietary intake of free sugars.

The information on sugars intake in India to date has centred on 'sucrose', 'sugar' and 'jaggery' (lump sugar) only, ignoring the sugars more widely available through those added to foods and drinks. The National Nutrition Monitoring Bureau (NNMB) produced two reports on sugar consumption in India [24, 25]. The report on 'sugar consumption by Indians' stated that a population sub-sample in New Delhi consumed an average of 23.2 grams of 'added sugar' per day [25]. For generating data on added sugar consumption, the team collated the 2015-16 dietary data of more than 5000 individuals from seven metropolitan cities, and re-coded it recipe-wise. The definition of added sugar adopted for this analysis was '*Added sugars are sugars and syrups that are added to foods or beverages when they are processed or prepared. This does not include naturally occurring sugars such as those in milk and fruits*.' The report showed that the average intake of added sugar by 12–17-year-old adolescents in India was 19.9 g/day and that in Delhi adolescents was 21.5 g/day [24]. However, the authors state that the quantity of sugars was computed using data provided on the pack labels and 'other' sources and not through an exact food compositional analysis. It is likely that the reported added sugar intake was sucrose only, obtained from the listed recipes. This may not accurately reflect added sugars intake from all dietary sources. Reliable and high-quality data on the amount, pattern and sources of intake of free sugars by children are required to inform on current levels of exposure to this NCD risk factor and to develop interventions to limit free sugars and subsequent NCD risk.

In Delhi there are public and private schools. Schools could be considered a proxy indicator of socioeconomic status (SES) i.e. children from lower income groups attend public schools and those from middle- and higher-income families are more likely to attend private schools [26]. Adolescents attending private schools may have access to disposable income and are potentially more exposed to foods and beverages containing free sugars, added salt and fat through the location and concentration of mobile vendors outside of school gates during the lunch break and school-leaving time and within the school canteens [18]. Despite this, information on the individual dietary behaviours by private school children in Delhi is scarce and there are no data on free sugars intake. There is an urgent need to generate evidence on the level and pattern of intake of free sugars by school children.

Therefore, the primary aim of this research was to determine the level of intake of total and free sugars, and identify principal dietary sources and patterns of consumption of free sugars by 11-13-year-old young adolescents attending private schools in Delhi, India. The specific objectives were to: (i) quantify the intake of total and free sugars as grams/day and by percent contribution to E; (ii) identify the principal dietary sources of free sugars in the diets; (iii) describe the pattern of free sugars intake based on the eating occasion (main meals and snacks), day of the week (weekday and weekend day) and identify any differences between school districts.

Methods

Study site and school selection

The information on the study location, school and pupil selection have been described in detail in Chapter 2. In brief, from a schedule of 150 random private schools generated using a list of all 1374 private schools in Delhi and stratified by Delhi districts (n=11), schools were invited to participate. A plain language study summary was shared with the school principals (Appendix B). If a school did not respond after three attempts, the next school in the schedule was approached and recruitment continued until 10 schools had consented using an online form hosted on the Qualtrics survey platform (Qualtrics XM Experience Management, North Sydney, Australia).

Participant selection

Within each school, a dedicated teacher shared study information with the parents of pupils aged 11-13-year-old- through email or the school social media network. Interested parents provided consent for their child to participate in the study using an online form hosted on the Qualtrics platform. When schools requested, the researcher visited the school in person and provided information on the purpose of the study and the expected level of involvement to potential participants. To allow for 20% attrition, the target for recruitment was set at 450 and the sample size of 360 was based on a ± 5% margin of error in estimated sugars intakes. Participants were requested to provide assent and data were collected only after consent and assent were obtained.

Data collection

The demographic information on the participant's name, age, and, date of birth, height (in inches/centimetres) and weight (in kilograms) and the area of residence was collected using the online Qualtrics survey tool. Parents were requested to measure their child's height and weight

at home or provide these data from previous records. A paper-based or electronic version of a purpose-designed three-day diary was used to collect information on the participant food and drink intake. Participants recorded all foods and drink consumed in the diary on three consecutive days including one weekend day This allowed for detailed dietary data to be captured on a non-school (Sunday) and school days (Monday and Tuesday or Friday and Saturday). Participants recorded the time and amount of all foods and drinks consumed. The amount was reported by participants using household measures (cups, glasses, bowls, spoons, plates etc.). Information recorded in the diary was transferred onto the online dietary assessment tool (Intake24 South Asia Locale 2022 Version) [27, 28] by the researcher (A.I.) during a one-on-one interview with each participant. Portion sizes were ascertained during this interview using the database of 2500 food portion size photographs of more than 100 foods. Food compositional tables, integrated in Intake24, enabled the daily intake of sugars to be derived. The estimation of Physical Activity Level ratios (PAL) using the available height and weight information was used to validate the reported E. The PAL was calculated by dividing the reported E by the Basal Metabolic Rate (BMR) [29].

Data management

Amount and percent contribution of free sugars to E intake: The data file was downloaded from Intake24 and after initial data cleaning, the data file was imported into STATA 17.0 (Stata Statistical Software: Release 17. College Station, TX: Stata Corp LLC). In the dataset, the daily dietary data were organised into eating occasions: main meals (breakfast, lunch and dinner) and snacks/drinks (early, mid-morning, afternoon and late evening). The details about creation of the global and indexing variables for dietary data analysis have been described in Chapter 2.
The intake of sugars for each of the three days of recording was averaged to obtain the daily intake of both total and free sugars. For each participant, E from total and free sugars (grams of intake x 4 kilocalories) was calculated and this figure was divided (total calorie intake /100) to give the percentage E provided by total and free sugars. Participants were classified according to their percentage E obtained from free sugars intake into the following categories based on the WHO recommended thresholds: (1) <5% E, (2) 5-<10% E, and (3) ≥10% E (i.e., participants exceeding the WHO recommended thresholds).

Dietary sources of free sugars: The food groupings used for the analysis were based on an earlier report by the India NNMB [24]. The search terms and descriptions of observations with non-zero values under the 'Free Sugars' variable in the data output were filtered as a first step. This yielded a list of 409 foods and beverages with unique food codes. Then, using the list of

food groupings in the India report as a reference, the 408 foods were categorised into 34 sub-groups and 19 main groups (Appendix J). The grams of free sugars consumed by each participant from each sub food group and main food group were determined. For each participant, the grams of free sugars obtained from each food group was calculated as a percentage of their daily free sugars intake.

***Pattern of free sugars intake*:** The grams of free sugars consumed by each participant from each eating occasion were determined and categorised into free sugars consumed in main meals and those consumed as snacks. The data on the daily intake of free sugars were used to compare the intake on weekdays (Friday, Saturday, Monday, and Tuesday) with that on the weekend day (Sunday) and to explore trends in free sugars intake between school districts.

Statistical analyses

The distribution of E and free sugars was analysed as the first step. Descriptive statistics for continuous variables that were normally distributed included mean, standard deviation and 95 % confidence intervals (CI). For variables with non-Gaussian distribution, the median and interquartile range (IQR) were reported. Generalised mixed linear models were fit examine the effect of age, gender, school district, eating occasion (meal versus snack), and the day of week (weekday versus weekend) on the amount and pattern of free sugars intake. The daily free sugars (g/day) and the amount of free sugars at meals (g/day) and snacks (g/day) were considered in these analyses. In these models, age, gender, school district, eating occasion and day of week were considered, with random effects used to take into account the repeated measurements for each participant for meals and snacks and for days of the week, as appropriate. Multivariable logistic regression models were used to explore the relationship between these same explanatory variables and meeting WHO (i.e. free sugars intake >5% E). In these models, age, gender, school district, eating occasion and day of week were considered, with random effects again used to take into account the repeated measurements for each participant for meals and snacks and for days of the week. The logistic regression results were expressed as Odds Ratios with associated 95% CI.

Results

Sample characteristics

Details of the intake of E has been reported in Chapter 4. In brief, the median E intake was 10.8 (IQR 9.0 -12.5) MJ for girls, and 12.3 (IQR 10.3- 15.2) MJ for boys. For the 97 girls and 144 boys providing body weight data, PAL ratios were 2.0 and 2.1 respectively

Amount of free sugars intake and percent contribution of free sugars to E

The data on amount and percent contribution of free sugars to E are presented in Table 5.1. The median (IQR) of the daily free sugars intake was 48.0(31.1 – 72.9) g/day. Intake of free sugars by boys (53.1 (IQR 34.1- 76.5)) g was significantly greater than that in girls (43.0 (IQR 28.1-68.5)) (P=0.004), however, no between-gender difference was observed in the percent contribution of sugars to E: total, and free sugars contributed 14.9 (IQR 11.4-18.1) % E and 7.1 (IQR 4.8-10.1) % E respectively. Analysis showed 27.2% and 46.7% achieved the WHO recommended thresholds to limit the intake of free sugars to <5% E and 5- <10% E respectively.

Table 5.1: Total and free sugars intake and percent contributions of sugars to energy for 393 11-13-year-old young adolescents (224 boys and 169 girls) attending private schools in Delhi, India

	Variable	Median	IQR	Minimum	Maximum
All participants (n=393)	Total Sugars (g/d)	98	75.6 - 129.1	21.2	326.0
	% E from Total Sugars	14.9	11.4 - 18.1	3.0	37.8
	Free Sugars (g/d)	48	31.1 - 72.9	0.5	263.5
	% E from Free Sugars	7.2	4.8 - 10.3	0.1	28.7
Boys (n=224)	Total Sugars (g/d)	104	80.2- 138.7	27.3	326.0
	% E from Total Sugars	14.7	11.3-17.8	3.6	35.5
	Free Sugars (g/d)	53	34.1- 76.5	6.7	263.5
	% E from Free Sugars	7.3	5.0- 10.3	0.9	28.7
Girls (n=169)	Total Sugars (g/d)	95	70.1- 120.2	21.3	303.1
	% energy from Total Sugars	15.0	11.4- 18.3	3.0	37.8
	Free Sugars (g/d)	43	28.1- 68.5	0.5	211.0
	% energy from Free Sugars	7.0	4.7- 10.3	0.1	26.9

Dietary sources of free sugars

Table 5.2 provides detailed information on the dietary sources of free sugars for the study population as a whole, and for consumers only. The three main food groups contributing to free sugars intake were: (1) Sugar, preserves and syrups; (2) Cakes and biscuits and (3) Desserts. These food groups contributed an average of 60.6% to free sugars. The complete list of all the foods and beverages contributing to free sugars, categorised into main and subgroups is included in Appendix J.

Table 5.2: Percent contribution of food sources to free sugars intake (for 393 11-13-year-old young adolescents (224 boys and 169 girls) and consumers).

	All participants (n=393)		Consumers only		
Food Group	**Median%**	**IQR**	**Median%**	**IQR**	**n**
Sugar, preserves and, syrups	31.2	9.6 – 51.7	37.4	23.4 – 56.4	314
Table sugar	28.9	9.0 – 50.7	36.4	22.2 – 55.0	311
Honey and syrups	0.0	0.0	20.5	11.7 – 41.7	14
Cakes and biscuits	13.7	0.0 -26.4	18.9	9.8 – 33.1	292
Cakes	0.0	0.0	8.1	4.7 – 14.8	80
Biscuits	9.8	0.0 – 23.4	17.0	9.6 – 30.6	267
Desserts	5.4	0.0- 17.5	16.0	9.4 – 27.3	222
Non-frozen non-milk desserts	0.0	0.0	12.2	5.1 – 20.2	69
Non-frozen milk-based desserts	0.0	0.0	9.8	4.9 – 19.2	92
Frozen, milk-based desserts	0.0	0.0 – 7.4	11.6	7.3 – 17.9	134
Frozen, non-milk desserts	0.0	0.0	6.0	1.4 – 6.6	3
Beverages	2.1	0.0 – 15.7	15.1	9.6 – 25.3	204
Sugar sweetened beverages	0.0	0.0 – 14.1	14.8	9.8 – 22.9	181
100% fruit and vegetable juices	0.0	0.0	9.0	5.5 – 10.4	50
Sweetened milk products	4.3	0.0 – 14.6	12.7	7.3 – 22.3	223
Milk-based drinks	3.0	0.0 – 13.2	11.8	7.0 – 21.0	216
Yoghurt(lassi)	0.0	0.0	8.8	5.6 – 12.8	21
Confectionery	0.0	0.0 – 5.7	11.4	6.4 – 23.8	122
Chocolates	0.0	0.0 – 4.7	10.9	6.4 – 23.5	114
Candies/sugar confectionery	0.0	0.0	6.6	2.4 – 12.0	21
Spreads and sauces	0.0	0.0	4.6	1.2 – 11.4	191
Savoury sauces	0.0	0.0	3.3	1.9 – 5.3	148
Sweet spreads	0.0	0.0	11.9	5.8 – 20.1	72
Bread and bread-based savouries	0.0	0.0 – 3.5	3.5	1.7 – 6.1	196
Bread, bread rolls, flat bread	0.0	0.0 – 1.5	3.1	1.9 – 5.1	124
Bread with fillings	0.0	0.0 – 1.0	2.2	1.1 – 3.9	120
Chutney and condiments	0.0	0.0	8.3	3.6 – 16.0	76
Breakfast foods	0.0	0.0 – 1.2	3.2	1.9 – 6.1	108
Breakfast cereals	0.0	0.0	3.6	2.5 – 6.5	75
Savoury breakfast foods	0.0	0.0	1.8	1.0 – 2.8	43
Curry	0.3	0.0 – 0.9	0.5	0.2 – 1.3	295
Vegetarian curries	0.2	0.0 – 0.7	0.4	0.2 – 1.1	271
Non-vegetarian curries	0.0	0.0	0.5	0.4 – 1.1	58
Pizza	0.0	0.0	5.1	3.8 – 8.8	41
Chicken/ meat dishes	0.3	0.0	0.7	0.3 – 1.2	31
Savoury snacks and crisps	0.0	0.0	0.7	0.4 – 2.2	63
Cereal-based savouries	0.0	0.0	1.0	0.6 – 1.8	71
Pulse-based dishes	0.0	0.0	1.7	0.8 – 3.6	38
Noodles	0.0	0.0	0.6	0.4 – 1.0	54
Other	0.0	0.0	0.9	0.4 – 1.8	99

Pattern of free sugars intake

Participants consumed more free sugars from snacks on average compared with meals Snacks contributed a daily average of 42.0 (SD 28.6) g free sugars and meals contributed 14.1 (SD 15.4) g (P<0.001). Table 5.3 provides information on the percent E obtained from free sugars consumed as snacks compared with that consumed in meals and shows how free sugars compared on weekend and weekdays.

Table 5.3: Pattern of free sugars intake for 393 11-13-year-old young adolescents (224 boys and 169 girls) attending private schools in Delhi, India

Eating occasion	Mean	SD	Median	IQR
Main meals				
Free Sugars (g/d)	14.1	15.4	10.1	3.8- 19.3
% E	2.0	1.9	1.4	0.5 – 2.9
Snacks				
Free Sugars (g/d)	42.0	28.6	35.0	22.4 – 55.1
% E	5.7	3.4	5.2	3.4- 7.8

Weekday Vs Weekend Intake	Mean	SD	Median	IQR
Weekend (Sunday) n=393)				
Free Sugars (g/d)	58.0	42.4	49.6	26.9 – 79.7
% E	7.9	5.2	7.0	4.3 – 10.9
Weekday- Monday (n=115)				
Free Sugars (g/d)	42.4	32.5	36.4	16.9 – 55.6
% E	6.4	4.7	5.6	2.8 – 8.4
Weekday- Tuesday (n=115)				
Free Sugars (g/d)	43.2	30.7	39.0	19.4 – 63.6
% E	6.1	3.9	5.9	3.1 – 8.4
Weekday-Friday (n=278)				
Free Sugars (g/d)	59.8	47.1	52.8	28.0 – 85.7
% E	8.2	6.2	6.9	4.3 – 10.9
Weekday-Saturday (n=278)				
Free Sugars (g/d)	60.6	41.7	52.4	29.3 – 79.8
% E	8.4	4.9	7.9	4.6 – 11.0

The amount of intake and percent E contributed by free sugars in young adolescents from different school districts is presented in Table 5.4. The participants from East and North West districts obtained consumed greater amounts of free sugars compared with the young adolescents attending schools in the remaining districts. The patterns of free sugars intake were investigated further through regression analyses to study the effect of school district on the free sugars intake by participants.

Table 5.4. Trends of free sugars intake and percent contribution of free sugars to E based on the school district for 393 11-13-year-old young adolescents (224 boys and 169 girls) attending private schools in Delhi, India

District	n	Median	IQR	%E
Central	56	48.2	37.3 – 70.9	7.7
New Delhi	43	45.9	27.7 – 69.8	6.5
North	29	46.8	37.7 – 71.2	7.6
North East	34	45.7	31.1 – 66.3	7.5
North West	24	66.8	34.7 – 102.0	9.5
East	57	72.4	52.4 – 89.5	10.1
West	23	38.6	29.6 – 60.6	6.4
South	52	46.9	30.0 – 74.1	7.8
South East	25	43.6	28.6 – 59.4	8.7
South West	50	34.9	25.5 – 52.3	6.6

The results from the regression analyses are summarized in Table 5.5 and show participants consumed significantly less free sugars on weekdays (P=0.01) and that the <5% E WHO threshold was more likely to be achieved on a Weekday (P<0.05), compared with the weekend. Further, compared with participants from the school in New Delhi, those from the less affluent North-West district (P<0.05) and the densely populated East district (P<0.001) consumed significantly more free sugars and consumed significantly more free sugars as snacks. The participants from the school in East district were least likely to achieve the <5% E WHO threshold for intake (P=0.001).

Table 5.5: Effect of gender, age, school district, day of record and eating occasion (meals vs. snacks) on free sugars intake (n=393)

Variable	Generalised Linear Mixed Model	Logistic Model	Generalised Linear Mixed Model
Dependent Variable	Daily Free Sugars(g/d)	% E contributed by Free Sugars categorised as binary outcome <5%E and >5% E	Daily Free Sugars (g/d) meals and snacks
	β (95% CI), P value	Odds Ratios, P value	β (95% CI), P value
Gender			
Girls	-10.3 (-17.5,-3.1); P=0.005	1.0 (0.7, 1.6); P=0.8	-5.1 (-8.6, -1.6) P=0.004
Boys (Referent)	-	-	-
Participant Age	3.4 (-0.7, 7.6); P=0.1	0.99 (0.8, 1.3); P=0.9	1.7 (-0.4, 3.8); P=0.1
Eating Occasion			
Snacks	-	-	27.9 (24.9, 30.9); P<0.001
Main Meals Referent)	-	-	-
School district			
Central	11.3 (0.06, 22.5); P=0.04	0.7 (0.3, 1.6); P=0.5	5.6 (-1.1, 12.3); P=0.05
North	9.5 (-3.8, 22.7); P=0.16	0.7 (0.3, 1.8); P=0.5	5.5 (-2.3, 13.3); P=0.16
North East	7.9 (-10.1, 26.0); P=0.4	1.3 (0.5, 3.1); P=0.6	4.8 (-2.9, 12.5); P=0.22
North West	19.8 (3.0, 36.7); P=0.02	0.6 (0.2, 1.8); P=0.4	10.7 (2.2, 19.1); P=0.01
East	28.6 (15.2, 42.0); P<0.001	0.2 (0.1, 0.6); P=0.001	15.1 (8.4, 21.7); P<0.001
West	6.8 (-9.3, 22.9); P=0.4	0.9 (0.3, 2.4); P=0.9	3.0 (-5.7, 11.7); P=0.47
South	11.7 (-1.2, 24.6); P=0.07	0.9 (0.4, 2.2); P=0.9	6.6 (0.2, 13.5); P=0.05
South East	7.0 (-7.2, 21.2); P=0.33	0.8 (0.3, 2.0); P=0.7	3.6 (-4.8, 12.0); P=0.4
South West	-3.3 (-14.6, 8.1); P=0.57	1.2 (0.5, 2.7); P=0.6	-1.9 (-8.9, 5.1); P=0.6
New Delhi (referent)	-	-	-
Day of week			
Monday	-7.3 (-12.9, -1.7); P=0.01	1.8 (0.99, 3.3); P=0.05	
Tuesday	-5.9 (-11.6, -0.2); P=0.04	1.4 (0.8, 2.5); P =0.24	
Friday	-2.5 (-8.0; 3.0); P=0.4	1.3 (0.9, 2.0); P =0.13	
Saturday	-1.3 (-6.0; 3.4); P=0.6	1.0 (0.7, 1.6); P=0.8	
Sunday (referent)	-	-	
Constant (Standard Error)	10.6 (26.3)	0.4 (0.7)	-9.7 (13.3)

Discussion

The present study aimed to determine the amount, sources, and patterns of free sugars intake by 11-13-year-old children in Delhi, India. The median the daily free sugars intake in this sample adolescents was high, and close to 10 teaspoons per day. Total and free sugars contributed 14.9% and 7.1% to E intake respectively, and around one quarter of participants achieved the WHO recommendation to limit the intake of free sugars to <5% E. The leading sources of free sugars were from discretionary items including sugars, preserves and syrups; cakes and biscuits; desserts. Participants consumed more free sugars as snacks compared with main meals. Average intake of free sugars on weekdays was significantly less than on the weekend.

Amount of free sugars intake and percent contribution to E

Although the median free sugars intake (grams) in the current study population is comparable with data for similar aged young adolescents in LMICs including Libya (54.3 g/d) [13] and China (53.1g/d) [30], it is lower than the reported intakes for adolescents in high-income countries (HICs) [8, 14, 31, 32]. A larger proportion (71%) of the current study sample achieved the WHO recommendation to limit intake of free sugars to <10% E, compared with reports from HIC including the Netherlands (5%) [33], UK (27%) [8] and, Australia (23.8%) [14]. The relatively lower percent contribution of free sugars to E observed in the current study could be due to the high reported overall E intake to which nutrients other than sugars (i.e. fat) contributed (Chapter 4).

Food sources of free sugars

Forms of free sugars added by the consumer, which include table sugar, honey and syrups contributed the largest proportion (median 31.2%) to overall free sugars intake. Participants reported adding sugars to milk-based drinks and consumed honey and syrups in combination with food and/or added these to tea/ warm water. This contrasts with the data on the contribution of table sugar, honey and syrups to free sugars by adolescents from HICs including Australia (7.7%) [14] and UK (4.9%) [8]. The current study findings highlight the need to improve health education aiming at lowering consumer added free sugars to foods and drinks. A unique finding from the current study is the low percent contribution of '*Beverages'* (median 2.1%) to free sugars intake. Beverages in the current study included fruit and vegetable juices and sugar-sweetened beverages (SSBs). Contrary to this, beverages including SSBs and juices have been reported to be the leading contributors to free sugars intake in adolescent schoolchildren in

many dietary surveys in many HICs [8, 14, 33-35] and middle [30]/ and LMICs [36], with the proportion of free sugars from this source ranging from 23% to 54.2%.

Despite the published reports on the rising intake of pre-packaged foods and beverages in Delhi [18] [37], there is evidence suggesting adolescents have switched to healthier alternatives since the onset of COVID-19 [38, 39] which may in part explain the lower intake of SSBs. The observation that more than 50% participants consumed warm turmeric milk, fresh tender coconut water, herb-infused water, citrus fruits, and herbal tea which contain low or no free sugars, supports this theory. Moreover, the individual pack size, serving size and sugars content is reported to vary across different countries which could explain the inter-county variation in the contribution of SSBs to free sugars [4, 40, 41]. Many governments have prioritised SSB taxation as a means to lower free sugars consumption and this has led to decreased sales, purchasing, and dietary intake of taxed beverages in many countries [42, 43]. However, the current data on SSB intake suggest taxation may have a lesser impact in India. This highlights that country-specific strategies, informed by data on the food sources that contribute to intake are needed to lower the intake of free sugars. The current findings suggest that it is essential that intake of consumer added free sugars such as table sugar and honey should be addressed as a priority. Educating parents must be prioritised as they are usually the primary meal providers and purchasers of food in a household.

The group contribution of Cakes and Biscuits to free sugars (median 13.7%) was lower than reported for adolescents in HICs including Spain (16%) [44] and UK (18.2%) [8]. However, the proportion of free sugars contributed by *Sweet and Savoury Biscuits* (median 9.8%) is high compared with the corresponding figure reported for adolescents in other countries [14, 30, 35] suggesting that young adolescents in India are exposed to hidden free sugars in savoury as well as sweet biscuits. Most of the current study participants reported the intake of biscuits along with a milk-based drink as an early morning snack or breakfast. This is suggestive of a consumption pattern of milk-based drinks (milk mixed with regular/fortified drink mix and table sugar) in combination with hidden free sugars in biscuits. It is important to address this pattern of intake. In the updated guidance on labelling of pre-packaged foods, the food safety authority in India recommends the display of the detailed nutrition profile and the use of star-ratings to educate the consumer and encourage intake of a balanced diet. Although it may not directly impact the preferences of young adolescents, such efforts could contribute to modifying the purchasing pattern and may help reduce the exposure of young adolescent schoolchildren to hidden free sugars in biscuits [45]. The percent contribution of *Sweetened Milk-Drinks* which

included flavoured milks, condensed milk and yoghurt-based drinks in the current study (median 4.3%) is lower than that reported for 9-13-year-olds in Australia [14] and Spain [44]. Although the consumption of yoghurt-based probiotic beverages and dairy products is believed to have health benefits [46], the current study findings show that there is a need to educate adolescents and parents about the harms associated with adding table sugar and syrups to these drinks.

Milk and Non-Milk Desserts contributed a lower proportion to free sugars (median 5.4%) than the reported percent of sugars obtained from 'Desserts' by adolescents in HICs [10, 14, 34, 47]. However, some of the non-frozen milk and non-milk desserts consumed by the current study participants are unique to Indian diet and therefore cannot be directly compared. As opposed to the data on the sources of free sugars in adolescent diets in HICs [8, 14, 44] and some LMICs [36], the current study participants obtained little free sugars from confectionery and breakfast cereals. Bread with sweet spreads/ preserves, savoury cereal-pulse combinations, unleavened whole wheat bread (chapatti/ paratha), savoury semolina/vermicelli porridge and deep-fried whole-wheat bread (puri) were the commonly reported breakfast foods in the present study. Cultural differences in breakfast intake perhaps explains the low percent contribution of cereals to free sugars intake in the present study [48]. Further, participants in the present study obtained free sugars from food groups that are exclusive to Indian cuisine like Savoury Breakfast Foods (*idli, dosa, upma*), Condiments including *chutneys* and pickles, Bread with fillings for e.g. *sheermal*, stuffed *paratha* and, Curries. There are no comparative international data for these culturally unique food groups.

Patterns of intake

The finding that the proportion of free sugars consumed as 'snacks' was higher than that obtained during main meals is similar to reports on free sugars intake by adolescents in other countries [13, 30, 31]. Although a specific definition of 'snack' was not adopted for this study, this result is based on the reported intake as a response to the pre-determined list of eating occasions provided in Intake24. The amount and percent E from free sugars were low on weekdays-Monday and Tuesday compared with Friday, Saturday and Sunday. This finding is similar to the sugars intake pattern reported in cohort studies from Europe [49, 50].

Participants in the present study reported the intake of a 'special meal' on Saturdays and / or Sundays. Participants also reported ordering food through online food aggregator applications, dining out of home with family, celebrating birthdays during Saturdays and Sundays. Participants from some districts reported visits to the 'weekly market' which are organized on

Fridays and Saturdays. In addition to fresh produce, fried food like '*bhatura'* (deep fried flat bread made with refined flour*)*, savoury snacks e.g. '*pani puri' 'samosa'* and '*chaat'*, ice creams and iced candies, sweet dishes for e.g. '*jalebi'* and 'fast food' for e.g. noodle dishes are available through mobile food stalls in these markets. In efforts to lower the risk of obesity and overweight, attention should be paid to high intake of sugar-rich and fried food outside home during weekends.

Trends in free sugars intake between school districts

The present study was not specifically designed to compare free sugars intake between districts. However, the finding that children from the schools in East and North West districts consumed more free sugars, were less likely to achieve the <5%E WHO threshold for intake, and were more likely to consume free sugars through snacks, suggest that there is an influence of wider socioeconomic factors on sugars intake. New Delhi is an urban district with better socioeconomic indicators [(51)]. East Delhi is reported to be the least resilient district with the population exposed to high retail and industrial intensity [(51)]. The densely populated North West district [(52)] has rural constituents, a literacy rate that is lower than the State average and a low level of health awareness compounded by poor access to services and resources [(51)]. Moreover, the school environments are impacted by the location of shops less than 100m from the school building in the less affluent North and North West districts with attractive displays of pre-packaged snacks including potato chips, cakes, biscuits, Indian savoury snacks and corn snacks at very low prices. This could partly explain the observed trends in free sugars intake between the different school districts. However, these observations need to be explored further in a larger study with sufficient power to explore differences by socioeconomic determinants or geographic location.

Strengths and limitations

To the authors' knowledge, this is the first report on the intake of free sugars by young adolescent school children in India. The limitations to the study have been described in detail in Chapter 4. In brief, Intake24 is the most comprehensive tool for South Asia, but the nutrient composition of all South Asian foods are not available. Accordingly, the system finds a best match based on the UK foods which may introduce inaccuracies in the estimation of E and free sugars. The present study was conducted post-pandemic (May-October 2022). Published research indicates modified dietary behaviours [(38, 39, 53)] and an adoption of a sedentary lifestyle [(54)] during and after the pandemic. Participants in the current study reported swapping SSBs and confectionery for warm turmeric milk, herb-infused warm water and citrus fruits (unpublished

data). Finally, it is possible that the collected data were subject to the bias of social desirability [55], so the reported results may be under-estimates of true consumption.

Future directions

The data from the current study help bridge the gap in the information on individual dietary intakes by adolescents in India. Results show that approximately 73% of adolescents exceeded the <5% E WHO threshold for free sugars intake. The results from the present study show that it is possible to obtain robust data on free sugars intake through well-validated dietary assessment methods. By using Intake24, with its integrated food tables, it is straightforward to derive free sugars intake. In the future, Intake24 could be applied to national surveys and could be further developed in local languages and with more culturally specific foods, to facilitate and possibly enhance this process. The data generated in this could be used to guide health promotion and public health education targeting young adolescents.

Conclusion

The median free sugars intake in this sample of young adolescents attending private schools in Delhi, India was above the WHO <5% E threshold. Forms of sugars that are added to foods by the consumer made the largest contribution to intake. Cakes, biscuits and desserts were the other leading sources. Young adolescents consumed greater proportion of free sugars as snacks and more free sugars at the weekend compared to weekdays. Strategies to lower free sugars intake by adolescent school children in India should focus on consumer-added free sugars and reduction in consumption as snacks.

Acknowledgements:

The authors thank the school principals, teachers, participants and, parents for their cooperation for the study. The authors thank the Intake24 team for setting up Intake24-South Asia Locale 2022 version for use in this study to analyse the dietary data. Intake24 is an open-source web-based dietary assessment research tool based on the 24-hour recall method, primarily designed for self-completion. Intake24 was created by Newcastle University (UK), funded by Food Standards Agency, Scotland and is now maintained and developed through a collaboration between Cambridge University (UK), Monash University (Australia) and Newcastle University (UK). The authors are thankful to the Health-Related Information Dissemination Amongst Youth (HRIDAY) team for support during the fieldwork.

Financial Support:

A.I's Ph.D. was funded through the Colgate-Betty Fanning Scholarship, The University of Adelaide.

Conflict of Interest:

The authors have declared no competing interests.

Authorship:

The study was conceptualized by P.M, A.I, L.G, L.D. Data collection, initial analysis, software, methodology, and validation: P.M, L.G, L.D, A.I. Funding acquisition: P.M. Statistical analyses: L.G, A.I, P.M, L.D; Writing: original draft: A.I as a part of her PhD studies with contributions from, P.M, L.G. L.D. Writing- review and editing: all authors.

Ethical Standards Disclosure:

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by The Human Research Ethics Committee (HREC) at The University of Adelaide (Approval Number H2021-027, Date: 8 March 2022) and by the Independent Ethics Committee, Centre for Chronic Disease Control, New Delhi, India (CCDC-IEC_14_2021 Date: 9 December 2021). Written informed consent was obtained from all participating schools and parents of the participants. Assent was obtained from all the participants.

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Chapter 6

Chapter 6: General discussion

6.1 Preface

This doctoral research study aimed to investigate the free sugars intake by younger people in Australia and India. The COVID-19 pandemic impacted the original research plan, prevented data collection and led to significant delays. Nonetheless, the change of plan to include the secondary analysis of data from the SMILE cohort study of Australian children, provided the unique opportunity to learn dietary data analysis methods and inform the methods to elicit robust data on sugars intake by young adolescents in India. Despite the challenges, the target sample size for the primary study in India was achieved.

At the outset, results show that free sugars intake exceeded the < 5% E threshold recommended by the World Health Organization (WHO) [(1)] in the 5-year-old children in Australia as well as the 11-13-year-old young adolescents in India. These findings suggest that the intake of free sugars remains high in young populations in both HICs and LMICs. This is concerning because the results point towards a high intake early on in life.

6.2 Perspectives on free sugars intake in Australian children

Diet in early childhood impacts on the longer-term risk of dental caries [(2)] and therefore the information on the sources of free sugars in the 5-year-olds of the SMILE cohort are useful to guide early intervention for caries prevention. As discussed in Chapter 3, the sources of free sugars are reported from the dental health perspective and therefore the classification of food groups is distinct from the AUSNUT food groups (Table 3.3). The results indicate that it is important to restrict the intake of Cakes, Biscuits, and Cereal Bars which were identified as the leading sources of free sugars, especially for dental caries prevention as these that tend to be consumed between meals, when salivary flow is relatively low [(3)].

In view of the rising rates of childhood obesity and overweight, Australia prioritised policy action to address the risks of unhealthy diet, especially consumption of sugared beverages [(4, 5)]. Prominent among the interventions is initiatives to raise public awareness through messages which reinforce healthier choices for example: swapping SSBs with plain water [(6)]. The low contribution to free sugars of SSBs in the SMILE study (median 1.2%) is indicative of successful campaigns and results are supportive of such interventions [(6, 7)]. The reports that compared the dietary intake in Australia from 1991-92 to 2011-12 suggest that the public are more health conscious and therefore avoid SSB intake [(8)].

The results of the secondary analysis which showed large contributions to free sugars from Cakes, Biscuits and Cereal Bars and Sweetened Yoghurts suggest that a holistic approach is needed to address free sugars and bring to account the hidden sources that may either be considered healthy (e.g. yoghurts and cereal bars) or considered an occasional treat (e.g. cakes). Australia's Partnership reformulation program [9] which received media attention in the recent years looks promising and the results on sources of sugars.

The findings on the determinants of intake highlight the need to prioritise initiatives that support migrant populations. Australia is among the countries with the highest proportion of population born overseas (nearly 30%) and immigration led to an increase in population by nearly 200,000 [10]. Previous research from Europe [11, 12] has shown that cultural factors impact eating habits. The results also indicate that there is scope to investigate further about the influence of the primary meal providers on the dietary intake in children. The analyses showed that wider socioeconomic factors including the family type (single versus two-parent families) and level of education (University versus vocational) were also found to have an effect on the sugars intake of children suggesting the need to focus on these factors in the upcoming interventions that aim to tackle free sugars.

6.3 Key learnings on dietary assessment from the secondary analysis

A customized food frequency questionnaire (SMILE-FFQ) was used in the SMILE study with a set list of foods mapped to the Food Standards Australia and New Zealand (AUSNUT) food codes (Table 3.3). The analysis of the responses to the range of frequency options in the SMILE FFQ is most ideal to classify the 5-year-olds into bands of intake [13]. However, in line with the earlier reports on free sugars intake by children in this cohort at 1 year and 2 years [14, 15], the amount of free sugars (grams) was assessed.

As discussed in Chapters 2 and 3, despite the SMILE FFQ being validated against repeat 24 hour recalls in an external cohort [16], it was not designed to measure total dietary intake and focussed only on sugars in view of the larger aim to study the impact on dental health. The goal of the research work conducted in India, as described in Chapters 4 and 5, was to conduct a detailed assessment of diet in young adolescents and generate high-quality evidence that would underpin interventions to promote a balanced diet and, lower sugars consumption. This required more comprehensive information on E, nutrient intake and, the patterns of sugars intake for e.g. comparison of intake as meals vs. snacks or by the day of the week, which the Australian sub-

study could not decipher. Therefore, it was decided that a 3-day prospective food diary would be used to collect dietary information.

The food and drink intake reported by participants in the purpose-designed diary (Appendix I) provided important information on the time of intake, the intake as main meals and snacks and since the data were collected on two weekdays and one weekend day, intake by day of the week could be discerned. This capsule of learning at the planning stage of the primary study also steered the aspects of the validation of food groups as sources of free sugars.

Besides the technical aspects of dietary assessment that were considered to obtain robust data on nutrient intake, practical and circumstantial aspects influenced the research design. The pandemic influenced the primary study research methods: digital materials and virtual interviews. A digital version of this diary was created in an editable Portable Digital Format (PDF). The majority of the 11-13-year-olds were familiar with the online video conferencing platforms (Zoom) subsequent to the digital learning during the pandemic years (2020-2021) and this enabled the seamless conduct of research-participant interviews using the online dietary assessment tool Intake 24 (South Asia Locale).

6.4 Intake24: key takeaways and the anticipated reshaping of nutrition surveys in India

Intake24, that has been tested and found to be reliable and well-validated, [17-19] is an open source and low-cost (free to use) digital application. The results of this doctoral project prove that it is possible to generate robust and high-quality data on nutrient intake including sugars using this tool (in combination with a 3 day diary) to assess portion size and to calculate nutrients consumed from reported data on food intake. The methods and results of the primary study show that the Intake24 tool has the potential to be applied to the nutritional epidemiological surveys in India, and make these surveys more affordable as fewer human resources are needed.

The integrated food compositional tables on Intake24 enabled assessment of nutrient intake from reported food intake in an effortless way and saved researcher time. This was because there was no requirement to validate portion sizes or to convert estimated food portion sizes to intake of nutrients through consulting food compositional tables. Intake24 fills the lacuna in dietary assessment and analysis software programs which are currently non-existent in India and hence the human resources are left with the arduous task of manual calculations [20]. This

is probably the main reason for a compromise in reporting dietary intake with researchers restricting to main categories (cereals, pulses, millets, green leafy vegetables, tubers etc.) and not reporting on the specific macro and micronutrient intake from local foods and food groups. Intake24 has facilitated the generation of this specific data on daily nutrient intake which would otherwise have been time consuming and expensive.

'Digital India' is known to be a highly successful initiative that has transformed consumer services, medical record management and health services at the tertiary care level in India [21]. The scope of utilising tools like Intake24 in nutritional surveys at the sub-national and national level in India could be explored as a part the multitude of initiatives under this far-reaching Government program. Further, Intake24 could be localised, and the content translated into multiple local languages which is a step forward from the existing English-only version. The Intake24 South Asia Locale which was used in this doctoral project is the most comprehensive database of foods commonly consumed in Southeast Asia and yet, the best match approach was used for few local foods that were reported to be missing. Therefore, the wider application of Intake24 in India and increased robustness of this application would require further development to include the diverse recipes from different regions in India. This further development of Intake24 is already happening for some LMIC such as Malaysia [22].

6.5 Approaches to address sugars intake by young adolescents in India and future research agenda

Researchers have shown that the strategies to address dietary intake, especially free sugars require an interwoven mix of upstream, midstream and downstream approaches with an element of pragmatism to design country-specific approaches to tackle sugars [23]. Based on the observations during data collection and the results of this doctoral work, some feasible approaches to address sugars intake by young adolescents in India (Figure 6.1) will be discussed in the next few pages, with inputs on the future research agenda.

6.5.1 Upstream approaches

A. Guidelines on sugars intake in India and the need for food-based dietary guidelines

The WHO recommendations on intake of free sugars are based on evidence, however, the best available evidence from cohort studies is largely from HICs. Information on free sugars intake from national and sub-national surveys in LMICs is also limited [24]. While many countries adopted the WHO guideline on free sugars intake as a national dietary guideline [25-28], the

Indian Council of Medical Research (ICMR) recommends limiting intake of 'sugar' to < 30g/day [29], citing the WHO guideline as a reference. However, there are no recommended thresholds for the intake of free sugars. The Indian population, especially schoolchildren are less likely to fully comprehend the meaning and purpose of such a guideline. The consumption of added sugar was analysed in 2019 [29]. However, these data are weak because an exact food compositional analysis was not used to report intake of free sugars from all dietary sources, and it is not clear if the reported results reflect only added 'sucrose' from the listed recipes.

The data on free sugars intake could be perused by stakeholders and policy makers to guide interventions and strategies to lower sugars intake. The results on sources of free sugars provide evidence to initiate discussions on creation of National Guidelines on Sugars and Food-based dietary guidelines on sugars.

The results of this research are the first to compare nutrient intakes with the newly-defined NIN-EAR [30]. Results showed that E and saturated fat intake are high. The young adolescents in Delhi obtained about 16% E from saturated fat while the recommended threshold is < 10% E [31]. The results imply a pattern of overeating by the young adolescents and the available information on the weight seemed to support this observation as the median weight (45 kgs) was well above the reference weights for 10-12-year-olds (34 kgs). Many participants reported the intake of sweet, and / or fried food and pre-packaged food as snacks and the results on the weekday vs. weekend intake provide the exact aspects that need attention. Results show that in young adolescents living in India, the problem is not limited to free sugars intake but also fat intake and overeating in general, which puts adolescents at the risk of obesity and other diet-related NCDs. Therefore, there is a need to develop specific food-based dietary guidelines. A further investigation on the sources of saturated fat will form part of the future research plan, to provide evidence to inform the development of these guidelines. The UK Food Smart campaign is a successful example of this approach [32, 33].

*B. **Agriculture diversification***

The fundamental aspects of sugar production and consumption have an overarching influence on sugars intake by populations. India is the largest consumer and the largest producers of sugar in the world. Large acres of land in the most fertile regions in India is allocated for sugarcane. Sugar and rice are subsidised under the Public Distribution System (PDS). Research has shown no evidence on the improvement of nutrition status of 5-14-year-olds as a consequence of the receipt of sugar and rice under the PDS [34], which was the primary goal of the National Food

Security Act and PDS. Sugar is affordable and easily accessible. On the other hand, in the urban affluent regions in India, sugar is marketed in several forms: date sugar, palm sugar, coconut sugar etc. with claims about the 'healthfulness' of each.

The results of this doctoral project clarify that all these forms constitute 'sucrose' and their consumption amounts to the intake of free sugars. In India, sugarcane is also diverted to produce ethanol, a biofuel and sugar exports also contribute a sizeable proportion of the economic revenue [35, 36]. Akin to the policy in Brazil [23], the diversification to ethanol in India is not to lower human consumption. Although agricultural diversification is a suggested approach for tobacco control [37], the feasibility of this strategy to lower human consumption of sugar remains unexplored. In the light of the results of this doctoral research, especially the large contribution of consumer-added sugars, it would be useful to initiate a dialogue with stakeholders including the sugar mills association to discuss the impacts of the existing farm policy and production targets on human health. Increased sugar production and export may contribute to the Gross Domestic Product (GDP). However, the likely burden of NCDs and the subsequent financial burden on households towards the treatment of these chronic diseases could be investigated to consolidate evidence, especially in LMICs like India where a reliable social protection for health is lacking.

C. Fiscal measures, labelling and, food reformulation

Manufacturers and vendors have a silent but overbearing influence on the food choices of adolescents. It has been recognised for a long time now that adolescents and children in LMICs are vulnerable to the marketing campaigns of the 'Big Sugar' industry [38, 39], especially SSBs and processed pre-packaged foods like confectionery, corn-based snacks and, potato crisps/ chips. Many governments have prioritised SSB taxation as a means to lower free sugars consumption and this has led to decreased sales, purchasing, and dietary intake of taxed beverages [40, 41]. Although this may be relevant to countries where intake of free sugars from SSBs is high, which is the case in a majority of HICs, its impact on adolescent children in India may not be as marked. This is because the results of this research showed a relatively lower contribution to free sugars from juices and SSBs.

In India, a 40% tax applies on all 'carbonated beverages'- a Goods and Services Tax (GST) of 28% and an additional 'sin tax' of 12%, a 28% GST applies on fruit-pulp and juice-based drinks. Despite these fiscal measures, the prices are much lower when compared with HICs and relatively small, on-the-go volumes are available in India (200 ml tetra packs and bottles).

Although this may be perceived as a reduction in portion size, the low price and smaller volume contribute to an easy access to young adolescents. The problem around beverage intake turns complex with the persistent marketing of 'health drinks' with sports personalities as the face of the massive advertising campaigns, including advertisements within the online streaming services which young adolescents have access to. Anecdotal evidence suggests that parents assume that fortified drink mixes improve vitamin and mineral intake when provided to growing children, which is the message of the marketing campaign. However, these malt-based drink mixes contain free sugars. In the current research, more than half of the study participants reported consuming fortified drink mix added to milk along with biscuits as an early snack, sometimes replacing breakfast. In addition to the free sugars present in the drink mix, the majority of the study participants added table sugar. This amounts to a large amount of consumer-added free sugars.

Milk-based fortified drinks are not included in taxed beverages and neither are biscuits subject to a sugars tax. Therefore, there is a need to tackle this peculiar pattern of intake using a more focused approach. Applying a levy on 'health drinks' could lead to an increased price and a decline in purchase, similar to the outcome of SSB taxation in HICs. However, a more evidence-based approach would be development of clear guidelines on food labelling and labelling 'health drinks' and drink mixes under the 'high-sugar' foods. In Chile, all packaged foods and beverages which contain added sugar, added salt and saturated fat that exceeds the set thresholds or the overall calorie content must carry a 'black octagon' with the words 'high-sugar/ saturated fat/ sodium' whichever applies. This labelling system is simple, impactful, and easy for consumers to understand. Researchers found that the purchase foods high in fat, salt and sugar declined after implementation of the law that called for the black signage [42].

In India, under the updated guidance on labelling [43], the food safety authority recommends the display of the detailed nutrition profile and the use of health star-ratings (HSR) to educate the consumer and encourage intake of a balanced diet. Although it may not directly impact the preferences of young adolescents, such efforts could contribute to modifying the purchasing pattern and may help reduce the exposure of young adolescent schoolchildren to hidden free sugars in drink mixes and foods like biscuits [43].

Evidence from Australia has shown that a HSR was more likely to be understood than the Nutrition Information Panel (NIP), Daily Intake Guide and other types of Front of Pack signage [44]. Further, studies recommended incorporating added sugars into the HSR label [45]. An

isolated strategy that recommends HSR may not suffice to address the intake of free sugars in India. Research shows that HSR is expected to not only drive consumer choice but also incentivise reformulation. Moreover, studies have shown that uptake of the rating is skewed towards the upper-end of the five-star spectrum [44]. In view of this evidence on the experience of countries which implemented the HSR, the upcoming strategy in India could be strengthened further by developing an updated nutrient profile of all the foods and beverages that contain high saturated fat, free sugars and added sodium (HFSS). Further, the evidence on implementation assessment of HSR in Australia has shown that a coalition of multiple sectors - industry, stakeholders, consumers and the Government was essential to enhance uptake with an emphasis on making such labelling norms mandatory and not voluntary.

Further, a strategy to lower free sugars could recommend manufacturers to 'use-less' sugars. Governments could mandate manufacturers to lower the amount of sugars used for manufacture of biscuits, cakes and Indian sweets as a part of product reformulation. Evidence from a meta-analysis showed that the reformulation to lower the sugar content contributes to a 11% reduction in sugars intake [46]. Governments in HICs like the UK have supported and monitored product reformulation efforts targeting specific foods. Recent data from the UK [47] on the progress of sugars reduction and product reformulation show that there was an overall 3.5% reduction in the total sugar per 100g (sales weighted average) in products sold between 2015 and 2020.

D. Vendor-support packages

Vendors are omnipresent in urban settings in India. There are convenience stores and shops as well as pushcarts and mobile food trucks. Published evidence from the year 2019 (pre-pandemic) [48] indicated that the young adolescents in Delhi private schools are exposed to offer of processed foods and HFSS foods within and outside schools. The foods identified were cakes, biscuits, confectionery, desserts and cereal-based deep-fried savouries. This 2019 study showed that some schools restricted the access to SSBs in the canteens but there was no regulation for fried snacks, confectionery or desserts.

In 2022, during data collection visits, the strategic timing of aggregation of vendors selling HFSS foods near schools and in school canteens, especially during recess, lunch break and school leaving time was observed. Cakes and Biscuits, Confectionery and Desserts have been identified as contributors of free sugars in this study. While it is unrealistic to completely restrict the presence of vendors, policy-led actions could facilitate restriction of HFSS foods, especially to children. For example, HFSS-restricted zones could be created, particularly in the city

environment around schools. In 2021 the Food Safety and Standards Authority of India (FSSAI) had initiated an upstream action to address intake of HFSS foods [49]. There are two important components of this regulatory approach: i) to restrict the sale and marketing of HFSS foods and beverages in and around schools; ii) provision of safe and balanced food through schools. It calls for the action by Food Business Operators (FBOs) to ban the sale of HFSS foods. However, a mechanism that drives the implementation of this regulation is lacking. Swapping HFSS foods with healthier options including fresh produce and incentivising vendors and FBOs that sell healthy foods and subsidising the retail prices of fresh produce could constitute a vendor-support package that contributes to the implementation of the 2021 regulation.

E. Action on food environments: restriction of free sugars and saturated fat

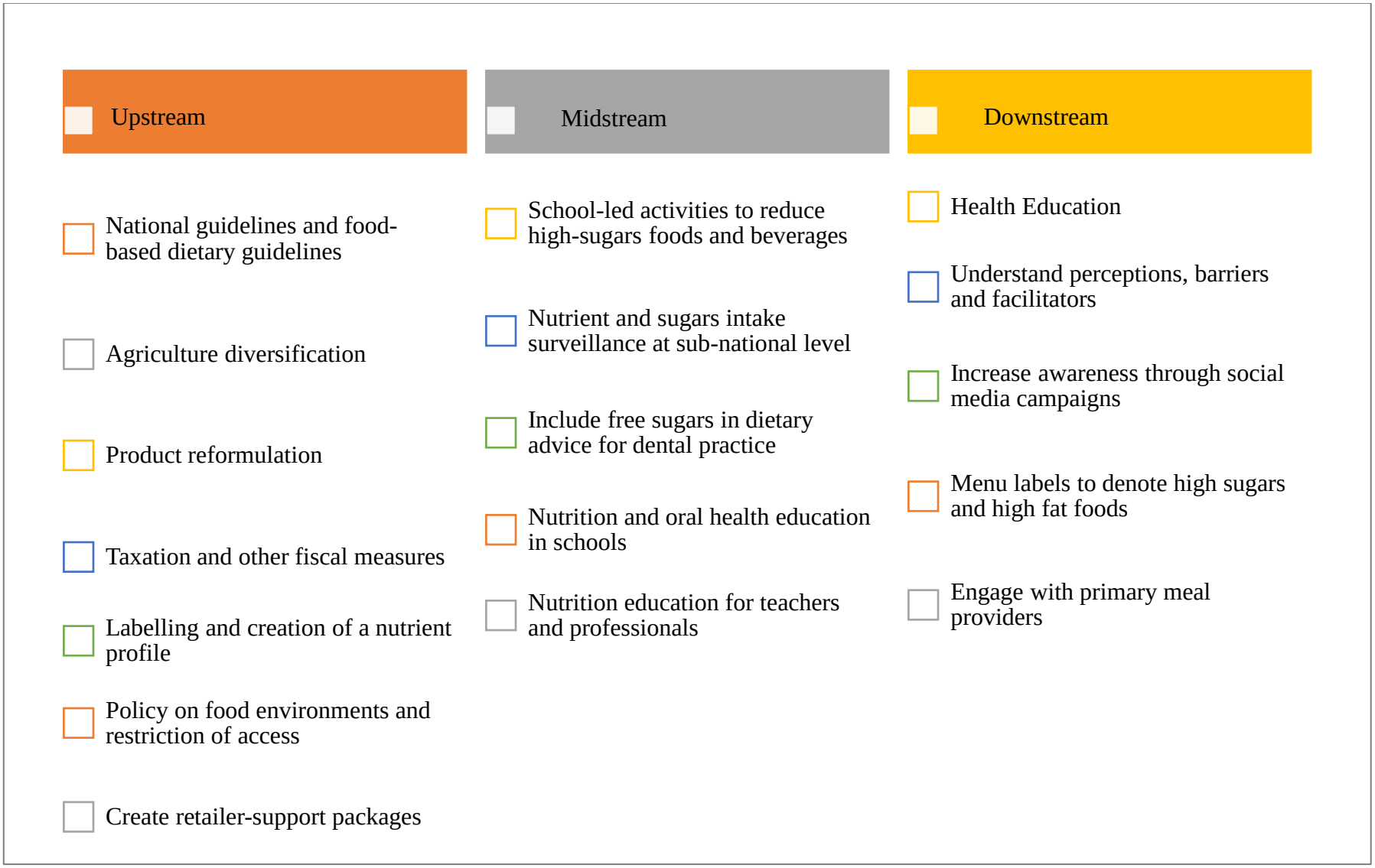
In India, the National Adolescent Health Program [50] and the Prime Minister's Overarching Scheme for Holistic Nutrition (POSHAN) [51] aim to achieve food security and balanced nutrition especially in children and adolescents. In collaboration with global health agencies like the UNICEF [52], targeted initiatives like school lunches and weekly fortification were designed to primarily address hunger and deficiencies among the lower SES groups. However, overnutriton and micronutrient deficiencies could soon emerge as a major public health problem in India [53, 54] creating a setback for achievement of nutrition goals in these programs. The agenda to address this problem is yet to take shape. The results from this research work particularly on the nutrient, saturated fat and free sugars intake could inform discussions on addressing the triple nutrition burden.

The POSHAN School meal program is a centrally-sponsored scheme under the National Food Security Act, 2013 and aims to improve the nutrition status of 118 million children and young adolescents aged 6-14-years in Government and aided schools. Anthropometric measurements and Body mass index (BMI) are used to monitor the nutrition status of the beneficiaries of this program along with haematological assessments to identify anaemia. A regular assessment of the quantity and quality of the meals provided is part of the monitoring framework [51]. Nutritionists are members of the expert group under this program. Private schoolchildren are not covered under the program, perhaps considering the SES status and the school meal program covers only one meal (lunch). The dietary intake of these children outside school hours, when they are exposed to pre-packaged foods with high fat and high free sugars remains unmonitored. The implementation of the restriction of HFSS foods suffers from the lack of evidence on the level of intake. The data on saturated fat and sugars intake by young adolescents from this doctoral project attempts to generate this much-needed evidence. A further analysis

will be undertaken to explore the intake of free sugars from traditional foods when compared with Westernised foods. Further, the intake of core food groups (cereals and grains; vegetables, legumes/beans; fruit; milk, cheese, yoghurts and alternatives and lean meats and alternatives) will be compared with the intake of discretionary foods (the foods which are high in saturated fat, sodium and free sugars) to inform the planned interventions of the Government of India.

The context of the current study augurs well because the results could inform the decisions of the policy makers working towards the restriction of HFSS, especially in Delhi school environments. The evidence generated in this research study on the exact sources that contribute to free sugars and the level of intake of saturated fat could underpin conversations around restriction of specific food groups. The forthcoming postdoctoral project aims to support the implementation of the 2021 regulation in Delhi, India and address the issues around the intake of HFSS food, in an iterative process involving stakeholders.

Figure 6.1: Suggested approaches to promote intake of a balanced diet and reduce sugars intake in young Indian adolescents



6.5.2 Mid and downstream approaches

None of the approaches described so far are standalone. A meaningful confluence of strategies at the midstream and downstream levels to address the wider determinants of sugars and dietary intake are needed to drive the upstream approaches. Some of the evidence-based interventions that could be applied to tackle sugars intake will be detailed in the next segment.

A. Nutrition education for teachers and role of professionals in sugars reduction

The experience of data collection in this study has revealed that the schools and the school teachers are well placed to influence the decisions of young adolescents in India. The Principal and the teachers in private schools that participated in this study were proactive and highly interested in understanding the scope and outputs of this research. This shows that teachers are amenable and could be the leaders to advocate healthier choices. Schools are the ideal settings for health promotion [55]. An accredited course on healthier food choices and a balanced diet could be added to educate teachers on nutrition. Governments in other countries (e.g. UK) have made available resource materials for training teachers on healthier eating. The resources cover a wide range of topics that cover healthy diets, understanding calories and also discuss poor diets and the impacts of unhealthy diets [56]. Under the larger objectives of the POSHAN program, the India National Institute of Nutrition could consider creation of such courses to empower teachers to be the leaders in encouraging healthier choices. Evidence shows that independent food business operators decide the menu of school canteens which sell packaged as well as non-standardised unpackaged foods [48] and the role of teachers is limited to restricting access to canteens during classes. It is possible to diversify the role of teachers and engage them in menu planning.

Adolescents and teachers could form a core group to discuss the availability of HFSS, the risks associated with their intake and subsequently advocate for the availability of healthier food within school premises. Through adolescent-led activities guided by teachers, strong advocacy efforts could be initiated that call for the restriction of the location of multinational fast-food chains and convenience stores that market and sell HFSS foods outside schools. A whole of school approach could thus be adopted to advocate a restriction on unhealthy foods that are high in free sugars and saturated fat.

The POSHAN program and the FSSAI policy seem to operate on two different tracks currently and do not address dietary intake comprehensively. Even though Government school children obtain a healthy lunch in school, the environment outside school is likely to make this strategy

ineffective as it may promote unhealthy choices. On the other hand, although children may bring packed lunch to school, the HFSS foods available in the private school canteens and in stores outside schools might invalidate the healthfulness of a healthy home-cooked meal. Moreover, setting national goals, especially for addressing HFSS intake maybe too ambitious considering the diverse food culture in India. However, the success of the POSHAN program, wherein Federal and State Governments coordinate to execute the supply of school meals and food grains offers lessons on the strategies to implement initiatives which aim to address unhealthy diet in children.

States in HICs like Australia devised a 'Healthy School Canteens Strategy' with clear process and outcome indicators. Food and drink criteria underpin this strategy which includes menu planning options and menu checks [57]. Similar strategies could be developed by private school managements under the guidance of a trained nutritionist. Materials on menu planning could be developed by the India NIN for wider adoption and state-level localisation. Menu labels indicating HFSS foods and beverages could be included, on the lines of the existing Green and Brown signage that indicates vegetarian and non-vegetarian foods/ beverages [58].

B. Dietary advice by health professionals

Preventive dental advice delivered by dentists through school oral health camps and community outreach programs should include specific information the risks of free sugars intake including specific food-based advice. This should encompass a message that the amount, frequency and pattern of free sugars intake would influence dental caries and that the intake of foods like dried fruit, cakes, biscuits and cereal bars outside of main meals could pose a higher risk for dental caries as the salivary flow is low during this time [59]. Health professionals must emphasise the risks associated with the intake of HFSS foods with clear messages about core versus discretionary foods, the exact sources of free sugars, saturated fat and added salt.

C. Role of parents in sugars reduction

Although evidence shows that the primary meal providers influence the food choices and decisions around the menu for main meals [60], little is known about the current knowledge of nutrition and sources of information on nutrition in the primary meal providers in India. There is a need to generate data on this specific aspect and a good starting point would be a qualitative study that includes parents to understand their perceptions around adolescent dietary behaviours. The outcomes of these discussions could inform home-based approaches for lowering the intake of free sugars and saturated fat (HFSS foods).

D. Role of media and stakeholders

Previous research has shown that the pervasive and uncontrolled marketing of the sugar industry in the media and internet creates confusion and influence the food choices. A study from the UK showed that despite sound information provided by the Government through well-designed applications and health education materials, parents faced challenges in controlling sugars intake [32]. Marginalised communities in LMICs like India are highly vulnerable to the misleading media campaigns of the sugars industry [39]. Strategies to address this trend should aim at generating clear and specific information on free sugars, added fat and salt. There are examples of not-for-profit organizations and stakeholders working towards raising awareness of the public in HICs [23, 32]. Evidence generated from high-quality research studies could be translated and communicated to public in plain language through attractive campaigns similar to the 'Action on Sugar' in the UK, the 'Sicklysweet' and 'rethink sugary drink' campaigns in Australia. People-centric approaches to restricting the demand for HFSS foods could be encouraged. Stakeholders (e.g. HRIDAY) that work towards health promotion in adolescents in Delhi could peruse the information on sources of free sugars to educate teachers and schoolchildren in their network.

In a recent exercise to develop oral health messages for Australian public [61], a Delphi model was adopted in which lay persons and experts worked together to reach consensus on the most appropriate messages on oral health for Australian public. This exercise received media attention and obtained support from stakeholders including the Australian Dental Association. In India, it is possible to involve public as well as professionals in the decision-making process, especially in cities. The starting point could be the creation of a key stakeholder group that includes adolescents, teachers, parents, vendors, professionals including dentists, and local leaders. A qualitative research study to understand the perceptions of this key group on diet, sugars and HFSS foods to inform approaches to lower exposure of Delhi school children to sugars is planned as a post-doctoral research. To conduct research on the qualitative aspects, especially the barriers and facilitators to sugars reduction in India was the part of the original thesis plan but could not be executed because of the COVID-19 pandemic.

6.6 Future research plans and overall research impact

The forthcoming postdoctoral research will investigate the food groups contributing to intake of saturated fat and report intake of core and discretionary foods by young Indian adolescents. Then, a qualitative exploration of the factors which inhibit and motivate restriction of sugars and saturated fat intake will be conducted to inform a whole-of-school approach.

To follow on from the work in this thesis, a grant application for research to support the implementation of healthier food zones around city schools in Delhi, India to reduce exposure of children to HFSS foods has already been prepared and submitted. This project involves collaboration between researchers from the University of Adelaide, Deakin University, India-NIN. HRIDAY and, Public Health Foundation of India. This was submitted to the Global Alliance for Chronic Diseases (GACD) in June 2023 and the outcome is pending. This five-year project plans to i) co-develop an implementation plan to introduce restricted HFSS food zones around schools and ii) evaluate the impact on the quality, availability, and price of available foods, and children's perceived impact of the intervention on their dietary behaviour, particularly free sugars intake. A key stakeholder group will be constituted with local leaders, the Ministry of Health, the FSSAI, school principals, adolescent schoolchildren aged 10-16 years, parents, and food vendors. This group will be engaged in workshops and through interviews to understand the challenges in implementation of the HFSS restricted zone and the mechanisms that would motivate implementation.

Overall research impact

This doctoral project reports the first-ever data on free sugars intake in India, and the first data generated by using a low-cost digital dietary assessment and analysis tool- Intake24. It was found that in addition to free sugars, the saturated fat intake of this study population also exceeded the recommended ranges. It is anticipated that these data will underpin continued research into exploring the effective means to lower free sugars consumption in India.

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Thesis Appendices

Appendix A: Email letter of Invitation to schools

Invitation to participate in the online research study: *Promoting eating well through schools in India- A survey of child's food and drink intake*

Dear Principal,

We are conducting an online survey on children's food intake. We are a team of researchers from The University of Adelaide. We are interested in looking at what 11-13-year-old children in India eat and drink. This is because we wish to find ways to promote better eating in children through schools. We are working on this project in collaboration with HRIDAY, a not-for-profit organisation working towards promotion of health in children in New Delhi.

Please find attached, detailed study information and a link to the online school consent form.

If you agree, we request you to help us recruit 11-13-year-old children from your school. We will randomly select sixty children from the roll number wise listing of all 11-13-year-old children.

We will then seek your help to share the study information with the parents of selected children and seek their consent for the participation of their children in the study. The first thirty children whose parents return the signed parent consent forms will enter the study.

If you are interested in your school's participation in the study, please complete the school consent form online by using this link:
https://adelaideresearcher.qualtrics.com/jfe/form/SV_8whLJc2YbZ2GVue

Please do not hesitate to call me if you have any questions.
Thank you.
Yours sincerely,
Dr Anupama Ivaturi

Appendix B: School Information Sheet

School Information Sheet

Study title: Promoting eating well through schools in India-A survey of food and drink intake in 11-13-year-old children.

Study PI: Paula Moynihan, Director, Food and Health, Adelaide Dental School, The University of Adelaide.

Contact details: Dr Anupama Ivaturi, Mobile: +91-9945595038

What is the study about?

We would like to explore the food and drink intake in children aged 11-13 years in India. We will use a purpose-designed online food and drink diary in which we will ask the selected child to report everything they consume for three consecutive days.

Who is doing this study?

We are researchers from The University of Adelaide, Australia. We will undertake this research in collaboration with Health-Related Information Dissemination Amongst Youth (HRIDAY), an organisation based in New Delhi, which is working on promotion of a healthy lifestyle in children.

What will the information be used for?

In the longer term, this information will help us work towards the promotion of eating well through schools in India and we are therefore inviting children from your school to help us with the study.

Are there any risks associated with participating in this project?

Some children may experience discomfort and may not feel free to discuss the food and drink diary with the researcher online. But the researcher will try to make this an interesting experience and ensure that the child is at ease throughout the virtual meeting.

Can a child withdraw from the project?

Participation in this project is completely voluntary. If a child agrees to participate, h/she can withdraw from the study at any time, up until the stage of data analysis without reason and with no consequence to any services. The data collected from the child will then be withdrawn.

What help do we seek from you?

We seek your help to obtain the roll number wise listing of all 11-13-year-old children in your school. We will select sixty pupils from this list. We would also like you to share study information with the parents of these children.

We will share the information to be sent to parents, for you to send it to parents.

What will the pupil be asked to do?

- Once you share study information with parents and after the parent consent, the children will be invited to an online group talk with Dr Anupama (the researcher), to tell them about the study. The link to this group talk will be sent through an email.
- During the online group talk, the researcher will show the children, how to access the online survey and how to record the food and drink that they eat and drink over a period of three consecutive days in the online diary.
- We will share the link to the online survey and the diary after the group talk.
- The child will be asked to record the food and drink they eat and drink on two weekdays and one weekend day. When the three days are completed, we would like the child to meet the researcher virtually through a one-on-one video call to discuss the online food and drink diary.
- During this video call, the researcher will go through the diary with the child and ask some questions to clarify what they have reported in the diary.
- The researcher may ask the children if she can take screenshots of the online group talk and / or the online one-to-one discussion on the food diary – but she will only take screenshots of the meeting with your child if parents have given permission. Any identifying features in the screenshots will be obscured.
- If possible, the researcher would also like the parent to take the measurements of the child's weight and height at home, using available scales.
- The child may share the recorded measurements with the researcher during the online interview.
- If the measurement is not feasible at home, the height and weight measurements will be accessed from the school medical record, along with the date last measured.
- Instructions for measurement of height and weight will be provided by email. The child must be in indoor clothing without any footwear for both height and weight measurement.

How much time will the child's involvement in the project take?

- We anticipate that the group talk to explain how to record food and drink in the online diary will take 20 minutes.
- The child may spend about 15 minutes every day to record food and drink intake in the diary.
- The meeting with the researcher to discuss the completed food diary will last approximately 30 minutes.
- If the parent agrees to the height and weight measurement, this will take an additional 5 to 10 minutes.

What are the potential benefits of the research project?

We want to explore the food and drink intake in 11-13-year-old school children in India by applying established methods so that we can work on promoting eating well through schools.

In the longer term, we will use this information to work with the school and the wider community to develop an approach to promote eating well through schools.

What will happen to the information collected?

- The information from all the children that take part in this study will be collated and then analysed. We will publish the findings from the whole group as an academic article in a scientific journal. Individual data will not be published.
- We may also publish the findings in conference presentations, news articles, and in a PhD thesis. The data may be stored and only de-identified data, without your personal information, will be shared, by following appropriate agreements, for future secondary analyses.
- We will remove anything from the written record which could identify the pupil or the parent in anyway. All the information we keep will be anonymous and we will never identify anyone by name in any report that we produce from this study. Anonymity will be maintained even in the shared datasets.
- Study information will only be used as described in this information sheet and it will only be disclosed according to the consent provided, except as required by law.

Will the child receive any feedback?

At the end of the study, we will provide a summary of the findings, for the group of children, to all the children and parents that have taken part through email. In the event that we identify malnutrition, we will advise the parent to discuss this with the child's doctor.

Are there any rewards for participation?

Your school will be thanked and will be rewarded for participation with an e-voucher for sports equipment (cricket or indoor game kits).

No financial reimbursement will be provided to individuals as a result of participation but e-vouchers for rewards (stationery including pens, pencils, craft paper) will be provided to participating pupils who submit the diary online with completed entries for all three days,

Who do I contact if I have questions about the project?

In case you have any further questions, you may please (contact

Anupama Ivaturi- Email: anupama.ivaturi@adelaide.edu.au Phone: +91-9945595038

Paula Moynihan-Email: paula.moynihan@adelaide.edu.au Phone: +61-8 8313 3073

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2021-027). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, Adelaide, South Australia, AUSTRALIA 5000
Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.
Local Contact for complaints: Anupama Ivaturi, +91-9945595038
If my school wants to participate, what do I do? In case you decide to participate, please return the consent form filled in and signed. Thank you for reading this information about our study.

Appendix C: School Consent Form

Online School consent form

School Name: Principal name: Date:

1. I have read the Information Sheet and agree on behalf of my school to take part in the following survey:

Title:	**Promoting eating well through schools in India-Recording child's food and drink intake.**
Ethics Approval Number:	**H2021-027**

2. The researcher has explained the reason for the study and I was able to ask the questions I had about the study and my school pupils taking part in it. My consent is given freely.
3. I understand that I am being asked for my consent for the following -
    a. For the school to provide the roll number wise listing of all the 11-13-year-old pupils attending our school and facilitating selection of pupils for the survey
    b. For sharing study information with the parents

I have indicated whether we agree to this or not below.

4. I understand that my school pupils, parents or I will not be named in any of the study reports.
5. I understand that pupils can stop taking part in the study at any time and that if pupils or their parents decide to stop taking part before the end of the study, any information that has been collected from my school pupil will be deleted from the study records.
6. I have been informed that information from this study will be shared as a write up in a scientific journal and may also be shared with other scientists in meetings/ conferences.
7. I have been informed that pupils' personal results will not be revealed at any stage of the study.
8. I agree -
    a. to provide the roll number wise listing of all the 11-13-year-old pupils attending our school to enable selection of pupils Yes ☐ No ☐
    b. to sharing study information with the parents Yes ☐ No ☐
9. I am happy for the researcher to look at the selected pupils' school medical record to get information on their height and weight, on obtaining parent's permission. Yes ☐ No ☐
10. I understand that the information will only be revealed if the parent has given permission except where disclosure is required by law.

Signature of School Principal/ In charge _____

Appendix D: Email letter of Invitation to Parents

Invitation to participate in the online research study: *Promoting eating well through schools in India- A survey of your child's food and drink intake*

Dear Parent,

This is an invitation for your child to take part in an online research study on children's food intake. We are a team of researchers from The University of Adelaide. We are interested in looking at what 11-13-year-old children in India eat and drink. This is because we wish to find ways to promote better eating in children through schools.

Please find attached more information about the study along with the link to an electronic consent form. This is to help you decide whether or not you wish your child to take part in the study.

If you agree for your child to participate, and once you have returned the signed consent form, you will receive a link for your child to access an online group talk where I will explain more to the children about the study. The school will provide the link to the online group talk, along with the schedule, in a separate email.

Attending the group talk and your child's potential participation in the research are completely voluntary.

If you are interested in your child's participation in the study, please complete the consent form online by using this link: https://adelaideresearcher.qualtrics.com/jfe/form/SV_77J9l2QAdv4MEyG

Please do not hesitate to call me if you have any questions.

Thank you.

Yours sincerely,

Dr Anupama Ivaturi

Appendix E: Parent Information Sheet

Parent Information Sheet

Study title: Promoting eating well through schools in India-A survey of your child's food and drink intake.
Study PI: Paula Moynihan, Director, Food and Health, Adelaide Dental School, The University of Adelaide.
Contact details: Dr Anupama Ivaturi, Mobile: +91-9945595038

What is the study about?
We would like to explore the food and drink intake in children aged 11-13 years in India. We will use a purpose-designed online food and drink diary in which we will ask your child to report everything they consume for three consecutive days.

Who is doing this study?
We are researchers from The University of Adelaide, Australia. We will undertake this research in collaboration with Health-Related Information Dissemination Amongst Youth (HRIDAY), an organisation based in New Delhi, which is working on promotion of a healthy lifestyle in children.

What will the information be used for?
In the longer term, this information will help us work towards the promotion of eating well through schools in India and we are therefore inviting your children to help us with the study.

Are there any risks associated with participating in this project?
Some children may experience discomfort and may not feel free to discuss the food and drink diary with the researcher online. But the researcher will try to make this an interesting experience and ensure that your child is at ease throughout the virtual meeting.

Can my child withdraw from the project?
Participation in this project is completely voluntary. If you agree to participate, you/ your child can withdraw from the study at any time, up until the stage of data analysis without reason and with no consequence to any services. The data collected from your child will then be withdrawn.

What your child will be asked to do?
We sought consent from your child's school for this project and they have agreed.

- If you agree for your child to take part, he/she will be invited to an online group talk with the researcher, to tell the children about the study. The link to this group talk will be sent through an email.

- During the online group talk, Anupama, (the researcher) will show the children, how to access the online survey and how to record the food and drink that they eat and drink over a period of three consecutive days in the online diary.
- We will share the link to the online survey and the diary after the group talk. You will receive this in an email.
- Your child will be asked to record the food and drink they eat and drink on two weekdays and one weekend day.
- When the three days are completed, we would like your child to meet the researcher virtually through a one-on-one video call to discuss the online food and drink diary.
- During this video call, the researcher will go through the diary with your child and ask some questions to clarify what they have reported in the diary.
- The researcher may ask the children if she can take screenshots of the online group talk and / or the online one-to-one discussion on the food diary – but she will only take screenshots of the meeting with your child if you have given your permission.
- If possible, the researcher would also like you to take the measurements of your child's weight and height at home, using available scales.
- Your child may share the recorded measurements with the researcher during the online interview.
- If the measurement is not feasible at home, the height and weight measurements will be accessed from your child's medical record, along with the date last measured only upon obtaining permission.
- Instructions for measurement of height and weight will be provided to you by email. Your child must be in indoor clothing without any footwear for both height and weight measurement.

How much time will my child's involvement in the project take?

- We anticipate that the group talk to explain how to record food and drink in the online diary will take 20 minutes.
- Your child may spend about 15 minutes every day to record food and drink intake in the diary.
- The meeting with the researcher to discuss the completed food diary will last approximately 30 minutes.
- If you agree to the height and weight measurement, this will take an additional 5 to 10 minutes.

What are the potential benefits of the research project?

We want to explore the food and drink intake in 11-13-year-old school children in India by applying established methods so that we can work on promoting eating well through schools. In the longer term, we will use this information to work with the school and the wider community to develop an approach to promote eating well through schools.

What will happen to my/my child's information?

- The information from all the children that take part in this study will be collated and then analysed. We will publish the findings from the whole group as an academic article in a scientific journal. Individual data will not be published.

- We may also publish the findings in conference presentations, news articles, and in a PhD thesis. The data may be stored and only de-identified data, without your personal information, will be shared, by following appropriate agreements, for future secondary analyses.
- We will remove anything from the written record which could identify your child or you in anyway. All the information we keep will be anonymous and we will never identify anyone by name in any report that we produce from this study. Anonymity will be maintained even in the shared datasets.
- Your information will only be used as described in this information sheet and it will only be disclosed according to the consent provided, except as required by law.

Will I receive any feedback?

At the end of the study, we will provide a summary of the findings, for the group of children, to all the children and parents that have taken part through email. In the event that we identify malnutrition, we will advise you to discuss this with your child's doctor.

Are there any rewards for participation?

No financial reimbursement will be provided to pupils as a result of participation but e-vouchers for rewards (stationery including pens, pencils, craft paper or sports accessories) will be provided to participating pupils who submit the diary online with completed entries for all three days.

Who do I contact if I have questions about the project?

In case you have any further questions, you may please (contact

Anupama Ivaturi- Email: anupama.ivaturi@adelaide.edu.au Phone: +91-9945595038

Paula Moynihan-Email: paula.moynihan@adelaide.edu.au Phone: +61-8 8313 3073

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2021-027). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028 Email: hrec@adelaide.edu.au

Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, Adelaide, South Australia, AUSTRALIA 5000

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

Local Contact for complaints: Anupama Ivaturi, +91-9945595038

If I want to participate, what do I do?

In case you decide to participate, please return the consent form filled in and signed using the online link provided in the email.

Thank you for reading this information about our study

Appendix F: Parent Consent Form

Online Parent Consent form

Human Research Ethics Committee (HREC)

CONSENT FORM

1. I have read the attached Information Sheet and agree on behalf of my child to take part in the following study:

Title:	**Promoting eating well through schools in India-A survey of your child's food and drink intake.**
Ethics Approval Number:	

2. My child and I have had the study, so far as it affects my child, and the potential risks and burdens fully explained to my satisfaction in the participant information sheet. I have had the opportunity to ask any questions I may have about the study and my participation. My consent is given freely.
3. I understand that I am being asked for my consent for my child to-
    a. Record the food and drink intake in the given online diary for three days in a row.
    b. Discuss the diary with the researcher during a video call, after completing the diary

and I have indicated my consent or otherwise below.

4. I understand that I am being asked to measure the height and weight measurement of my child at home or, provide the height and weight measurements from my child's medical record and I have indicated my consent or otherwise below.
5. I understand that my child's participation is anonymous and he/she can withdraw any time up until the stage of data analysis. I am aware that if my child decides to withdraw, this will not affect any services he/she receives or any advice regarding the management of my child's health, now or in the future.
6. My child and I have been informed that the information gained in the study may be published in an academic journal article/thesis/news article/conference presentations/website/book/report.
7. My child and I have been informed that in the published materials my child/I will not be identified and personal results will not be divulged.
8. My child and I have been informed that all the information from this study will be kept private and confidential.
9. I consent for my child to-
    a. Record the food and drink intake in the online diary for three days in a row. Yes ☐ No ☐
    b. Discuss with the researcher online after completing the diary. Yes ☐ No ☐
10. I give consent to measure my child's height and weight at home, using appropriate scales. I understand that my child must be in indoor clothing without footwear for this activity.

Yes ☐ No ☐

11. I consent to give access to my child's school medical record along with the date for the researcher to record information on his/her height and weight. Yes ☐ No ☐
12. Both I and my child have been informed and I give my consent to the researcher, to take screenshots, during the online discussion. Yes ☐ No ☐
13. I understand that the results of this study, but not individual information, will be used in a follow-on study, by the same researcher.
14. I hereby provide extended consent for the use of the information from this research in a future study that is an extension of the original research and involves a discussion to understand my views around promotion of eating well through schools in India. Yes ☐ No ☐
15. I understand that my child's information will only be disclosed according to the consent provided, except where disclosure is required by law.
16. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

Date: _____

Please fill the details below:

Name: _____

Name of the child: _____

School: _____

Date of Birth of child:_____

Address: _____

Mobile Number _____

Appendix G: Participant Information Sheet

Study title: Promoting eating well through schools in India-Recording your food and drink intake.

Study PI: Paula Moynihan, Director, Food and Health, Adelaide Dental School,
The University of Adelaide.

Contact details: Dr Anupama Ivaturi, Mobile: +91-9945595038

What is this study about?

- We would like to know more about what the children of your age eat and drink.
- We will use an online food and drink diary to find out. We will ask you to fill in everything you eat and drink for three days in a row.
- By taking part in this study, you will help us work for better eating through schools

Who is doing this study?

We are a team of researchers from The University of Adelaide. We are doing this study along with a team from HRIDAY, a not-for-profit organization located in Delhi, India. HRIDAY works for promotion of health among children.

Is there any risk if I decide to take part in this study?

You may feel uneasy during the online meetings and as we discuss the food and drink diary online.

But, Anupama will make sure that you are comfortable. This will be a potentially exciting activity that you are probably engaging in, for the first time in India.

Can I stop taking part in the project at any time?

Yes, and if you do stop taking part, it will not affect your school activities in any way.

We will remove all your information from our record, if you decide to quit (up until the point where we analyse your diary).

What will I be asked to do?

We have obtained consent from your school for school's participation in the study.

After your parent agrees, Anupama will invite you to an online group talk to be scheduled in consultation with the school.

During the online talk, Anupama will show you every step of the online survey - starting with opening the link on your email, agreeing to the assent statement, answering the questions in the survey and the steps in completing the online food and drink diary.

In order to ensure you understand the steps for filling the food and drink diary, Anupama will also connect with you online separately, in a one-on-one video call after the survey link is shared with you, to see how you go about completing the diary on all of the three days.

You will need to fill the diary on two weekdays and one weekend day. That is three days in a row.
Once complete, you need to submit the diary online.
Following the submission of the completed online diary, Anupama will discuss the diary with you. She will ask some questions about what you have written in the diary. This will be through a video call.
She will ask you if she can take screenshots during the online discussion. Only if you agree, she will save some screenshots of the meeting and add them to her report. Some screenshots may be shown to other scientists in meetings.

Your parent will be advised to measure your height and weight at home or provide height and weight from available records. If your height and weight is being measured at home, you will be asked to wear indoor clothes and remove any footwear during the measurement.

How much of my time will this take?

- The group talk to explain how to record the food and drink diary will take 20 minutes.
- You may spend about 15 minutes every day filling in the diary.
- The discussion of the diary will take 30 minutes.
- The height and weight measurement may take 10 minutes.

What are the benefits of this study?

This study helps us know more about what children of your age eat and drink. We will be using a new method to record and measure what you eat and drink and this will help scientists make better measurements of food intake. We will gather the information from over 400 children and use our findings to help us work towards improving what children eat, through schools in India.

What will happen to my information?

- We will share the findings as a write-up in a scientific book. We may share results with other scientists in meetings.
- This work is a part of Anupama's studies. She will write a report and submit it to her university for review.
- We will not reveal your name or any other personal information. We will only share information after seeking permission from your parent.
- We may store information from this study on a computer for future use but will protect it with a password to make sure only the scientists who work on this study can see it.

Will I receive any feedback?

We will provide a summary of the results for the whole group of children to you and your parent through email. If we notice any problem with your results we will ask your parent to speak to your doctor.

Will I receive any reward for participation?

Children who submit the diary online with completed entries for all three days will be given an e-gift card for stationery or sports accessories. Money will *not* be given as a reward to any participant.

Who do I contact if I have questions?

In case you have any further questions please contact

Anupama Ivaturi
Local Phone: +91-9945595038
Email: anupama.ivaturi@adelaide.edu.au
Paula Moynihan-
Email: paula.moynihan@adelaide.edu.au Phone: +61-8 8313 3073

What if I have a complaint?

We will do this work by following all the standard rules.

In our university, there is a group which monitors our work. We have received permission from them to conduct this study.

If you or your parent have any concerns or if you wish to raise a complaint, please call Anupama on the local phone number provided below:

+91-9945595038

If you want to contact our university for any concerns, the address, email ID and phone number are provided below:

The University of Adelaide
Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000

Your name will not be revealed to anyone if you contact them. An officer will talk to you and conduct a review. They will then inform you and your parent about the outcome.

If I want to participate, what do I do?

If you want to take part, please bring the signed consent form to school.

Thank you for reading this information about our study.

Appendix H: Participant assent form

Child assent form

Human Research Ethics Committee (HREC)

ONLINE ASSENT FORM

1. I have read the Information Sheet and agree to take part in the following study:

Title:	**Promoting eating well through schools in India-Recording your food and drink intake.**
Ethics Approval Number:	

2. The researcher has explained the reason for the study and I was able to ask the questions I had about the study and me taking part in it My assent is given freely.
3. My parent was present while the study was explained to me.
4. I understand that I am being asked for my assent for the following -
    a. For me to enter everything I eat and drink for three days in a special online diary that has been given to me for this study.
    b. For the researcher to meet with me in a video call on the next day after I have filled in the online diary to discuss what I have entered.

I have indicated whether I agree to this or not below.

5. I understand I am being asked for my assent to get my height and weight measured by my parent at home while wearing indoor clothing but taking my shoes/ other footwear off and I have indicated whether or not I agree to this below.
6. I understand that I will not be named in any of the study reports.
7. I understand that I can stop taking part in the study at any time and if I decide to stop taking part before the end of the study I understand that any information that has been collected on me will be deleted from the study records.
8. I have been informed that information from this study (but not me individually) will be shared as a write up in a scientific book and may also be shared with other scientists in meetings.
9. I have been informed that my personal results will not be revealed at any stage of the study.
10. I agree to-
    a. Record the foods and drinks that I eat and drink in the online diary for three days in a row.

    Yes ☐ No ☐

    b. Meet with the researcher on the next day after completing my diary to discuss it online.

    Yes ☐ No ☐
11. I am happy for the researcher to look at my school medical record to get information on my height and weight.

Yes ☐ No ☐

12. I agree to the researcher taking screenshots during the online discussion.
    Yes ☐ No ☐
13. I understand that the results of the group, but not my individual information, will be used in a follow-on study, by the same researcher.
14. I understand that my information will only be revealed if my parent has given permission except where disclosure is required by law.

Appendix I: Purpose-designed three day dietary diary

Attachment 9
Survey instrument

Promoting eating well through schools in India: Recording your food and drink intake

Welcome!

Thank you for agreeing to answer the survey.

- Please feel free to call me on +91-9945595038 if you have any questions.
- Please fill in the personal information page, including height and weight recorded at home or from your school medical record.
- Please read the instructions before you begin to fill in the food and drink diary.

Personal information

Name

Class

Your Date of Birth

Height _____cm /_____Feet ___ inches

Weight _____ kgs

Date recorded

School name

Parent's Name

Parent's Age

Your home address

Thank you for your response.

Now please answer the question below in your own words

Has there been any change to the food and drink you consume since school closure due to the COVID-19 pandemic?

Kindly describe in your own words about any changes to your food and drink intake.

It could be the quantity of food or drink including water, the number of times you ate or drank and the time of intake: eating or drinking at meals, before bed time, in between meals.

Here are some instructions for filling in the diary

Please read the instructions once again, before you fill in the diary.

- Please record everything you eat and drink on three days.
- Please fill in the diary ***day by day***, as you go along.
- **Please do not try and recall everything at once.**
- Please write in detail about the everything you eat and drink.

For example:

If you eat roti or rice, please write how many rotis/ how much rice and what you ate along with rotis and rice e.g. two rotis with one cup dal or one bowl rice with one cup of curry.

If you drink milk, please write what was added to milk e.g. one spoon sugar and one spoon bournvita etc.

- Please use the guidance on how to measure and fill in the amount in cups, glasses, teaspoons etc. e.g. 1 cup milk with 1 teaspoon sugar, 1 roti with 1 cup dal etc;
- Please see the example sheet for guidance.
- Kindly complete the diary, check that you entered everything on all three days and then click submit.

I hope you find this activity exciting.

I will connect with you in a video call to discuss the diary further.

Thank you.

Here is an Example

Time	What did I eat and drink?	How much did I eat and drink?
7:00	water	1 glass
7:10	Milk	1 cup milk 1 teaspoon sugar
7:30	Roti with ghee	1 Roti 1 teaspoon ghee
8:00	Banana	1 banana
10:00	Chocolate cream biscuits	2 biscuits
12:00	khichdi	1 bowl

Here are a few suggested ways to measure water, some of the foods and drinks

Food and drink examples	Suggested ways to measure
Water	Cups or glasses
Milk and other drinks e.g. lassi, soup, juice	Cups or glasses
Breakfast cereals e.g. cornflakes	Tablespoons or cups
Roti, paratha, bread or bun	Number or slices
Whole fruit e.g. apple, banana, orange	Number
Rice, vegetables, curry, dal	Cups, bowls, tablespoons
Sugar	Teaspoons or tablespoons
Biscuits	Number and type
Jam, cheese spread, butter, ghee	Teaspoons
Cheese slices or cubes	Number
Sweets	Number or cups
Chocolates and ice creams	Number
Syrups/medicines	Teaspoons
Squash e.g. Roohafza, mango squash	Glasses or cups

Day 1 Date

Please write everything including water, morning milk/tea, breakfast, morning snacks, lunch, afternoon snacks, evening tea/milk, evening snacks, dinner and post dinner snacks. Please fill in the date in the space provided. When you complete Day 1, please move on to the Day 2 page.

Time	What did I eat and drink?	How much did I eat and drink?

Day 1

Please write everything including water, morning milk/tea, breakfast, morning snacks, lunch, afternoon snacks, evening tea/milk, evening snacks, dinner and post dinner snacks. When you complete Day 1, please move on to the Day 2 page.

Time	What did I eat and drink?	How much did I eat and drink?

If you need to write more, please use extra pages at the end of the diary.

Day 2 Date

Please write everything including water, morning milk/tea, breakfast, morning snacks, lunch, afternoon snacks, evening tea/milk, evening snacks, dinner and post dinner snacks. Please fill in the date in the space provided. When you complete Day 2, please move on to the Day 3 page.

Time	What did I eat and drink?	How much did I eat and drink?

Day 2

Please write everything including water, morning milk/tea, breakfast, morning snacks, lunch, afternoon snacks, evening tea/milk, evening snacks, dinner and post dinner snacks. When you complete Day 2, please move on to the Day 3 page.

Time	What did I eat and drink?	How much did I eat and drink?

If you need to write more, please use extra pages at the end of the diary.

Day 3 Date

Please write everything including water, morning milk/tea, breakfast, morning snacks, lunch, afternoon snacks, evening tea/milk, evening snacks, dinner and post dinner snacks. Please fill in the date in the space provided. When you complete Day 3, please recheck what you have entered and then click "Submit."

Time	What did I eat and drink?	How much did I eat and drink?

Day 3

Please write everything including water, morning milk/tea, breakfast, morning snacks, lunch, afternoon snacks, evening tea/milk, evening snacks, dinner and post dinner snacks. When you complete Day 3, please recheck what you have entered and then click "Submit."

Time	What did I eat and drink?	How much did I eat and drink?

If you need to write more, please use extra pages at the end of the diary.

Here are some extra pages:

Please fill this page only if you cannot complete the record using the space provided for the specific day. Please indicate the day e.g. Day 2 in the first column below so that I know what day you are reporting for.

Day	Time	What did I eat and drink?	How much did I eat and drink?

Here are some extra pages:

Please fill this page only if you cannot complete the record using the space provided for the specific day. Please indicate the day e.g. Day 2 in the first column below so that I know what day you are reporting for.

Day	Time	What did I eat and drink?	How much did I eat and drink?

Thank you!

Appendix J

List if main groups, sub-groups and foods contributing to the intake of free sugars in the young adolescents living in Delhi, India

Main Group	Sub-group	Description
Beverages	100% fruit and / or vegetable juices	Freshly squeezed orange juice
		Coconut water
		Freshly squeezed lemon juice
		Orange juice, 100% fruit (e.g. Tropicana)
		Mixed fruit juice, 100% fruit (e.g. Tropicana)
		Cranberry fruit juice drink, with no added sugar
		Pomegranate juice, freshly squeezed
		Coconut water
		Freshly squeezed orange juice, 100% juice
		Sugarcane juice (Ganne ka juice)
		Mango pulp, with sugar (Aamras)
		Grape juice, 100% juice
		Vegetable juice
		Vegetable juice, canned
	Sugar Sweetened Beverages	Lemonade, still
		Lemonade (including cloudy varieties)
		Fresh lemon drink, with sugar
		Orange squash, hi juice, diluted
		Tang drink mix, flavoured, fortified, made up with water
		Fresh lemon drink, spiced (Nimbu paani/ Shikanji, namkeen / Fresh lime, salty)
		Spicy mango drink (Aam panna)
		Fresh lemon drink, with sugar (Nimbu paani/ Shikanji, meetha / Fresh lime, sweet)
		Mojito, flavoured (no alcohol)
		Crushed ice drink, coloured and flavoured, with syrup (Golla)
		Sparkling apple juice drink (e.g. tango apple)
		Vitamin water
		Flavoured water, still or fizzy (with added sugar)
		Mixed fruit juice drink, ready to drink,
		Mango juice drink, ready to drink (e.g. Frooti)
		Pomegranate juice
		Apple and mango juice
		Pineapple juice
		Apple juice
		Copy of Apple juice
		Fruit flavour juice, ready to drink
		Coca-Cola/Coke/Pepsi
		7 up / Sprite
		Lime soda
		Fanta
		Lemon and lime flavoured carbonated soft drink (e.g. Limca)
		Energy drink (e.g. Red bull)
		Fruit flavoured carbonated soft drink

Cakes and biscuits	Cakes and cake-type foods	Croissant, plain Cup cake/fairy cake, without icing Cupcake, with icing Doughnut filled with cream Fruit buns Fruit cake Danish pastry Chocolate sponge cake with no filling Chocolate mini roll Chocolate chip muffin Chocolate and nut brownie Chocolate brownie (without nut) Chocolate gateau, including black forest Chocolate fudge cake Chocolate tart/torte Tea bun, sweet Cinnamon buns Eclair/choux bun with chocolate icing and cream filling Chocolate cake Coffee cake (including coffee and walnut cake) Sponge cake with butter cream filling, iced (e.g. birthday cake) Sponge cake with buttercream filling Swiss roll sponge, with fresh cream Sponge cake, with no filling American-style waffles, plain (Waffle, plain) Rusk, dry toast, baked with sugar (Rusk) (e.g. Britania)

	Biscuits	Biscuit, plain (e.g. Parle-G) Semi-sweet biscuit Chocolate chip biscuits (e.g. Hide and seek) Oaty biscuit Digestive biscuit Digestive biscuits, light Chocolate puff biscuit Biscuits filled with cream (e.g. bourbons) Shortbread biscuits (Nankhatai) Crunchy biscuit Chocolate short or sweet biscuit half coated (e.g. chocolate butter biscuit, chocco) Rich Tea biscuits, light Shortbread biscuits (Khatai) All butter biscuits Biscuits filled with jam and cream Threptin biscuits / diskettes, high protein, fortified Wafer sandwich biscuit Wheat biscuits Cookies, other flavours (not chocolate) (e.g. Good day) Oreos, including supermarket brands Chocolate chip cookie with nut Cream filled wafer Chocolate chip cookie Puff pastry biscuit (Fan / Khari) Saltines (e.g. Lu) (Crack biscuit) Cheese biscuits
Confectionery	Chocolate confectionery	Mars bar (including supermarket brand equivalents) Snickers Chocolate bars with nuts Kit Kat / Kit Kat Chunky (including supermarket own brand equivalents) Chocolate coated biscuit with cream filling Chocolate coated biscuit Chocolate coated wafer Smarties Chocolate truffles/pralines Lindt Lindor chocolate Plain/dark chocolate bar (e.g Bournville) Milk chocolate bar (e.g. Dairy Milk) Hersheys milk chocolate Nuts covered in chocolate Coated and flavoured peanuts Chocolates, mixed, soft and hard centres, e.g. Celebrations White chocolate bar (e.g. milky bar)

	Candies/Sugar confectionery	Lollipops Chewing gum, not sugar free Coated chewy sweets (e.g Skittles) Candy floss (Cotton candy) Hard mints Marshmallows Jaggery and sugar roasted peanuts (Gachak) Jelly sweets, flavoured (Soft jelly)
Desserts	Frozen non-milk desserts	Ice lolly, fruit flavoured Sorbet Ice cream with choc / nut / caramel / toffee / biscuit Feast ice cream Soft scoop vanilla ice cream Ice cream, any flavour Ice cream sandwich Kulfi, Indian ice cream

	Non-frozen milk-based desserts	Cake with refined flour, milk, ghee, sugar, nuts, dried fruit and spices (Ghevar) Sweet milk cake dessert, with milk, paneer and sugar (Kalakandh) Sweet milk pudding, with vermicelli (Vermicilli kheer) Sweet milk pudding, with vermicelli (Payasam vermicell / Sheer khurma) Sweet milk pudding, with vermicelli (Sawaiyan) Sweet dessert, roasted vermicelli noodles, milk, cream and sugar (Dudh Shemai) Paneer dumplings, in syrup (Rasgulla) Sweet dessert, milk solid based, balls, deep fried, in sugar syrup (Gulab jamun / Jamoon/ Kalajamun) Sweet dessert, with condensed milk and ghee (Barfi/ Burfi) Sweet dessert, with milk and sugar (Shandesh / Sondesh) Milk toffee, with condensed milk, sugar and spices Sweet dessert, with vermicelli noodles and sugar (Sevyian) Sweet, semi-soft, with thickened milk and sugar (Malai pedha /Doodh peda/ Paal kova/ Milk kova/ Milk peda) Custard, ready to serve Rice pudding, not canned Rice pudding, low fat, ready to eat, not canned (e.g. Muller rice) Custard, flavoured, ready to eat (e.g. Ambrosia chocolate custard) Custard, made with sugar (homemade) Sweet milk pudding, with sago (Sabudana kheer) Paneer dumplings, in sweet milk (Rasmalai)

	Non-frozen non-milk desserts	Coconut burfi Carrot halwa (Gajar halwa) Moong dhal halwa Gram flour halwa (Besan halwa) Halwa (Sheera/ Sooji halva/ Kesari) Fudge, bengal gram flour, syrup and ghee (Mysore pak) Sweet dessert, gram flour balls, deep fried, in syrup (Ladoo / Motichur ladoo) Sweet dessert, black gram or maida flour pretzels, deep fried, in sugar syrup (Jalebi) Sweet flaky dessert, gram flour, sugar, ghee and milk (Sohn papdi) Semolina, nuts, seeds, coconut, gum arabic (gond), fried in ghee and sugar (Panjeeri/ Panjiri) Sweet, chickpea flour balls, small, deep fried (Meethi boondi) Chickpea flour balls, with sugar and ghee (Besan ladoo) Cashewnut burfi (Cashewnut chikki/ Munthiri burpi / Kaju chikki/ Kaju katli) Chickpea flour dessert, with sugar and ghee, balls or squares (Magaj / Besan ladu/ Besan laddoo/ Besan burfi)
Sweetened Milk Products	Milk-based drinks	Condensed milk Complan powder, any flavour Casein protein powder Malt based powder (E.g. Boost, Horlicks) Bournvita, malt based chocolate powder Hot chocolate, made with whole milk Milo, malt based chocolate powder Hot chocolate, made with milk Strawberry and banana smoothie (Strawberry and banana milkshake) Iced coffee/frappe with added sugar Milkshake made with whole milk, chocolate Milkshake made with ice cream, vanilla Almond milk, with sugar (Badaam dudh) Milkshake not made with ice cream, fruit flavoured Milkshake made with whole milk, vanilla Milk (whole) with soda / Milk soda (Doodh soda) Milkshake made with ice cream, fruit flavoured Milkshake made with ice cream, chocolate Milk flavoured with rose syrup (Roubza dudh) Fruit milkshake, with sugar (homemade) (e.g. Banana milkshake, Mango milkshake) Flavoured milk drink (not chocolate) (e.g. Highland, Kotmale)

	Yoghurt(lassi)	Lassi, sweet (Meethi lassi) Lassi, sweet (Mistee lassi) Lassi
Sugar, preserves and syrups	Table Sugar	Brown sugar, with added molasses Brown sugar, with added molasses (e.g Jaggery/ Gur) White sugar
	Honey and syrups	Honey Maple syrup Flavoured syrup, for coffee/milkshake (e.g vanilla, caramel, hazelnut) Rosehip syrup (Sherbet)
Spreads and sauces	Savoury sauces	BBQ sauce Cheese spread/triangle Hot sauce Chilli sauce Sweet chilli sauce Thousand Island / Marie Rose dressing (seafood sauce) Garlic mayonnaise/sauce Mayonnaise Mustard (including English, dijon, wholegrain) Arrabiata sauce (Red pasta sauce) Fusilli/penne pasta in a tomato-based sauce Peri-Peri sauce Tomato based sauce Tomato ketchup
	Sweet spreads	Jam/conserve, (e.g. strawberry) Chocolate and nut spread (e.g Nutella) Peanut butter and chocolate spread Chocolate sauce Chocolate spread Peanut butter, crunchy (with bits) Peanut butter, smooth

Savoury snacks	Crisps and savoury snacks	Banana chips / Banana crisps Banana chips / Banana crisps, fried in coconut oil Nachos, with cheese and salsa Crispy flaked rice snack (Chiwra) Rice and corn snacks (e.g. Tedhe medhe) Rice snacks (e.g. Bingo mad angles) Corn snacks (e.g. Monster Munch, Wotsits, Transform-A-Snack) Ringos (wheatflour and potato snacks) Cheese balls (e.g. Cheetos, Oriental, Peppy) Biscuit, flaky, deep fried, flour, yoghurt and ghee (Mathri/ Mathi) Noodles, thin, chickpea flour and potato, deep fried (Aloo bhujia namkeen / Aloo sev) Fried crisp snack, rice, sago and wheat flours (Vadam/ vadagam / Vathal) Pastry strips, deep fried, with spices (Namakpare) Pastry strips, deep fried, with spices (Namak paray)
Cereal-based savouries	Cereal-based savouries	Dumplings, made with wholemeal chapati flour, ghee and sugar, deep fried (Churma/ Churi) Rice, puffed, with deep fried noodles (Sev), vegetable or potato (Bhel puri) Chickpea chaat with potato, onion and spices (Channa chaat) Crepe balls, deep fried, stuffed with potato and chickpeas (Pani puri/ Pani poori / Gol guppa/ Puchaka) Potato samosa (Aloo samosa) Vegetable samosa (Sobji samosa) Potato fritter, wrapped in bread, deep fried (Bread roll)
	Dumplings	Vegetable maida flour dumplings, tandoori sauce (Tandoori momos / Tandoori dimsums) Vegetable Dim Sum (Chinese dumplings) Spring roll with meat and vegetables Chinese meat roll, stuffed with meat and potato, coated, deep fried (Meat roll / Chinese meat roll / Meat patties)
Bread and bread-based savouries	Bread and breadrolls	Toast, brown bread Toast, wholemeal (brown) bread Brown bread (Paan) Burger buns Bread roll, white Wholemeal (brown) bread Bread roll, cheese topped Plain naan bread Bread, made with maida flour (Kulcha) Naan, made with butter/oil/ghee and sesame seeds

	Bread with fillings	Cheese burger, in a bun, not quarter pounder Chicken burger, in a bun, with lettuce and mayo Chicken and vegetable roll or wrap, made with chickpea flour (Shawarma) Chicken and vegetable roll or wrap, made with white chapati flour (Shawarma) Chicken kebab, roll or wrap, made with white chapati flour Paneer roll or wrap, made with white chapati flour Vegetable roll or wrap, made with white chapati flour (Kathi roll) Vegetable roll or wrap, made with chickpea flour (Kathi roll) Potato and pea burger, in a bun (Aloo tikki burger) Vegetarian burger, vegetable-based, in a bun Bread, leavened, stuffed with potato (Aloo wala naan/ Amritsari kulcha) Sweet bread, made with maida flour, sugar and ghee (Bakarkhani/ Baqarkhani) Paratha, made with white chapati flour and stuffed with cauliflower (Gobi paratha/ Cauliflower paratha) Naan, stuffed with cheese (Cheese naan) Paratha, made with white chapati flour and stuffed with radish (Mooli paratha/ Radish paratha) Paneer sandwich (Paneer sandwich) Coleslaw and cheese sandwich, grilled (Grilled veg coleslaw sandwich) Coleslaw sandwich Egg mayo sandwich with white/malted bread Cheese sandwich with white/malted bread
Pizza	Pizza	Chicken pizza Vegetable pizza Vegetable pizza, stuffed crust French bread pizza (Pizza bread) Garlic pizza bread (e.g. stonebaked) Cheese and tomato pizza (e.g. Margherita)

Chutney and condiments	Chutney and condiments	Tomato and onion chutney (Vengayam, thakkali chutney / Ullipaya, kobbari pachadi/ Irulli, tomato chutney) Coconut chutney (Thengai chutney/ coconut sambol/ Kobbari pachadi/ Nariyal chutney) Mango chutney Vegetable chutney Tomato chutney/relish Mint chutney (Pudhina chutney/ Pudhina pachadi / Pudhina chammanthi) Mint chutney (Minchi sambola) Tamarind chutney (Lmli ki chutney) Garlic chutney (Lehsan ki chutney) Red chilli paste/ chutney (Lunu miris) Chilli chutney / pickle Tamarind chutney (Sauth) Chilli chutney/Pickle (Morich er chutney/achar) Pickled onion (including silverskin) Lime pickle (Lunu Dehi) Lime pickle Vegetable pickle (Achcharu) Mango pickle (Amba Achcharyu) Mango pickle (Aam ka achar/ Mango achar/ Mangai urukai) Carrot pickle (Gajar achaar)
Noodles and noodle dishes	Noodles and noodle dishes	Chicken chow mein, stir fry (with noodles) Egg noodles Vegetable chop suey Vermicelli / rice noodles (including glass/thread noodles) Noodles, with vegetables (Veg Noodles) Vegetable chow mein, stir fry (with noodles)
Breakfast foods	Savoury breakfast foods	Rice and lentil crepe, stuffed with potato and vegetable (Dosa / Dosai / Thosai, Masala, Mysore masala) Pitha, pancake, wheat or rice flour Savoury cake, with rice, steamed (Idli) Rice flour and coconut rolls, steamed (Pittu/ Puttu) Semolina cake, steamed (Rava Idli) Upma, semolina (Rava upma/ Kitchidi/ Suji upma / Rava uppitu)
	Breakfast cereals	Muesli, Swiss style, with added sugar (e.g. Alpen original) Crunchy nut cereal bar Choco flakes (Chocos) Cornflakes, supermarket brand Kellogg's Special K (original) Wheat flakes

Pulse-based dishes	Pulse-based dishes	Heinz Beans Black chick peas curry Split chickpea curry (Chana dal / Split bengal gram curry) Dumplings, pulse based, deep fried, soaked in yoghurt (Dahi vada / Dahi bhalla) Split bengal gram curry (Chana dal) Red gram dahl (Arhar dal)
Savoury rice dishes	Savoury rice dishes	Rice, dahl and vegetables (Bisebelabath / Sambar rice/ Sambhar sadham) Yellow rice, with onion, coconut milk and spices

Curry	Vegetarian curry dishes	Paneer with green pepper and chilli (Chilli paneer/ Paneer chilli) Paneer tikka (Paneer tikka) Potato and paneer dumplings, deep fried, in creamy curry sauce (Aloo and paneer kofta / Malai kofta) Okra (bhindi) curry (Bandakka Vyanjanaya) Capsicum/Banana pepper curry (Malu miris/ Malu miris theldala) Cauliflower stem curry, dry (Danthal sabzi) Vegetable curry, thick (without pau) (Pau bhaji (without pau)) Paneer butter curry (Paneer butter masala / Paneer gravy/ shahi paneer) Paneer and pea curry (Matar paneer) Potato and green pepper curry, dry (Aloo shimla mirch) Bottle gourd dumpling curry (Dudhi kofta / Ghia kofta/ Lauki kofta) Spinach curry / mustard greens curry (Palak Saag/ Sarso saag / Sarson da saag) Vegetable curry (Sabji tarkari/vaji/vuna) Potato and cauliflower curry, dry (Aloo gobi/ gobhi) Potato and radish curry (Aloo mooli sabzi) Bottle gourd curry, dry (Ghia/ Lauki/ Lau/ koddu curry) Pumpkin curry, with coconut milk (Vattakka kalupol curry) Beetroot curry, with coconut milk (Beet root maluwa) Ridge gourd curry, dry (Kali tori/ Jhinga) Bitter gourd curry, dry (Karavila Vyanjanaya) Paneer and bell pepper curry (Kadhai paneer) Ridge gourd curry, with coconut milk (Watakolu curry) Paneer and spinach curry (Palak paneer) Bitter gourd curry, dry (Karela bhujia) Vegetable curry, with chickpeas Banana blossom curry, dry (Kesel muwa themparaduwa / Vazhaippoo/Valaippoo sundal) Pumpkin curry (Petha/Paitha/Kaddu) Soya pieces/ chunks curry (Soybean vadi / Soya chunks curry/ nutrella curry) Cabbage and potato curry, dry (Gova Ala vyanjanaya) Sponge gourd curry, dry (Ghiya bhujia) Jackfruit curry (Kathal curry) Vegetable tikka curry (Veg tikka masala) Cauliflower, potato and pea curry (Aloo mattar gobi/ bhaji/ subzi) Mushroom and pea curry (Mushroom matar curry)

		Round gourd curry, dry (Tinda veg) Vegetable curry Tomato based curry, with gramflour pancakes (Cheela curry) Bitter gourd curry, dry (Kerala poriyal/ Karela subji/ Pakarkai porriyal) Lotus root/ stem curry, with coconut milk (Nelum ala curry) Cabbage and potato curry, dry (Bandh gobi/Bandha kopi aloo) Pointed gourd curry, dry (Parwal sabzi) Bitter gourd curry, with coconut milk (Karawila maluwa / Pagarkai curry / Pavakkai curry) Potato and okra curry (Aloo bhindi) Bitter gourd curry, dry (Karala tarkari/vaji) Okra (bhindi) curry Vegetable curry, cream/coconut based (e.g. korma) Spiny gourd curry, with coconut milk (Thumba karavila curry) Aubergine, grilled or roasted, mashed with oil and tomato (Baingan bharta) Stuffed bitter gourd (Bharwa karela veg)
	Nonvegetarian curry dishes	Chicken curry (Murgir tarkari) KFC chicken wraps (e.g. Zinger Twister) Chicken balti, curry Oriental chicken stir fry (including noodles) (Chilli chicken) Chicken tikka masala, curry Chicken curry home made Mutton and vegetable curry (Gravy mutton) Pork/pork and beef meatballs, grilled Stuffed marrow Egg mayonnaise sandwich filler Prawn or shrimp curry (Chingree)
Chicken/Meat dishes	Rice cooked with meat/chickem	Mutton biryani (Briyani mutton/ Aatukari biriyani) Chicken biryani Chicken biryani/ pulao (Murgi biriyani)
	Kebab/tikka	Chicken goujon/nugget/dipper, in breadcrumb or batter Chicken/turkey kebab Chicken mayonnaise sandwich fillers (e.g. chicken and sweetcorn, tikka, coronation) Chicken legs/wings marinated Coated chicken pieces, fried Chicken satay

Other sources	Other sources	Instant noodles, flavoured (e.g. Maggi masala noodles/ Maggi chicken masala noodles/ Yippee noodles) Instant noodles (e.g. Supernoodles) Instant noodles, made with atta or oats (e.g. Maggi atta noodles/ Maggi oats noodles) Carrot, cooked in syrup (Gajar ka murabba) Soup, with tamarind juice or pulp and tomato (Rasam) Cream of tomato soup, canned Beetroot salad with an oil-based/French type dressing Coleslaw Ginger toffee, with condensed milk, ginger and sugar (Inguru dosi) Gooseberry, boiled, soaked in syrup (Amla Murabba) Chyawanprash, herbal supplement (chyavanaprasha, chyavanaprash) Chicken and sweetcorn soup Salami Roasted black chickpea flour drink, with water and sugar (Sattu with shakkar)

CENTRE FOR CHRONIC DISEASE CONTROL

WHO Collaborating Centre for Surveillance, Capacity building and Translational Research in Cardio-Metabolic Diseases

Institutional Ethics Committee (IEC)

IRB00006330 Expires on: MAR/02/2023

Organization No: IORG0005264 Expires on : MAR/02/2023

OHRP FWA No : FWA00012746 Expires on : MAY/12/2025

Protection of Human Subjects

IEC Certification/Declaration of Exemption

1. Request Type	2. Type of Mechanism	3. Name of Funding Agency and, if known, Application or Proposal Identification No.:
☒ ORIGINAL ☐ CONTINUATION ☐ EXEMPTION.	☐ GRANT ☐ CONTRACT ☒ FELLOWSHIP ☐ COOPERATIVE AGREEMENT ☐ OTHER	Student project, with no objection from Dr Harpreet Sandhu, International Health Division, ICMR regarding HMSC division – reasoning student project **University funding** Adelaide Dental School, The University of Adelaide

4. Title of Application or Activity	5. Principal Investigator CCDC/Hriday:
Study: Sugars Intake by 12-year-old school children in India: Data to inform strategies for sugars reduction through schools (Sugar Smart Schools)". **[CCDC-IEC_14_2021]**	Dr. Monika Arora, PhD (India PI) Health Related Information Dissemination Amongst Youth (HRIDAY).

6. **List of documents submitted for review and approval:**

1. IEC Application (**revised submission: version 2, dated 8th November 2021**)
2. Child Information Sheet_ Version Date 27.8.2021
3. Parent Information Sheet_ Version Date 27.8.2021
4. Child Assent form_ Version Date 27.8.2021
5. Parent consent form_ Version Date 27.8.2021
6. Invitation letter to the parent_ Version Date 27.8.2021
7. School Consent form_ Version Date 27.8.2021
8. School Information Sheet_ Version Date 27.8.2021
9. Invitation letter to the school_ Version Date 27.8.2021
10. Survey instrument (questionnaire) _ Version Date 8.7.2021
11. Email correspondence regarding HMSC approval_ Date July 2020, accessed 13.9.2021

7. Certification of IRB Review

☒ This activity has been reviewed and approved by the IEC in accordance with the Indian Council for Medical Research (ICMR) Guidelines and other GCP recommendations.

by: ☐ Full IEC Review [date/month/year] or ☒ Expedited Review [11/November/2021]

☐ This activity contains multiple projects, some of which have not been reviewed. The IEC has granted approval on condition that all projects covered by the Indian Council of Medical Research Guidelines will be reviewed and approved before they are initiated and that appropriate further certification will be submitted.

8. Comments: **APPROVED**

9. The official signing below certifies that the information provided above is correct and that, as required, future reviews will be performed until study closure and certification will be provided. For queries please reach out on the following contact details	10. Name and Address of Institution **CENTRE FOR CHRONIC DISEASE CONTROL** **C1/52, SECOND FLOOR, Safdarjung Development Area (SDA), New Delhi-110016.**
11. Phone No. : **+011 - 46082601** 12. Fax No. : **+011 - 41618456** 13. Email : shifalika.goenka@ccdcindia.org	
14. Name of Official: **Dr. Shifalika Goenka**	15. Title: **Member Secretary, CCDC Ethics Committee**
Signature	Date: 09-12, **2021**

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Our reference 34871

08 March 2022

Professor Paula Moynihan
Dental

Dear Professor Moynihan

ETHICS APPROVAL No: H-2021-027
PROJECT TITLE: Sugar intake by 12 year old school children in India: data to inform strategies for sugar reduction through schools (Sugar Smart Schools)

The amendment request to add "HRIDAY - Promoting Sustainable Health" logo to the invitation letter, as submit on the 17th of February 2022 is approved.

The ethics amendment for the above project has been reviewed by the Secretariat, Human Research Ethics Committee and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)*.

You are authorised to commence your research on: 23/02/2021
The ethics expiry date for this project is: 29/02/2024

NAMED INVESTIGATORS:

Chief Investigator:	Professor Paula Moynihan
Student - Postgraduate Doctorate by Research (PhD):	Dr Anupama Ivaturi
Associate Investigator:	Associate Professor Lynne Giles
Associate Investigator:	Professor Loc Giang Do
Associate Investigator:	Dr Carly Moores

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled Annual Report on Project Status is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/research-services/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the information sheet and the signed consent form to retain. It is also a condition of approval that you immediately report anything which might warrant review of

ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol or project investigators; and
- the project is discontinued before the expected date of completion.

Yours sincerely,

Miss Sarah Harman
Secretary

The University of Adelaide

THE UNIVERSITY of ADELAIDE

RESEARCH SERVICES
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY
THE UNIVERSITY OF ADELAIDE

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31 August 2021

Professor Paula Moynihan
Dental

Dear Professor Moynihan

ETHICS APPROVAL No: H-2021-027
PROJECT TITLE: Sugar intake by 12 year old school children in India: data to inform strategies for sugar reduction through schools (Sugar Smart Schools)

Thank you for the amended ethics application, the latest revision of which was provided on the 31st of August, requesting interviews and dietary diaries to be conducted/filled out online with participating private-school-students in India, in order to work within COVID health-restrictions. This amendment has been approved.

The ethics amendment for the above project has been reviewed by the Human Research Ethics Committee and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research 2007 (Updated 2018)*.

You are authorised to commence your research on: 23/02/2021
The ethics expiry date for this project is: 29/02/2024

NAMED INVESTIGATORS:

Chief Investigator:	Professor Paula Moynihan
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Participants in the study are to be given a copy of the information sheet and the signed consent form to retain. It is also a condition of approval that you immediately report anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol or project investigators; and
- the project is discontinued before the expected date of completion.

Yours sincerely,

Professor Paul Delfabbro
Convenor

The University of Adelaide

Appendix L

Estimated Average Requirement for Indians (10-12-year-olds)

Source: Nutrient Requirements for Indians 2020 -Indian Council of Medical Research National Institute of Nutrition (ICMR-NIN)

Variable	EAR (Boys)	EAR (Girls)
Energy (kcal/d)	2220	2060
Protein (g/d)	26.2	26.6
Carbohydrate (g/d)	100	100
Fat (g/d) (Visible fat)	35	45
Vitamin A (µg)	360	370
Vitamin D (µg)	10	10
Vitamin B12 (µg)	2	2
Folate (µg)	180	186
Calcium (mg)	650	650
Iron (mg)	12	16
Zinc (mg)	7.0	7.1
Iodine (µg)	100	100
Selenium (µg)	40	40