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Measuring the Nutrition Transition among Adolescents in India

By

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Doctor of Philosophy

Laney Graduate School

Nutrition and Health Sciences

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Abstract

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Nutrition transition, shifts in dietary patterns accompanying globalization and urbanization, are contributing to the emergence of nutrition-related chronic diseases in low- and middle-income countries, including India. Nutrition transition-related changes are believed to comprise shifts towards diets high in fat, sugar, and salt; these are also risk factors for chronic diseases. Little is known about the nutrition transition among adolescents, partly due to lack of appropriate data and metrics. The aim of this dissertation was to measure the nutrition transition among adolescents in India, home to 13.5% of the world's adolescents. First, dietary patterns were assessed in a representative sample of 399 school-going adolescents ages 13-16 years in a globalizing region in South India. Next, a comprehensive Nutrition Transition-Food Frequency Questionnaire (NT-FFQ), including a 125-item semi-quantitative FFQ and 27-item eating behavior questionnaire, was developed and evaluated for its reproducibility and validity to measure nutrition transition against three 24-hour dietary recalls in a sub-sample of 198 adolescents. Lastly, a pre-defined Nutrition Transition-Diet Score was developed using nutrition transition literature and dietary guidelines to measure nutrition transition, and evaluated for its validity against empirical dietary patterns derived from responses to the NT-FFQ. Adolescents' dietary patterns reflect a combination of global/non-local and traditional foods and can be categorized into three patterns; global, animal-source, and traditional (factor loadings $\geq$0.4). Compared with recommended guidelines, adolescents consumed higher-than-recommended energy-dense foods and lower-than-recommended dairy, fruits, and vegetables. Gender and school type were the main predictors of dietary patterns. The NT-FFQ showed good reproducibility and validity for most foods and eating behaviors and can measure nutrition transition among adolescents. The Nutrition Transition-Diet Score (mean 5.6 $\pm$ 1.2, range 0-10) included 10 components (7 food groups and 3 nutrients) and had good construct validity against empirical Global Diet pattern (factor 1; 60% concordance, 5% discordance, and Pearson correlation=.59, $p<.0001$). Based on the results, adolescents' dietary patterns in a globalizing Indian region reflect unhealthy and healthy nutrition transition features. Validated instruments, NT-FFQ and Nutrition Transition-Diet Score can effectively measure nutrition transition and can be utilized in programs and policies to improve adolescent health.

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CHAPTER 1: Introduction

Nutrition transition, the concept of the shifts in dietary patterns and physical activity patterns accompanying globalization and urbanization, is contributing to the emergence of nutrition-related non-communicable diseases (NR-NCDs) including diabetes and cardiovascular diseases[1,2] in low and middle income countries (LMICs) including India.[3-5] The nature and pace of nutrition transition differs across countries, populations, and social strata,[6] with health implications not only for adults but also for youth or adolescents ages 10-19 years.[7] Today's generation of adolescents is the largest in human history totaling 1.8 billion or ¼th of the world's population;[8] of these 90% live in LMICs[8] that bear the burden of 80% of all NR-NCDs related deaths.[3]

Nutrition transition, rooted in the processes of globalization, is believed to be driven by rising urbanization, migration, and income, globalization of food markets, food production, and food marketing, expansion of global mass media and communication, and changing food tastes and preferences.[9,10] There are favorable and unfavorable components to the nutrition transition. The former includes the globalization of food markets in LMICs that has over the past two decades helped decrease food scarcity, increase access to affordable dietary diversity,[11] increase the quantity and quality of animal-source foods (e.g., dairy, eggs, and meats), increase the availability of micronutrient rich food,[3] and increase the access to new foods and beverages, thereby expanding food choices.[9,12] Alternatively, the unfavorable components of the nutrition transition include food surplus[13] and the shifts in diets from traditional cereal-based diets to more globalized dietary patterns of foods high in fat, sugar and salt, more animal-source foods and ready-to-eat foods among children and adults, irrespective of socioeconomic status.[5,14] In addition, there is increased accessibility to affordable energy-dense (high calorie poor-nutrient) processed foods in regions with emerging NR-NCDs;[3,11,15] including commercially available unbranded packaged foods catered to low income groups and youth and to fit local tastes.[9] Lifestyle practices and eating behaviors in LMICs too have undergone transformation with globalization;[11] the latter are molded by the meeting of traditional and global factors,[16] which occurs within the broader contexts of socioeconomic status, urbanization, and gender relations. Eating behaviors that may be part of the nutrition transition include the more frequent practice of eating outside the home[7] and watching TV while eating meals.[17]

India, since the mid-1990s, has witnessed a demographic and epidemiological transition accompanied by a nutrition transition.[18] Following the 1991 trade liberalization policy that opened up the Indian economy, the country has experienced urbanization, migration,[10] and expansion of the affluent middle class, along with changes in diets and lifestyles and concomitant increases in NR-NCDs.[19] At present, 62 million adults of a population of 1.2 billion have diabetes, and by 2035, 101 million adults are expected to have diabetes.[20] About 10% of Indians, ages 0-54 years are overweight or obese.[21] Among adolescents, who comprise one-fifth of the population (~243 million),[22] 37% are underweight and 5% are overweight or obese.[21] Studies have reported changes in dietary patterns across social strata[3,23,24] where refined carbohydrates, snack foods, processed foods, and fried foods appear to be replacing traditional foods such as unrefined whole grains, fruit, vegetables, and nuts.[25] These dietary changes have appeared concurrently with the transformation of the modern retail food environment in India in cities and urbanizing regions[9]; both kiraanas (local grocery stores less than 100 m^2 in size) and supermarkets provide access to new foods and beverages.

The unfolding of the nutrition transition can be measured from changes in dietary patterns, but there is no validated dietary instrument specific to nutrition transition. Evidence of nutrition transition has been reported from dietary data using Food Frequency Questionnaires (FFQs),[26,27] 24-hour dietary recalls (DRs),[28] and diet pattern analyses,[29,30] from data on food availability using Food and Agricultural Organization's food balance sheets,[3] and from anthropometric data describing shifts in the prevalence of overweight and obesity.[31-33] Much of the evidence of nutrition transition has been limited to dietary data on adults[29,30] and from urban regions,[34] and to data from Food and Agricultural Organization's food balance sheets;[3,35] which provide estimates of food availability across countries but not food consumption.[36,37] However, shifts in dietary patterns in nutrition transition are limited not only to food consumption but also to eating behaviors.

Furthermore, at the forefront of global trends and social change in LMICs including India, [38] adolescents may be experiencing nutrition transition-related shifts in food consumption and eating behaviors. India, home to 13.5 % of the world's adolescents,[22] is believed to be undergoing nutrition transition from traditional to more globalized diets. Most research on the nutrition transition in India has focused on globally connected metropolitan areas.[39-41] For adolescents in India, the type of school attended can be a marker of socioeconomic status and connectivity. The two school types are private and public or government-funded; those attending the former tend to have more resources[42,43] and may be more globally connected. Furthermore, studies of child health in India have drawn attention to concerns about differences in resources provided to boys and girls.[44-46] Lower privilege and less freedom of movement for girls may entail that they may have less access to new foods. There is a paucity of data on what the process of nutrition transition entails for adolescents, and those in remote and urbanizing regions. For these reasons, India serves as a prototype region to investigate the nutrition transition among adolescents.

Assessing dietary shifts in nutrition transition among Indian adolescents requires validated dietary assessment instruments that assess long-term food consumption and eating behaviors; such instruments would have potential applicability for research and programs. The dietary shifts in nutrition transition are hereafter referred to as *nutrition transition-related dietary shifts.* In India, the 24-hour DR method has been most commonly used to assess diets of adolescents, [47] but unlike FFQs, 24-hour DRs are not representative of long-term food intake[48] and are also not as practical and cost-effective.[49,50] A few FFQs have been developed for adolescents in India; [39,40,51] however the evaluation of those instruments has not been documented. Other relatively new methods of dietary assessment that may be useful in assessing nutrition transition include analyses of dietary patterns and development of diet scores; these can summarize foods and/or nutrients as an overall measure of diet at a time or over time. The only systematic review of studies on dietary patterns in India found highly diverse dietary patterns ranging from traditional vegetarian patterns to diets high in fat, sugar, and meat and some evidence of dietary change over time.[52] However, six of the eight studies in this review included diet data on adults[52] while the other two were limited to data on adolescent girls[53] and young children ages 9.5 years.[54] With regard to diet scores, most have been developed for adults[55-57] and for youth in high-income countries and European settings.[58-63] Few diet scores have been developed for LMICs setting.[64-66] However, no validated instrument specific to the nutrition transition currently exists. Put together, there are gaps in sound diet metrics to comprehensively measure nutrition transition; including the assessment of food consumption and eating behaviors.

This dissertation herein addresses these gaps in the current literature and is centered on understanding and measuring the nutrition transition among adolescents in India. The research seeks to (A) describe the dietary patterns of adolescents in India and (B) develop and evaluate dietary assessment methods to measure the extent of nutrition transition-related dietary shifts. The aims of the research presented here are as follows:

Research Aim 1

To describe eating patterns of adolescents and the factors that may influence food consumption, access, and preferences in a globalizing city.

In this aim, dietary patterns of adolescents are described in terms of their intake of global, mixed, and traditional foods and beverages. In addition, the hypothesis that there may be socioeconomic and gender differences in consumption of and access to foods and beverages was tested. To address this question, data were drawn from a representative school-going sample of adolescents ages 13-16 years (n=399) in the baseline 2012 Home

Environment and Adolescent Weight Survey in Vijayapura, India. The school-going adolescents completed a cross-sectional survey including a 16-item FFQ designed to identify traditional and global foods. Briefly, Vijayapura is a mid-size or tier III city with a population of 350,000 located in the state of Karnataka in South India in a district which is categorized as economically underdeveloped but is undergoing urbanization as a result of the major economic growth of its small-and large scale industries.[67]

Research Aim 2

To develop and evaluate the reproducibility and validity of a Nutrition Transition Food-Frequency Questionnaire for adolescents in South India.

In this aim, a Nutrition Transition-Food Frequency Questionnaire (NT-FFQ) was developed to measure nutrition transition among adolescents in South India. The reproducibility and validity of the NT-FFQ was evaluated among a non-random sample of 198 adolescents interviewed during the follow-up wave of the 2012 Home Environment and Adolescent Weight Survey. This tool was developed to address the gap in validated dietary instruments to measure foods consumption and eating behaviors in nutrition transition.

Research Aim 3

To develop and validate a pre-defined Nutrition Transition-Diet Score to measure nutrition transition among adolescents in India.

In this aim, a pre-defined Nutrition Transition Diet Score was developed to measure the extent of the nutrition transition-related dietary shifts among adolescents.

The pre-defined Nutrition Transition Diet Score was validated against empirical or data-driven dietary patterns from responses to the validated NT-FFQ provided by the adolescents in Aim 2. Exploratory factor analysis was used to derive dietary patterns. Given that there is no dietary score to measure nutrition transition at the individual level, this tool was developed.

The subsequent chapters of this dissertation discuss the nutrition transition in LMICs with an emphasis on the nutrition transition in India and among adolescents and existing diet metrics to assess nutrition transition among this population, as well as the main findings and their public health implications. Chapter 2 is the review of the literature. Chapter 3 provides information about the methods and research setting. Chapter 4-6 are standalone manuscripts written for the intent of publication in peer reviewed journals. Chapter 4 describes adolescents' dietary patterns in terms of traditional, global/non-local, and mixed foods and the factors that may influence food consumption, access, and preferences in the globalizing city of Vijayapura, India. Chapter 5 describes the development and evaluation of the reproducibility and validity of the NT-FFQ for adolescents in South India. Chapter 6 describes the development and validation of the pre-defined Nutrition Transition-Diet Score for adolescents in India. Finally, Chapter 7 is a summary of the overarching findings and the discussion of the strengths, limitations, future directions, and public health implications. The findings of this dissertation will contribute to the field of public health and nutrition in several ways. First, describing dietary patterns and eating behaviors of adolescents residing in urbanizing regions and how they might differ by socioeconomic status and gender could contribute to the understanding of the nutrition transition and what it entails for adolescent health. Second, the development and validation of two novel dietary instruments to measure nutrition transition-related dietary shifts will contribute to field of diet metrics and help move the field forward in measuring and describing dietary patterns and eating behaviors of adolescents relevant to the nutrition transition.

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CHAPTER 2: Background

Global Nutrition Transition

The concept of a nutrition transition has been proposed as a multidimensional and complex process of global shifts in dietary and physical activity patterns that follows the demographic and epidemiological transitions of countries.[1,2] The nutrition transition has been described to include five stages; hunter-gatherer or Paleolithic; modern agriculture and famine; receding famine; degenerative disease, and behavioral change.[3] These patterns however, are not restricted to particular periods of human history.[4] The nature and pace of nutrition transition, also believed to accompany globalization and urbanization, differs across countries and between regions in the same country.[5] At present, low and middle-income countries (LMICs) are believed to be in the midst of the fourth or degenerative disease stage. In this stage, the changes in activity levels and diet are believed to lead to increased nutrition related-non-communicable diseases (NR-NCDs). Also, LMICs such as China are reported to be advancing more quickly through the stages of the nutrition transition compared to the higher-income countries that underwent nutrition transition in the earlier part of the 20th century.[2,3,6,7]

The global burden of NR-NCDs is concerning; particularly in LMICs, which account for 80% of all NR-NCDs related deaths.[8] In India, as in other LMICs, NR-NCDs are now being recognized as a huge threat. According to World Economic Forum, by 2030, an estimated $47 trillion of the expected global economic burden will be from NR-NCDs; [9] India is expected to bear US$ 4.58 trillion of that burden.

In the early stages of the nutrition transition, the diets of LMICs including China[10] and India[11,12] were considered insufficient in quantity and inadequate in quality. As income increases and economies open, diets of those in urban and rural regions begin to undergo shifts from traditional dietary patterns with high intake of cereals and grains to more diversified diets that include increase consumption of animal-source foods (dairy, eggs, and meats), [13] fruits and vegetables, and fats and oils. The dietary shifts also include increased consumption of sugars and processed and packaged foods (e.g., packaged snacks, ready-to-eat foods, and take-out foods) and decreased consumption of nutrient-dense foods including fruits and vegetables.[10,11] Urban regions in LMICs including India,[8,14-17] Brazil,[18] and China,[15] are experiencing the penetration of new foods, from other countries or other regions[19] along with the shifts in diets from traditional to more globalized dietary patterns among children and adults, irrespective of socioeconomic status.[1,20] In Asia, specific dietary changes as part of the nutrition transition have also been reported such as increased pork consumption in China, increased dairy and egg consumption in India,[21] high consumption of fat and oil in Malaysia, and high consumption of sugar-sweetened beverages (fruit juices and carbonated beverages) in Thailand and Philippines.[22]

Several factors are believed to be driving the nutrition transition-related dietary shifts in LMICs. These include urbanization and migration, rising per capita income, globalization of food markets, food production, and food marketing, expansion of global mass media and communication, mechanization, and changing food tastes and preferences.[11,12] In addition, nutrition transition encompasses both healthy and unhealthy features. The globalization of food markets in LMICs has over the past two decades helped decrease food scarcity, increase access to affordable dietary diversity,[23] increase the quantity and quality of animal-source foods (dairy, eggs, and meats), increase the availability of micronutrient rich foods,[8] and increase access to new foods and beverages, thereby expanding food choices.[11,24] Further, as communities urbanize, the presence, use and popularity of supermarkets,[25] bakeries, and street eateries also increase, allowing new food and beverages to reach more remote areas and diverse social and economic groups.[26,27] Alternately, nutrition transition has also brought about food surplus and greater accessibility to affordable energy-dense (high calorie poor-nutrient) processed foods in regions with emerging obesity and NR-NCDs.[8,23,28] There is a growing market of commercially available unbranded packaged foods that are unregulated, cheaper and often low quality, marketed by poorly regulated industries and produced to cater to low income groups and youth and to fit local tastes.[11] These foods are becoming increasingly popular, particularly among youth, but could worsen nutritionally poor diets.[11,29]

Furthermore, nutrition transition-related dietary shifts are believed to accompany changes in eating behaviors and lifestyles. Shifts in eating behaviors are reported to encompass the movement away from traditional to more convenient ways of preparing meals with mechanized appliances (e.g., microwaves), more frequent consumption of foods away from home than at home from increased access to street eateries, restaurants, and food courts in malls, and more access to convenient foods (e.g., ready-to-eat foods, home delivery, vending machines at the work place and in schools) than before.[11,30] Lifestyle practices too have undergone global transformation; longer hours at work and school have left little time to engage in physical activity and eating meals while watching TV has become common practice.[31] While more women are working outside the home than before but still bear the responsibility for providing meals, the nature of the meals may change, including have to rely on convenience processed foods and more frequently eating outside the home or bringing home take-out food.[11]

Nutrition Transition in India

History of diet transformation in India

India has diverse foods and cuisines, [32] where food intake and eating behaviors are strongly associated with agricultural practice,[33] culture, and religion.[12,34] In the past 25 years, India has experienced a demographic and epidemiological transition believed to be accompanied by the nutrition transition.[35] From the 1980s, India has witnessed remarkable economic growth, steady rises in incomes, and increased per capita expenditure across social strata. In the 1980s, food consumption did not significantly change but a rise in the demand across all food groups was noted.[11] The consumption of both animal-source foods and non-animal-source foods increased substantially as did the consumption of spices and oil crops.[11] Among animal-source foods, the largest increase was in the consumption of milk. Among non-animal-source foods, there were large increases across all food groups, but particularly for rice, pulses, and wheat; considered key staples of the traditional diet.

In the early 1990s, India introduced a trade liberalization policy that opened the economy, introduced global foods and beverages to the country, and led to dietary diversification.[11] There was a rapid growth of urban population and migration from rural to urban areas between 1991-2001;[12] inter-state migration doubled from 20 million people to 41 million people.[12] Soon after, *Gopalan* was among the first to highlight that India, in addition to other countries in South Asia was beginning to experience trends of rapid urbanization, expansion of the affluent middle class, and changes in diets, occupations, and lifestyles accompanied by increases in NR-NCDs.[36] At present, 62 million adults of a population of 1.2 billion have diabetes, and, by 2035, 101 million adults are expected to have diabetes.[37] About 10% of Indians ages 0-54 years are overweight or obese.[38]

Continuing from the 1990s and since then, shifts in dietary patterns were more pronounced and included more dietary diversity, decreased consumption of and preference for staple grains (e.g.; rice and wheat),[39-41] increased availability of energy-dense foods including fats, oils and starchy roots in households,[11] and increased consumption of foods considered relatively more expensive such as animal-source foods,[11,12,39-41] and fruits and vegetables. With increases in income food preferences are reported to change even within foods that have been a part of the traditional diet. For instance, wheat and rice are harvested and eaten more commonly in northern and southern India, respectively, but the consumption and availability of these foods is believed to be converging.[11] Increases in wheat consumption and decreases in rice consumption have been reported not only in India, but also in other countries across

Asia.[12,42,43] Furthermore, shifts in choices of grain from those considered inferior (e.g., maize, sorghum or jowar, pearl millet or bajra, finger millet or ragi, barley, etc.) to rice and wheat have been reported; especially among low socioeconomic groups.[12,15] With globalization and urbanization, the use of wheat in the diet is reported to be changing; moving from traditional chapati to commercialized western bread products[11] and to processed versions of traditional dishes[42] (e.g., fresh or frozen ready-to-eat packaged chapati sold in food stores). Another example of a change in food preference during the 1990s was the increased consumption of potatoes not as a cooked dish but more so as fries and potato chips.[11]

While the traditional Indian diet was predominantly considered a high-carbohydrate grain and pulse based diet, since the 1990s, dietary patterns indicate more diversity and replacement of traditional food groups[11] for ones that have been termed the western-style diet; those higher in refined carbohydrates, meats, oils and other fats, and sugars.[4] However, much of the evidence of the said dietary changes are reported from shifts in household food expenditure, [11,12] which although provides insights on food availability in the household, does not inform of food consumption at the individual level. For instance, Tripathi et al. compared nationally representative 1993-1994, 1999-2000, and 2004-2005 household food consumption expenditure National Sample Survey (NSS) data.[12] Between 1993-2005, there was a decline in regional heterogeneity in household food consumption and consumers in both rural and urban regions shifted their preferences from cereals to dairy, meat, eggs and fish, and fruits and vegetables; however some regional disparities in food consumption remained.[12] These findings were confirmed by other studies using different rounds of NSS household level food expenditure data[44,45] and are in accordance with *Bennett's law*[46]; with the increase in affluence level, consumers allocate the share of their additional income away from cereal such as rice and wheat towards fruits, vegetables, and animal-source foods.

Food prices in relation to family income can affect a family's purchasing decisions and type of foods and beverages consumed. According to *Engel's* law, as people become wealthier, food's share to total expenditure declines.[47] Findings from the 2011-2012 NSS showed, on average, food items accounted for 53% of a rural family's monthly expenditure of INR 1430 (USD 22, 1 USD=66.0 Indian Rupees as of May 2016) compared to 43% of an urban family's monthly expenditure of INR 2630 (USD 39).[48] The foods purchased varied across socioeconomic groups; rural families reported greater proportion of monthly expenditure on cereals (10.8% vs. 6.7%) and dairy (8% vs. 7%) than urban families, who reported greater proportion of monthly expenditure on beverages and processed foods (9% vs. 7.9%).[48] Another study in India found similar results, especially in urban areas; with increases in household income the caloric share of rice and other cereals decreased, the caloric share of pulses, meat, fish and eggs, vegetables and fruits, and sugar and spices increased marginally, and the caloric share of more expensive items including dairy, edible oils, and processed foods increased sharply.[12]

In terms of the shifts in consumption of animal-source foods in India, there have been significant increases in the consumption of dairy[15] and eggs,[21] but modest increases in meat consumption.[3] While the daily consumption of meat is reported as a striking feature of nutrition transition in LMICs including China and Brazil, is not expected to increase in India.[42] The consumption of animal-source foods may be driven by religion, caste, and beliefs; for the majority of people in India, particularly those belonging to the Hindu religion, food habits are driven by religious vegetarianism.[49,50]

Instead, the consumption of fat, saturated fat, sugar, and salt, has increased among Indians in the last three decades.[16,51] Over a 20 year period from 1981-2001, a doubling of intake of calories from fat was reported.[11] The per capita consumption levels in 2001 indicate that relative to 1979–1981, the average eggs and vegetable oil consumption doubled, while milk intake rose by 50%.[11] In addition, household food expenditure NSS data showed that per capita fat consumption have increased across rural and urban regions.[12] The increased consumption and universal availability[8] of relatively cheap vegetable oils in LMICs,[15,42] but most marked in India, China, and Brazil has made high fat diets accessible across social strata.[8] Vanaspati, a partially hydrogenated vegetable oil high in trans fatty acids, is consumed typically by low socioeconomic communities (e.g.; those in rural regions and the urban poor) and is commonly used to prepare unbranded snacks.[29] A recent survey of food vendors in rural and urban slum communities in north India identified refined oil, mustard oil, vanaspati, and ghee as the most common type of fat being used to prepare street foods.[29] Furthermore, there is a regional preference for oils in India; mustard oil is used in northern and eastern states, while western and southern states except Kerala use peanut or groundnut oil; coconut oil is predominantly used in Kerala.[52] As with vegetable oils, there have been marked increases in the consumption of sugar.[15,42]

Nutrition transition-related dietary shifts in LMICs include not only increased consumption of foods high in sugar and fat, but also foods high in salt. Several studies have reported high dietary salt intake between 8.5-9 g/day among Indian adults[53] and children[54] compared with the WHO's recommendation of 5 g salt per day or 1950 mg sodium per day. A study reported that the consumption of salted potato chips by children may be a major source of salt.[54] The high salt intake in the diet may be coming from several foods including pickles, papads (lentil wafer that is thin, crispy, and salty), namkeens (salty fried snacks), chutneys (chopped vegetable or fruit with added seasonings, mixed with salt),[16] and biscuits and salted snacks.[16,55,56] With the introduction of global foods, people may consume not only traditional high salt foods but also global packaged and processed items that are high in salt (e.g., potato chips).

Furthermore, India has witnessed a remarkable transformation in the food environment since the mid-1990s.[11] Modern retail in India, both kiraana (local grocery store less than 100 m^2 in size) and supermarkets, common in urban cities,[57] now provide smaller cities access to new foods and beverages. In addition, the introduction of transnational food corporations including KFC, McDonalds, Kraft and Nestle´ have made global fast foods and processed foods available.[58] The presence of food stores and eating establishments shape the type of food availability in neighborhoods[59,60] and drive food consumption and preferences.[61] In India, fresh fruits and vegetables, typically sold at open air markets, are now also sold in larger size kiraana stores and in supermarkets including Reliance, More, and Walmart. Fruits and vegetables are supplied to supermarkets mostly though supply chain and retailing operations. Processed foods are not only global foods but also processed versions of traditional Indian dishes,[42] available at supermarkets and convenience stores including instant or ready-to-eat foods (e.g.; heat-and-eat Indian curries, parathas), minimal preparation items (e.g., instant soups and noodles, fry-and-eat frozen vegetable cutlets, instant idli mix, and instant gulab jamun mix and other desserts). In addition, as in other countries, supermarkets not only stock packaged and processed items high in salt, fat, and sugars, but also sell 'diet or health' foods (e.g., ground and powdered grains such as finger millet marketed as a strength-building food and to diabetics as a low glycemic index food) and herbal drinks (e.g., ginger, jaljeera, and kokum) and organic products. There is a growing market for these products; targeted toward the health conscientious and higher socioeconomic groups.

Food preferences and food availability shape not just supermarkets, [62] but also bakeries and street eaters. Bakeries not only sell fresh bread, cakes, and biscuits, but some also sell candy, sandwiches, pizzas, burgers, and sugar-sweetened beverages. In addition, street foods are prepared and/or sold by vendors and hawkers in public places.[29] Street foods may be those eaten as a meal (e.g., pav bhaji, egg-rice, dosa-sambar, idli-chutney, etc.) or between meals (e.g., chaats, samosa, sugar cane juice and other juices).[63] Foods and beverages sold on streets range from traditional freshly prepared foods (e.g., samosa and laddoo), global foods (e.g., Indo-Chinese foods and sandwiches), ready-to-eat items (e.g., juices, ice candy, boiled corn, fruit slices, etc.), packaged branded snacks (e.g., biscuits, chocolates, and ice-creams), packaged unbranded snacks and open snacks, sold in unlabeled transparent packages and open glass jars (e.g., soan papdi and mathri).[29] The cost of the unbranded or open street snacks typically range between 50 paisa to 5 Indian Rupees (1 USD=62 INR as of May 2016; 1INR=100 paisa) (*field observations*). Indo-Chinese food typically includes fried and oily noodles or fried rice with curried meats and vegetables (e.g., Gobi Manchurian) and is very popular among adolescents.[64] The recent food vendor study in North India reported the food environments in low-socioeconomic communities in India are saturated with energy-dense street and snack foods containing high amounts of trans fatty acids and saturated fat.[29] Low-cost fried and packaged foods are reported as a key feature of the nutrition transition in urban areas in India.[16,55,56] Some street foods are traditional but also healthy (e.g., boiled corn, boiled eggs, fresh fruits, and roasted nuts) while others are traditional but contain high amounts of sugar (e.g., ice candy and lemonade). As such, people may be gaining access to new items entering their local food ecologies through supermarkets, bakeries, and street eateries. In turn, the presence of and access to these new foods and beverages may influence peoples' food perceptions and preferences.

Adolescent Health and Nutrition Transition

Countries around the world are undergoing changes that are altering the nature of adolescence in their societies. Adolescence is defined by WHO as between 10 and 19 years. According the recent Lancet Commission's report on adolescent health and wellbeing, today's generation of adolescents is the largest in human history totaling 1.8 billion; comprising more than 25% of the world's population.[65] Of the global adolescent population, 90% live in LMICs and represent a large proportion of the population.[65] A little over a third of the adolescents are growing up in countries where NCDs are predominant compared to communicable diseases and where the major adolescent burden lies in chronic physical illness and in mental and substance use disorders.[65]

At the forefront of social change and global trends, [66] adolescents may be experiencing nutrition transition-related shifts in food consumption and eating behaviors. Adolescence is a period of rapid growth and development, where prolonged inadequate nutrition (deficits or excess) can have long-term growth and development consequences tracking into adulthood[67-70] including NCDs. Global trends include those promoting unhealthy lifestyles and commodities, less family stability, environmental degradation, armed conflict, and mass migration, all of which pose major threats to adolescent health and wellbeing.[65] Addressing the nutrition needs of adolescents could be an important step towards breaking the vicious cycle of intergenerational malnutrition and NR-NCDs. The implications of nutrition transition are concerning for adults, but there is limited information on what the nutrition transition process might entail for adolescent health. Lifestyle changes including shifts in dietary and physical patterns are believed to be transforming adolescent development and, in so doing, changing the prospects for health now and in the future.

Nutrition Transition among Adolescents in India

In India, adolescents comprise one-fifth of the population (~243 million),[71] of which 37% are underweight and 5% are overweight or obese.[38] A systematic review of childhood overweight and obesity trends between 1981 to 2013 across 16 of 28 Indian states found a prevalence of childhood overweight/obesity of 16.3% in 2001-2005 and 19.3% in 2010; the prevalence increased across social strata but was higher in northern than southern India.[72] One of the factors behind emerging childhood overweight and obesity in India is the suggested shifts in dietary patterns among children and adolescents following socioeconomic growth and globalization of the food environment.[73] Dietary patterns are molded by the meeting of traditional and global factors,[74] which occurs within the broader contexts of socioeconomic status, urbanization, and gender relations. Healthy eating can be challenging for adolescents in the context of new, trendy, palatable processed foods and fast foods appearing with globalization and promoted through peers and the media.[11,75,76]

Most research on the nutrition transition in India has focused on globally connected metropolitan areas.[17,77,78] In India, the type of school attended by an adolescent can be a marker of socioeconomic status and connectivity. The two school types are private and public or government-funded; those attending the former tend to have more resources[79,80] and may be more globally connected. School-going adolescents from higher socioeconomic families in the urban Indian cities of Bengaluru,[77] Hyderabad,[78] and Baroda[81] had more global foods comprising processed foods, fast foods and sugar-sweetened beverages in their diets while rural adolescents across nine states of India had more traditional diets including grains, pulses, and green leafy vegetables.[82] Adolescents in Hyderabad preferred global fast foods (e.g., noodles and corn flakes) to traditional foods (e.g., idli).[78] Those from higher socioeconomic families had higher traditional food group intake including fruits, vegetables, and dairy products than those from lower socioeconomic families.[78] The diets of adolescents in Bengaluru were higher in fat, especially saturated fats and lesser in carbohydrates.[77] Among adolescents across social strata in Baroda and Hyderabad, half consumed sugar-sweetened beverages and over one-third consumed fast foods once or twice a week.[78,81] Reports suggest excessive consumption of sugar in the form of sugar-sweetened beverages among Indian children and adolescents may be related with emerging obesity in this population;[83] the odds of becoming obese among children increased 1.6 times for each additional can or glass of sugar-sweetened beverages consumed beyond their usual daily beverage intake.[84] Studies have reported an increase in the consumption of processed and packaged foods including candy and bakery items,[85,86] high fat, saturated fat from animal foods, and sugar, processed foods[8,15,77,87] among urban Indian adolescents. Furthermore, studies have drawn attention to concerns about differences in resources provided to boys and girls,[88-90] given the dominant patriarchal society, with preference for sons over daughters.[88,89,91] There is persistent concern that girls tend to receive lower-quality food, less food, and less expensive food, such as grains rather than milk and fat.[88-90] Pervasive gender discrimination against girls has been reported in education including school attendance, immunization coverage, use of health care services, child nutrition status, and in resource allocation with households.[89]

Eating Behaviors of Adolescents in India

Adolescence is an important life stage where eating behaviors and food habits learnt are carried into adulthood with implication for future health.[70,92] Unlike younger children, adolescents' eating habits are characterized by snacking, meal-skipping, irregular meals, and eating often away from home.[69,79] Several studies reported skipping of daily breakfast among adolescents; 37% of adolescents ages 16-18 years from middle- to upper-socioeconomic groups in Mumbai, Maharashtra[93] and 40% of adolescents in Baroda, Gujarat; where a third also missed meals once or twice a week.[81] Among adolescents ages 7-15 years in Bangalore, the daily energy intakes increased with increased monthly frequency of eating out.[77] A cross-sectional assessment of eating behaviors, physical activity patterns, sleep duration, and sedentary habits among 598 children ages 6-16 years in Bangalore, Karnataka found the increased consumption of fried and high fat foods significantly associated with being overweight;[31] while the weekly consumption frequency of chocolates, ice-creams, bakery foods, soft drinks, and non-vegetarian food and the weekly frequency of eating out were not associated with adolescents' BMI. However, several studies have reported more frequent practice of eating outside the home[8,15,77,87] among urban adolescents in India.

In addition, urbanization,[42] peer influences, family environment, and access to modern mass media and TV advertisements and food marketing shape adolescent eating behaviors and food choices.[69,70,94] A study among students in New Delhi found daily breakfast consumption was associated with less overweight and with healthier eating- and physical activity-related behaviors.[95] A nutritional-knowledge and behavioral intervention study reported that major gaps exist in health and eating behaviors of urban Indian children.[96] A study that assessed the extent of exposure to food marketing and its relation with eating behaviors and BMI of 306 children ages 3-13 years in Vellore, Tamil Nadu, found those from higher income groups had higher brand logo recognition ability and are possibly exposed to more food marketing; but found no link between exposure to marketing and poor eating behavior, distorted nutritional knowledge or increased purchase requests was found.[94]

Assessment of Eating Behaviors in Nutrition Transition

Shifts in eating behaviors are believed to accompany the shifts in dietary patterns in nutrition transition, including the frequent practice of eating outside the home[73] and watching TV while eating meals.[31] Eating behavior questionnaires have been developed such as one on eating behaviors and food habits of adolescents in Italy[97] and a fat-related dietary habits questionnaire for Chinese Americans and Chinese Canadians adults.[98] Other ways of assessing adolescents' eating behaviors have included anthropological methods to assess food choices and the meaning that foods and beverages hold for them.[64,99] Although studies indicate that shifts in eating behaviors as part of the dietary shifts in nutrition transition may be becoming more common, especially in adolescents, [73] there is no dietary assessment instrument that quantifies eating behaviors related to the nutrition transition. Adolescents' food choices are driven not only by the healthfulness of foods, but by its taste, convenience, and approval from peers.[100-102] Investigating both eating behaviors and food consumptions will inform future policies and interventions that attempt to counteract the negative consequences of nutrition transition.

Measuring Nutrition Transition

Nutrition transition has been described from dietary data using FFQs[6,103] and 24-hour DRs,[104] from using country-level food availability data,[42] and from the analysis of dietary patterns.[105] A study also conducted a qualitative assessment of nutrition transition, wherein interviews, focus group discussions, and analyses of government reports were used to investigate the relationship between changes in food patterns and nutrition transition amongst adults in Philippines, Malaysia, and Indonesia.[106] Nutrition transition in these three countries was attributed to increasing food availability and food purchasing power, rather than shifts in food preferences from traditional towards 'western' foods.[106]

Food balance sheets

Food availability data at the country-level using Food Balance Sheets are collected by the Food and Agricultural Organization;[42] these have been used to assess long-term trends in food availability across countries worldwide, for every food item.[42] However, the Food Balance Sheets describe food availability or the consumption of foods per capita of the population for a country, but do not provide information on food consumption at the household- or individual level.

Individual dietary surveys

Nationally representative individual dietary surveys are used to assess and understand long-term changes in dietary intake at the individual-level and to identify trends in foods, nutrients and dietary patterns among populations and sub-populations of interest.[42] In addition, the comparison of dietary intake across countries using individual dietary surveys are likely to have differences in methodologies used to collect and analyze this data; this could curtail the ability to make meaningful comparisons of results. A recent systematic assessment of the consumption of ten foods and ten nutrients from 1990 to 2010 pooled from 325 dietary surveys representing 89% of adults from 187 countries (233 of which were nationally representative) showed that the consumption of foods considered healthy improved, while the consumption of unhealthy foods worsened across the world, with heterogeneity across countries and regions.[107] Although this was a comprehensive analysis of individual dietary surveys data that provided insights on global dietary patterns, the data were limited to the adult population.

Anthropometric indicators

Several studies have alluded to the presence of the nutrition transition by describing changes in the prevalence of underweight and overweight/obesity.[3,79,108-111] For instance, a study in Brazil used BMI z-scores and reported evidence of nutrition transition from the high prevalence of overweight among pre-school children ages 2-6 years.[111]

Dietary Assessment Instruments

Emergence of the globalization of the human diet along with nutrition transition among adolescents in LMICs including India has drawn attention to existing methods used in dietary assessment of this section of the population. Estimating food and nutrient consumption in global populations is a valuable but challenging process. Traditional methods of dietary assessment include FFQ, 24-hour dietary recall (24-hour DRs) methods, and food records.[112,113] The FFQ is a practical, cost-effective, and widely accepted dietary assessment instrument that can measure long-term intake over 6-12 months[114,115] and dietary changes in intervention studies[116,117] and can be used to investigate diet-disease associations across populations.[32,112] Unlike FFQs, 24-hour DRs and food records are not representative of long-term food intake[118] and are also not as practical and cost-effective.[114,115] A few FFQs have been developed for adolescents in India, [77,78,119] but the evaluation of the validity and reproducibility of these instruments have not been documented. Instead, the 24-hour DR method has been used to periodically assess the nutritional status of adolescents in select states by the National Nutrition Monitoring Bureau of India[120] and in other cross-sectional studies.[121-123]

Dietary Patterns and Dietary Scores

Newer dietary assessment methods that have been introduced are diet scores or indices and analysis of dietary patterns. These go beyond the FFQ and 24-hour DR methods as they quantify diet as a whole.[124] Identifying distinct dietary patterns provides a more accurate representation of dietary intake and allows for the investigation of the relationships between NCDs and complete diets rather than individual food items or nutrients.[125] In India, as in other LMICs with a high burden of NR-NCDs, the study of dietary patterns is emerging.[126-130] A recent systematic review (8 studies; 2 with data on children and adolescents) found highly diverse dietary patterns in India including traditional vegetarian patterns and diets high in fat, sugar, and meat; with some evidence of dietary change over time.[125] Diets of children ages 9-11 years (n=7199) from urban regions of 12 countries including Bangalore in Karnataka, India showed a common unhealthy diet pattern (principal component analysis (PCA) from responses to 23-item FFQ; factor loading > 0.6 for fast foods, ice cream, fried food, fries, potato chips, cakes and sugar-sweetened beverages) and a healthy diet pattern (factor loading > 0.6 for vegetables and fruits), despite variations in food culture, geographical location, and ethnic background.[131]

A study of dietary pattern analysis of children (n=538) ages 9.5 years in Mysore, Karnataka reported two dietary patterns – a snack and fruit pattern (snacks, fruits, sweetened drinks, rice and meat dishes, and leavened breads) and a lacto-vegetarian pattern (finger millet, vegetarian rice dishes, yoghurt, vegetable dishes, and infrequent meat consumption).[126] A cross-sectional dietary patterns study of 686 adolescent boys and 689 adolescent girls in Orissa, India found among boys, six food groups patterns and three nutrient patterns that explained 52% and 76% of total variation of the diet, respectively.[129] Among girls, seven food group patterns and three nutrient patterns that explained 67% and 80% of total variation of the diet, respectively.[129] In Pune, India, five dietary patterns reflecting intakes of different cereals were identified among 630 girls with lacto-vegetarian food habits; inadequate intakes of energy, protein, and micronutrients including zinc were found across the five identified dietary patterns when compared with the recommended dietary guidelines of India.[127] Among 7067 pairs of adult and their siblings enrolled in the Indian Migration Study across Lucknow, Nagpur, Hyderabad, and Bangalore, three dietary patterns namely cereals-savory foods (cooked grains, rice-based dishes, snacks, condiments, soups, and nuts), fruit-veg-sweets-snacks (western cereals, vegetables, fruit, fruit juices, cooked milk products, snacks, sugars, and sweets),and animal-source foods were found.[128] While findings from these studies inform of dietary patterns, they are limited mainly to adults or adolescents in metropoles in India.

Diet scores quantify foods or nutrients as a whole as opposed to individual constituents; they have been designed to assess adherence to dietary guidelines,[132,133], diet quality,[134-136] and dietary diversity.[137] They development of diet scores follows either a pre-defined or theoretical approach [134] or an empirical or data-driven apporach.[124] Pre-defined scores are developed using dietary guidelines or nutrition knowledge such as the Healthy Eating Index[138] or Mediterranean Style Dietary Pattern Score.[133] Empirical scores are developed using statistical approaches such as factor or cluster analysis.[124] Diet scores have been developed mostly for adults[132,133,139] and for the youth in high-income countries and European settings.[135,136,138,140-142] Few diet scores exist in LMICs; examples of those for youth include a dietary diversity score developed for adolescents in Iran,[143] the Indian Adolescent Micronutrient Quality Index, developed to measure the dietary adequacy and micronutrient quality of the diets of adolescent girls ages 10-16 years consuming lacto-vegetarian diets,[122] and a group of four scores, namely the Fruit and Vegetable score, Animal food score, Western food score, and Sweet food score, created and evaluated for their reliability among adolescents in China.[144] A six-point scoring system was developed to identify the stage of nutrition transition of the country of origin among a non-random sample of Latino immigrant adults living in Baltimore but originally from one of 12 Latin American countries.[5] The indicators for the six-point scoring system included 'the percentage of the population living on < $1/day, infant mortality rate, NCD mortality percentage, prevalence of BMI in the population in 2008 from the WHO Global Health Observatory Database, and total energy intake and percentage of energy intake from fat from the UN Food and Agriculture Organization food balance sheets for the 12 Latin American countries.'[5] Put together, there is a dearth of diet metrics or dietary assessment instruments that can measure nutrition transition at the individual-level.

Summary

Nutrition transition, the shifts in dietary patterns and physical activity patterns, accompany globalization and urbanization in LMICs including India, with health implications not only for adults but also adolescents ages 10-19 years. Most available evidence of nutrition transition in India has come from data on household level food consumption expenditure, from adults and from metropoles, leaving little known about the nutrition transition-related dietary shifts among those in regions outside the metropoles and in younger populations. There is limited research on the assessment of the nutrition transition, both the shifts in dietary patterns and eating behaviors at the population level; in part from the lack of tailored dietary assessment instruments or diet metrics. The proposed study will investigate these gaps.

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CHAPTER 3: Methods

Study setting: Vijayapura, India

Vijayapura is the 3rd largest district in the state of Karnataka in Southern India, with a population of 1,800,000.[67] The district is categorized as economically underdeveloped but is rapidly urbanizing as a result of the major economic growth of its small scale industries, including agriculture and of its large scale industries, including sugar and textiles.[67] Vijayapura City is a mid-size city with a population of 350,000 located in Southern India in Vijayapura district **(Figure 1).**[67] Vijayapura city can be considered representative of mid-size Indian cities that have been traditionally underdeveloped but are undergoing socio-economic development and with the likely penetration of global and urban influences; making it a promising location to investigate nutrition transition among adolescents.

Data Sources

Baseline study

Data for aim 1 come from the baseline wave of the 2012 Home Environment and Adolescent Weight study; a representative school-based sample of 407 adolescents ages 13-16 years and their families from the remote mid-size Vijayapura city. Three public (government-funded) and three private schools were randomly selected from a list of schools with grades 8-12 in Vijayapura city. A stratified simple random sample of 201 public school students (102 boys, 99 girls) and 206 private school students (105 boys, 101 girls) was drawn from school rosters. The sample size was calculated with the prevalence of unhealthy weight as the outcome, assumed at 40%, 6% precision, 95% confidence intervals, and a design effect of 1.5. Between January-April 2012, adolescents completed an interviewer-administered survey on home environment and nutrition at school. The survey included a 16-item food frequency questionnaire (FFQ) that was developed by a trained nutritionist from Karnataka. In addition, a primary caregiver and opposite gender sibling closest in age to the adolescent participant were also selected from the household and administered the same survey during a subsequent home visit. Trained interviewers conducted interviews in the local language, Kannada, having obtained informed consent from the caregivers and assent from the adolescents.

Adolescents responses to demographic information and the FFQ were used for the analysis in aim 1. In addition, for this analysis, we also used the socioeconomic information provided by the primary caregiver that included monthly family, religion, and caste. To generate population representative results of school-going adolescents in Vijayapura, survey weights were constructed to adjust for survey design as the inverse of the probability of selection.

Follow-up study

The follow-up wave of the Home Environment and Adolescent Weight study was carried out in two phases from June 2013-January 2014. In the first phase a non-random sample of 156 of the 407 adolescents from the baseline study completed the interviewer-administered health and nutrition survey. In the second phase, and for aims 2 and 3, a non-random sub-sample of 200 of 407 adolescents were recruited to participate in the evaluation of the Nutrition Transition-Food Frequency Questionnaire (NT-FFQ). The NT-FFQ was administered in the local language, Kannada. The design and evaluation of the NT-FFQ are described in Chapter 5. Dietary data from responses to the NT-FFQ were used to determine dietary patterns and to evaluate the validity of the pre-defined Nutrition Transition-Diet Score to measure nutrition transition among adolescents in India. The development and evaluation of the pre-defined Nutrition Transition-Diet Score are described in Chapter 6.

Ethical consent

The Institutional Ethical Committees at BLDE University, Vijayapura and at the Center for Chronic Disease Control, New Delhi approved the baseline 2012 Home Environment and Adolescent Weight study and the Institutional Review Board at Emory University, Atlanta approved the secondary data analysis. The development and evaluation of the NT-FFQ was approved by the Institutional Review Board at Emory University, Atlanta, US and the Institutional Ethical Committee at BLDE University, Vijayapura, India.

Figure 1. Location of Vijayapura city in India[†]

[†] Source: d-maps.com http://www.d-maps.com/conditions.php?lang=en. Accessed July 15, 2016

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CHAPTER 4: Going global: Indian adolescents' eating patterns

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Abstract

Objective: To describe adolescents' eating patterns of traditional, global/non-local, and mixed foods and the factors that may influence food consumption, access, and preferences in a globalizing city.

Design: A representative sample of school-going adolescents completed a cross-sectional survey including a food frequency questionnaire designed to identify traditional and global foods. Student's *t* test and ordinal logistic regression were used to examine weekly food intake, including differences between boys and girls and between adolescents attending private and public schools.

Setting: Vijayapura City, Karnataka State, India.

Subjects: Adolescents (n 399) aged 13-16 years.

Results: Compared with dietary guidelines, adolescents consumed fruit, green leafy vegetables, non-green leafy vegetables, and dairy less frequently than recommended and consumed energy-dense foods more frequently than recommended. Traditional but expensive foods (fruits, dairy, homemade sweets, and added fat) were more frequently consumed by private school students, generally from wealthier, more connected families, than by public-school students; the latter more frequently consumed both traditional (tea, coffee, eggs) and mixed foods (snack and street foods) ($P \leq 0{\cdot}05$). Girls reported more frequent consumption of global/non-local packaged and ready-to-eat foods, non-green leafy vegetables, and added fat than boys ($P \leq 0{\cdot}05$). Boys reported more frequent consumption of eggs and street foods than girls ($P \leq 0{\cdot}05$).

Conclusions: Adolescents' eating patterns in a globalizing city reflect a combination of global/non-local and traditional foods, access, and preferences. As global foods continue to appear in low- and middle- income countries, understanding dietary patterns and preferences can inform efforts to promote diversity and healthfulness of foods.

Keywords: adolescents, food, nutrition transition, globalization, India

Introduction

Globalization, urbanization, and economic development are contributing to shifts in food accessibility and food consumption patterns in low- and middle-income countries (LMICs), including India.[1,2] Urban regions in LMICs including India,[1-5] Brazil,[6] and China[2] are experiencing the penetration of new foods, from other countries (global) or other regions (non-local).[7] Refined carbohydrates, snack foods, processed foods, and fried foods appear to be replacing traditional foods such as unrefined whole grains, fruit, vegetables, and nuts.[8] "Nutrition transition," the term used to describe these shifts, may be implicated in increasing nutrition-related non-communicable diseases (NR-NCDs), including diabetes and obesity in many parts of the world.[9] Global and non-local foods are also beginning to reach rural areas and poorer individuals; at the same time, NR-NCDs are also increasingly prevalent not only among upper- and middle socioeconomic groups, as observed in the past, but also in lower socio-economic groups.[10-12] In India, 62 million adults of a population of 1.2 billion have diabetes, and, by 2035, 101 million adults are expected to have diabetes.[13] About 10% of Indians ages 0-54 years are overweight or obese.[14] Among Indian adolescents, that comprise one-fifth of the population (~243 million),[15] 37% are underweight and 5% are overweight or obese.[14]

Adolescence is a critical life period when eating habits are established[16] and during which adequate nutrition promotes healthy growth and health in adulthood.[17] Adolescents are also often at the forefront of social change and global trends [18] and are experiencing increasing spending power relative to earlier generations.[19] Healthy eating can be challenging for adolescents in the context of new, trendy, palatable processed foods and fast foods appearing with globalization and promoted through peers and the media.[20-22] Eating patterns are molded by the meeting of traditional and global factors, [23] which occurs within the broader contexts of socioeconomic status (SES), urbanization, and gender relations. In LMICs, including India, urban, wealthier, more globally connected families are often the first to adopt Western foods, many of which are energy-dense (high calorie poor-nutrient) and high in sugar, saturated fat, and salt.[24] Most research on the nutritional transition in India has focused on globally connected metropolitan areas.[5,25,26] In India, the type of school attended by an adolescent can be a marker of SES and connectivity. School-going adolescents from higher socioeconomic families in the urban Indian cities of Bengaluru,[25] Hyderabad,[26] and Baroda[27] had more global foods comprising processed foods, fast foods and carbonated beverages in their diets while rural adolescents across nine states of India had more traditional diets including grains, pulses, and green leafy vegetables (GLV).[28] Adolescents in Hyderabad preferred global fast foods (e.g., noodles and corn flakes) to traditional foods (e.g., idli).[26] Those from higher socioeconomic families had higher traditional food group intake including fruits, GLV, and dairy products than those from lower socioeconomic families.[26] The diets of adolescents in Bengaluru were higher in fat, especially saturated fats and lesser in carbohydrates.[25] Among adolescents across social strata in Baroda and Hyderabad, half consumed carbonated beverages and over one-third consumed fast foods once or twice a week.[26,27] We expect that, as private schools tend to have more resources[29,30] and be more globally connected, they may offer more opportunities for learning about and accessing global foods.

Furthermore, studies of child health in India have drawn attention to concerns about differences in resources provided to boys and girls.[31-33] There is persistent concern that girls tend to receive lower-quality food, less food, and less expensive food, such as grains rather than milk and fat.[31-33] It is unclear whether there are gender differences in food allocation and how these may change during the nutrition transition. Lower privilege and less freedom of movement for girls may entail that they may have less access to non-local and global foods. We expect that socioeconomic and gender differences in access to global and non-local foods.

Data on food consumption among adolescents in India has been limited, though food availability is believed to be changing. This study examines the nutrition transition in a community outside the global metropolitan areas, drawing on a representative study of school-going adolescents in a remote mid-size city in South India. We provide new data on adolescents' food consumption in the context of changing nutritional environments and examine differences therein by gender and socioeconomic status. Given the penetration of new foods and beverages from other countries (global) and regions within India (non-local) [7] along with existing ones, we also classify foods and beverages in terms of being traditional, global/non-local, or a combination of both.

Methods

Setting

Data are from a representative school-based sample of 407 adolescents ages 13-16 years and their families from a remote mid-size city in Karnataka, South India. With a population of 350,000, Vijayapura city is the main urban center in the Vijayapura district, which is considered to be an under-developed district. The region is undergoing socio-economic development and urbanization through the growth of large-scale industries.[34]

Three public (government-funded) and three private schools were randomly selected from schools with grades 8-12 in Vijayapura city. A stratified simple random sample of 201 public school students (102 boys, 99 girls) and 206 private school students (105 boys, 101 girls) was drawn from school rosters. The sample size was calculated with the prevalence of unhealthy weight as the outcome, assumed at 40%, 6% precision, 95% confidence intervals, and a design effect of 1.5. In January-April 2012, adolescents completed a survey at school; additional information was collected from their primary caregiver during a subsequent home visit. Trained interviewers conducted interviews in the local language, Kannada, having obtained informed consent from the caregivers and assent from the adolescents. During training of the interviewers, inter-rater reliability was assessed and low discordance was reported (<10%).

Variables

Adolescents reported demographic information and primary caregivers provided socioeconomic information. A 16-item food frequency questionnaire (FFQ) was developed for this study in collaboration with a trained nutritionist from Karnataka to assess adolescents' consumption of prominent traditional and global foods. The FFQ comprised key foods that are commonly consumed by adolescents. To our knowledge this is the first brief FFQ for adolescents in Vijayapura. We conceptualized foods into three categories, created based on previous literature and the authors' field observations; i) *traditional items*: GLV, non-GLV, fruits, eggs, dairy, tea or coffee, addition of dietary fat (e.g., butter, ghee, oil) to prepared food, homemade Indians sweets, ii) *global or non-local items*: carbonated beverages, packaged foods (e.g., biscuits, chips, chocolates), bakery products (e.g., bread, cakes), and ready-to-eat foods (e.g., instant noodles, packaged cereals) and iii) *mixed items*: non-vegetarian foods (e.g., fish, poultry, mutton), fruit juices, Indian savory snacks (e.g., chaats, chooda), and street food (e.g., fried samosa, fried fritters). The category of *mixed items* refers to foods that are both traditional and global or non-local, such as fruit juices, which can include 'traditional' fresh juices made at home or at a restaurant and 'global' bottled fruit juices.

Participants were asked "how often in a week do you eat or drink the following foods?" Response categories were daily, few times per week, once per week, and less than once per week or never. For analysis, frequencies were coded as a measure of days per week consumed: daily=7, few times per week=3.5, once per week=1, and less than once per week or never=0. To measure exposure and access to foods and beverages, the control variables were age, family income, religion, and caste. Adolescents provided their age while the primary caregiver provided information of the other control variables. Monthly family income was dichotomized as ≥ INR 20,000 and < INR 20,000 (1 USD=51.0 Indian Rupees (INR) as of April 2012). Caste was dichotomized as general caste and Other Backward Caste (OBC) and Scheduled Tribe (ST) and Scheduled Caste (SC) as the reference category. OBC, SC, and ST are terms used by the Government of India to classify socially and educationally disadvantaged sections of the population. The religion variable was also dichotomized; Hindu and Jains were collapsed as the reference category while Muslims, Christians, and other minorities were collapsed as the second category.

Statistical methods

The distribution of intakes of each item were first examined. All food groups had a normal distribution. Student's *t* tests were used to compare weekly consumption by gender (boy, girl) and type of school attended (public, private). Ordinal logistic regression analysis was used to identify the correlates of weekly intake of each traditional, mixed, and global/non-local food. All models were run separately for each food variable with less than once per week or never as the reference category. The variables included in the ordinal logistic regressions were gender, school type, age, family income, caste, and religion. Given our hypothesis, we first ran unadjusted ordinal logistic regressions models with each food variable as the primary outcome (dependent variable) and gender and school type as the main predictor variables (independent variable) (model 1). In the next step of the analysis, we ran adjusted ordinal logistic regressions models with both gender and school type as the predictor variables and controlled for age (model 2). We entered age in the model, given that food intake and food choices may change as individuals become older. The unconfounded effect of age would thus be obtained from this equation. Extending the above model, we ran adjusted ordinal logistic regressions models with both gender and school type as the predictor variables and controlled for family income in the presence of age (model 3). Family income, an indicator of socio-economic status, was entered in the model as economic resources may guide food choices.[35] Lastly, we further extended the above model; caste and religion were entered as the third-level variables (model 4) and their associations with the outcomes assessed in the presence of age and family income. Given that religion and caste are also relevant to consumption patterns in India, these were entered in the model.[36,37] To check for robustness, we also carried out multivariate linear regression analysis of the predictors of weekly intake of traditional, mixed and global/non-local foods and beverages. As an additional analysis, the frequency of intake of fruit, GLV, non-GLV, and dairy were compared with those recommended under the Dietary Guidelines of India.[38]

Eight adolescents were excluded from the analyses: the caregivers of five adolescents did not know or refused to respond to questions about monthly family income and three adolescents could not be interviewed after the initial selection. The final analytic sample was 399 participants. To generate population representative results of school-going adolescents in Vijayapura, survey weights were constructed to adjust for survey design as the inverse of the probability of selection. Data were analyzed using Statistical Analysis Software (SAS version 9.2; SAS Institute, Cary, NC).

Results

Demographic and socioeconomic characteristics

Adolescents in grades 8-12 were on average 14 years old; 53% were boys, 80% ascribed to the Hindu religion, 53% were classified as OBC, and 72% attended public schools in Vijayapura **(Table 1.1)**. The majority of adolescents lived in permanent structure (*pucca*) homes (78%) with a separate room for cooking (86%) and used gas or electricity for cooking (80%). The largest number were from families in the second poorest income group (32.5%) with a monthly income of Indian rupees 5,000-10,000 ($98-196 USD as of April 2012).

Food consumption patterns

Overall, the foods and beverages that were most frequently consumed by the adolescents were tea or coffee (5.5 d/week), dairy (5.0 d/week), packaged foods (4.8 d/week), and non-GLV (4.7 d/week) and the least frequently consumed foods and beverages ($\leq$ 1.0 d/week) were homemade sweets, ready-to-eat foods, non-vegetarian foods, fruit juices, and carbonated beverages. Compared with the Dietary Guidelines of India, adolescents consumed fruit 51.4%, GLV 45.7%, non-GLV 32.9 %, and dairy 28.6% less frequently and energy-dense foods more frequently than recommended.

The weekly consumption (d/week) of traditional, mixed, and global/non-local foods and beverages among adolescents are given in **Table 1.2**. Among the *traditional foods and beverages*, the more expensive ones, including fruit (5.0 vs. 2.7 d/week; 58% vs. 18% daily), dairy (5.7 vs. 4.7 d/week; 85% vs. 74% daily or several times per week), homemade sweets (1.1 vs. 0.4 d/week, 20% vs. 5.5% daily or several times per week), and fat added to prepared food (3.8 vs. 2.0 d/week, 44% vs. 21% daily) were more frequently consumed by private school students compared to public school students. The relatively less expensive traditional foods including tea or coffee (5.9 vs. 4.4 d/week) and eggs (2.0 vs 1.0 d/week) were more frequently consumed by public school students compared to private school students. Girls reported significantly more frequent consumption (d/week) of non-GLV (5.0 vs. 4.3 d/week), and fat added to prepared food (3.*0* vs. 2.1 d/week) than boys. Boys reported more frequent consumption of eggs (2.0 vs. 1.5 d/week; 42% vs. 29% daily) than girls.

Among the *mixed foods and beverages*, public school students had significantly higher consumption of snack foods (1.5 vs. 0.8 d/week), street food (1.3 vs. 0.8 d/week), and non-vegetarian foods (0.8 vs. 0.2 d/week) than private school students; who had a significantly higher consumption of fruit juices (1.3 vs. 0.8 d/week; 25% vs. 13% daily). Boys reported significantly more frequent consumption of street foods (1.5 vs 0.9 d/week*;* 28% vs. 15% few times a week) than girls. With regard to the *global/non-local foods and beverages*, public school students had a significantly higher consumption of carbonated beverages (1.1 vs. 0.4 d/week) compared to private school students and *g*irls reported a significantly more frequent consumption of energy-dense packaged global/non-local foods (5.1 vs. 4.5 d/week) and ready-to-eat foods (1.5 vs. 0.8 d/week) than boys.

Differences in consumption of traditional, mixed, and global/non-local foods between private and public school students and between boys and girls were robust to controlling for age, income, caste, and religion **(Table 1.3)**. Among *traditional foods*, non-GLV (OR=0.55, 95% CI: 0.38-0.81) were less likely to be consumed by boys than girls. Boys were also less likely to add fat to food (OR=0.49, 95% CI: 0.33-0.71) than girls. Fruit (OR=5.46, 95% CI: 3.50-8.52), dairy (OR=2.30, 95% CI: 1.41-3.75), added fat (OR=3.25, 95% CI: 2.13-4.97), and homemade sweets (OR=2.57, 95% CI: 1.64-4.01) were more likely to be consumed by those attending private schools than public schools. Alternatively, tea or coffee (OR=0.28, 95% CI: 0.17-0.46) was more likely to be consumed by those attending public schools than private schools. Eggs were more likely to be frequently consumed by boys (OR=2.03, 95% CI: 1.39-2.95), public school students (OR=0.32, 95% CI: 0.21-0.49), and younger adolescents (OR=0.81, 95% CI: 0.67-0.98) than girls, private school students, and older adolescents, respectively.

With regards to the *mixed foods*, street foods (OR=1.88, 95% CI: 1.28-2.76) were more likely to be frequently consumed by boys than girls. Non-vegetarian foods (OR=0.20, 95% CI: 0.11-0.36) and Indian snacks (OR=0.64, 95% CI: 0.42-0.99) were more likely to be consumed and fruit juice (OR=2.12, 95% CI: 1.39-3.24) was less likely to be consumed by public schools adolescents than private school adolescents, respectively.

Among *global and non-local foods,* ready-to-eat foods were more likely to be consumed by private school adolescents (OR=1.98, 95% CI: 1.29-3.03), girls (OR=0.46, 95% CI: 0.31-0.68), and younger adolescents (OR=0.71, 95% CI: 0.58-0.87) than public schools adolescents, boys, and older adolescents, respectively. Private school adolescents (OR=0.54, 95% CI: 0.33-0.87) and those belonging to the general caste (OR=0.59, 95% CI: 0.35-0.97) were less likely to consume carbonated beverages than were public school adolescents and those belonging to OBC, ST, and SC, respectively. Boys (OR=0.63, 95% CI: 0.43-0.92) and adolescents in higher-income households were less likely to frequently consume packaged foods (OR=0.62, 95% CI: 0.41-0.96) than girls and those in lower-income households, respectively. Results are consistent using multivariate linear regression **(Supplemental Table 1.1).**

Discussion

With urbanization and globalization, the access to, preferences for, and consumption of foods and beverages may be changing in LMICs. The present study investigated adolescents' consumption patterns in a remote mid-size city in South India and contextualized foods and beverages in three main categories; traditional foods, mixed foods, and global/non-local foods. Overall, compared with dietary guidelines, adolescents consumed energy-dense foods more frequently than recommended and consumed fruit, green leafy vegetables, non-green leafy vegetables, and dairy less frequently than recommended.[38] Adolescents' exposure to global, non-local, and traditional foods is showing resemblance to levels reported in urban areas. Still, dietary quality seems to be better in this remote mid-sized city than in Indian metropoles, with moderate intake of

GLV, fruits, and dairy (~3.5-4 d/week) and low intake of homemade sweets (~0.6-2 d/week).[26,27,39]

The Dietary Guidelines of India recommend daily intake of GLV and fruits[38] while the WHO recommends a daily intake of 400g of fruits and vegetables to prevent chronic diseases and micronutrient deficiencies.[40] In our study, only 29% ate GLV and fruits daily while 10% did so less than once a month or not at all. A study in two Indian cities showed that all adolescents ages 12-14 years consumed GLV at least once a week and those in the higher SES group consumed GLV almost daily,[26] so our population may be better off. Studies worldwide, including in India, have reported low fruits and vegetables intake among adolescents from low-income households.[26,41] Data from across 35 countries indicated that adolescents ate fruit on average 2.8-5.0 d/week, vegetables 2.4 - 5.5 d/week, and sweets 2.6 - 5.0 d/week.[42] In comparison, Vijayapura adolescents had less frequent consumption of fruit (0.8 to 6 d/week) and sweets (0.6 to 1.8 d/week) but similar frequency of GLV (1.5 to 6.2 d/week) and non-GLV (2.4 to 7.0 d/week). The majority of adolescents (91%) in our study consumed homemade sweets less than once a week, contrary to recent reports of increasing sweets consumption among children and adolescents in Asia.[39,43] The infrequent weekly intake of homemade sweets may be due to their high cost and the traditional practice of making them mainly during festivals or special family occasions such as weddings.

In our study, the more frequent consumption of processed *global/non-local* foods among public school students than among private school students may be explained by the availability of low-cost versions of branded processed foods, produced to cater to low income groups and to fit local tastes.[22] These unregulated cheaper and often lower-quality foods could worsen nutritionally poor diets.[22] Our findings align with reports from urban areas that biscuits and salted snacks are being eaten more since the past two decades and that low-cost fried and processed foods are a key feature of the nutrition transition in India.[4,44,45] Frequent consumption of processed foods has been reported to be associated with NR-NCDs among adolescents.[22,45,46] Contrary to reports of increasing consumption of carbonated beverages documented among adolescents in Asia in the past few decades,[39,43] the majority of adolescents (85%) in our study consumed carbonated beverages less than once weekly. The low consumption of carbonated beverages may be due to its relatively higher cost (e.g., 200 ml Pepsi at INR 8 and 500 ml Pepsi at INR 20) when compared to the ready availability of cheaper alternatives for ≤ INR 5 such as juice on street carts, ice candy, biscuit, chips, etc. that adolescents could purchase.

Food prices in relation to family income can affect a family's ability purchasing decisions. In our study, traditional but expensive foods including fruits, dairy, added fat, and homemade sweets were more frequently consumed by private than public school adolescents. The National Family Health Surveys (NFHS 2)[47] and a study in Hyderabad, India[48] both reported higher intakes of milk and fruits among children of higher income groups. In our study, 41% of adolescents attending public schools but only 22% of those attending private schools consumed eggs daily or a few times per week. Eggs (raw and boiled) are mainly sold on street carts placed outside centrally-located public schools and markets in the city for INR 5-6 (USD 7-9 cents) each (as of April 2012) that make them accessible to public school students. The intake of eggs may be also be driven by religion or caste. Although eggs are often not consumed by some religious groups (for e.g. Jains),[36] we did not find significant differences in egg intake by religion or caste. Adolescents drank tea and coffee frequently (~5d/week), with 82% of public school adolescents and 60% of private school adolescents consuming daily. Only 63% of adolescents consumed dairy daily and 22% had dairy less than once a week. Drinking tea or coffee cooked with milk does not provide the same nutritional benefits of consuming milk, known to be rich in protein and calcium. Drinking tea or coffee instead of milk is likely a result of cultural norms and the high cost of milk (INR 30-40 per liter as of April 2012), which could explain higher tea or coffee intake by public than private school adolescents.

In addition to food prices, religion, caste, and gender norms are also relevant to consumption patterns in India. For the majority of people in India, particularly those of Hindu religion, food habits are driven by religious vegetarianism.[36,37] With increasing incomes, studies have reported increased intake of animal-source foods.[3,49] In addition, for much of history, people may have liked to eat non-vegetarian foods but were effectively vegetarian because of lack of access. In our study, public school adolescents more frequently consumed non-vegetarian foods, Indian snacks, and street food compared to private school adolescents after accounting for age, gender, caste, and religion. More frequent intake of non-vegetarian foods among public than private school adolescents in our study as also reported in Hyderabad[26] could be an indicator of changing food access and norms reflecting globalizing diets. More frequent eggs and street foods consumption by boys may be a result of gender and cultural norms that allow boys more access to foods believed to be strength-building, like eggs and meat and to be away from home or outdoors more than girls. The cultural norms and religious taboos around eating eggs and meat may also be a barrier for girls more than for boys.

This study has some limitations. Dietary assessment methods, including FFQs, may be limited by children's inadequate knowledge of and difficulty in estimating the foods they consumed.[50] Still, by ages 8-10 years, children can report their food intake as reliably as their parents.[50] Furthermore, minimal food recall difficulty is expected, as a weekly, not monthly or yearly, FFQ was used. There may be gender differences in perceiving or reporting food consumption. For example, boys may under-report adding fat to food as cultural norms have mothers in traditional Indian households typically serve children food. Mothers would add extra fat to food while serving but may also follow this practice more so for boys than girls. More frequently adding fat to food among girls than boys could also be explained by the belief that consuming ghee will help girls build strength to sustain future childbirth. Another consideration is that our FFQ used only 16 food groups and did not explicitly ask about some major food groups such as pulses and grains. The FFQ was designed to capture prominent traditional and global foods, and so was well suited to address the research topic of this study.

This study presents several strengths and contributions. While many studies from India have focused on urban areas, our research was in a prototype remote city that is traditionally underdeveloped but undergoing urbanization and experiencing new exposure to non-local and global trends. This setting is particularly well suited to investigate adolescents' dietary patterns in a globalizing context. Our sample was representative of school-going adolescents from across the socioeconomic spectrum in this setting. We have also proposed a way of categorizing foods and beverages as traditional, mixed, and global/non-local that contextualize the components of a diet in terms of the nutrition transition. Lastly, our study quantified differences in consumption according to gender, school type attended, and access to foods and beverages.

Conclusions

Adolescents' eating patterns in a globalizing city reflect a combination of global/non-local and traditional foods, access, and preferences. Adolescents' exposure to global, non-local, and traditional foods are beginning to mirror urban levels reported in more metropolitan areas. Girls reported more frequent consumption of energy-dense traditional, mixed, and global or non-local foods and boys reported more frequent eggs and street foods consumption. As global and non-local foods continue to emerge but have not yet overwhelmed the local culture in rural and urbanizing communities in LMICs, it may be possible to intervene at this stage to promote healthy eating behaviors among the youth. An important direction for future research will be to understand emerging dietary patterns and preferences that can inform efforts to promote dietary diversity and healthful food consumption.

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Tables

Table 1.1: Demographic and socio-economic profile of school-going adolescents ages 13-16 years in Vijayapura, India (n 399)

	Overall		Public School		Private School	
Characteristic †	Mean	95% CI	Mean	95% CI	Mean	95% CI
Age (years) ‡	14.3	14.3, 14.5	14.4	14.3, 14.6	14.2*	14.1, 14.3
Boys	53.4	48.0, 58.7	51.8	44.9, 58.7	57.7	50.7, 64.3
Religion						
Hindu	79.5	74.8, 83.5	80.2	74.1, 85.2	77.5	71.0, 82.9
Muslim	17.3	13.6, 21.8	17.4	12,7, 23.3	17.2	12.5, 23.3
Others	3.2	1.9, 5.5	2.4	1.0, 5.7	5.3	2.9, 9.4
Caste						
General	25.3	20.9, 30.3	5.9	20.3, 32.4	23.8	18.3, 30.3
Other Backward Class	53.1	47.7, 58.4	50.7	43.8, 57.6	59.3	52.2, 66.0
Scheduled Caste and Scheduled Tribe	21.6	17.4, 26.9	23.4	18.1, 29.8	16.9	12.2, 22.9
Monthly family income (INR, USD) §						
< 5000 ($98)	15.2	11.6, 19.5	15.9	11.5, 21.7	13.2*	9.0, 19.0
5001-10,000 ($98-196)	32.5	27.6, 37.7	34.3	28.0, 41.1	27.8	22.0, 34.5
10,001-20,000 ($196-392)	25.6	21.2, 30.6	25.9	20.4, 32.5	24.7	19.1, 31.3
≥ 20,000 ($392)	26.7	22.3, 31.7	23.9	18.4, 30.3	34.3	27.9, 41.2
Size of family ‡	5.3	5.0, 5.4	5.0	4.7, 5.3	5.6*	5.2, 6.0
Type of house						
Permanent structure (*pucca*)	78.4	73.6, 82.5	78.6	72.3, 83.7	78.0	71.5, 83.4
Non-permanent structure *(semi-pucca & kaccha)* ‖	21.6	17.4, 26.4	21.4	16.3, 27.7	22.0	16.6, 28.5
Separate room for cooking						
Yes	86.3	82.1, 89.7	85.1	79.4, 89.4	89.7	84.5, 93.3
No	13.7	10.3, 17.9	14.9	10.6, 20.6	10.3	6.7, 15.5
Type of fuel used in family for cooking						
Gas/LPG, Electricity	80.2	75.6, 84.1	81.5	75.4, 86.3	76.8	70.3, 82.2
Wood, Kerosene	19.8	15.9, 24.4	18.5	13.7, 24.5	23.2	17.8, 29.7

LPG, liquid petroleum gas.
Data were collected in January-April 2012.
*P<0.05.
† Data are presented as percentage and 95% CI unless indicated otherwise.
‡ Continuous variables are presented as mean and 95% CI.
§ US1= 51.0 Indian Rupees (INR), April 2012.
‖ *Kaccha* house is a makeshift one wherein roof and walls are made of mud or dried brick (organic materials). *Semi-pucca* house is also a not permanent structure house, it lack columns and beams but is built with some cement.

Table 1.2: Weekly consumption (d/week) of traditional, mixed, and global/non-local foods and beverages among school-going adolescents ages 13-16 years in Vijayapura, India (n 399)

	Consumption (d/week) †									
	Overall		Public school (n 201)		Private school (n 198)		Boys (n 200)		Girls (n 199)	
Food/beverage item	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI	Mean	95% CI
Traditional										
GLV	3.8	3.5, 4.0	3.8	3.5, 4.1	3.8	3.4, 4.0	3.8	3.5, 4.1	3.8	3.4, 4.1
Non-GLV	4.7	4.4, 4.9	4.6	4.3, 4.9	4.9	4.6, 5.2	4.3	4.0, 4.7	5.0**	4.7, 5.3
Fruit	3.4	3.1, 3.6	2.7	2.4, 3.1	5.0***	4.7, 5.4	3.3	2.9, 3.6	3.5	3.1, 3.8
Eggs	1.8	1.6, 2.0	2.0	1.7, 2.3	1.0***	0.8, 1.2	2.0	1.7, 2.3	1.5*	1.2, 1.7
Dairy ‡	5.0	4.7, 5.3	4.7	4.3, 5.1	5.7**	5.3, 6.0	5.0	4.6, 5.4	4.9	4.5, 5.3
Homemade Indian sweets	0.6	0.5, 0.7	0.4	0.3, 0.6	1.1***	0.8, 1.3	0.7	0.5, 0.8	0.6	0.4, 0.7
Extra fat added to prepared food §	2.5	2.2, 2.8	2.0	1.7, 2.4	3.8***	3.4, 4.2	2.1	1.7, 2.5	3.0**	2.6, 3.4
Tea or coffee	5.5	5.2, 5.7	5.9	5.5, 6.2	4.4***	3.9, 4.8	5.4	5.0, 5.8	5.5	5.1, 5.9
Mixed										
Fruit juices	1.0	0.8, 1.1	0.8	0.6, 1.0	1.3**	1.1, 1.5	1.0	0.8, 1.2	0.9	0.7, 1.1
Indian snacks ||	1.3	1.1, 1.5	1.5	1.2, 1.8	0.8**	0.6, 0.9	1.2	1.0, 1.5	1.4	1.0, 1.7
Street foods ¶	1.2	1.0, 1.4	1.3	1.1, 1.6	0.8*	0.6, 1.0	1.5	1.2, 1.8	0.9**	0.7, 1.1
Non-vegetarian foods ††	0.6	0.5, 0.7	0.8	0.6, 0.9	0.2***	0.1, 0.3	0.7	0.5, 0.9	0.5	0.4, 0.7
Global/non-local										
Carbonated beverages	0.9	0.7, 1.1	1.1	0.8, 1.3	0.4**	0.3, 0.5	0.9	0.7, 1.2	0.9	0.6, 1.1
Packaged foods ‡‡	4.8	4.5, 5.0	4.9	4.5, 5.3	4.6	4.2, 4.9	4.5	4.1, 4.9	5.1*	4.8, 5.5
Bakery products §§	2.5	2.2, 2.7	2.6	2.2, 3.0	2.2	1.9, 2.5	2.5	2.1, 2.9	2.4	2.1, 2.8
Ready-to-eat foods ||||	1.2	1.0, 1.3	1.1	0.9, 1.4	1.3	1.1, 1.6	0.8	0.6, 1.1	1.5**	1.2, 1.8

GLV, green leafy vegetables.
Data were collected in January–April 2012. Results are survey-adjusted. Differences in food consumption between private- and public-school students and between boys and girls were tested using *t* tests.
*P <0·05, **P <0·01, ***P<0·001.
†Weekly food consumption values are presented as mean and 95% CI.
‡Dairy includes milk and milk products.

§‘Extra fat added to prepared food’ includes butter, ghee and oil added to prepared food.
||Indian snacks include *chaats, chooda*, etc.
¶Street foods include samosa, *kachori*, etc.
††Non-vegetarian foods include fish, poultry and mutton.
‡‡Packaged foods include biscuits, chips and chocolates.
§§Bakery products include bread, sandwiches, pizza, burgers and cakes.
||||Ready-to-eat foods include instant noodles, cereals, etc.

Table 1.3: Intakes of traditional, mixed, and global/non-local foods and beverages (d/week) among adolescents ages 13-16 years in Vijayapura, India (n 399). Odds ratios and 95% CI from ordered logistic regression models

	Traditional foods							
Variable	GLV	Non-GLV	Fruit	Egg	Dairy	Added fat	Homemade sweets	Tea/coffee
Gender (ref=Girl)								
Boy	1.04 (0.72, 1.50)	0.55 (0.38, 0.81)**	0.88 (0.61, 1.27)	2.03 (1.39, 2.95)**	1.02 (0.68, 1.53)	0.49 (0.33, 0.71)**	1.05 (0.69, 1.59)	1.11 (0.69, 1.79)
School type (ref= Public school)								
Private	0.99 (0.66, 1.50)	1.30 (0.84, 1.99)	5.46 (3.50, 8.52)***	0.32 (0.21, 0.49)***	2.30 (1.41, 3.75)**	3.25 (2.13, 4.97)***	2.57 (1.64, 4.01)***	0.28 (0.17, 0.46) ***
Age (years)	0.96 (0.79, 1.15)	0.93 (0.77, 1.12)	0.89 (0.74, 1.08)	0.81 (0.67, 0.98)*	1.07 (0.87, 1.31)	1.07 (0.89, 1.30)	0.96 (0.78, 1.19)	0.79 (0.62, 1.01)
Monthly family income (ref= <INR 20,000) †								
≥ INR 20,000	0.96 (0.65, 1.51)	1.26 (0.82, 1.96)	1.33 (0.87, 2.03)	0.88 (0.58, 1.34)	0.90 (0.57, 1.42)	1.04 (0.68, 1.60)	0.93 (0.57, 1.49)	1.30 (0.75, 2.27)
Caste (ref= OBC and SC and ST)								
General	0.99 (0.64, 1.52)	1.32 (0.84, 2.07)	1.37 (0.89, 2.13)	1.21 (0.78, 1.86)	1.12 (0.69, 1.80)	0.79 (0.50, 1.23)	0.97 (0.59, 1.58)	0.97 (0.56, 1.70)
Religion (ref=Hindu)								
Muslim and others	0.79 (0.50, 1.25)	0.77 (0.48, 1.24)	0.81 (0.51, 1.29)	0.90 (0.56, 1.43)	0.70 (0.43, 1.15)	1.16 (0.72, 1.85)	0.79 (0.46, 1.35)	1.14 (0.62, 2.09)

Variable	Mixed foods				Global/non-local foods			
	Non-vegetarian foods	Indian snacks	Street foods	Fruit juices	Carbonated beverages	Packaged foods	Bakery products	Ready-to-eat foods
Gender (ref=Girl)								
Boy	1.34	1.13	1.88	1.06	1.03	0.63	1.04	0.46
	(0.88, 2.04)	(0.77, 1.64)	(1.28, 2.76)**	(0.72, 1.57)	(0.69, 1.56)	(0.43, 0.92)*	(0.71, 1.50)	(0.31, 0.68)**
School type (ref= Public school)								
Private school	0.20	0.64	0.70	2.12	0.54	0.80	0.86	1.98
	(0.11, 0.36)***	(0.42, 0.99)**	(0.46,1.09)	(1.39, 3.24)***	(0.33, 0.87)**	(0.53, 1.23)	(0.58, 1.29)	(1.29, 3.03)**
Age (years)	0.93	0.94	1.13	0.81	0.92	0.92	0.95	0.71
	(0.75, 1.14)	(0.78, 1.14)	(0.94, 1.37)	(0.67, 0.99)*	(0.75, 1.13)	(0.75, 1.11)	(0.80, 1.14)	(0.58, 0.87)**
Monthly family income (ref= <INR 20,000) †								
≥ INR 20,000	1.03	1.13	1.13	1.03	0.98	0.62	0.94	1.24
	(0.64, 1.66)	(0.52, 1.23)	(0.73, 1.74)	(0.66, 1.60)	(0.61, 1.57)	(0.41, 0.96)*	(0.62, 1.41)	(0.80, 1.92)
Caste (ref= OBC and SC and ST)								
General	1.11	0.81	0.64	1.01	0.59	1.12	1.27	1.17
	(0.68, 1.80)	(0.52, 1.23)	(0.41, 1.01)	(0.64, 1.60)	(0.35, 0.97)*	(0.71, 1.75)	(0.83, 1.93)	(0.74, 1.84)
Religion (ref=Hindu)								
	1.44	0.90	1.22	0.95	0.90	1.43	0.97	1.21
Muslim and others	(0.86, 2.42)	(0.56, 1.44)	(0.76, 1.95)	(0.58, 1.56)	(0.54, 1.50)	(0.87, 2.35)*	(0.62, 1.52)	(0.74, 1.98)

GLV, green leafy vegetables; ref., reference category; OBC, Other Backward Caste; ST, Scheduled Tribe; SC, Scheduled Caste.
Data were collected in January–April 2012. Results are survey-adjusted.
*P<0·05, **P<0·01, ***P <0·001.
†$US 1 =51·0 Indian Rupees (INR), April 2012. Family income was asked over a month.

Supplemental Table 1.1: Multivariate linear regression analysis of the predictors of weekly intake of traditional, mixed, and global/non-local foods and beverages (d/week) among adolescents ages 13-16 years in Vijayapura, India (n 399)

	Traditional foods								**Mixed foods**				**Global/non-local foods**			
Variable	GLV	Non-GLV	Fruit	Egg	Dairy	Added fat	Home-made sweets	Tea/ coffee	Non-veg foods	Indian snacks	Street food	Fruit juices	Carbonated beverages	Packaged foods	Bakery foods	Ready-to-eat foods
Boy	.003	-0.68**	-0.28	0.68**	0.006	-1.0**	0.07	0.07	0.21*	-0.09	0.61**	0.04	0.08	-0.6*	0.09	-0.61**
Private school †	-0.02	0.3	2.3***	-1.1***	1.0**	1.8***	0.61***	-1.6***	-0.52***	-0.74**	-0.54**	0.46**	-0.68***	-0.26	-0.38	0.16
Age	-.05	-0.1	-0.1	-0.28**	0.09	0.12	-0.02	-0.3^{+}	-0.01	-0.1	0.11	-0.11	-0.01	-0.13	-0.17	-0.31***
Family income ‡	-.02	0.27	0.34	0.03	-0.14	0.17	0.02	-0.27	-0.06	0.04	0.13	-0.05	-0.06	-0.65	-0.13	0.21
General caste §	.004	-0.34	-0.36	0.17	0.16	-.35	-0.07	-0.09	0.18	-0.1	-0.31	0.02	0.03	0.04	0.55	0.01
Religion ‖	-.31	-0.29	0.26	0.01	-0.48	0.07	-0.11	-0.08	0.2	-0.16	0.1	0.04	-0.04	0.41	-0.02	-0.21
Intercept	4.64	6.31	4.21	5.76	3.44	0.82	0.84	9.59	0.73	3.13	-0.46	2.47	1.3	7.19	4.92	5.81

GLV, Green leafy vegetables.
*p<0.05, **p<0.01, ***p<0.0001.
Results are survey-adjusted. One unit change = 1 day/week.
Data were collected in January-April 2012.
† Public school is the reference group.
‡ Family income categorized as ≥ INR 20,000 per month and < INR 20,000 (reference group). $ US1 = 51.0 INR, April 2012.
§ Caste including Other Backward Caste, Scheduled tribe and Scheduled caste is the reference group.
‖ Hindu religion is the reference group.

CHAPTER 5: Development and Evaluation of a Nutrition Transition-Food Frequency Questionnaire for Adolescents in South India

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Abstract

Objective: To develop and evaluate a Nutrition Transition-Food Frequency Questionnaire (NT-FFQ) to measure nutrition transition among adolescents in South India.

Design: We developed an interviewer-administered NT-FFQ comprised of a 125-item semi-quantitative FFQ and 27-item eating behavior survey. The reproducibility and validity of NT-FFQ was assessed using Spearman correlations, intra-class correlation coefficients (ICC), and levels of agreement using Bland-Altman and cross-classification over two months (NT-FFQ1 and NT-FFQ2). Validity of foods was evaluated against three 24-hour dietary recalls (DRs). Face validity of eating behaviors was evaluated through semi-structured cognitive interviews. The reproducibility of eating behaviors was assessed using weighted kappa and cross-classification analyses.

Setting: Karnataka, India.

Subjects: A representative sample of 198 adolescents aged 14-18 years.

Results: Reproducibility of NT-FFQ: Spearman correlations ranged from 0.33 (pulses) to 0.80 (red meat) and ICC from 0.05 (fruits) to 1.00 (tea). On average, concordance was 60% and discordance was 7% for food groups. For eating behaviors, the weighted kappa ranged from 0.24 (eating snacks while watching TV) to 0.67 (eating lunch at home) with a mean of 0.40. Validity of NT-FFQ: Spearman correlations ranged from 0.11 (fried traditional foods) to 0.70 (tea) and ICC ranged from 0.02 (healthy global foods) to 1.00 (grains). The concordance and discordance were 49% and 8%, respectively. The Bland-

Altman Plots showed acceptable agreement between NT-FFQ2 and the 24-hour DRs. The eating behaviors had acceptable face validity.

Conclusion: The NT-FFQ has good reproducibility and acceptable validity for food intake and eating behaviors. The NT-FFQ can quantify nutrition transition among Indian adolescents.

Keywords: Adolescents, Reproducibility, Validity, Nutrition Transition-FFQ, India

Introduction

Globalization, urbanization, and economic growth in low- and middle-income countries (LMICs) including India are associated with the nutrition transition – the phenomenon hypothesized to encompass shifts in dietary patterns, eating behaviors, and physical activity patterns.[1,2] Concomitant with nutrition transition, obesity, diabetes, and other chronic diseases have emerged among adults, adolescents, and children across social strata.[3-6] Validated dietary assessment instruments can measure the extent of nutrition transition through food intake and eating behaviors associated with it. Typical dietary assessment instruments such as FFQ and 24-hour dietary recalls (DRs) have been used to determine food consumption and nutritional status.[7] However, there is no FFQ developed to assess the nutrition transition. In addition, with the availability of and accessibility to global or non-local foods and beverages through globalizing food markets, the diets of individuals are likely to include both global and traditional items. In addition, studies have reported behaviors that may be part of the nutrition transition, including eating outside the home[8] and watching TV while eating meals.[9] Although studies indicate that these trends may be becoming more common, especially in adolescents,[8] currently there is no dietary assessment instrument that quantifies these and other nutrition transition-related food consumption and eating behaviors.

At the forefront of social change and global trends, [10] adolescents in LMICs may be experiencing nutrition-related shifts in food consumption and eating behaviors. In India, adolescents comprise one-fifth of the population (~243 million),[11] of which 37% are underweight and 5% are overweight or obese.[12] A few FFQs have been used in epidemiological studies among adolescents in India, [13-15] but the validity and reproducibility of these FFQs have not been documented. The 24-hour DR method has been used by the National Nutrition Monitoring Bureau of India to assess periodically the nutritional status of adolescents in select states.[16] Unlike FFQs, 24-hour DRs are not representative of long-term food intake[17] and are also not as practical and cost-effective.[18,19] The lack of validated dietary instruments limits the information known about the nature of dietary changes that may be occurring among adolescents in India. Assessing the dietary changes that are part of the nutrition transition requires validated dietary assessment instruments to measure long-term trends and changes not only in food intake but also in eating behaviors.

The objective of this study was to develop and to evaluate the validity and reproducibility of a Nutrition Transition-Food Frequency Questionnaire (NT-FFQ) to measure nutrition transition-related food consumption and eating behaviors among adolescents aged 14-18 years in South India.

Methods

Setting

The study was carried out from June 2013 - January 2014 in Vijayapura in Karnataka, India. Vijayapura is a mid-size city (population: 350,000) located in South India in a district which is categorized as economically underdeveloped but is urbanizing as a result of the major economic growth of its small scale industries, including agriculture, and its large scale industries, including sugar and textiles.[20] Vijayapura serves as a prototype mid-size Indian city that is traditionally underdeveloped but undergoing urbanization and experiencing exposure to non-local and global trends.[21]

Interviewer recruitment and training

Twelve field interviewers proficient in English and the local language, Kannada, were recruited and trained to administer the NT-FFQ and 24-hour DRs. The interviewers were also trained to obtain written informed consent from the adolescent's caregivers and assent from participants. Mock interview sessions were conducted in Kannada prior to fielding of the instrument to ensure that interviewers were familiar with food items and to ensure uniformity in the data collection techniques.

Development of the NT-FFQ

Qualitative fieldwork to identify food items

The NT-FFQ was developed using a sequenced mixed methods approach including formative qualitative fieldwork. The NT-FFQ comprised a 125-item semi-quantitative FFQ section that measured food consumption over a month and a 27-item eating behavior section that quantified eating behaviors over a week. The food items listed in the NT-FFQ were built using two methods: (1) identification of food items, including the commonly consumed local, regional, and global foods from our previous 24-hour DRs from adolescents (2) and written freelists of the most commonly available food and beverages in stores identified by a purposive sample of adolescents (n=26) ages 14-18 years. Freelisting, an elicitation technique, involves asking individuals to list all the items that they can think of for a given cultural domain.[22] A cultural domain is a collection of items related in the minds of informants, which helps them label, interpret, and understand items in their lives. Through these two methods, the food list was build and categorized into ten food groups based on their ingredients and preparation methods: global foods, snack foods, non-vegetarian foods, sweets and desserts, dairy, beverages, fruit and seasonal fruit, vegetables, traditional foods, and miscellaneous foods. For the eating behavior section of the NT-FFQ instrument, questions were developed on eating behaviors associated in the literature with the nutrition transition.[8,23] The eating behaviors included the adolescent's practice of eating at friends' homes or vice versa, the frequency of eating meal at home versus away from home (e.g., at restaurants, street carts, and at the home of a friend or family), the frequency of watching TV while eating meals, and the practice of consuming vitamin or minerals supplements.

Frequency response section of 125-items NT-FFQ

The NT-FFQ had 11 frequency categories for food consumption over one month, from several times per day to never **(see Supplement 2.1)**. The intake of seasonal fruit was asked over a three-month period, which is the length of a typical season for most seasonal fruit in India. An additional column beside these frequency categories was included to record whether the participants believed that his or her consumption of each food had increased, decreased, or remained the same in the past six months. This additional column was tailored from a previous study where participants were asked to report if 'the intake of a food item has greatly increased or decreased during the past 10 years.[24] This information was added to the traditional FFQ format to capture dietary changes that may be occurring as part of the nutrition transition.

Frequency response section of 27-item eating behaviors

Of the 27 eating behavior questions, 18 questions had the response categories of daily, 4-6 days/week, 1-3 days/week, and never and 8 questions asked participants about their perceptions of the novelty of eating habits using a four point Likert scale with the options totally traditional, somewhat traditional, somewhat modern, or totally modern. The 8 questions included the perception of a family with a working mother and the perceptions of eating home cooked food, outside food, eggs, meat, and bread, and drinking milk and fruit juice. The remaining one question asked participants whether they have had a vitamin or mineral supplement in the past year.

NT-FFQ portion size

We specified a standard serving size for each food (e.g., slices of bread, glass of milk) and included an additional column for participants to report the portion size they consumed if different from the one specified. The standard serving size was determined using those listed in the Dietary Guidelines of India[25] and those listed most frequently in our previous 24-hour DRs. Portion size estimates were based on household utensils including cups, spoons, and natural units (e.g., small, medium, and large size for fruits, etc.). Food models were constructed to measure traditional Indian breads including chapati and puri that were typically consumed in varying sizes including small, medium, or large **(see Supplemental Figure 1)**. For instance, three food models were constructed for chapati: small (45 g), medium (50g), and large (55 g). Given that packaged foods including chips, chocolates, and popcorn were available in several sizes, participants were asked to report both the quantity consumed over a month and the cost of one unit of that item (e.g., cost of 1 bar of chocolate). A database of packaged foods was developed to include the items' cost, weight, and nutritional information from the food label. The weight of food in grams was determined according to the cost of the packaged foods and quantity eaten (e.g., one bar of chocolate).

Pre-testing the NT-FFQ

The initial NT-FFQ included 154 items and was rigorously pre-tested using cognitive interviews among a purposive sample of five adolescents aged 14-18 years attending a private school in Vijayapura, India. In the pre-test, adolescents were asked to report their usual intake of foods and beverages over a three-month period. Using established guidelines, [26] the NT-FFQ was tested for content including the clarity of the meaning of food names, portion-size descriptions, unfamiliar food items, length of the instrument, and ease of administration. Cognitive interviews have been shown to help identify cognitive problems in dietary questionnaires and improve the accuracy of FFQs.[27,28] We observed that adolescents found it difficult to recall food consumption over a three-month period and reported that it would be easier to recall food intake over a one-month period. In addition, adolescents found 29 items unfamiliar (e.g., tofu). Using this feedback, the NT-FFQ was revised to 125 items with a reference period of one month. The revised 125-item NT-FFQ was pre-tested again among five adolescents of the same age without encountering additional problems. The NT-FFQ was finalized at 125 items to assess food intake over a month. On average, it took 35-40 minutes to administer the instrument.

Evaluation of the NT-FFQ

Study population

The reproducibility and validity of the NT-FFQ were evaluated among 200 adolescents aged 14-18 years. These 200 adolescents were interviewed as a part of the follow-up of a longitudinal study of 407 adolescents who participated in the 2012 Home Environment and Adolescent Weight study in Vijayapura, India.[29] In the 2012 baseline study, a representative stratified random school-based sample of 407 adolescents was drawn from three public and three private schools in Vijayapura.

Design of the evaluation study

The NT-FFQ was administered during home visits at baseline (NT-FFQ1) and two months later (NT-FFQ2) to 200 adolescents. Two adolescents were lost to follow-up during the second administration of NT-FFQ, yielding a final sample of 198 participants. A sub-sample of 97 adolescents completed three additional interviewer-administered 24-

hour DR over the two months period as shown in **Figure 1**. The trained interviewers using the multi-pass method for all 24-hour DRs. For each participant, two of the three 24-hour DRs were taken on a weekday and one recall was taken on the weekend.

Statistical methods

Data from the NT-FFQ were transformed into daily intake of each food (g/d) and beverage (ml/d). The daily intake was calculated by multiplying the specified portion unit by the frequency of intake, using the following values for reported frequencies: more than 3 times a day=3, twice a day=2, once a day=1, 2-4 times a week=0.43, 5-6 times a week=0.79, once a week=0.14, 2-3 times a month=0.082, monthly=0.03, less than once a month=0.016, and never eaten or don't know the food=0. The 125 foods in the NT-FFQ were collapsed to 21 meaningful food groups based on nutrient content **(Supplement 2.2)**. The reproducibility and validity of the NT-FFQ were assessed using a food-based approach, as done elsewhere.[24,30-35]

The reproducibility of the NT-FFQ for foods and food groups was assessed at baseline (NT-FFQ1) and after two months (NT-FFQ2) using Spearman correlation coefficients, intra-class correlation coefficients (ICC), and cross-classification of food group intake into tertiles. The measures of agreement or cross-classification were calculated using the percentage of participants in the same (concordance), adjacent, and extreme (discordance) tertiles of food intake by both NT-FFQs. The reproducibility of the eating behavior questions was assessed using weighted kappa statistics and cross-classification analyses.

The validity of the FFQ portion of the NT-FFQ was assessed, in a sub-sample of 97 adolescents, by comparing the intake of 21 food groups from the NT-FFQ2 to the average intake from the three 24-hour DRs. For each individual in the validation study, the daily intake of foods consumed during each of the three 24-hour DR was computed and used to calculate the mean daily intake of foods and foods groups from the three 24-hour DR. The mixed dishes from the 24-hour DR were divided into their components and allocated to the appropriate food items of the questionnaire as would routinely be done in the analysis of these dishes.[36] Spearman correlation coefficient was used to measure the strength of the relationship between food and food group intakes estimated by NT-FFQ2 and the 24-hour DRs. The relative agreement between NT-FFQ2 and the average of the three 24-hour DRs was tested by cross-classification of the food group intake and estimation of the proportion of subjects who were classified by the two methods into the same tertile (concordance) and extreme tertiles (discordance). To assess the 'limits of agreement' between NT-FFQ2 and the average of three 24-hour DR, the Bland-Altman method was performed for each of the food groups. The differences of mean intake between the two methods were plotted against the average intake of the two instruments for each food group. These estimates were analyzed with Statistical Analysis Software (SAS version 9.4; SAS Institute, Cary, NC). P values are indicated as two sided and significant at 0.05.

The face validity of the 27-item eating behaviors in the NT-FFQ was evaluated through semi-structured cognitive interviews using paraphrasing and response latency. To evaluate the face validity of the eating behavior questions, 30 adolescents aged 14 - 18 years were selected by purposive sampling. Trained interviewers administered the semi-structured cognitive interviews at the home of the participant. To assess paraphrasing, the interviewers elicited a response from the participant and probed for the meaning of each eating behavior question to ensure consistency with the intent of the question. For instance, a question 'how many times in a week do you eat with foods prepared outside the home with friends?' Response latency was assessed through the time taken to answer the eating behavior questions. In addition, at the end of the interview, the participants were asked if they preferred reporting frequency of eating behaviors over a month instead of over one week.

Results

Demographic characteristics

The demographic characteristics of the participants in the NT-FFQ evaluation study are given in **Table 2.1**. Of the 198 school-going adolescents eligible for analysis, the mean age was 16.8 years, 55% were female and 66% attended public (government funded) schools.

The intake of each food group based on both administrations of the NT-FFQ and the average intake from the three 24-hour DRs are shown in **Table 2.2**. The mean daily intake of most food groups were overestimated by the NT-FFQs when compared with the mean daily intake of food groups estimated from the 24-hour DRs. However, intakes were higher when estimated by 24-hour DR for the fried traditional food group, red meat food group, lean meat food group, and sugar food group.

Reproducibility

Estimates of the reproducibility and validity of the NT-FFQ are given in **Table 2.3**. The Spearman correlation coefficients for foods ranged from 0.12 (cooked lentils) to 0.80 (red meat). For food groups, the Spearman correlations ranged from 0.33 (pulses and nuts) to 0.80 (red meat) (mean =0.58) and ICC ranged from 0.05 (fruits) to 1.00 (tea and coffee) (mean =0.94). Of the 21 food groups, Spearman correlation coefficients were ≥ 0.5 for 16 food groups and ≥ 0.7 for 5 food groups. On average, concordance was 60% and discordance was 7%. Very good concordance (≥65%) was determined for lean meat, ghee, and healthy global food group comprising oats, cereal, and multigrain biscuits, (clarified butter). The analysis showed good concordance (50-65%) for the food groups dairy, tea and coffee, red meat, sugar, soda and energy drinks, unhealthy global foods, eggs, fried snacks, grains, fried traditional foods, breads, processed foods, fruit juices, vegetables, snacks, and sweets and desserts and fair concordance (30-49%) for the food groups fruits and pulses and nuts. The discordance was less than 10% for all food groups except for fruit juices (12%) and snacks (11%).

For eating behaviors, the weighted kappa ranged from 0.24 (eating snacks while watching TV) to 0.67 (eating lunch at home) with a mean of 0.40, suggesting moderate agreement **(Table 2.4)**. On average, the concordance (exact agreement) was 59% and discordance (opposite agreement) was 1%. Concordance ranged from 42% (practice of eating sweets prepared outside the home and eating sweets prepared at home) to 94% (practice of eating dinner at home). Discordance was ≤ 4% for 24 of the 26 eating behavior questions. A maximum discordance of 5% was found for the practice of eating breakfast outside home and for the perception question, from totally traditional to totally modern, of a family with a working mother.

Validity

For the 125-item NT-FFQ, Spearman correlation coefficients for foods ranged from 0.14 (buns) to 0.79 (chocolate milk powder) and for food groups ranged from 0.11 (fried traditional foods) to 0.70 (tea or coffee) (mean =0.37). The ICC for food groups ranged from 0.02 (healthy global foods) to 1.00 (grains) (mean =0.93). Of the 21 food groups, Spearman correlation coefficients were ≥ 0.5 for 5 food groups and ≥ 0.3 for 11 food groups. Comparing the intake of food groups between the NT-FFQ and the 24-hour DR, concordance was 49% and discordance was 8%. The agreement analysis revealed very good concordance (≥ 65%) for the red meat and healthy global food groups, good concordance (50-65%) for the food groups tea and coffee, ghee, breads, grains, pulses and nuts, processed foods, and eggs, fair concordance (30-49%) for vegetables, fruit juices, sweets and desserts, dairy, unhealthy global foods, snacks, fruits, fried snacks, soda and energy drinks, and fried traditional foods, and low concordance (27%) for the sugar food group. The discordance was less than 10% for all food groups except for the fried snacks (14%) and fried traditional foods (14%). The Bland Altman plots showed acceptable agreement for food groups between the NT-FFQ2 and the 24-hour DRs as given in **Figure 2.2**.

The 27-item eating behavior questions in the NT-FFQ were found to have acceptable face validity. Through the assessment of paraphrasing, participants were found to be able to understand, explain, and repeat the questions in their own words. Additionally, all participants reported that it was easier to report eating behaviors over a week as opposed to over a month.

Discussion

Changing dietary patterns from the ongoing nutrition transition among adolescents in India has drawn attention to the lack of validated dietary assessment instruments to assess the nutrition transition among this population. To address this gap, we followed a systematic and sequenced mixed-methods approach to develop and to evaluate the reproducibility and validity of a dietary instrument that can be used to assess the nutrition transition among adolescents in South India. A food-based approach with multiple 24-hour DRs as the reference method, as done elsewhere, [24,30-35] was used to validate the NT-FFQ for the intake of foods. This novel NT-FFQ provides reasonably reproducible and valid estimates for most foods, food groups, and eating behaviors. To our knowledge, this is the first validated FFQ for adolescents in India and the first validated dietary instrument to assess nutrition transition-related food consumption and eating behaviors.

As seen in other studies among adults[31,36-38] and adolescents, [39,40] the FFQ overestimated intakes relative to the reference method, for most food groups. In Western settings, correlations in the range of 0.5-0.7 for food intakes are considered acceptable.[41] The direct comparison of our study with similar FFQ evaluation studies is complicated by the fact that the food groups chosen were not similar across studies. Reference instruments also differed between studies.[24,33] To the extent that comparisons can be made for the evaluation of the reproducibility of FFQs for individual foods and food groups, Spearman correlation coefficients for our study are comparable to those described for other studies.[24,31,34,42] The correlations of individual foods in our NT-FFQ ranged from 0.12 (lentils) to 0.80 (red meat). In our study, Spearman correlation coefficients were ≥ 0.7 for 5 food groups and ≥ 0.5 for the remaining 16 of 21 food groups, suggesting that the reproducibility of the NT-FFQ was good. The Spearman correlation coefficients for the reproducibility of the NT-FFQ tended to be higher (≥ 0.65) for commonly consumed foods than for infrequently consumed foods (< 0.30), as reported elsewhere.[43] Salvini et al. reported Pearson correlation coefficients > 0.70 for 23% of the foods and > 0.50 for 73% of the foods on a 55-item self-administered FFQ completed six months apart among 173 women in the Nurses' Health Study.[24] Even though Pearson correlation coefficients were reported, these were found very similar to the Spearman correlation coefficients.[24] Another study among 1497 women that compared two Nurses' Health Study FFQs (1979 FFQ version vs. 1980 FFQ version), found that Spearman correlation coefficients ranged between 0.34 (readymade pie) to 0.76 (tea).[42] In a third study, high reproducibility using Spearman correlations ($r \geq 0.7$) was reported for half of the food groups and moderate reproducibility ($r < 0.7$) was reported for the other half of the foods groups.[31] The validation study was carried out among 104 German adults aged 35-64 who completed an 158-item FFQ administered at two intervals six months apart and 24-hour DRs at monthly intervals.[31] Ocke et. al reported Spearman correlations for foods and food groups in the range from 0.45 to 0.92 (median r=0.7) on an 178-item self-administered FFQ completed thrice during 6 month intervals among 121 adults.[34]

In our study, discordance (extreme tertiles) between the intakes in NT-FFQ1 and NT-FFQ2 was < 10% (range: 3.5-12%) for most foods groups except for fruit juices (12%) and snacks (11%). Fruit intakes had a low ICC of 0.05 with 8% being misclassified. In a FFQ validation study among 99 participants interviewed within 1.5 years, the concordance (exact agreement) ranged from 57% (coleslaw) to 98% (vodka).[44] In another study where an FFQ was administered to 63 participants at the beginning and the end of three months, the concordance (same or adjacent category) was 90%.[45]

The validity of the NT-FFQ to measure nutrition transition was assessed against the 24-hour DRs. The correlations of each food and food group between the NT-FFQ and the 24-hour DRs were examined. In the validation of FFQs, mean correlation coefficients of 0.40 are indicative of good validity between the FFQ and the reference method, [46] whereas correlations in the range of 0.50-0.70 are desired between the study and the reference method.[41] In the present study, the mean Spearman correlation coefficient was 0.37 with the correlations ≥ 0.40 for 17 of the 21 food groups, indicating fair agreement. Other FFQ studies, validated for foods and foods groups, have reported correlation coefficients ranging from 0.3 - 0.8.[24,31,33,35] In the validation of an 158-item FFQ among middle-aged German adults, Spearman correlations for foods and food groups between FFQ2 and 24-hour DRs showed values between 0.14 - 0.90, with most values between 0.4 - 0.6.[31] Four food groups yielded correlations > 0.6, 11 groups showed values between 0.4 - 0.6, and the remaining nine food groups yielded correlations < 0.4.[31] In another study that validated an 53-item FFQ among German adults aged 18-80, Spearman rank correlations between the FFQ and two 24-hour DRs ranged from 0.15 (pizza) to 0.80 (tea), with two thirds of the Spearman correlations > 0.30.[35]

The cross-classification of intakes (concordance and discordance) reported in NT-FFQ2 and the three 24-hour DRs in our study is similar to that reported in other studies.[31,33,36] In a study that evaluated food group intakes from a FFQ against a three day diet record among Flemish children, the concordance (same or adjacent category) was 67% (meat products) to 88% (fruit juices) and discordance (opposite category) was < 10% for all food groups.[33] In the Bohlscheid-Thomas et al. paper, the concordance (exact quintile) ranged from 21.2% for legumes to 59.6% for alcoholic drinks, with most values lying between 30% and 40% and discordance (extreme quintile) was < 4.8%.[31] As reported by Haftenberger et al., the concordance (same or adjacent quartile) ranged between 68% (cooked vegetables) to 94% (coffee).[35] Similar to our study, other studies reported that discordance was < 10% for most foods groups.[35,36]

Bland-Altman plots were generated to visually examine the agreement between the NT-FFQ and 24-hour DRs across the range of intake of food groups. The Bland-Altman method also allows one to identify bias between the administrations of the questionnaires and to see the nature of the bias across the range of intakes.[47] As given in Figure 2.2, the Bland-Altman plots of food groups demonstrated good agreement between the NT-FFQ and 24-hour DRs. For all food groups, fewer than 10% of the participants were out of the limits of agreement.

The study has certain limitations that need to be taken into account. First, dietary assessment of children have been shown to have methodological problems relating to their limited knowledge of food and difficulty in the estimation of frequency of consumed foods.[48,49] However the reliability of dietary recalls from 14-18 year olds should not be a concern as numerous studies have reported that by ages 8-10, children can report their food intake as reliably as their parents.[49-51] Second, the 125-item NT-FFQ took 35-40 minutes to complete and might be considered lengthy, but a response rate of 99% shows that participants were motivated to participate in the study. The length of the NT-FFQ also falls within the acceptable limit of 130 items at which adolescents have been found willing to complete long questionnaires.[41] Third, the sources of error in FFQs have been reported due to the restriction imposed by a fixed list of foods, seasonal and regional variations in the availability of foods, memory, perception of portion sizes, and interpretation of questions.[41] However, given the vast variety of foods and beverages and their variations across India, the NT-FFQ was developed to capture the salient intake of global, national, and regional items as relevant to adolescents in South India. We expect minimum error in the measurement of seasonal foods, given that the NT-FFQ and 24-hour DRs were administered within the same winter season (November-January). Across the three 24-hour DRs recorded as part of the evaluation of the NT-FFQ's validity, participants did not consume 29 of 125 foods listed on the NT-FFQ. Of the 29 foods, 7 were seasonal foods that were not typically consumed during the period of the validation study and the remaining foods were infrequently consumed (≤ once per month) by adolescents. These 29 foods were likely to be consumed at festivals, in summer, or may be relatively new to this region. Fourth, the low ICC (0.02) for the intake of healthy global foods between the NT-FFQ2 and 24-hour DR may be attributed to their infrequent intake (0.3 g/d or < once per month). The healthy global food group includes oats, breakfast cereals, and multigrain biscuits, which are not commonly consumed by adolescents in our study. However, some infrequently consumed foods were included in the NT-FFQ to capture foods that may be relatively new food to this region but may soon become a part of the local food environment. This phenomenon is corroborated in a similar study that reported low probability of eating rarely consumed foods.[35,36] In order to validate the intake of infrequently consumed foods with better accuracy we would require large calibration studies, as reported elsewhere.[32] The documentation of the increasing availability of global, national, and regional foods not only in urban regions but also in remote, but urbanizing regions is a large part of our work.

The study offers several strengths. First, the estimates of the reproducibility and validity of the foods in the NT-FFQ were evaluated with a comprehensive range of tests, including correlations coefficients and cross-classification in conjunction with the Bland-

Altman method. The Bland-Altman method has been preferred over correlation analysis as a method to evaluate the reproducibility and validity of a FFQ.[52] Furthermore, the sample size of the present study was large enough to allow for the estimation of the limits of agreement from the Bland-Altman analysis as a component of the evaluation of the validity of the NT-FFQ. Second, the reproducibility of eating behavior questions were assessed using cross-classification and weighted kappa. The use of semi-structured cognitive interviews strengthened the validation of the eating behavior questions. Third, the validated NT-FFQ can serve as a useful instrument in ranking adolescents according to both food intake and eating behaviors intake and can be used in epidemiological research. Lastly, the acceptable measures of agreement between the NT-FFQ and 24-hour DRs may be a result of the NT-FFQ's flexibility wherein participants were able to describe a portion size if they did not find a suitable portion size on the questionnaire. This method, where participants were able to describe their own portion size, has been found to provide the highest estimates of correlation coefficients (0.5-0.6) compared with the method where portion size was specified on the questionnaire (correlation coefficients 0.4–0.5) or when no portion size was specified but the average portion weights were used to compute intakes (correlation coefficients 0.2–0.5).[52]

Conclusions

Globalization and nutrition transition in India have drawn attention to the lack of existing validated dietary assessment instruments to assess the food consumption and eating behaviors of adolescents. To address this gap, we developed and evaluated the reproducibility and validity of a NT-FFQ for adolescents that includes nutrition transition-related foods and eating behaviors. The NT-FFQ has good reproducibility and acceptable validity for most food groups and eating behaviors. The validated NT-FFQ can be used in epidemiological studies to assess food intake and eating behaviors associated with the nutrition transition among adolescents in South India. Our team is evaluating the NT-FFQ among adolescents residing in an urban region in India. The development of the NT-FFQ represents an important and much needed first step that allows us to measure dietary changes and eating behaviors among adolescents in a globalizing society.

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S.A.C. designed the study; N.I.S. and S.S.P. carried it out. All authors provided interpretative input, helped revise the manuscript, and approved the final version. *Ethics of human subject participation:* The Institutional Review Board at Emory University, Atlanta, US and the Institutional Ethical Committee at BLDE University, Vijayapura, India approved this study.

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Tables and Figures

Table 2.1: Characteristics of the adolescents in the evaluation study of the Nutrition Transition-Food Frequency Questionnaire in Vijayapura, India (n 198) †

Characteristics	**N (%)**
Age (years) ‡	16.8 ± .07
Boys	108 (54.5)
Public school	130 (65.7)
Grade in which studying	
X	25 (12.6)
XI	97 (49.0)
XII	24 (12.1)
Short-term or diploma course	31 (15.7)
School or college dropout	21 (10.6)

Data were collected in November 2013-January 2014.
† Data from the second administration of the Nutrition Transition-FFQ (NT-FFQ2).
‡ mean ± SD.

Table 2.2: Comparison of mean, median, and interquartile range of food group intake estimated from the NT-FFQ and 24-hour dietary recalls among adolescents in Vijayapura, India (n 198)

		NT-FFQ1 (g/d) ‡				NT-FFQ2 (g/d) ‡				24-hour Diet Recalls (g/d) §			
	Food Group†	**Mean**	**SE**	**Median**	**IQR‖**	**Mean**	**SE**	**Median**	**IQR**	**Mean**	**SE**	**Median**	**IQR**
Energy-dense	Breads	31.3	2.8	14.5	4.8 - 45.0	30.7	2.7	14.8	4.9 - 44.3	9.3	1.7	0	0 - 16.7
	Unhealthy global foods	25.9	2.7	12.2	4.9 - 31.7	27.7	2.8	12.2	4.9 - 31.7	5.8	2.6	0	0
	Healthy global foods	1.1	0.4	0	0	0.9	0.4	0	0	0	.	0	0
	Processed foods	38.9	2.3	31.2	14.8 - 53.3	33.3	2.0	24.9	14.3 - 46.9	15.3	2.4	6.7	0 - 20.3
	Snacks	34.9	2.3	25.6	10.0 - 47.5	36.4	2.5	28.3	10.9 - 48.0	16.0	2.7	0	0 - 20.0
	Fried snacks	81.2	5.8	50.4	25.3 - 106.2	78.9	5.5	51.4	23.3 - 113.4	21.2	4.0	0	0 - 20.0
	Fried traditional foods	23.8	1.5	16.1	9.9 - 31.8	23.7	1.4	17.2	9.8 - 31.0	34.5	5.5	4.0	0 - 50.0
	Sweets and desserts	55.2	3.6	38.1	20.2 - 71.3	51.1	3.1	39.8	19.7 - 64.9	19.7	2.9	0	0 - 38.3
Animal-source	Red meat	3.0	0.5	0	0 - 2.0	3.2	0.5	0	0 - 1.6	7.1	2.3	0	0
	Lean meat	9.6	1.4	0	0 - 12.2	9.3	1.5	1.3	0 - 10.0	11.1	3.2	0	0
	Eggs	19.5	1.7	9.0	2.2 - 26.7	17.8	1.8	8.3	1.6 - 25.7	7.9	1.6	0	0 - 16.7
	Dairy	195.6	16.8	117.3	48.6 - 237.1	172.4	12.4	123.1	44.6 - 239.7	84.0	10.9	50.0	0 - 116.7
Drinks	Soda and energy drinks ¶	13.1	1.8	4.0	0 - 16.4	17.3	2.1	4.0	0 - 20.6	5.5	2.3	0	0
	Tea and coffee ¶	152.1	8.3	114.0	56.9 - 203.3	158.4	8.1	200.0	100.0 - 202.0	134.3	9.7	133.3	66.7 - 200.0
	Fruit juices ¶	27.0	2.5	13.9	6.5 - 34.1	29.3	2.3	18.4	7.2 - 37.9	7.7	2.5	0	0
Traditional	Fruit	131.6	8.6	107.8	58.9 - 160.5	101.0	5.6	85.8	42.0 - 135.9	26.4	3.7	0	0 - 49.3
	Vegetables	128.0	6.8	103.6	60.0 - 169.4	114.9	7.4	88.9	52.3 - 144.3	79.8	7.1	61.3	33.3 - 103.3
	Pulses and nuts	102.2	6.1	83.4	42.2 - 134.5	256.0	9.9	240.6	159.9 - 337.2	159.1	9.2	155.0	96.7 - 208.7
	Grains	588.1	19.3	537.9	490.3 - 548.0	550.6	18.9	507.6	481.0 - 571.9	447.9	15.5	420.3	323.3 - 526.0
	Sugar	3.9	0.4	0.9	0 - 5.7	4.2	0.4	1.2	0 - 6.4	8.4	4.6	8.3	5.0 - 10.0
	Ghee	1.4	0.2	0.1	0 - 1.7	1.2	0.2	0.1	0 - 1.7	0.9	0.2	0	0 - 1.3

IQR, Interquartile range. Data were collected in November 2013-January 2014.
† For analysis, the 125 items in the NT-FFQ were reduced to 21 meaningful food groups.
‡ A total of 198 adolescents aged 14-18 years were in the reproducibility study.
§ Sub-sample of 97 adolescents ages 14-18 years were in the validity study.
‖ IQR of 25% to 75% of the population.
¶ ml/day.

Table 2.3: Reproducibility and Validity of the Nutrition Transition-FFQ (NT-FFQ) Among Adolescents in Vijayapura, India (n 198)

	Food Group (g/day)	Reproducibility †					Validity ‡				
		Spearman correlation	ICC	Cross-classification, by tertiles (%)			Spearman correlation	ICC	Cross-classification, by tertiles (%)		
				Same	Adjacent	Opposite			Same	Adjacent	Opposite
Energy-dense	Breads	0.62*	0.99	55.1	41.4	3.5	0.63***	0.99	56.0	35.0	9.0
	Unhealthy global foods	0.60*	0.99	59.0	35.0	6.0	0.24*	0.99	40.0	54.0	6.0
	Healthy global foods	0.58*	0.97	90.4	0.0	9.6	-‖	0.02	87.0	7.8	5.2
	Processed foods	0.56*	0.99	55.0	37.0	8.0	0.47***	0.99	54.0	37.0	9.0
	Snacks	0.34*	0.99	51.0	38.0	11.0	0.23*	0.99	40.0	49.0	11.0
	Fried snacks	0.62*	0.99	58.0	35.0	7.0	0.26**	0.99	39.0	47.0	14.0
	Fried traditional foods	0.54*	0.99	57.0	35.0	8.0	0.11	0.99	37.0	49.0	14.0
	Sweets and desserts	0.50*	0.99	50.0	42.0	8.0	0.17	0.99	42.0	48.0	10.0
Animal-source	Red meat	0.80*	0.98	61.0	0.0	9.0	0.43***	0.99	75.3	20.0	4.7
	Lean meat	0.78*	0.99	75.0	21.0	5.0	0.24*	0.99	49.0	42.0	9.0
	Eggs	0.73*	0.99	58.1	38.4	3.5	0.47***	0.99	51.5	41.0	7.5
	Dairy	0.68*	0.99	63.0	34.0	4.0	0.55***	0.99	42.0	51.0	7.0
Drinks	Soda and energy drinks §	0.57*	0.99	60.0	30.0	10.0	0.25**	0.99	39.0	51.0	10.0
	Tea and coffee §	0.73*	1.00	61.2	33.8	5.0	0.70***	0.99	61.0	36.0	3.0
	Fruit juices §	0.48*	0.99	52.0	36.0	12.0	0.37**	0.99	43.2	47.0	9.7
Traditional	Fruit	0.48*	0.05	48.0	41.0	8.0	0.21*	0.99	40.2	51.2	8.6
	Vegetables	0.51*	0.99	51.0	43.0	8.0	0.43***	0.99	48.0	42.0	9.0
	Pulses and nuts	0.33*	0.99	48.0	43.0	9.0	0.52***	0.99	53.6	37.1	9.3
	Grains	0.51*	0.99	57.0	34.0	11.0	0.54***	1.00	55.0	35.0	10.0
	Sugar	0.50*	0.97	60.1	31.3	8.1	0.23*	0.95	27.0	67.0	6.0
	Ghee	0.70*	0.86	68.2	27.8	4.0	0.43***	0.72	57.7	36.1	6.2

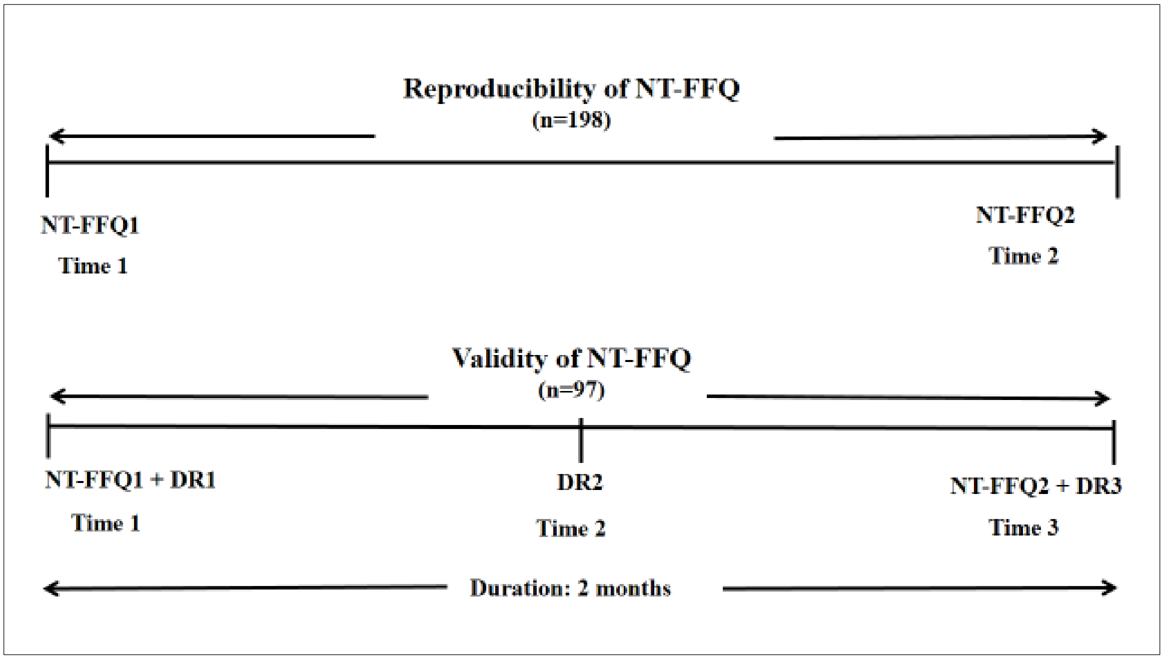
ICC, Intra-class correlation coefficient.
*p<0.05, **p<0.01, ***p<0.001.Data were collected in November 2013-January 2014.
† Reproducibility of the NT-FFQ is the comparison of NT-FFQ1 vs. NT-FFQ2. There were 198 adolescents aged 14-18 years in reproducibility study.
‡ Validity of the NT-FFQ is the comparison of NT-FFQ2 vs. the average of the three 24-hour dietary recalls. A sub-sample of 97 adolescents were in the validity study.
§ ml/day.
‖ Spearman Correlation cannot be computed as there is no reported intake of the global healthy foods in three 24-hour dietary recalls**.**

Table 2.4: Reproducibility of the Eating Behavior section of the Nutrition Transition-FFQ among Adolescents in Vijayapura, India (n 198)

Eating behavior †		Weighed Kappa	Cross-classification (%) ‡	
			Concordance	Discordance
Eating with friends at home		0.32	57	0
Eating outside food with friends		0.41	48	0
Eating outside food brought home		0.37	46	0
Eating Indian sweets made outside home		0.29	42	1
Eating Indian sweets made at home		0.29	42	0
Eating fried foods made at home		0.30	46	1
At home:	Eating breakfast	0.50	71	1
	Eating lunch	0.67	78	1
	Eating evening snack	0.40	52	3
	Eating dinner	0.35	94	1
Outside home:	Eating breakfast	0.49	60	5
	Eating lunch	0.60	70	2
	Eating evening snack	0.37	58	1
	Eating dinner	0.38	83	3
Watching TV:	While eating breakfast	0.39	70	0
	While eating lunch	0.41	74	0
	While eating evening snack	0.24	63	3
	While eating dinner	0.41	78	0
Eating habits:	Traditional or modern §			
	Eating home cooked food	0.37	49	3
	Eating outside food	0.25	57	0
	Eating eggs	0.34	46	4
	Eating meat	0.41	48	3
	Eating bread	0.28	52	1
	Drinking milk	0.40	52	4
	Drinking fruit juice	0.39	55	1
	Family with working mother	0.42	50	5

Data were collected in November 2013-January 2014.
† A total of 198 adolescents aged 14-18 years in the reproducibility study.
‡ Cross-classification: concordance (exact agreement) and discordance (opposite agreement).
§ Perceptions of the novelty of eating habits were asked using a four point Likert scale with the options totally traditional, somewhat traditional, somewhat modern, or totally modern.

Figure 2.1. Design of the Reproducibility and Validation study to evaluate the Nutrition Transition-FFQ among adolescents in South India †



† Data were collected in November 2013-January 2014. The NT-FFQ was administered by trained interviewers at homes of 198 adolescents aged 14-18 years at baseline (NT-FFQ1) and after two months (NT-FFQ2). A subsample of 97 adolescents also completed three interviewer-administered 24-hour dietary recalls (DR) during the two months between NT-FFQ1 and NT-FFQ2.

Figure 2.2: Bland-Altman Plots showing the difference between the intake of processed foods, breads, grains, and tea and coffee of the Nutrition Transition-FFQ and 24-hour dietary recall among adolescents in Vijayapura, India.

Figure 2.2.1. Bland-Altman Plot analysis of processed foods

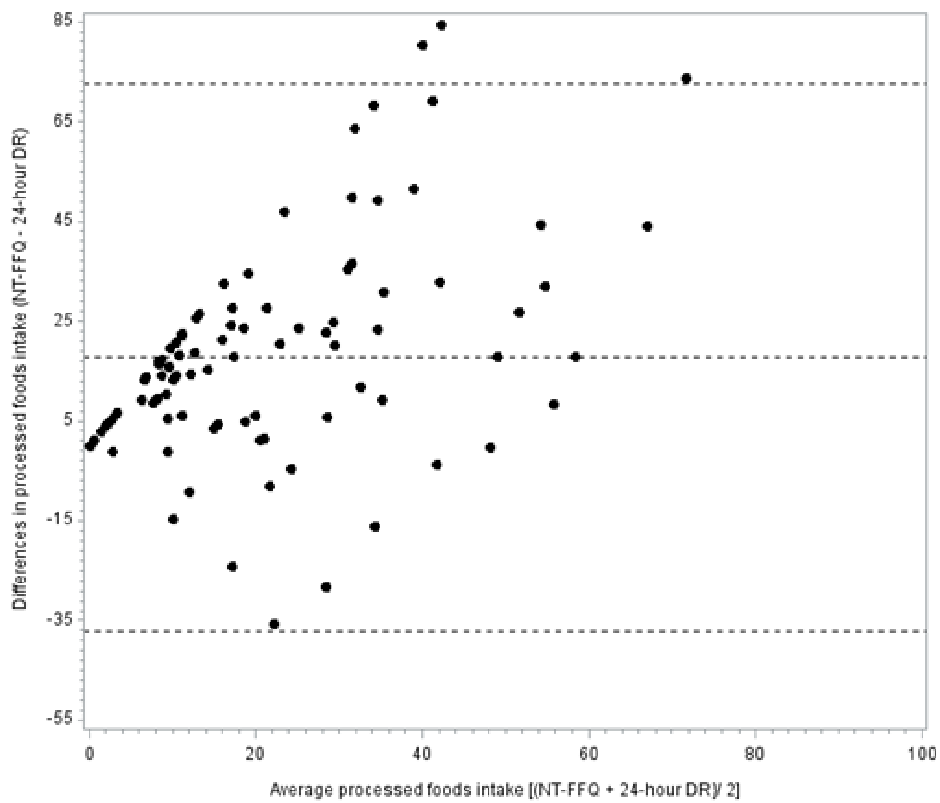


Figure 2.2.1-4. For each food group, the Y axis is the difference of the food group intake measured by NT-FFQ2 and 24-hour DRs (average of three 24-hour DRs). The X axis is the mean food group intake of the two methods. The central dotted line represents the mean difference between the two methods, and the dotted lines above and below it are ±2 SDs.

Figure 2.2.2. Bland-Altman Plot analysis of breads

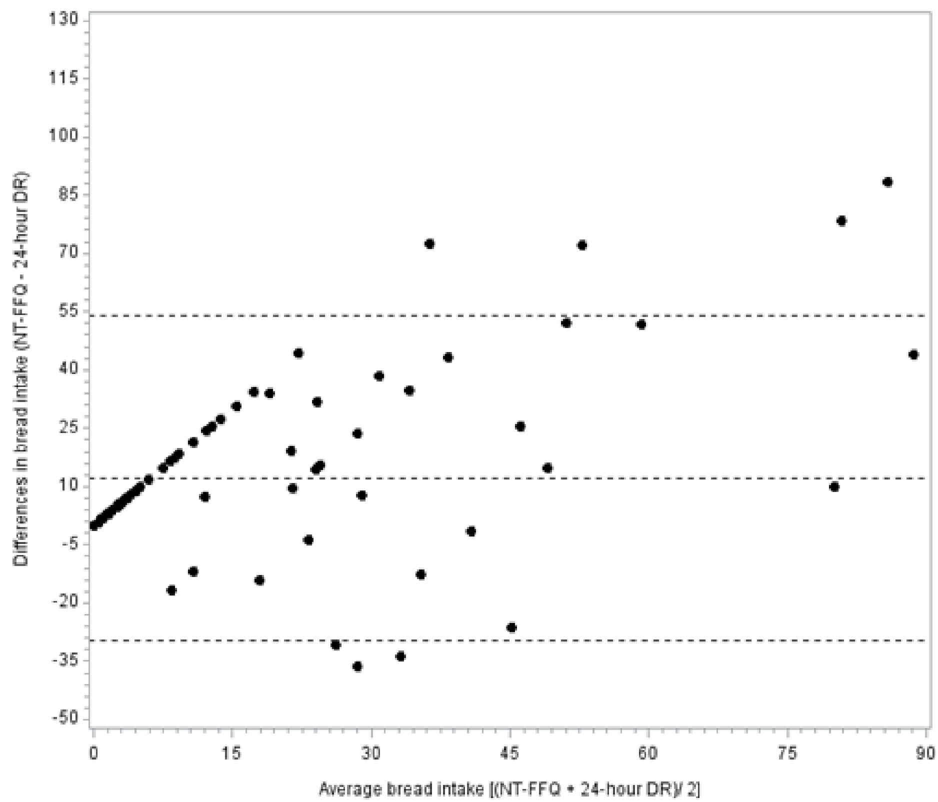


Figure 2.2.3. Bland-Altman Plot analysis of grains

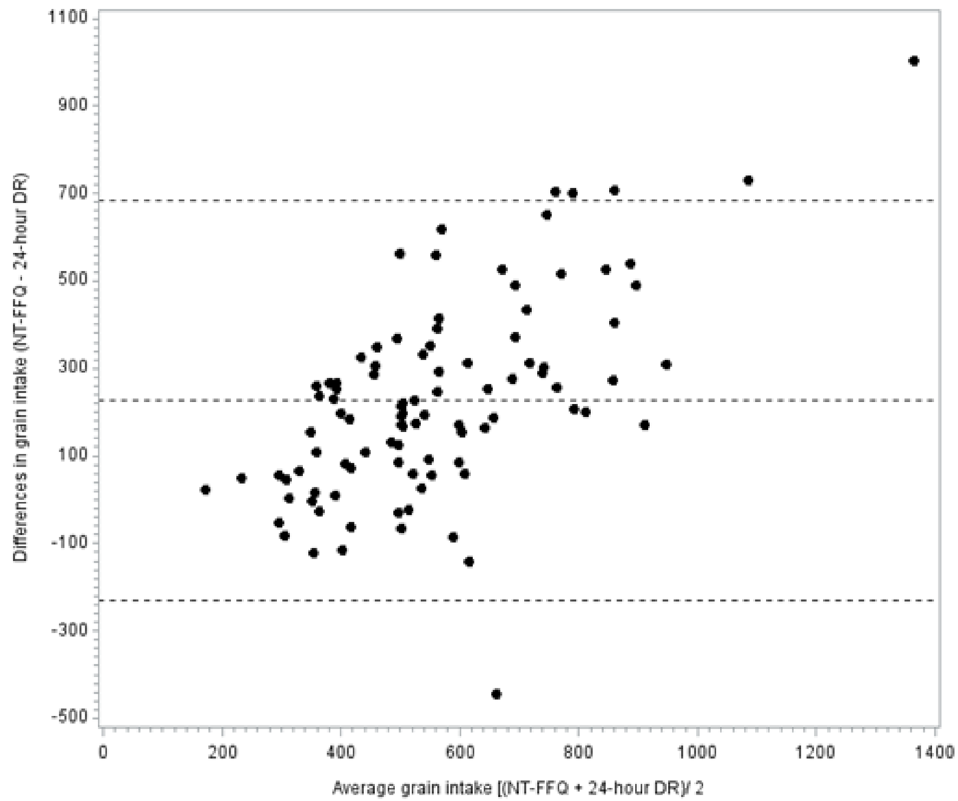
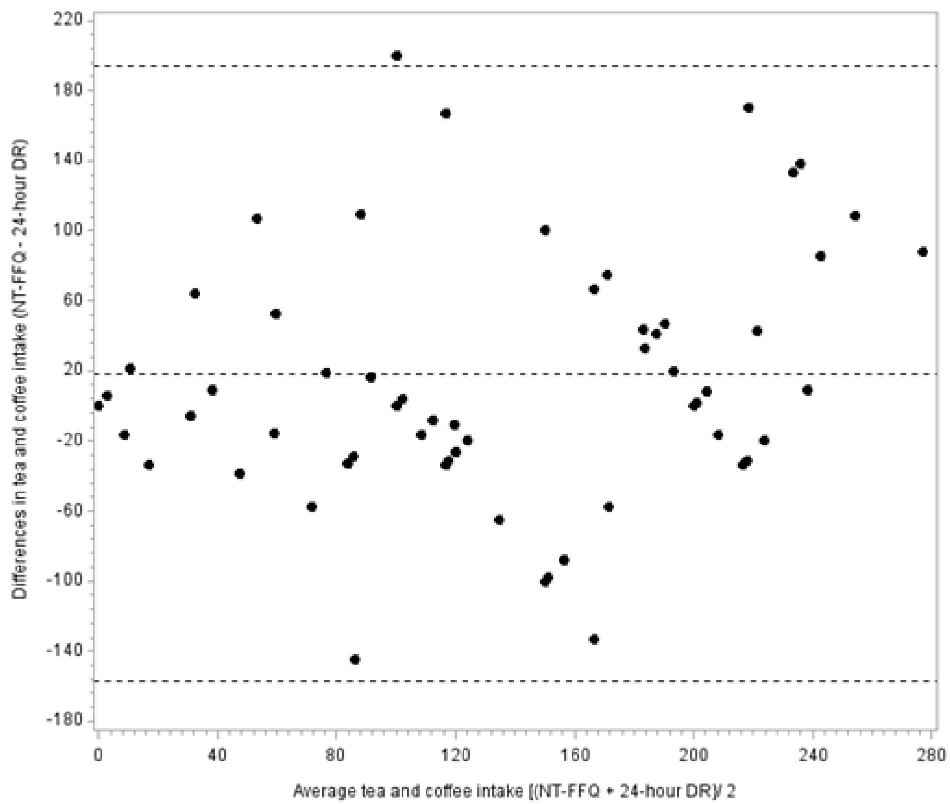


Figure 2.2.4. Bland-Altman Plot analysis of tea and coffee



Supplemental Table 2.1: A Section of the Nutrition Transition-FFQ for adolescents in South India

No.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	Don't know (11)	Increa-sed (12)	Decre-ased (13)	Same (14)
GLOBAL FOODS																	
C1	Bread (white)	2 slice															
C2	Bread (brown)	2 slice															
C3	Vegetable sandwich	2 No.															
C4	Multigrain biscuits, (e.g., Ragi, Oats)	2 No.															
C5	Vegetarian Burger	1 No.															
C6	Chicken/Fish Burger	1 No.															
C7	Vegetarian Pizza	1 slice															
C8	Chicken Pizza	1 slice															
C9	Vegetarian Puffs	1 No.															
C10	Egg puffs	1 No.															
C11	Toffee (e.g., Eclairs, Mango bite)	1 No.															

Supplemental Table 2.2: Description of 21 Food Groups from the 125-item Nutrition Transition-FFQ

Food group	Food items in the food group
Energy-dense foods	
Bread	White bread, brown bread, veg sandwich, paav/bun
Unhealthy global foods	Vegetarian burger, non-vegetarian burger, vegetarian pizza, chicken pizza, vegetarian puff, egg puff, pancake, pasta
Healthy global foods	Oats, multigrain biscuit, breakfast cereal
Processed foods	Toffee (candy), chocolate, instant noodles (e.g., Maggi), biscuit (non-cream), cream biscuit
Snacks	Popcorn, pavbhaji, chooda, khaari/rusk/butter
Fried snacks	Potato chips, packaged, finger chips, frozen paratha, frozen cutlet, samosa, wada pav, dahi wada, medhu wada, sabudana wada, chaats, bhajji, potato bonda, kachori
Fried traditional foods	Puri, paratha, puranpoli, papad
Sweets and dessert	Cream bun, cake, ice candy, ice cream, gulab jamun, rasmalai/rasgulla, peda/barfi/laddoo, jalebi, kheer/basundi, sheera, halwa, chikki, shreekhand
Animal-source foods	
Red meat	Lamb, beef
Lean meat	Chicken, fish, prawns
Eggs	Boiled egg, fried egg/omelet
Dairy	Milk, flavored milk, curd, raita, cottage cheese (paneer), butter, cheese, milkshake, lassi, buttermilk
Drinks	
Fruit juices ¶	Sugarcane, coconut water, fresh fruit juices, fruit juices (packaged)
Soda and energy drinks ¶	Soda (carbonated beverages/soft drinks), diet sodas, energy drink
Tea or coffee ¶	Tea, Coffee
Traditional foods	
Fruit	Banana, apple, chickoo/sapota, papaya, citrus fruits, fruits salad, Indian gooseberries, watermelon, grapes, mango, custard apple
Vegetables	Green leafy vegetables, potato, cabbage/cauliflower, other vegetables, salad
Pulses and nuts	Pulses (e.g., red kidney beans, chickpeas), sprouts (e.g., matki moong), lentils (e.g., dal, sambar), nuts (e.g: almonds, groundnuts)
Grains	Chapati, roti, rice, pulao, biryani, idli, dosa, uttapa, upma, poha, sago khichdi, dhokla, corn
Sugar	Sugar, Unprocessed cane sugar (Jaggery), Glucon-D
Ghee	Visible ghee (ghee added to cooked food)

Supplemental Figure 1. Food models used to assist participants in estimating quantity and portion size of of foods and beverages consumed †

† The food models includes three that were constructed for traditional Indian breads (e.g., chapati): R (small), R1 (medium), and R2 (large), glass sizes (G1 and G2). In addition, standard spoons (stainless steel spoons: S1; teaspoon, S2; rice serving spoon, S3; lentil and curry serving spoon, S4; vegetable and meat serving spoon) and measuring spoons: teaspoons (1/4th, ½, and 1 teaspoon) and 1 tablespoon, and cups (1/4th, ½, ¾, and 1 cup) were also used.

CHAPTER 6: Development and Validation of a Nutrition Transition-Diet Score for Adolescents in India

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Abstract

Background: The unfolding of nutrition transition might be measured by changes in dietary patterns but no validated instrument currently exists.

Objective: To develop and validate a pre-defined Nutrition Transition-Diet Score to measure the nutrition transition among adolescents in India.

Methods: The pre-defined Nutrition Transition-Diet Score for adolescents was developed using dietary guidelines and nutrition transition literature; it was validated against empirically-derived dietary patterns in Vijayapura City, India. Dietary patterns were identified using exploratory factor analysis with varimax rotation from answers provided by 198 adolescents to a validated 125-item Nutrition Transition-FFQ, developed in prior work. The Nutrition Transition-Diet Score was validated against the first dietary pattern factor score using Pearson correlation, cross-classification using tertiles, and linear regression.

Results: The Nutrition Transition-Diet Score (range 0-10) includes 10 components: seven food groups (fried foods, packaged foods, sugar-sweetened beverages, dairy, fruits and vegetables, bread, and added sugar) and three nutrients (total dietary fat, saturated fat, and sodium). Three dietary patterns were identified; global, animal-source, and traditional (factor loadings ≥ 0.4). The validity of the pre-defined Nutrition Transition-Diet Score was evaluated against the Global Diet pattern score (first factor), characterized by fried snacks, unhealthy global foods, packaged foods, soda and energy drinks, fried traditional foods, sweets and desserts, fruits juices, and bread. Mean Nutrition Transition-Diet Score was 5.6 ± 1.2 and was significantly higher ($p < 0.0001$) among adolescents with high Global Diet (upper quartile) (6.5 ± 0.9; range: 4-8) than those with low Global Diet (other quartiles) (5.3 ± 1.1; range: 1-8). There was moderate correlation (Pearson $r=0.59$, $p < 0.0001$), good concordance (60%), and low discordance (5%) between the Nutrition Transition-Diet Score and Global Diet pattern score.

Conclusions: The validated pre-defined Nutrition Transition-Diet Score effectively measures nutrition transition in Indian adolescents. The Nutrition Transition-Diet Score has potential uses for research and programs.

Key words: nutrition transition, adolescents, dietary patterns, validity, exploratory factor analysis, India

Introduction

Globalization and urbanization are believed to bring about changes in dietary patterns and physical activity patterns, a concept often referred to as the nutrition transition. These changes are believed to contribute to the emergence of nutrition-related non-communicable diseases (NR-NCDs) including diabetes and cardiovascular diseases, [1,2] most recently in low-and middle-income countries (LMICs) including India.[3-5] Indeed, LMICs[6] bear the burden of 80% of all NR-NCDs related deaths.[3] The nature and pace of the nutrition transition differs across countries, populations, and social strata,[7] with health implications for adults and for youths.[8] Today's generation of adolescents (youth ages 10-19 years) is the largest in human history, totaling 1.8 billion or one-fourth of the world's population, [6] 90% of adolescents live in LMICs.[6] At the forefront of global trends and social change,[9] adolescents are believed to be experiencing nutrition transition-related shifts in food consumption.

The study of the global nutrition transition and its implications for health is an emerging area of research.[1,2,5,10] Prior studies have described dietary changes using food availability data from the Food and Agricultural Organization's food balance sheets[11,12] or from the systematic assessment of dietary patterns across 187 countries.[13] Yet, the food balance sheets provide estimates of country-level food availability, not individual-level food consumption.[14,15] Global dietary patterns assessments over the past 20 years have accounted for 89% of the world's population, but were focused on adult data pooled from dietary surveys.[13] Quantifying the extent of nutrition transition-related dietary shifts has been limited, given the lack of diet metrics for this purpose.

Newer dietary assessment methods that have been introduced are diet scores and indices. These go beyond the Food Frequency Questionnaires (FFQ) and 24-hour dietary recall methods because they can quantify foods or nutrients as an overall measure of diet. Diet scores have been designed to assess adherence to dietary guidelines,[16,17] diet quality,[18-20] and dietary diversity,[21] and are developed using pre-defined or theoretical methods[18] or empirical or data-driven methods.[22] Pre-defined or theoretical diet scores are developed using dietary guidelines or nutrition knowledge such as the Healthy Eating Index[23] or Mediterranean Style Dietary Pattern Score.[17] Empirical or data-driven diet scores are developed using statistical approaches such as factor or cluster analysis.[22] Diet scores have been developed for adults[16,17,24] and for the youth in high-income countries and European settings.[19,20,23,25-27] In comparison, few diet scores exist in LMICs. Examples include a dietary diversity score from Iran developed for adolescents,[28] four scores from China, namely the Fruit and Vegetable score (FVS), Animal food score (AFS), Western food score (WFS), and Sweet food score (SFS) created from responses to a 26-item non-quantitative FFQ administered to 824 school-going adolescents ages 12-14 years and evaluated for its reliability,[29] and the Indian Adolescent Micronutrient Quality Index (AMQI), developed to measure the dietary adequacy and micronutrient quality of the diets of adolescent girls ages 10-16 years consuming lacto-vegetarian diets.[30] The unfolding of nutrition transition could be measured by changes in dietary patterns but no validated instrument specific to the nutrition transition currently exists.

The objective of the study was to develop and evaluate the validity of a pre-defined Nutrition Transition-Diet Score to measure nutrition transition, more specifically the extent of nutrition transition-related dietary shifts. The construct validity of the pre-defined Nutrition Transition-Diet Score was evaluated against empirical-derived dietary patterns. Construct validity is the ability of the construct to measure what it was intended to measure. We developed the pre-defined Nutrition Transition-Diet Score for adolescents in India for several reasons. Given that unprecedented global forces are believed to be shaping the health and wellbeing of the largest ever generation of adolescents in human history (1.8 billion), [6] 13.5% of whom reside in India, [31] the ability to measure nutrition transition in this population can inform program and policy efforts to improve adolescent health and nutrition. Second, most research on the nutrition transition in India has focused on globally connected metropolitan areas[32-34] and has come from National Sample Survey household-level food consumption data.[35] Results indicate diverse dietary patterns, including vegetarian diets and high-fat, high-sugar and meat diets.[36] The dietary shifts also include dietary diversification and movement of foods within (regional or non-local) and outside (global) the country. One example is a shift in preference and consumption from rice to wheat; even they have long remained traditional staples. Another example is a shift in preference from traditional flatbreads (chapati) to commercialized western white bread.[37] Given that the change in dietary patterns from those that may be traditional to ones that are newer may be irreversible, [37] we need sound diet metrics to assess nutrition transition and to promote healthful diets. For these reasons, India and the adolescent population therein is well suited as a prototype model to develop a diet metric to measure nutrition transition.

Methods

Development of the pre-defined Nutrition Transition-Diet Score

We used the pre-defined approach and followed a three step-process from previously established guidelines in the development of the Nutrition Transition-Diet Score. The three step process comprises 1) choice of score components or constructs to include 2) choice of cut-off values for score components, and 3) exact quantification of score components judged against cut-off values.[18] The components of the Nutrition Transition-Diet Score were pre-defined based on the literature on nutrition transition. Cut-off values of each score component was decided based on the 2011 Dietary Guidelines of India, [38] the WHO guidelines for fruits and vegetables, [39] and the 2015 Dietary Guidelines for Americans.[40] We used the recent US food-based recommendations for cut-off values for specific nutrients (e.g.: sodium and saturated fat) [40] for which quantitative intakes were not available in the Indian dietary guidelines.

The pre-defined Nutrition Transition-Diet Score is the sum of 10 component scores designed to measure nutrition transition-related dietary shifts **(Table 3.1)**. Based on the dietary guidelines and the literature on nutrition transition, we included the following food groups (g/day) as components 1 to 7: fried foods, packaged foods, sugar-sweetened beverages (fruit juices and carbonated beverages), dairy, fruits and vegetables, bread, and added sugar. Components 8-10 of the pre-defined Nutrition Transition-Diet Score comprised the nutrients - total dietary fat, saturated fat, and sodium. Using the cut-off value, each component of the pre-defined Nutrition Transition-Diet Score was assigned a score of either 1 (indicating presence of the nutrition transition dietary behavior) or 0 (indicating absence of the nutrition transition dietary behavior). Components 1-7 of the pre-defined Nutrition Transition Diet-Score were food groups. For both the first (packaged foods) and second components (fried foods), an intake of ≥ 30g/day was assigned a score of 1, while < 30g/day was assigned a score of 0. The Dietary Guidelines of India recommends sparing intake of packaged and fried foods, [38] but provides no quantitative intake recommendations for intake levels. A recent study reported 30-45 grams as the serving size of unbranded packaged foods (e.g.: samosa, pakora, and salted biscuits) sold in urban markets in North India.[41] Other studies have reported that biscuits and salted snacks are being eaten more in the past two decades and that low-cost fried and packaged foods are a key feature of the nutrition transition in urban areas in India.[42-44] Frequent consumption of packaged foods has been associated with NR-NCDs among adolescents.[37,44,45] Component 3 is sugar-sweetened beverages, we assigned any daily intake of sugar-sweetened beverages a score of 1 while not consuming any daily was assigned a score of 0. Sugar-sweetened beverages are a source of empty calories that should be consumed sparingly.[46] Moreover, studies have documented an increase over the past few decades in the consumption of sugar-sweetened beverages among adolescents in Asia.[47,48]

Component 4 is dairy; we assigned a score of 1 for dairy intake of ≥ 500 g/day or 2 servings per day while < 500 g/day of dairy was assigned score 0. We chose 2 servings per day as the cut-off for dairy since the Dietary Guidelines of India recommends this amount for adolescents.[38] For component 5 or fruits and vegetables, we assigned a score of 1 if the intake of fruits and vegetables was ≥ 400 g/day and a score of 0 if the intake of fruits and vegetables was < 400 g/day. The WHO recommends daily intake of 400g of fruits and vegetables to prevent chronic diseases and micronutrient deficiencies.[39] Studies worldwide, including in India, have reported low fruits and vegetables intake among adolescents from low-income households.[33,49] For component 6 or bread, we assigned a score of 1 if the intake of bread was ≥ 30 g/day and a score of 0 if the intake of bread was < 30 g/day. On average, a slice of bread weighs 25-30 g. We chose this component, given the increasing preference of western bread than traditional wheat foods (e.g.: chapati).[37] Component 7 is added sugar intake or the intake of sugar added to foods (e.g.: milk, tea, coffee, etc.). We assigned a score of 1 if the added sugar intake is > 30 g/day and a score of 0 if the added sugar intake is < 30 g/day. In India, sugar or jaggery is an integral part of cooking. According to the Dietary Guidelines of India, a daily intake of six servings of sugar is considered adequate for growing children, but supplementing the diet with extra sugar or jaggery is discouraged.[38]

Components 8-10 of the pre-defined Nutrition Transition Diet-Score are the nutrients total fat, saturated fat, and sodium, respectively. Component 8 is the total daily intake of dietary fat. We assigned a score of 1 to this component if the total fat from participants' diet exceeded 30% of the total calories and a score of 0 if the total fat intake was < 30% of the total calories. Studies have recommended that fats should represent approximately 30-40% of the daily energy intake.[23,50,51] Component 9 is saturated fat. We assigned a score of 1 to this component if saturated fat exceeded 10% of total calories and assigned a score of 0 if saturated fat comprised <10% total calories. The cut-off for saturated fat was drawn from the recent 2015 Dietary Guidelines for Americans that recommended < 10% of total calories should come from saturated fat.[40] Component 10 is sodium intake. We assigned a score of 1 if sodium intake ≥ 2300mg/d and a score of 0 if sodium intake was < 2300 mg/day. Sodium was chosen as a component of the pre-defined Nutrition Transition-Diet Score since several studies have reported high dietary salt intake between 8.5-9 g/day among Indian adults[52] and children[53] compared with the WHO's recommendation of 5 g salt per day or 1950 mg sodium per day. Excess salt in the Indian diet may be coming from several foods including pickles, papads (lentil wafer that is crispy, thin, and salty), namkeens (salty fried snacks), chutneys (chopped vegetable or fruit with added seasonings, mixed with salt), [42] and salted potato chips.[53] Sodium intake (mg) can be converted to salt equivalents (g) using the conversion; 1 g of sodium chloride (salt) = 390 mg sodium.[54]

Subjects

The pre-defined Nutrition Transition-Diet Score was evaluated for its validity against empirical or data-derived dietary patterns among adolescents in India. Dietary patterns were derived from responses to the 125-item validated Nutrition Transition-FFQ (NT-FFQ) among 198 adolescents aged 14-18 years in Vijayapura in South India *(Chapter 5)*. Vijayapura is a mid-size city (population: 350,000) located in South India in a district, which is categorized as economically underdeveloped but is rapidly urbanizing as a result of the growth of its small scale industries including the agricultural industry and of its large scale industries including sugar and textiles.[55] We developed the NT-FFQ in prior work to measure nutrition transition; it included a 125-item semi-quantitative FFQ designed to assess average food consumption over a month and a 27-item weekly eating behavior survey. The NT-FFQ was found to have good reproducibility and validity to measure most foods and eating behaviors among adolescents in South India. These dietary data are from the follow-up interviews of 198 adolescents of a representative school-based sample of 407 adolescents from Vijayapura. The non-random sub-sample of 198 adolescents were interviewed as part of the follow up-wave from June 2013 - January 2014. The baseline wave was a stratified simple random sample of 407 adolescents selected from three public and three private schools in Vijayapura.[56] and interviewed in January - April 2012.

Dietary assessment

To calculate the pre-defined Nutrition Transition-Diet Score, we determined the intakes of the foods and nutrients for all ten components. Using adolescents' responses to the NT-FFQ, we calculate the intake (g/d) of the seven food groups (score components 1 to 7). Data from the NT-FFQ were transformed into daily intake of each food (g/d) and beverage (ml/d). The daily intake was calculated by multiplying the specified portion unit by the frequency of intake, using the following values for reported frequencies on the NT-FFQ: more than 3 times a day=3, twice a day=2, once a day=1, 2-4 times a week=0.43, 5-6 times a week=0.79, once a week=0.14, 2-3 times a month=0.082, monthly=0.03, less than once a month=0.016, and never eaten or don't know the food=0. To calculate the intake of sodium, total fat, and saturated fat (score components 8 to 10), we created a database of nutrient values of the 125 foods in the NT-FFQ. The nutritional values of nutrient database of nutrient values of raw foods from the Nutritive Value of Indian Foods[57] and of cooked foods from Nutritionist Pro software. Using this database, we calculated sodium (mg/d) and the proportion of saturated fat and total fat from total daily calorie intake.

Variables

As part of the follow-up study, adolescents also provided their age, gender, and type of school attended (private or public). The adolescent's primary caregiver, also interviewed as part of the baseline study, provided other socio-demographic information including religion and caste. The religion variable was dichotomized; Hindu and Jains were collapsed as the reference category while Muslims, Christians, and other minorities were collapsed as the second category. Caste was also dichotomized as general caste and Other Backward Caste (OBC) and Scheduled Tribe (ST) and Scheduled Caste (SC) as the reference category. OBC, SC, and ST are terms used by the Government of India to classify socially and educationally disadvantaged sections of the population. From adolescents responses to the intake of animal-source foods (eggs, poultry, seafood, and red meat) in the NT-FFQ, we categorized eating practice as strict vegetarian, lacto-ovo vegetarian, and non-vegetarian. Strict vegetarians were described as those that did not consume eggs, poultry, seafood, or red meat while lacto-ovo vegetarians were described as vegetarians that ate eggs but did not eat poultry, sea food, or red meat. Non-vegetarians were described as those that ate any poultry, sea food, or red meat.

Statistical methods

Dietary patterns was determined using exploratory factor analysis; for this foods and beverages from the 125-items NT-FFQ were collapsed into 21 meaningful food groups (g/day) as given in **Supplement 2.2**.The identified factors from exploratory factors analysis of the 21 food groups were rotated by an orthogonal transformation (varimax rotation) to enhance the difference between factor loadings and to enhance interpretability. To characterize the factors, foods groups with factor loadings ≥ 0.4 were considered. In addition, the number of factors retained was determined using the eigenvalues, scree plot, and the interpretability of the factors. The factor score for each pattern was constructed by summing up observed intake of the component food items weighted by the factor loading. The factor scores of the identified dietary patterns were categorized into quartiles. We evaluated the validity of the pre-defined Nutrition Transition-Diet Score against the factor score of the first dietary pattern using Pearson correlation, cross-classification of score tertiles, and multivariate linear regression. We chose to evaluate the pre-defined Nutrition Transition-Diet Score against the factor score of the first dietary pattern based on the assumption that the diet in the globalizing region in South India may show features of the nutrition transition – high fat, salt, and sugar foods.

The distribution of the pre-defined Nutrition Transition Diet-Score and factor score of the first dietary pattern was first examined. Since both scores had a normal distribution, Pearson correlation was used to investigate the association between them. We carried out the tests of validity using a linear distribution of both scores. In addition we dichotomized both scores at the 75^{th} percentile and categorized them as highest quartile ($\geq 75^{th}$ percentile) and remaining quartiles ($< 75^{th}$ percentile). For the rest of the paper, highest vs. lower (remaining quartiles) will be used to refer to the dichotomized pre-defined Nutrition Transition-Diet Score and empirically-derived factor score of the first dietary pattern.

Mean pre-defined Nutrition Transition-Diet Score of participants were calculated. Student's *t* tests were used to compare the mean scores and the differences in food intake between participants in the two groups, respectively. Multivariate linear regression analysis was used to identify the association between the pre-defined Nutrition Transition-Diet Score and the factor score of the first dietary pattern. In the unadjusted model, we considered the pre-defined Nutrition Transition-Diet Score as the independent variable and the factor score of the first dietary pattern as the dependent variable. In the next step of the analysis, we ran an adjusted model controlling for age, gender, type of school attended, religion, and caste; as these variables are relevant to dietary patterns in India. [58-60] Agreement between the pre-defined Nutrition Transition-Diet Score and the first diet pattern score was tested using cross-classification analysis. The measures of agreement were calculated using the percentage of participants in the same (concordance) and extreme (discordance) tertiles of both scores. Lastly, we described the socio-demographic and food intake characteristics of the adolescents in the highest vs. lower pre-defined Nutrition Transition-Diet Score and the factor score of the first dietary pattern, respectively. Student's *t* tests were used to compare Nutrition Transition-Diet

Score and the first diet pattern score group by age, respectively. Chi-sq tests were used to test associations between Nutrition Transition-Diet Score and the first diet pattern score group by socio-demographic characteristics (gender, school type, religion, caste) and food habits (strict vegetarian, lacto-ovo vegetarian, and non-vegetarians), respectively. All analyses were conducted using Statistical Analysis Software (SAS version 9.4; SAS Institute., Cary, NC).

Results

Dietary patterns

We found three distinct dietary patterns among the adolescents namely the Global Diet pattern (factor 1), the animal-foods diet pattern (factor 2), and the traditional diet pattern (factor 3) **(Table 3.2**). The first factor hereafter referred to as the Global Diet pattern was characterized by factor loadings ≥ 0.4 for fried snacks, unhealthy global foods, packaged foods, soda and energy drinks, fried traditional foods, sweets and desserts, fruits juices, and bread. We called the second factor the animal-foods pattern as it was characterized by factor loadings ≥ 0.4 for lean meat, red meat, and eggs. Factor 3 or the traditional diet pattern was characterized by factor loadings ≥ 0.4 for sugar and jaggery, fruits, vegetables, dairy, grains, traditional fried foods, and ghee (clarified butter). Traditional fried foods was the only group that loaded on both the global and traditional diet patterns.

Characteristics of the pre-defined Nutrition Transition-Diet Score

The mean pre-defined Nutrition Transition Diet-Score (range 0-10) was 5.6 ± 1.2 and was significantly greater among adolescents with highest Global Diet pattern (mean score 6.5 ± 0.9; range: 4-8) than those with lower Global Diet pattern score (mean score 5.3 ± 1.1; range: 1-8) ($p < 0.001$) **(Figure 3)**. On average, the mean age of the adolescents was 16.8 years, 55% were boys, 81 % ascribed to the Hindu religion, 74.5 % were classified as OBC, 65% attended public schools in Vijayapura, 20% were strict vegetarians, and 78% were lacto-ovo vegetarians (**Table 3.3)**. Gender was associated with both the pre-defined Nutrition Transition-Diet Score and empirical Global Diet pattern score, respectively ($p < 0.01$).

Validity of the pre-defined Nutrition Transition-Diet Score

We evaluated the validity of the pre-defined Nutrition Transition-Diet Score against the Global Diet pattern score (factor 1 score) using three tests - Pearson correlation, cross-classification of score tertiles, and multivariate linear regression. There was moderate correlation between the two scores (Pearson correlation, $r=0.59$, $p < 0.001$). Cross-classification of adolescents using tertiles of pre-defined Nutrition Transition-Diet Score and the empirical Global Diet pattern score factor score showed good concordance or exact agreement of 60% and low discordance or disagreement of 5% (data not shown). Lastly, adolescents with highest Global Diet pattern score had a pre-defined Nutrition Transition-Diet Score that was 1.2 points significantly greater than adolescents with lower empirical Global Diet pattern score, after controlling for age, gender, school type, religion, and caste ($p < 0.001$) **(Table 3.4)**.

The differences in food intake among adolescents with highest vs. lower pre-defined Nutrition Transition-Diet Score and the empirical Global Diet pattern score, respectively are given in **Table 3.5.** Adolescents with highest pre-defined Nutrition Transition-Diet Score Global Diet pattern score were found to consume significantly higher intake of energy-dense foods including breads, unhealthy global foods, packaged foods, fried and non-fried snacks, fried traditional foods, and sweets and desserts than adolescents with lower pre-defined Nutrition Transition-Diet Score and lower empirical Global Diet pattern score, respectively ($p < 0.05$). Similar differences were seen across intake of animal-source foods including dairy and eggs and beverages including fruit juices, soda and energy drinks and grains ($p < 0.05$). Alternatively, adolescents with lower pre-defined Nutrition Transition-Diet Score and those with lower empirical Global Diet pattern score had significantly higher intake of tea and coffee than their counterparts ($p < 0.05$).

Discussion

Nutrition Transition following globalization and urbanization are believed to contribute to emerging NR-NCDs in LMICs including India. However, no diet score exists to measure the changes in diets believed to constitute this nutrition transition. In this study, we developed and evaluated a pre-defined Nutrition Transition-Diet Score to quantify nutrition transition among adolescents in India. We found that the pre-defined Nutrition

Transition-Diet Score has good construct validity against empirical-derived dietary patterns from the same population.

The multi-component pre-defined Nutrition Transition-Diet Score reflects the complexity of the nutrition transition. As highlighted by Waijers et al., the construction, composition, and scoring approaches used in diet scores affect their usefulness and validity as a tool for assessing diet.[25] We used the pre-defined approach to select score components and defined cut-offs for each using relevant literature on the nutrition transition, the 2011 Dietary Guidelines of India, the WHO guidelines for fruits and vegetables,[39] and the 2015 Dietary Guidelines for Americans.[40] Findings confirm good construct validity of the pre-defined Nutrition Transition-Diet Score through correlation, cross-classification, and regression analyses; which means the score can effectively measure what it was intended to measure - nutrition transition-related dietary change.

Adolescents in this globalizing region in South India had a moderate Nutrition Transition Diet-Score (mean 5.6 ± 1.2; range 0 -10). Further, the difference between adolescent's Nutrition Transition-Diet Score for those with the highest vs. lower Global Diet pattern score (mean score 6.5 vs. 5.3) was statistically significant ($p < 0.001$); however its interpretability needs to be taken into account. The food consumption of adolescents in this globalizing region showed resemblance to food consumption reported among adolescents in urban regions in India.[33,47,61,62] Also, the dietary patterns in this study were consistent with other studies,[61,63] where a clear dichotomy in diary intake was seen through the animal-food pattern (eggs, poultry, and meat) versus non-animal-foods pattern. This dichotomy may be expected since, for the majority of people in India, particularly those of Hindu religion, food habits are driven by religious vegetarianism.[58,59] In addition, the positive loading of traditional fried foods on both the global and traditional dietary patterns suggest that a high-fat, energy-dense food group is an integral part of adolescent's diet even as they may chose other foods or retain foods that are traditional or global/non-local. These findings may reflect an early stage of the nutrition transition among adolescents in this globalizing region in South India, which, till a decade ago, was considered underdeveloped, as compared to the nutrition transition expected in urban metropoles.

Some study limitations are notable. First, the limited quantitative food-based dietary guidelines for adolescents restricted our ability to determine the cut-offs for some score components (e.g.: intake of packaged foods, fried foods, and breads), a problem that has been acknowledged before.[64] This limitation was discussed in a review of 20 existing pre-defined diet quality scores which reported that arbitrary choices have been made in determining the cut-off values of prior diet scores.[18,23] The cut-off values of the components of the pre-defined Nutrition Transition-Diet Score were chosen, to the extent possible, on dietary guidelines and published literature on the nutrition transition pertaining to our study population. We used the recent US food-based recommendations for cut-off values for sodium and saturated fat.[40] In addition, we justified the source used in the development of the scoring criteria and cut-offs of each score component. The AMQI was also developed using US dietary guidelines to measure micronutrient diet quality of lacto-vegetarian adolescent girls in India; [30] however it is unclear which components of the AMQI were designed using these guidelines.

Next, to measure nutrition transition using the pre-defined Nutrition Transition-Diet Score among adolescents, we need to conduct an assessment of the diet using either a validated FFQ, such as the Nutrition Transition-FFQ developed in our prior work *(Chapter 5)*, or using multiple non-consecutive 24-hour dietary recalls. While our validated NT-FFQ provides a comprehensive assessment of global/non-local and traditional foods and was easily administered with low respondent burden, it took 35-40 minutes to administer. The 24-hour dietary recall method may provide a quicker assessment of the diet, but unlike FFQs, this method is not representative of long-term food intake[65] and are also not as practical and cost-effective.[66,67] Instead it may also be useful to adapt and validate a shorter version of the NT-FFQ instrument to more quickly assess nutrition transition. Studies have reported value in the use of shorter tools including them being more practical to administer and having more utility in large surveys.[20,68] Lastly, the three dietary patterns explained 7.2% of the total variation of the diet. Low variance may indicate the nutrition transition among adolescents in globalizing region in South India is at a stage where the bulk of the diet is comprised of traditional grains and pulses and tea/coffee, but also includes global/non-local items such as packaged foods and those high in fat, salt, and sugar.

The study has several strengths and contributions. To our knowledge, the validated pre-defined Nutrition Transition-Diet Score is the first diet score that can measure the extent of nutrition transition. This study adds to the limited body of literature describing innovative diet metrics that can measure the nutrition transition. The ten pre-defined components of the Nutrition Transition-Diet Score capture key constructs of the nutrition transition. The advantages of using a multi-component diet score is that it takes into account the diet as a whole rather than focusing on single or few nutrients and foods[25] and it takes into account the interrelations between nutrients.[69] Also, the development of a diet score using the pre-defined approach has the added advantage of being reproducible across populations and allows for the comparison of nutrition transition across population sub-groups and locations, for example rural and urban areas.[19] Good construct validity of the pre-defined Nutrition Transition-Diet Score against empirical dietary patterns confirms the ability of the score to measure the nutrition transition.

Conclusions

Given the need for diet metrics to measure nutrition transition-related dietary changes in places experiencing globalization and urbanization, emerging NR-NCDs, and a burgeoning adolescent population in LMICs, a pre-defined Nutrition Transition-Diet Score (10 components: seven food groups and 3 nutrients) was developed and evaluated for its validity to measure nutrition transition among Indian adolescents against empirical dietary patterns from a population in Southern India. The pre-defined Nutrition Transition-Diet Score was found to have good construct validity against the empirical Global Diet pattern to measure nutrition transition among adolescents in India. The validated pre-defined Nutrition Transition-Diet Score is a promising diet metric that can measure the extent of nutrition transition at one time or over time. The pre-defined Nutrition Transition-Diet Score has potential to be used for research and programs and to be scaled for use among adolescents in other regions and among adults.

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Tables and Figure

Table 3.1: The pre-defined Nutrition Transition-Diet Score for adolescents in India

	Nutrition Transition-Diet Score Components	Criteria for score 1[1]	Criteria for score 0[2]
Food groups	1. Packaged foods	≥ 30 g/d	< 30 g/d
	2. Fried foods	≥ 30 g/d	< 30 g/d
	3. Sugar-sweetened beverages	> 0 ml/d	0 ml/d
	4. Dairy	≥ 500 ml/d	< 500 ml/d
	5. Fruits and vegetables	≤ 400 g/d	> 400 g/d
	6. Breads	≥ 30 g/d	< 30 g/d
Nutrients	7. Added sugar	≥ 30 g/d	< 30 g/d
	8. Fat, total	≥ 30% of total calories	< 30% of total calories
	9. Saturated fat	≥ 10% of total calories	< 10% of total calories
	10. Sodium	≥ 2300 mg/d	< 2300 mg/d

[1] Indicates presence of the nutrition transition dietary behavior
[2] Indicates absence of the nutrition transition dietary behavior

Table 3.2: Dietary patterns of adolescents in Vijayapura, India identified using exploratory factor analysis (n 198)

Food group[1]	Factor 1 Global Diet Pattern	Factor 2 Animal-source Diet pattern	Factor 3 Traditional Diet Pattern
Snacks, fried	0.76*	0.31	0.07
Global foods, unhealthy	0.61*	0.31	0.17
Packaged foods	0.61*	-0.07	0.23
Soda and energy drinks	0.54*	0.34	-0.04
Fried traditional food	0.49*	-0.06	0.42*
Sweets and desserts	0.46*	0.24	0.37
Fruit juice	0.45*	0.10	0.29
Breads	0.42*	0.18	0.18
Lean meat	0.20	0.80*	-0.01
Red meat	0.06	0.67*	0.00
Eggs	0.39	0.54*	0.00
Added sugar and jaggery	0.05	0.05	0.58*
Fruit	0.21	0.19	0.49*
Vegetables	0.09	0.26	0.49*
Dairy	0.15	-0.07	0.48*
Grains	0.17	0.37	0.47*
Ghee	0.04	-0.16	0.43*
Snacks, non-fried	0.35	0.21	0.23
Global foods, healthy	0.29	-0.09	0.06
Pulses and nuts	0.01	0.40	0.23
Tea and Coffee	0.22	0.15	-0.09
Eigen values	4.8	1.6	1.0
Variance explained (%)	3.0	2.2	2.0

*Factor loadings ≥ 0.4.

[1] Dietary data were from adolescents' responses to the 125-item validated Nutrition Transition-FFQ in Vijayapura, India. To carry out exploratory factor analysis, the 125 foods in the NT-FFQ were collapsed to 21 foods groups. Dietary data were collected in November 2013-January 2014.

Table 3.3: Socio-demographic and diet characteristics according to the pre-defined Nutrition Transition-Diet Score and the empirical Global Diet pattern score among adolescents aged 14-18 years in Vijayapura, India (n 198)

		Nutrition Transition-Diet Score		Global Diet pattern score [1]	
Characteristics	**Overall N (%)**	**Highest quartile (n 51)**	**Lower quartiles (n 147)**	**Highest quartile (n 49)**	**Lower quartiles (n 149)**
Age (years)[2]	16.8 (0.9)	16.8 (0.78)	16.8 (0.96)	16.8 (0.86)	16.8 (0.96)
Gender					
Boy	108 (54.6)	36 (70.6)	72 (49.0)**	34 (69.4)	74 (49.7)**
Girl	90 (45.4)	15 (29.4)	75 (51.0)	15 (30.6)	75 (50.3)
School type					
Private	69 (34.9)	15 (29.4)	54 (36.7)	13 (26.5)	56 (37.6)
Public	129 (65.1)	36 (70.6)	93 (63.3)	36 (73.5)	93 (62.4)
Grade in school					
X	25 (12.6)	6 (11.8)	19 (12.9)	5 (10.2)	20 (13.4)
XI	97 (49.0)	25 (49.0)	72 (49.0)	24 (50.0)	73 (49.0)
XII	24 (12.1)	7 (13.7)	17 (11.6)	8 (16.3)	16 (10.7)
Short-term or diploma program	31 (15.7)	8 (15.7)	23 (15.7)	9 (18.4)	22 (14.8)
Dropped out of school or college	21 (10.6)	5 (9.8)	16 (10.9)	3 (6.1)	18 (12.1)
Religion					
Hindu and Jain	160 (80.8)	45 (88.2)	32 (21.8)	42 (85.7)	118 (79.2)
Muslims and Christian	38 (19.2)	6 (11.8)	115 (78.2)	7 (14.3)	31 (20.8)
Caste					
General caste	48 (24.2)	14 (27.5)	34 (23.1)	10 (20.4)	38 (25.5)
OBC and ST/SC[3]	150 (75.8)	37 (72.5)	113 (76.9)	39 (79.6)	111 (74.5)
Food habits[4]					
Strict Vegetarian	39 (19.7)	7 (13.7)	32 (21.8)	7 (14.3)	32 (21.5)
Lacto-ovo vegetarian	154 (77.8)	42 (82.4)	112 (76.2)	42 (85.7)	112 (75.2)
Non-vegetarian	45 (22.2)	9 (17.6)	35 (23.8)	7 (14.3)	37 (24.8)
Nutrition Transition-Diet Score[2]	5.6 (1.2)	7.1 (0.27)	5.1 (0.91) ***	6.5 (0.87)	5.3 (1.1)***
Nutrition Transition-Diet Score range	0-10	7-8	1-6	4-8	1-8

Dietary data were collected in November 2013-January 2014.

*p<0.05, **p<0.01, ***p<0.001. Chi-sq test for categorical variables and t-tests for continuous variables.

[1] For both the pre-defined Nutrition Transition-Diet Score and the Global Diet pattern score, the 'highest' group indicates participants in the top quartile (≥75th percentile) and 'lower' group indicates those in the remaining quartiles. Dietary data were from adolescents' responses to the validated Nutrition Transition-FFQ in Vijayapura, India.

[2] mean (SD).

[3] OBC, Other Backward Class; SC, Scheduled Class; ST, Scheduled Tribe.

[4] Strict vegetarian defined as one that consumes a plant based diet and dairy but does not consume eggs and any meat. A lacto-ovo vegetarian is one that consumes a plant based diet, dairy, and eggs and a non-vegetarian eater is one that consumes all foods including all meats (red meat, lean meat, and seafood).

Table 3.4: Multivariate linear regression to test the association between the pre-defined Nutrition Transition-Diet Score and empirical Global Diet pattern score among adolescents aged 14-18 years in Vijayapura, India (n 198)

Variable	Nutrition Transition-Diet Score	
	Unadjusted model	Adjusted model
Global Diet pattern score (ref=lower)[1]	1.23***	1.24***
Age (years)	-	-.03
Gender (ref=girl)		
Boy	-	.096
School (ref=public school)		
Private school	-	0.94
Religion (ref=Hindu and Jain)		
Muslims and Christians	-	0.13
Caste (ref=OBC & SC & ST)[2]		
General caste	-	0.11
Intercept	5.28	5.62
R-square	0.201	0.209

Dietary data were collected in November 2013-January 2014.
+p<0.1, *p<0.05, **p<0.01, ***p<0.001. One unit change = 1 point change on the pre-defined Nutrition Transition Diet Score.
[1] Highest Global Diet pattern indicates top quartile of the Global Diet pattern factor score and lower Global Diet pattern indicates other three quartiles of the Global Diet pattern factor score. Dietary patterns were derived using exploratory factory analysis of dietary data from adolescents' responses to the validated 125-item Nutrition Transition-FFQ in Vijayapura, India.
[2] OBC, Other Backward Class; SC, Scheduled Class; ST, Scheduled Tribes.

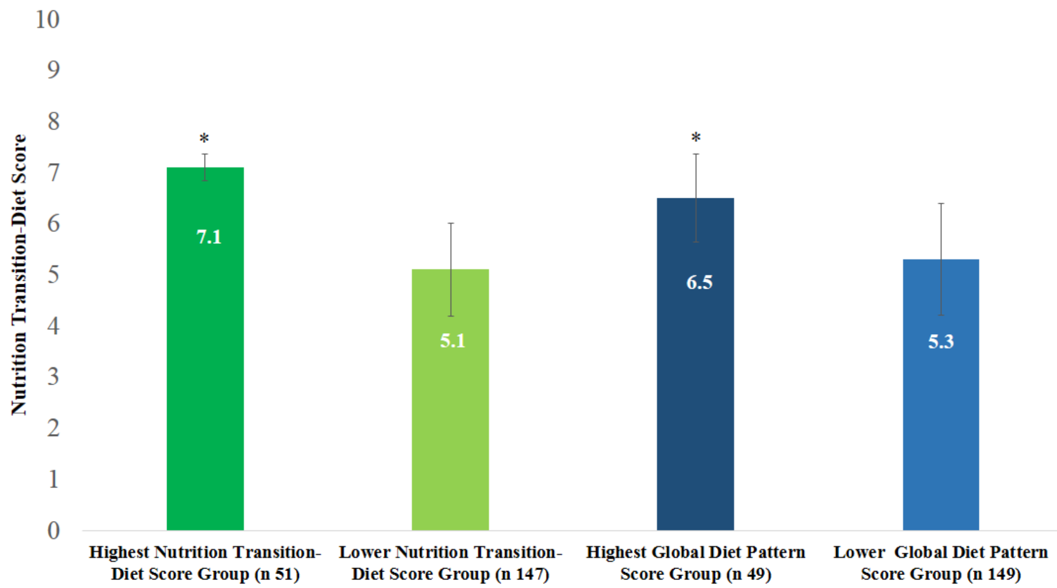
Table 3.5: Differences in food intake (g/day) according to the highest vs. lower pre-defined Nutrition Transition-Diet Score and the highest vs. lower empirical Global Diet pattern score among adolescents aged 14-18 years in Vijayapura, India (n 198)

Food group (g/d)[1]		Overall (n 198)	Nutrition Transition-Diet Score Highest quartile (n 51)	Nutrition Transition-Diet Score Lower quartiles (n 147)	Global Diet pattern score Highest quartile (n 49)	Global Diet pattern score Lower quartiles (n 149)
Energy-dense foods	Breads	30.7 (38.4)	72.7 (40.7)	24.6 (28.6)***	58.9 (41.6)	29.8 (34.5)***
	Global foods, unhealthy	27.7 (39.7)	54.3 (52.2)	19.4 (29.7)***	67.9 (53.6)	15.4 (22.1)***
	Global foods, healthy	0.9 (6.1)	2.4 (10.0)	0.9 (3.9)	3.5 (11.3)	0.5 (2.4)
	Packaged foods	33.3 (28.8)	62.5 (25.4)	23.7 (22.5)***	59.3 (35.5)	25.3 (20.2)***
	Snacks, non-fried	36.4 (36.6)	48.8 (44.1)	34.4 (33.0)*	59.1 (40.1)	31.2 (32.7)***
	Snacks, fried	78.9 (78.9)	137.4 (103.3)	59.4 (56.3)***	177.3 (91.6)	47.3 (36.9)***
	Fried traditional food	23.7 (19.7)	35.1 (25.2)	19.7 (15.6)***	37.6 (24.0)	19.1 (15.7)***
	Sweets and desserts	51.1 (55.7)	98.6 (59.0)	55.6 (50.2)***	108.5 (57.4)	52.9 (47.9)***
Animal-source foods	Red meat	3.2 (6.7)	6.1 (11.1)	4.0 (9.8)	5.7 (11.3)	4.1 (9.8)
	Lean meat	9.3 (24.7)	18.6 (35.6)	9.9 (19.2)	20.5 (37.9)	9.4 (17.7)
	Eggs	17.8 (25.6)	27.8 (37.2)	14.6 (19.1)*	32.1 (37.9)	13.4 (17.8)**
	Dairy	172.4 (176.9)	249.9 (194.6)	149.7 (163.3)**	221.5 (156.0)	160.4 (181.3)**
Beverages	Soda and energy drinks	17.3 (31.0)	35.1 (42.2)	11.2 (23.1)**	47.1 (44.4)	7.5 (15.6)***
	Tea and coffee	158.4 (113.8)	72.7 (40.7)	149.4 (109.9)*	202.8 (139.3)	144.5 (100.5)**
	Fruit juices	62.1 (67.1)	102.0 (79.8)	48.2 (56.1)***	109.9 (74.2)	46.3 (56.6)***
Traditional foods	Fruit	101.0 (83.5)	126.5 (76.8)	103.8 (85.2)	147.4 (75.9)	97.2 (82.4)**
	Vegetables	114.9 (104.3)	139.0 (137.1)	106.8 (89.2)	128.6 (85.2)	110.6 (109.7)
	Pulse and nuts	256.0 (140.9)	301.1 (132.3)	251.7 (141.9)*	284.3 (117.3)	258.3 (147.7)
	Grains	550.6 (267.5)	588.6 (156.3)	404.6 (155.5)***	563.9 (128.1)	415.2 (169.9)**
	Added sugar	4.2 (6.7)	5.9 (7.9)	4.0 (6.2)	4.7 (5.2)	4.5 (7.1)
	Ghee	1.2 (2.7)	1.7 (3.7)	1.2 (2.2)	1.3 (1.9)	1.3 (2.9)

*p<0.05, **p<0.01, ***p<0.001. T-tests for differences in food groups between dichotomized (highest vs. lower) Nutrition Transition-Diet Score and Global Diet pattern score.

[1] Values are mean ± SD. Dietary data were from adolescents' responses to the validated Nutrition Transition-FFQ in Vijayapura, India. Dietary data were collected in November 2013-January 2014.

Figure 3. Differences in highest vs. lower pre-defined Nutrition Transition-Diet score and empirical Global Diet pattern score among adolescents aged 14-18 years in Vijayapura, India[1]



*p <0.001.
[1] Values of scores are mean (SD)

CHAPTER 7: Summary and Conclusions

Main findings

The overarching goals of this dissertation were to contribute to the measurement and understanding of the nutrition transition. Specifically, we sought to measure and document shifts in dietary patterns and eating behaviors among adolescents in India through the assessment of dietary patterns and the development and evaluation of diet metrics. The research was based in the globalizing mid-size city of Vijayapura in the state of Karnataka in South India. First, dietary patterns of adolescents and the factors that may influence their consumption, access, and preferences were assessed using a brief 16-item non-quantitative FFQ administered to a representative sample of school-going adolescents in Vijayapura as part of the baseline Home Environment and Adolescent Weight study. Adolescents' dietary patterns were found to reflect a combination of global (other countries) or non-local (regional) and traditional foods, access, and preferences. When compared with the Dietary Guidelines of India, [1] adolescents consumed fruit, green leafy vegetables, non-green leafy vegetables, and dairy less frequently than recommended and consumed energy-dense foods more frequently than recommended. Gender and school type attended were the main predictors of food consumption of the adolescents among the characteristics examined. Traditional but expensive foods (e.g., fruit, dairy, homemade sweets, and added fat) were consumed more frequently by private school students, generally from wealthier, more connected families, than by public-school students; the latter more frequently consumed both traditional (e.g., tea, coffee, and eggs) and mixed foods (snack and street foods). Girls reported more frequent consumption of global/non-local packaged and ready-to-eat foods, non-green leafy vegetables, and added fat compared to boys, who reported more frequent consumption of eggs and street foods than girls.

Next, given the lack of a validated dietary instrument to measure food consumption and eating behaviors specific to the nutrition transition, a Nutrition Transition-Food Frequency Questionnaire (NT-FFQ) was developed and evaluated for its reproducibility and validity to measure food consumption and eating behaviors related to the nutrition transition among adolescents in South India. The interviewer-administered NT-FFQ, developed using mixed methods, comprised a 125-item semi-quantitative FFQ section that assessed food consumption over a month and a 27-item eating behavior section that quantified eating behaviors over a week. Reproducibility and validity of the NT-FFQ was evaluated using correlation and cross-classification analyses in a non-random sub-sample of 198 adolescents in Vijayapura; the latter against the average of three 24-hour DRs also provided by the participants. These adolescents were interviewed as a part of the follow-up wave of the 2012 Home Environment and Adolescent Weight study (Chapter 5). The NT-FFQ was found to have good reproducibility and validity for most foods and eating behaviors and can measure the nutrition transition among adolescents in South India at a time and over time.

Lastly, a pre-defined Nutrition Transition-Diet Score was developed and evaluated for its validity or ability to measure nutrition transition among adolescents in India. The pre-defined Nutrition Transition-Diet Score (mean 5.6 ± 1.2; range 0-10) included 10 components; seven food groups (fried foods, packaged foods, sugar-sweetened beverages, dairy, fruits and vegetables, bread, and added sugar) and three nutrients (total dietary fat, saturated fat, and sodium). The validity of the pre-defined Nutrition Transition-Diet Score was examined against empirical dietary patterns from answers provided by 198 adolescents to the validated 125-item NT-FFQ in Vijayapura, India. Adolescents were found to have three dietary patterns; global (factor 1), animal-source (factor 2), and traditional (factor 3). We evaluated the validity of the pre-defined Nutrition Transition-Diet Score against the factor score of the first dietary pattern and dichotomized both scores as highest (top quartile) versus lower (remaining quartiles). The pre-defined Nutrition Transition Diet-Score was significantly greater among adolescents with highest Global Diet pattern (mean score 6.5 ± 0.9; range: 4-8) than those with lower Global Diet pattern score (mean score 5.3 ± 1.1; range: 1-8) ($p<0.001$). Using correlation, cross-classification and linear regression analyses, the validated pre-defined Nutrition Transition-Diet Score was found to effectively measure nutrition transition in Indian adolescents at one time or to assess change over time. The NT-FFQ and pre-defined Nutrition Transition-Diet Score have the potential to be used not only for research and programs but also to be scaled for use among adults as well as adolescents in other regions.

Limitations

Adolescents' dietary patterns suggest exposure to global/non-local foods and intake of traditional foods high in fat, sugar, and salt, but explained only 7.2% of the total variation of the diet. The evolving food environment, food access, and preferences in this remote region of South India which till recently was underdeveloped, may be indicative of a lower nutrition transition as compared to urban metropoles. Even so, the dietary patterns and food consumption of adolescents in this remote region showed resemblance to intakes reported among adolescents in urban regions in India[2-5] but more studies are needed to assess if these findings extrapolate to adolescents in other urbanizing regions in India. Moreover, even though the adolescents' dietary patterns reflect a combination of global/non-local and traditional foods and beverages, the use of a non-quantitative 16-item FFQ limited the ability to quantify food intake and to assess major food groups such as pulses and grains. Even so, the NT-FFQ was developed to more comprehensively assess dietary intake including the intake of pulses and grains. Although, the NT-FFQ had good overall reproducibility and validity for most foods and eating behaviors to measure the nutrition transition among adolescents in South India; some foods such as fried traditional foods had low correlation coefficient and discordance (spearman correlation r=0.11 and discordance=14%) that need to be taken into account.

The Nutrition Transition-Diet Score was designed using a pre-defined approach to select the components and cut-offs values. However, the availability of limited quantitative food-based dietary guidelines for adolescents restricted the ability to determine the cut-offs for some score components (e.g., intake of packaged foods, fried foods, and breads), a problem that has been acknowledged before.[6] Instead, we used the recent 2015 US food-based recommendations[7] for cut-off values for these components.

Strengths and Innovations

This dissertation addresses gaps in understanding and measuring the nutrition transition among adolescents in India, home to 13.5% of the global adolescent population (243 million[8] of 1.8 billion[9]). A major contribution of this dissertation was the development and validation of two novel dietary assessment instruments, the NT-FFQ and the Nutrition Transition-Diet Score, to quantify and measure the extent of nutrition transition among adolescents in India. These dietary instruments contribute to a limited body of validated diet metrics that can quantify nutrition transition at one time or over the long-term. To our knowledge, the NT-FFQ is also the first validated FFQ for Indian adolescents. While typical FFQs primarily assess food intake, a strength of the validated NT-FFQ was the inclusion of a comprehensive section on eating behaviors. Furthermore, the NT-FFQ has wide applicability through its ability to be used to assess dietary patterns, diet quality, and eating behaviors.

In addition, to our knowledge, the pre-defined Nutrition Transition-Diet Score is the first diet score developed and evaluated to quantify nutrition transition at the individual level. Good construct validity and internal validity of the pre-defined Nutrition Transition-Diet Score against the empirical Global Diet pattern confirms its ability to measure the nutrition transition-related dietary shifts. Also, the added advantage of using the pre-defined approach as opposed to the empirical approach is, as reported elsewhere,[10] the ability for the Nutrition Transition-Diet Score to be reproducible or replicable across populations; extending the utility of the diet metric to measure nutrition transition across sub-populations, regions, and urbanicity. Next, a strength of the study design and sampling was its generalizability to Vijayapura district. For instance, the population of Vijayapura comprised 17.3% Muslims from our weighted estimates while the 2011 official Census showed Vijayapura district to include 16.97% Muslim population.[11]

Furthermore, while most research on the nutrition transition in India has focused on globally connected metropolitan areas, [3,12,13] our research was in a prototype remote city that is traditionally underdeveloped but experiencing urbanization and new exposure to global and non-local trends. For these reasons, this region in South India was well suited to investigate adolescents' dietary patterns in a globalizing context. Three distinct dietary patterns namely global, animal-source, and traditional were identified among adolescents in this urbanizing region. This analysis also contributes to the limited research on dietary patterns of Indian adolescents.[14,15] Lastly, new methods of categorizing foods were proposed that can help understand the nature of nutrition transition in terms of healthfulness versus modernity of foods, diet quantity versus diet quality, and global versus local.

Next steps in developing validated dietary instruments to measure nutrition transition

Moving forward, several changes and additions to the NT-FFQ and Nutrition Transition-Diet Score could increase the richness of the dietary instruments. The addition of eating behaviors along with key food groups specific to the Nutrition Transition-Diet Score could provide a measure to quantify both diet and eating behaviors associated with the nutrition transition. While we evaluated the internal validity of the Nutrition Transition-Diet Score against empirical derived dietary patterns, a next step would be to evaluate its external validity and ability of the score to predict unhealthy weight (overweight and underweight) using the anthropometric data of the study participants collected at baseline and follow-up. For instance, the Healthy Eating Index, a scoring system used to assess adherence to the Dietary Guidelines for Americans[16] has been evaluated among adults for its ability to predict chronic disease.[17,18]

Next, while the validated NT-FFQ provided a comprehensive assessment of global, national, and local foods and beverages and eating behaviors of adolescents and was easily administered with low respondent burden, it took on average 40 minutes to administer. It may be useful to develop a shorter version of this instrument that assesses the nutrition transition more quickly and efficiently. Shorter tools are known to be more practical and convenient to administer and may have greater utility in large survey designs.[19,20] As an example, multiple non-consecutive 24-hour DRs may serve as a quicker alternate to assess food consumption than the NT-FFQ. While we could evaluate the validity of the pre-defined Nutrition Transition-Diet Score against multiple 24-hour DRs, however, as reported elsewhere, the 24-hour DR method is not reflective of long term intake as are FFQs.[21] Such a tool would need to be evaluated for its external and internal validity to measure nutrition transition-related dietary shifts.

Lastly, the implications of the findings draw attention to the methods of categorization of food and beverages that have mainly been described as a function of healthfulness; healthy versus unhealthy, [22-28] but have meaning beyond that. The findings lend to the development of a theoretical framework for the contextualization of food and beverages specific to the nutrition transition **(Figure 4)**. Briefly, I propose a Nutrition Transition foods framework that is comprised of four components or domains that lie within two scales. Healthy and unhealthy domains lie on two sides of the healthfulness scale while traditional and modern domains are the two ends of the modernity scale. The four components or quadrants are traditional and healthy, traditional and unhealthy, modern and healthy, and modern and unhealthy. Any food or beverage would find a place on one of the four quadrants and would be considered either traditional and healthy, traditional and unhealthy, modern and healthy, and modern and unhealthy. The four quadrant model with the position of some foods and beverages available in India are illustrated in **Figure 4**. The model allows foods and beverages to be a function of both healthfulness and modernity. The Nutrition Transition foods framework will be further developed as part of future work.

Public Health Implications

Overall, the dissertation makes several contributions. First, this dissertation provides methodological contributions through the development and validation of two dietary instruments, the NT-FFQ and the pre-defined Nutrition Transition-Diet Score that can provide comprehensive, quantifiable, and reliable assessment of the nutrition transition-related food consumption and eating behaviors of adolescents. The dietary instruments developed here provide a basis for future studies that seek to adapt and evaluate the instruments to measure nutrition transition across populations and urbanicity in India and elsewhere. Further, the ability to measure and quantify nutrition transition can inform program and policy efforts to improve the food environment including the diversity and healthfulness of foods. The utility of pre-defined validated dietary assessment instruments that can quantify nutrition transition are far reaching. Investments in adolescent health through the development of validated diet metrics that can assess dietary patterns, food consumption and eating behaviors are likely to bring benefits today and for decades to come.

The findings from this dissertation provide insights on dietary patterns of adolescents in an urbanizing region in South India. The dietary patterns of adolescents in our study reflect a combination of foods and beverages that are traditional and global/non-local and had three distinct patterns namely global, animal-source foods, and traditional. The global pattern was characterized by foods high in fats, sugar and salt, which are often referred to as the 'western diet', however, this pattern also included traditional foods high in fat and salt such as fried traditional foods, fried snacks, and sweets and desserts. In addition, though the dietary patterns of adolescents in our study reflect a combination of foods and beverages that are traditional and global/non-local, the latter have not overwhelmed the local food culture in the urbanizing region. Given that the change from traditional dietary patterns and eating behaviors to newer ones is considered largely irreversible, [29] this may be a critical junction to intervene and promote healthy eating behaviors and food consumption among adolescents.

Future Directions

Addressing adolescent health in LMICs including India, given the ongoing nutrition transition and emerging NR-NCDs burden, calls for a paradigm shift, high levels of commitment and multi-sectorial actions. The dietary instruments developed in this dissertation could be adapted and scaled to use in other populations to understand what the nutrition transition entails for them. As a first step, since the NT-FFQ was developed and validated for an urbanizing region, I propose the evaluation of the NT-FFQ among adolescents in an urban region in India. The NT-FFQ, if found valid to measure the nutrition transition in an urban region, would extend the scope and utility of the instrument to be used to compare the nutrition transition among adolescents across urbanicity. The ability of the NT-FFQ to comprehensively assess food consumption and eating behavior can also be used to assess diet quality by comparing food and nutrient intake against the recommended Dietary Guidelines of India.

Next, I propose an analysis of the dietary data using NT-FFQ and the assessment of the external validity of the pre-defined Nutrition Transition-Diet Score, to describe the nutrition transition across gender, socioeconomic status, and eating practices (vegetarian vs. non-vegetarian) among the adolescents. The assessment of adolescents' eating behaviors will add to the limited body of research which suggest that the more frequent practice of eating outside the home[30] and of watching TV while eating meals[31] may be becoming more common, especially in adolescents.[30] In addition, while the food-based evaluation of the NT-FFQ provided estimates of food consumption (g/d), we could extend the analysis to investigate the nutrient intake of the adolescents. The nutrient analysis could be carried out using the food and nutrient database that was created using nutrient values of raw foods from the Nutritive Value of Indian Foods[32] and of cooked foods from the database of the Nutritionist Pro software.

Furthermore, extending the dietary patterns analyses in Aim 3 *(Chapter 6)*, I propose to examine temporal dietary patterns of adolescents by examining the time and location at which meals were consumed. Adolescents' meal time (time of the day and day of week) and meal location (e.g., home, school, and restaurant, etc.) were recorded during the three 24-hour DRs (*Chapter 5*). Temporal dietary patterns analysis is an emerging area of research that incorporates the time of food intake in addition to the frequency and amount of intake.[33] For instance, a recent temporal dietary pattern analysis of 1999-2004 National Health and Nutrition Examination data of 9326 US adults ages 20-65 years found temporal dietary patterns associated with differences in daily diet quality, demonstrating that elements beyond food and nutrient intake such as time can be incorporated with dietary patterns to determine links to diet quality.[34] Identifying temporal dietary patterns will provide additional insights on the nature of food choices and eating behaviors, specific foods and beverages that may be eaten at home versus outside the home, and those items that may be consumed more frequently on weekdays versus weekends. Findings would provide additional insights to the nutrition transition among Indian adolescents.

Lastly, I propose an analysis to investigate the association between adolescents' dietary patterns and body weight. In addition to the diet data, we also collected adolescents' anthropometric measurements including height, weight, and waist circumference (*Chapter 5*). Adolescents would be classified into BMI z-score categories using gender- and age- specific WHO cut points. We hypothesize that adolescents with higher Global diet pattern will have higher BMI. For this study, multivariate logistic regression analyses using both unadjusted and adjusted models will be used to investigate the association between the adolescents' dietary patterns and weight using BMI z-scores.

Summary

The research presented in this dissertation sought to measure and understand the nutrition transition among adolescents in India. Based on the results of this research, adolescents' dietary patterns reflect global/non-local, animal-source foods, and traditional diets that included both healthy and unhealthy nutrition transition features. Gender and school type were the main predictors of dietary patterns. As global/non-local foods have not yet overwhelmed the local food culture in this globalizing region, findings from this dissertation can inform efforts to promote dietary diversity and healthful food consumption. The two dietary assessment instruments, the Nutrition Transition-FFQ and the pre-defined Nutrition Transition-Diet Score, can effectively measure the nutrition transition among Indian adolescents and be utilized in research, programs, and policies to measure nutrition transition at a time and over time, across sub-populations and urbanicity.

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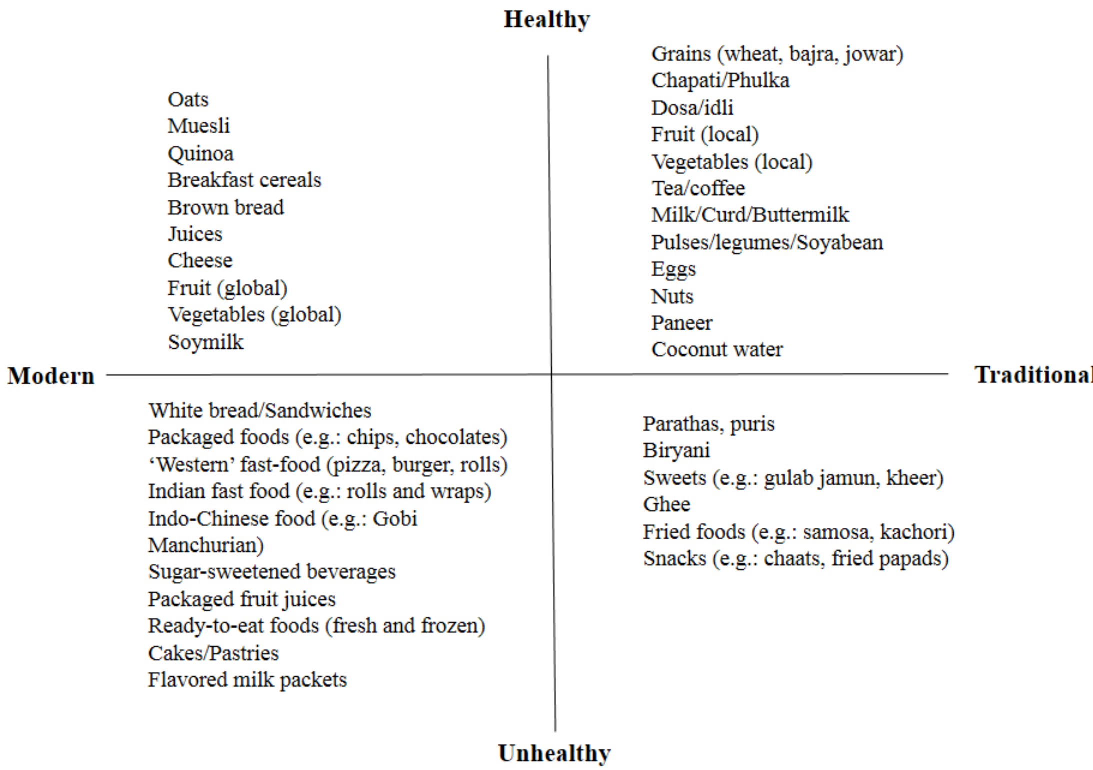
Figure 4. The Nutrition Transition Foods Framework



APPENDICES

Appendix A: Nutrition Transition-Food Frequency Questionnaire (NT-FFQ)

BLDE UNIVERSITY'S SHRI B.M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTER, BIJAPUR

NUTRITION TRANSITION ASSESSMENT QUESTIONNAIRE

In collaboration with:
Emory University, Atlanta, USA
&
Public Health Foundation of India, New Delhi, India

STUDY FUNDED BY:
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2013-2014

BLDE UNIVERSITY'S SHRI B.M. PATIL MEDICAL COLLEGE, BIJAPUR
NUTRITION TRANSITION ASSESSMENT QUESTIONNAIRE

INTERVIEWER's CODE: [__|__|	DATE OF INTERVIEW (DD/MM/YY): [__|__]/[__|__]/[__|__]
INTERVIEW NO (circle any one): 1 2	START TIME OF INTERVIEW (HR: MIN): [__|__]:[__|__] AM/ PM
INTERVIEW RESULT (circle any one): 1=Completed 2=Terminated/Incomplete 3=Refused 4=Not found/Not available	
COORDINATOR's CODE: [__|__| FORM CHECKED ON:[__|__]/[__|__]/[__|__] (DD / MM/ YY)	DATA ENTRY BY: [__|__| DATA ENTRY COMPLETED: [__|__]/[__|__]/[__|__] (DD / MM/ YY)

	SECTION A: PARTICIPANT INFORMATION :	
A1	Participant name	
A2	Participant sex	**(circle any one):** (1) Male (0) Female
A3	Age	[__|__] years
A4	Class in which studying:	**(circle any one)** (1) VIII (2) IX (3)X (4) XI (5) XII (6) no attending school nor college; reason: ___________________ (7) other: ___________________
A5	Participant address:	**(ENTER House Number, Street, Locality, Nearest Landmark):**
A6	Participant's contact information	Landline telephone number [__|__|__|__|__|__|__] Mobile number (Mother/Father) [__|__|__|__|__|__|__|__|__|__]
A7	Marital status	**(circle any one):** (0) Unmarried (1) Married

INTRODUCTION: This study is being conducted by BLDE University, Bijapur, India and Emory University, Atlanta, USA to find out foods choices and eating behaviors of children. I will ask you about your background, foods that you usually eat and your eating habits. Your responses will be kept confidential.

SECTION B: Food preferences and eating habits assessment

B1. How many times in a week do you do the following practices? For each item that I will mention, please tell me if you do it every day, a few times a week, once a week, less than once a week, or never.

	Category	**Everyday (0)**	**A few times a week (1)**	**Once a week (2)**	**Less than once a week (3)**	**Never (4)**
B1a	How many times in a week do you eat with friends at your home/your friend's home?					
B1b	How many times in a week do you eat outside food with friends?					
B1c	How many times in a week are outside food brought in your home to eat?					
B1d	How many times in a week do you eat mithai (sweets) outside the home/ brought from outside? **Prompt: like Jamun, peda, etc**					
B1e	How many times in a week are mithai (homemade sweets) made at home?					
B1f	How many times in a week are fried foods prepared in your home? **Prompt: like Fried papad, bhajji, etc**					

B2. How many times in a week do you usually eat the following meals at home with or without watching TV/computer? For each item that I will mention, please tell me if you do it every day, a few times a week, or never. INTERVIEWER: If no TV in the house, write NA.

	Meal	Everyday (0)	4-6 days/ week (1)	1-3 days/ week (2)	Less than once/ week (3)	Never (4)	Watches TV/computer while eating		
							Yes (0)	No (1)	NA (2)
B2a	How many times in a week do you usually eat breakfast at home?								
B2b	How many times in a week do you usually eat lunch at home?								
B2c	How many times in a week do you usually eat dinner at home?								
B2d	How many times in a week do you usually eat evening snacks at home?								

B3. How many times in a week do you eat the following meals outside the home? For each item that I will mention, please tell me if you do it every day, few times, a week, less than once a week, or never.

	Meal	Everyday (0)	4-6 days/ week (1)	1-3 days/ week (2)	Less than once/ week (3)	Never (4)
B3a	How many times in a week do you usually eat breakfast outside the home?					
B3b	How many times in a week do you usually eat lunch outside the home?					
B3c	How many times in a week do you usually eat dinner outside the home?					
B3d	How many times in a week do you usually eat evening snacks outside the home?					

B4	During the past year have you taken any vitamin or minerals supplements?	Yes. ……………………….,,,,,,,,,,,,,…,1 If yes got to B4a, else skip to Section C. No.. …,,0 Refused …,,,98 Don’t know...…99
B4a	If yes, what supplements do you take regularly?	____________________________________ ____________________________________ Refused …,,,98 Don’t know...…99

Section C: DIETARY ASSESSMENT: Now I would like to ask you about how often you eat certain foods in a month. Please tell me if you have each item daily, 2-3 times a week, 3-6 times/week, once a week, 2-3 times a month, monthly, less than once a month, never, or don't know (DK) the food. Also, please tell me if consumption of each food has increased, decreased, or remained the same in the past 6 months.

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Increased (12)	Decreased (13)	Same (14)
GLOBAL FOODS																	
C1	Bread (white)	2 slice															
C2	Bread (brown)	2 slice															
C3	Vegetable sandwich	2 No.															
C4	Multigrain biscuits, (e.g: ragi, oats)	2 No.															
C5	Veg Burger	1 No.															
C6	Chicken/Fish Burger	1 No.															
C7	Veg Pizza	1 slice															
C8	Chicken Pizza	1 slice															
C9	Veg Puffs	1 No.															
C10	Egg puffs	1 No.															
C11	Toffee **(e.g., eclairs, mango bite)**	1 No.															
C12	Chocolate (bar) **(Ask cost: Rs.__)**	1 bar															

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Increased (12)	Decreased (13)	Same (14)
C13	Cream bun/cream rolls	1 No.															
C14	Pastries/cake	1 slice															
C15	Potato chips **(Ask cost: Rs.__)** **(Prompt: Circle size)**	1 packet															
C16	Popcorn **(Ask cost: Rs.__)** **(Prompt: Circle size)**	1 packet S M L															
C17	Cereal/ Muesli with milk (e.g., corn/wheat)	1cup															
C18	Oats	1cup															
C19	Pancake	1 No.															
C20	Pasta	1 cup															
C21	Finger chips (ask: if fresh or frozen)																
C22	Frozen parathas	1 No.															
C23	Frozen cutlets	2 Nos.															
INDIAN SNACK FOODS																	
C24	Samosa (potato)	1 No.															
C25	Wada pav	1 No.															
C26	Kachori	1 No.															
C27	Pav bhaaji	1 plate															
C28	Paav/bun	2 No.															

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Incre ased (12)	Decr eased (13)	Same (14)
C29	Pakoda/ Bhajji (onion, mirchi)	4 Nos.															
C30	Potato Bonda	2 Nos.															
C31	Dahi wada	2 Nos.															
C32	Wada (medhu)	2 Nos.															
C33	Sabudana wada	2 Nos.															
C34	Chaats (e.g: Pani Puri)	1 plate															
C35	Chooda/mixture	1cup															
C36	Khaari/rusk/butter	2 No.															
C37	Biscuits, non-cream **(E.g., parle G, marie)**	2 No.															
C38	Cream biscuits **(E.g. borbon, hide n seek)**	2 No.															
C39	Noodles **(e.g: Maggi)**	1 packet															
NON-VEGETARIAN FOODS																	
C40	Eggs – boiled	1 No.															
C41	Fried egg/omlette	1 No.															
C42	Chicken fried/curry	1 cup															
C43	Fish fry/curry	2 pieces															
C44	Mutton/kheema	1 cup															
C45	Prawns curry	1 cup															
C46	Chicken/mutton biryani	1 cup															

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Incre ased (12)	Decr eased (13)	Same (14)
SWEETS, MITHAI, DESSERTS																	
C47	Ice candy (pepsi cola)	1 No.															
C48	Ice-cream/kulfi	1 cup															
C49	Gulab jamun	2 Nos.															
C50	Rasmalai/rasgulla	2 Nos.															
C51	Peda/barfi/laddoo	1 No.															
C52	Jalebi	2 Nos.															
C53	Kheer/Baasundi	1 cup															
C54	Sheera/sooji	1cup															
C55	Halwa **(e.g., carrot, moong dal)**	1 cup															
C56	Chikki	2 pieces															
C57	Shreekhand	1 TBSP															
DAIRY																	
C58	Curd (plain)	1 cup															
C59	Raita	1 cup															
C60	Paneer	1 cup															
C61	Butter	1 tsp															
C62	Cheese –slice/spread	1 TBSP															

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Increased (12)	Decreased (13)	Same (14)
BEVERAGES																	
C63	Water	1 glass															
C64	Milk	1 glass															
C65	Flavored milk (e.g., badam, elaichi)	1 glass															
C66	Milkshakes	1 glass															
C67	Lassi	1 glass															
C68	Buttermilk	1 glass															
C69	Tea	1 cup															
C70	Coffee	1 cup															
C71	Sugarcane juice	1 glass															
C72	Coconut water	1 No.															
C73	Fruit juice, fresh	1 glass															
C74	Fruit juice, packaged **(e.g. frooti,** Rasna**)**	1 glass															
C75	Soft drink (regular)	1 glass															
C76	Soft drink (diet) **(e.g: Diet Pepsi)**	1 glass															
C77	Energy drink (200ml) **(E.g. Red bull)**	1 can															
C78	Glucon-D (glucose)	1 TBSP															

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Incre ased (12)	Decr eased (13)	Same (14)
FRUITS																	
C79	Banana	1 med.															
C80	Apple	1 small															
C81	Chickoo	1 small															
C82	Papaya	2 slice															
C83	Citrus (e.g., Orange, mosambi)	1 med.															
C84	Fruit salad	1 cup															
SEASONAL FRUITS (ask: usual intake during a season)																	
C85	Indian gooseberries	1 cup															
C86	Watermelon	2-3 slice															
C87	Grapes	1 cup															
C88	Mango **(Prompt: size)**	1 S B															
C89	Custard apple **(Prompt: ask size)**	1 S B															
VEGETABLES																	
C90	Green leafy vegetables **(e.g., palak, methi)**	½ cup															
C91	Potato	½ cup															
C92	Cabbage, caulifower	½ cup															
C93	Other veg **(e.g., brinjal, capsicum)**	½ cup															
C94	Corn (butta)	1 No.															
C95	Veg salad (eg: carrots)	1 cup															

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Increased (12)	Decreased (13)	Same (14)
INDIAN FOODS																	
C96	Chapati –wheat flour **(Prompt: ask size)**	1 S M L															
C97	Poori **(Prompt: ask size)**	1 S L															
C98	Aloo paratha **(Prompt: ask size)**	1 S M L															
C99	Puran poli *(holige)* **(Prompt: ask size)**	1 S M L															
C100	Roti bajra/jowar **(Prompt: ask size)**	1 S M L															
C101	Rice	1 cup															
C102	Curd rice	1 cup															
C103	Veg pulao	1 cup															
C104	Idli	2 Nos.															
C105	Dosa	1 No.															
C106	Uttapa	1 No.															
C107	Upma	1 cup															
C108	Poha	1 cup															
C109	Sabudana khichdi	1 cup															
C110	Dhokla	2 Nos.															
C111	Dal	½ cup															
C112	Sambar	½ cup															

NO.	Food item	Amount (A)		Average consumption in a month (B)											Intake during the past 6 months has (C):		
		Standard serving size	Serving size if different	3+ time per day (1)	2 time per day (2)	1 time per day (3)	5-6 time per week (4)	2-4 time per week (5)	1 time per week (6)	2-3 time per month (7)	1 time per month (8)	Less than 1 per month (9)	Never (10)	DK (11)	Incre ased (12)	Decr eased (13)	Same (14)
C113	Rajma/chana masala/soybean/peas	½ cup															
C114	Sprouts (matki/moong)	½ cup															
MISCELLANOUS																	
C115	Sugar	1 tsp.															
C116	Jaggery	1 tsp.															
C117	Honey	1 tsp.															
C118	Sweetener (e.g., sugar free)	1 No.															
C119	Ketchup	1 tsp.															
C120	Jam	1 TBSP															
C121	Papad **(Prompt: circle fried or roasted)**	1 No.															
C122	Nuts (e.g., almonds)	¼ cup															
C123	Groundnuts	¼ cup															
C124	Add ghee to food	1 tsp.															
C125	Horlicks/ bornvita	1 TBSP															

SECTION D: Some things are considered traditional (old/from before) while others are considered 'modern (recent/new)'. Please keep this card in your hand. For each item that I will ask, please tell me where on the scale from totally traditional to totally modern you think the item lies. Please pick one of the 4 response options on your card. INTERVIEWERS: circle one option for each item. You may circle don't know (DK) or refused.

D1	Home cooked food	1 Totally traditional	2 somewhat traditional	3 somewhat modern	4 totally modern	DK....98	Refused...99
D2	Outside food (PROMPT: e.g., gobi manchuri, chaats)	1 Totally traditional	2 somewhat traditional	3 somewhat modern	4 totally modern	DK....98	Refused...99
D3	Eating eggs	1 Totally traditional	2 somewhat traditional	3 somewhat modern	4 totally modern	DK....98	Refused...99
D4	Eating meat	1 Totally traditional	2 somewhat traditional	3 somewhat modern	4 totally modern	DK....98	Refused...99
D5	Eating bread	1 Totally traditional	2 somewhat traditional	3 somewhat modern	4 totally modern	DK....98	Refused...99
D6	Drinking milk	1 Totally traditional	2 somewhat traditiona	3 somewhat modern	4 totally modern	DK....98	Refused...99
D7	Drinking fruit juice	1 Totally traditional	2 somewhat traditional	3 somewhat modern	4 totally modern	DK....98	Refused...99
D8	Is a family with a working mother more traditional or more modern?	1 Totally traditional	2 somewhat traditional	3 somewhat modern	4 totally modern	DK....98	Refused...99

PART E: Now may I check how tall you are, how much you weigh, and the width of your waist. As with the rest of this survey, this is voluntary and will be confidential. I will take each measurement twice in order to get the most accurate numbers, but this should just take a minute.

Sl.NO	**Height (cm)**	**Scale code**	**Weight (kg)**	**Scale code**	**Waist (cm)**	**Scale code**
1						
2						
Average						

Thank you for talking with me today! We look forward to talking with you again next month.

END TIME OF INTERVIEW (HR: MIN): [__|__].[__[__]

Interviewer comments: if you faced any problem while taking interview and/or anthropometric measurements write that also

Appendix B: 24-hour Dietary Recall template

BLDE UNIVERSITY, BIJAPUR, INDIA
24-hour FOOD RECALL

INTERVIEWER's CODE: [__|__|	DATE OF INTERVIEW (DD/MM/YY):[__|__]/[__|__]/[__|__]
INTERVIEW NO (circle any one): 1 2 3	START TIME OF INTERVIEW (HR: MIN): [__|__]:[__|__]
INTERVIEW DAY(circle any one): Sat Sun Mon Tue Wed Thu Fri	RECALL DAY (circle any one): Sat Sun Mon Tue Wed Thu Fri
INTERVIEW RESULT (circle any one): 1=Completed 2=Terminated/Incomplete 3=Refused 4=Not found/Not available	
COORDINATOR's CODE: [__|__| FORM CHECKED ON:[__|__]/[__|__]/[__|__] (DD / MM/ YY)	DATA ENTRY BY: [__|__| DATA ENTRY COMPLETED: [__|__]/[__|__]/[__|__] (DD / MM/ YY)

INTRODUCTION: We would like to know everything that you ate and drank yesterday. Please tell me everything you ate and drank from the time you woke up in the morning to the time you went to sleep at night. I would also like to know what amount you ate, where you were when you ate, and what was the time when you ate.

Q1. Was yesterday a routine/regular day for you?	Yes .... 1 **If yes, go to Page 2, else go to Q1a.** No.. .... 2 Refused. .... 98 Don't know. 99
Q1a. What was the reason for yesterday not being a regular/routine day for you?	Birthday/festival .... 1 Unwell/sick .... 2 Travelled .... 3 Did not go to school/college .... 4 Other: .... 96 Specify;______________________ Refused .... 98 Don't know. 99

FOR INTERVIEWERS: Here is an example of a meal given by a child.

Time	Food and ingredients	Quantity	Serving size (e.g: 1 cup, 1 no.)	Location (where food was had)
8am	Tea	1	Cup	Home
	Milk (cows)	½	Cup	
	Sugar	2	Teaspoons	
10 am	Parle –G biscuit	2	Nos.	School

I. What did you eat and drink before breakfast in the morning?

A	B	C	D	E
Time (AM/PM)	Food and ingredients	Quantity	Serving size (e.g: tsp, TBSP, small/medium)	Location (where food was had)

PROMPT: Is there anything else that you ate or drank before breakfast in the morning?

II. What did you eat and drink for breakfast in the morning?

A	B	C	D	E
Time (AM/PM)	Food and ingredients	Quantity	Serving size (e.g: tsp, TBSP, small/medium)	Location (where food was had)

PROMPT: Is there anything else that you ate or drank for breakfast in the morning?

III. What did you eat and drink between breakfast and lunch?

A	B	C	D	E
Time (AM/PM)	Food and ingredients	Quantity	Serving size (e.g: tsp, TBSP, small/medium)	Location (where food was had)

PROMPT: Is there anything else that you ate or drank between breakfast and lunch?

IV. What did you eat and drink for lunch?

A	B	C	D	E
Time (AM/PM)	Food and ingredients	Quantity	Serving size (e.g: tsp, TBSP, small/medium)	Location (where food was had)

PROMPT: Is there anything else that you ate or drank for lunch?

V. What did you eat and drink between lunch and dinner?

A	B	C	D	E
Time (AM/PM)	Food and ingredients	Quantity	Serving size (e.g: tsp, TBSP, small/medium)	Location (where food was had)

PROMPT: Is there anything else that you ate or drank between lunch and dinner?

VI. What did you eat and drink for dinner?

A	B	C	D	E
Time (AM/PM)	Food and ingredients	Quantity	Serving size (e.g: tsp, TBSP, small/medium)	Location (where food was had)

PROMPT: Is there anything else that you ate or drank for dinner?

VII. What did you eat and drink after dinner and before going to sleep?

A	B	C	D	E
Time (AM/PM)	Food and ingredients	Quantity	Serving size (e.g: tsp, TBSP, small/medium)	Location (where food was had)

PROMPT: Is there anything else that you ate or drank after dinner and before going to sleep?

Thank you for talking with me today! We look forward to talking with you again in two weeks.

END TIME OF INTERVIEW (HR: MIN): [__|__].[__|__]

Interviewer comments: please write additional comments from participant and/or if you faced any problem while interviewing:

Appendix C: Article Attachment

Shaikh NI, Patil SS, Halli S, Ramakrishnan U, Cunningham SA. Going global: Indian adolescents' eating patterns. *Public Health Nutr*. 2016:1-9.

Public Health Nutrition: page 1 of 9 doi:10.1017/S1368980016001087

Going global: Indian adolescents' eating patterns

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Abstract

Objective: To describe adolescents' eating patterns of traditional, global/non-local and mixed foods, and the factors that may influence food consumption, access and preferences, in a globalizing city.

Design: A representative sample of school-going adolescents completed a cross-sectional survey including an FFQ designed to identify traditional and global foods. Student's *t* test and ordinal logistic regression were used to examine weekly food intake, including differences between boys and girls and between adolescents attending private and public schools.

Setting: Vijayapura city, Karnataka State, India.

Subjects: Adolescents (n 399) aged 13–16 years.

Results: Compared with dietary guidelines, adolescents consumed fruit, green leafy vegetables, non-green leafy vegetables and dairy less frequently than recommended and consumed energy-dense foods more frequently than recommended. Traditional but expensive foods (fruits, dairy, homemade sweets and added fat) were more frequently consumed by private-school students, generally from wealthier, more connected families, than by public-school students; the latter more frequently consumed both traditional (tea, coffee, eggs) and mixed foods (snack and street foods; $P \leq 0{\cdot}05$). Girls reported more frequent consumption of global/non-local packaged and ready-to-eat foods, non-green leafy vegetables and added fat than boys ($P \leq 0{\cdot}05$). Boys reported more frequent consumption of eggs and street foods than girls ($P \leq 0{\cdot}05$).

Conclusions: Adolescents' eating patterns in a globalizing city reflect a combination of global/non-local and traditional foods, access and preferences. As global foods continue to appear in low- and middle-income countries, understanding dietary patterns and preferences can inform efforts to promote diversity and healthfulness of foods.

Keywords
Adolescents
Food
Nutrition transition
Globalization
India

Globalization, urbanization and economic development are contributing to shifts in food accessibility and food consumption patterns in low- and middle-income countries, including India[1,2]. Urban regions in low- and middle-income countries including India[1–5], Brazil[6] and China[2] are experiencing the penetration of new foods from other countries (global) or other regions (non-local)[7]. Refined carbohydrates, snack foods, processed foods and fried foods appear to be replacing traditional foods such as unrefined whole grains, fruit, vegetables and nuts[8]. 'Nutrition transition', the term used to describe these shifts, may be implicated in increasing nutrition-related non-communicable diseases, including diabetes and obesity, in many parts of the world[9]. Global and non-local foods are also beginning to reach rural areas and poorer individuals; at the same time, nutrition-related non-communicable diseases are also increasingly prevalent not only among upper and middle socio-economic groups, as observed in the past, but also in lower socio-economic groups[10–12]. In India, 62 million adults of a population of 1·2 billion have diabetes and, by 2035, 101 million adults are expected to have diabetes[13]. About 10 % of Indians aged 0–54 years are overweight or obese[14]. Among Indian adolescents, who comprise one-fifth of the population (~243 million)[15], 37 % are underweight and 5 % are overweight or obese[14].

Adolescence is a critical life period when eating habits are established[16] and during which adequate nutrition

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promotes healthy growth and health in adulthood[17]. Adolescents are also often at the forefront of social change and global trends[18] and are experiencing increasing spending power relative to earlier generations[19]. Healthy eating can be challenging for adolescents in the context of new, trendy, palatable processed foods and fast foods appearing with globalization and promoted through peers and the media[20–22]. Eating patterns are moulded by the meeting of traditional and global factors[23], which occurs within the broader contexts of socio-economic status, urbanization and gender relations. In low- and middle-income countries, including India, urban, wealthier, more globally connected families are often the first to adopt Western foods, many of which are energy-dense (high-energy poor-nutrient) and high in sugar, saturated fat and salt[24]. Most research on the nutritional transition in India has focused on globally connected metropolitan areas[5,25,26]. In India, the type of school attended by an adolescent can be a marker of socio-economic status and connectivity. School-going adolescents from higher socio-economic families in the urban Indian cities of Bengaluru[25], Hyderabad[26] and Baroda[27] had more global foods comprising processed foods, fast foods and carbonated beverages in their diets, while rural adolescents across nine states of India had more traditional diets including grains, pulses and green leafy vegetables (GLV)[28]. Adolescents in Hyderabad preferred global fast foods (e.g. noodles and corn flakes) to traditional foods (e.g. *idli*)[26]. Those from higher socio-economic families had higher traditional food group intake including fruits, GLV and dairy products than those from lower socio-economic families[26]. The diets of adolescents in Bengaluru were higher in fat, especially saturated fats, and lesser in carbohydrates[25]. Among adolescents across social strata in Baroda and Hyderabad, half consumed carbonated beverages and over one-third consumed fast foods once or twice weekly[26,27]. We expect that, as private schools tend to have more resources[29,30] and be more globally connected, they may offer more opportunities for learning about and accessing global foods.

Furthermore, studies of child health in India have drawn attention to concerns about differences in resources provided to boys and girls[31–33]. There is persistent concern that girls tend to receive lower-quality food, less food and less expensive food, such as grains rather than milk and fat[31–33]. It is unclear whether there are gender differences in food allocation and how these may change during the nutrition transition. Lower privilege and less freedom of movement for girls may entail that they may have less access to non-local and global foods. We expect socio-economic and gender differences in access to global and non-local foods.

Data on food consumption among adolescents in India have been limited, although food availability is believed to be changing. The present study examines the nutrition transition in a community outside the global metropolitan areas, drawing on a representative study of school-going adolescents in a remote mid-size city in South India. We provide new data on adolescents' food consumption in the context of changing nutritional environments and examine differences therein by gender and socio-economic status. Given the penetration of new foods and beverages from other countries (global) and regions within India (non-local)[7] along with existing ones, we also classify foods and beverages in terms of being traditional, global/non-local or a combination of both.

Methods

Setting

Data are from a representative school-based sample of 407 adolescents aged 13–16 years and their families from a remote mid-size city in Karnataka, South India. With a population of 350 000, Vijayapura city is the main urban centre in the Vijayapura district, which is considered to be an underdeveloped district. The region is undergoing socio-economic development and urbanization through the growth of large-scale industries[34].

Three public (government-funded) and three private schools were randomly selected from schools with grades 8–12 in Vijayapura city. A stratified simple random sample of 201 public-school students (102 boys, ninety-nine girls) and 206 private-school students (105 boys, 101 girls) was drawn from school rosters. The sample size was calculated with the prevalence of unhealthy weight as the outcome, assumed at 40 %, 6 % precision, 95 % CI and a design effect of 1·5. In January–April 2012, adolescents completed a survey at school; additional information was collected from their primary caregiver during a subsequent home visit. Trained interviewers conducted interviews in the local language, Kannada, having obtained informed consent from the caregivers and assent from the adolescents. During training of the interviewers, inter-rater reliability was assessed and low discordance was reported (<10 %).

Variables

Adolescents reported demographic information and primary caregivers provided socio-economic information. A sixteen-item FFQ was developed for the study in collaboration with a trained nutritionist from Karnataka to assess adolescents' consumption of prominent traditional and global foods. The FFQ comprised key foods that are commonly consumed by adolescents. To our knowledge this is the first brief FFQ for adolescents in Vijayapura. We conceptualized foods into three categories, created based on previous literature and the authors' field observations: (i) traditional items, i.e. GLV, non-GLV, fruits, eggs, dairy, tea or coffee, addition of dietary fat (e.g. butter, ghee, oil) to prepared food and homemade Indian sweets; (ii) global or non-local items, i.e. carbonated beverages, packaged foods (e.g. biscuits, chips, chocolates), bakery products (e.g. bread, cakes) and ready-to-eat foods (e.g. instant noodles, packaged cereals); and (iii) mixed items, i.e. non-vegetarian foods (e.g. fish, poultry, mutton), fruit juices, Indian savoury snacks (e.g. *chaats, chooda*) and street foods (e.g. fried samosa, fried fritters). The category of 'mixed items' refers to foods that are both traditional and global or non-local, such as fruit juices, which can include 'traditional' fresh juices made at home or at a restaurant and 'global' bottled fruit juices.

Participants were asked: 'How often in a week do you eat or drink the following foods?' Response categories were 'daily', 'few times per week', 'once per week' and 'less than once per week or never'. For analysis, consumption frequencies were coded as a measure of days per week: daily = 7, few times per week = 3·5, once per week = 1 and less than once per week or never = 0. To measure exposure and access to foods and beverages, the control variables were age, family income, religion and caste. Adolescents provided their age while the primary caregiver provided information on the other control variables. Monthly family income was dichotomized as ≥INR 20 000 and <INR 20 000 ($US 1 = 51·0 Indian Rupees (INR) as of April 2012). Caste was dichotomized as general caste with Other Backward Caste (OBC), Scheduled Tribe (ST) and Scheduled Caste (SC) as the reference category. OBC, SC and ST are terms used by the Government of India to classify socially and educationally disadvantaged sections of the population. The religion variable was also dichotomized: Hindus and Jains were collapsed as the reference category while Muslims, Christians and other minorities were collapsed as the second category.

Statistical methods

The distribution of intake of each item was first examined. All food groups had a normal distribution. Student's *t* tests were used to compare weekly consumption by gender (boy, girl) and type of school attended (public, private). Ordinal logistic regression analysis was used to identify the correlates of weekly intake of each traditional, mixed and global/non-local food. All models were run separately for each food variable with less than once per week or never as the reference category. The variables included in the ordinal logistic regressions were gender, school type, age, family income, caste and religion. Given our hypothesis, we first ran unadjusted ordinal logistic regression models with each food variable as the primary outcome (dependent variable) and gender and school type as the main predictor variables (independent variable; model 1). In the next step of the analysis, we ran adjusted ordinal logistic regression models with both gender and school type as the predictor variables and controlled for age (model 2). We entered age in the model, given that food intakes and food choices may change as individuals become older. The unconfounded effect of age would thus be obtained from this equation. Extending the above model, we ran adjusted ordinal logistic regression models with both gender and school type as the predictor variables and controlled for family income in the presence of age (model 3). Family income, an indicator of socio-economic status, was entered in the model as economic resources may guide food choices[35]. Lastly, we further extended the above model; caste and religion were entered as the third-level variables (model 4) and their associations with the outcomes assessed in the presence of age and family income. Given that religion and caste are also relevant to consumption patterns in India, these were entered in the model[36,37]. To check for robustness, we also carried out multivariate linear regression analysis of the predictors of weekly intake of traditional, mixed and global/non-local foods and beverages. As an additional analysis, the intake frequencies of fruit, GLV, non-GLV and dairy were compared with those recommended under the Dietary Guidelines of India[38].

Eight adolescents were excluded from the analyses: the caregivers of five adolescents did not know or refused to respond to questions about monthly family income and three adolescents could not be interviewed after the initial selection. The final analytic sample was 399 participants. To generate population-representative results of school-going adolescents in Vijayapura, survey weights were constructed to adjust for survey design as the inverse of the probability of selection. Data were analysed using the statistical software package SAS version 9.2.

Results

Demographic and socio-economic characteristics

Adolescents in grades 8–12 were on average 14 years old; 53 % were boys, 80 % ascribed to the Hindu religion, 53 % were classified as OBC and 72 % attended public schools in Vijayapura (Table 1). The majority of adolescents lived in permanent structure (*pucca*) homes (78 %) with a separate room for cooking (86 %) and used gas or electricity for cooking (80 %). The largest number were from families in the second poorest income group (32·5 %) with a monthly income of INR 5001–10 000 ($US 98–196 as of April 2012).

Food consumption patterns

Overall, the foods and beverages that were most frequently consumed by the adolescents were tea or coffee (5·5 d/week), dairy (5·0 d/week), packaged foods (4·8 d/week) and non-GLV (4·7 d/week) and the least frequently consumed foods and beverages (≤1·0 d/week)

Table 1 Demographic and socio-economic profile of school-going adolescents aged 13–16 years in Vijayapura, India (*n* 399)

	Overall		Public school		Private school	
Characteristic†	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI
Age (years)‡	14·3	14·3, 14·5	14·4	14·3, 14·6	14·2*	14·1, 14·3
Boys	53·4	48·0, 58·7	51·8	44·9, 58·7	57·7	50·7, 64·3
Religion						
Hindu	79·5	74·8, 83·5	80·2	74·1, 85·2	77·5	71·0, 82·9
Muslim	17·3	13·6, 21·8	17·4	12·7, 23·3	17·2	12·5, 23·3
Others	3·2	1·9, 5·5	2·4	1·0, 5·7	5·3	2·9, 9·4
Caste						
General	25·3	20·9, 30·3	25·9	20·3, 32·4	23·8	18·3, 30·3
Other Backward Caste	53·1	47·7, 58·4	50·7	43·8, 57·6	59·3	52·2, 66·0
Scheduled Caste and Scheduled Tribe	21·6	17·4, 26·9	23·4	18·1, 29·8	16·9	12·2, 22·9
Monthly family income (INR) ($US)§						
<5000 (<$US 98)	15·2	11·6, 19·5	15·9	11·5, 21·7	13·2*	9·0, 19·0
5001–10 000 ($US 98–196)	32·5	27·6, 37·7	34·3	28·0, 41·1	27·8	22·0, 34·5
10 001–20 000 ($US 196–392)	25·6	21·2, 30·6	25·9	20·4, 32·5	24·7	19·1, 31·3
≥20 000 (≥$US 392)	26·7	22·3, 31·7	23·9	18·4, 30·3	34·3	27·9, 41·2
Size of family‡	5·3	5·0, 5·4	5·0	4·7, 5·3	5·6*	5·2, 6·0
Type of house						
Permanent structure (*pucca*)	78·4	73·6, 82·5	78·6	72·3, 83·7	78·0	71·5, 83·4
Non-permanent structure (*semi-pucca* & *kaccha*)‖	21·6	17·4, 26·4	21·4	16·3, 27·7	22·0	16·6, 28·5
Separate room for cooking						
Yes	86·3	82·1, 89·7	85·1	79·4, 89·4	89·7	84·5, 93·3
No	13·7	10·3, 17·9	14·9	10·6, 20·6	10·3	6·7, 15·5
Type of fuel used in family for cooking						
Gas/LPG, electricity	80·2	75·6, 84·1	81·5	75·4, 86·3	76·8	70·3, 82·2
Wood, kerosene	19·8	15·9, 24·4	18·5	13·7, 24·5	23·2	17·8, 29·7

LPG, liquid petroleum gas.
Data were collected in January-April 2012.
*$P<0·05$.
†Data are presented as percentage and 95 % CI unless indicated otherwise.
‡Continuous variables are presented as mean and 95 % CI.
§$US 1 = 51·0 Indian Rupees (INR), April 2012.
‖*Kaccha* house is a makeshift one wherein the roof and walls are made of mud or dried brick (organic materials). *Semi-pucca* house is also not a permanent structure house, it lack columns and beams but is built with some cement.

were homemade sweets, ready-to-eat foods, non-vegetarian foods, fruit juices and carbonated beverages. Compared with the Dietary Guidelines of India, adolescents consumed fruit 51·4 %, GLV 45·7 %, non-GLV 32·9 % and dairy 28·6 % less frequently and energy-dense foods more frequently than recommended.

The weekly consumption (d/week) of traditional, mixed and global/non-local foods and beverages by adolescents is given in Table 2. Among the traditional foods and beverages, the more expensive ones, including fruit (5·0 *v.* 2·7 d/week; 58 % *v.* 18 % daily), dairy (5·7 *v.* 4·7 d/week; 85 % *v.* 74 % daily or several times per week), homemade sweets (1·1 *v.* 0·4 d/week, 20 % *v.* 5·5 % daily or several times per week) and fat added to prepared food (3·8 *v.* 2·0 d/week, 44 % *v.* 21 % daily), were more frequently consumed by private-school students than by public-school students. The relatively less expensive traditional foods including tea or coffee (5·9 *v.* 4·4 d/week) and eggs (2·0 *v.* 1·0 d/week) were more frequently consumed by public-school students than by private-school students. Girls reported significantly more frequent consumption of non-GLV (5·0 *v.* 4·3 d/week) and fat added to prepared food (3·0 *v.* 2·1 d/week) than boys. Boys reported more frequent consumption of eggs (2·0 *v.* 1·5 d/week; 42 % *v.* 29 % daily) than girls.

Among the mixed foods and beverages, public-school students had significantly higher consumption of snack foods (1·5 *v.* 0·8 d/week), street foods (1·3 *v.* 0·8 d/week) and non-vegetarian foods (0·8 *v.* 0·2 d/week) than private-school students, who had a significantly higher consumption of fruit juices (1·3 *v.* 0·8 d/week; 25 % *v.* 13 % daily). Boys reported significantly more frequent consumption of street foods (1·5 *v.* 0·9 d/week; 28 % *v.* 15 % few times per week) than girls. With regard to the global/non-local foods and beverages, public-school students had a significantly higher consumption of carbonated beverages (1·1 *v.* 0·4 d/week) compared with private-school students and girls reported a significantly more frequent consumption of energy-dense packaged global/non-local foods (5·1 *v.* 4·5 d/week) and ready-to-eat foods (1·5 *v.* 0·8 d/week) than boys.

Differences in consumption of traditional, mixed and global/non-local foods between private- and public-school students and between boys and girls were robust to controlling for age, income, caste and religion (Table 3). Among traditional foods, non-GLV (OR = 0·55; 95 % CI 0·38, 0·81) were less likely to be consumed by boys than girls. Boys were also less likely to add fat to food (OR = 0·49; 95 % CI 0·33, 0·71) than girls. Fruit (OR = 5·46; 95 % CI 3·50, 8·52), dairy (OR = 2·30; 95 % CI 1·41, 3·75),

Table 2 Weekly consumption (d/week) of traditional, mixed and global/non-local foods and beverages among school-going adolescents aged 13–16 years in Vijayapura, India (*n* 399)

	Consumption (d/week)†									
	Overall		Public school (*n* 201)		Private school (*n* 198)		Boys (*n* 200)		Girls (*n* 199)	
Food/beverage item	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI
Traditional										
GLV	3·8	3·5, 4·0	3·8	3·5, 4·1	3·8	3·4, 4·0	3·8	3·5, 4·1	3·8	3·4, 4·1
Non-GLV	4·7	4·4, 4·9	4·6	4·3, 4·9	4·9	4·6, 5·2	4·3	4·0, 4·7	5·0**	4·7, 5·3
Fruit	3·4	3·1, 3·6	2·7	2·4, 3·1	5·0***	4·7, 5·4	3·3	2·9, 3·6	3·5	3·1, 3·8
Eggs	1·8	1·6, 2·0	2·0	1·7, 2·3	1·0***	0·8, 1·2	2·0	1·7, 2·3	1·5*	1·2, 1·7
Dairy‡	5·0	4·7, 5·3	4·7	4·3, 5·1	5·7**	5·3, 6·0	5·0	4·6, 5·4	4·9	4·5, 5·3
Homemade Indian sweets	0·6	0·5, 0·7	0·4	0·3, 0·6	1·1***	0·8, 1·3	0·7	0·5, 0·8	0·6	0·4, 0·7
Extra fat added to prepared food§	2·5	2·2, 2·8	2·0	1·7, 2·4	3·8***	3·4, 4·2	2·1	1·7, 2·5	3·0**	2·6, 3·4
Tea or coffee	5·5	5·2, 5·7	5·9	5·5, 6·2	4·4***	3·9, 4·8	5·4	5·0, 5·8	5·5	5·1, 5·9
Mixed										
Fruit juices	1·0	0·8, 1·1	0·8	0·6, 1·0	1·3**	1·1, 1·5	1·0	0·8, 1·2	0·9	0·7, 1·1
Indian snacks‖	1·3	1·1, 1·5	1·5	1·2, 1·8	0·8**	0·6, 0·9	1·2	1·0, 1·5	1·4	1·0, 1·7
Street foods¶	1·2	1·0, 1·4	1·3	1·1, 1·6	0·8*	0·6, 1·0	1·5	1·2, 1·8	0·9**	0·7, 1·1
Non-vegetarian foods††	0·6	0·5, 0·7	0·8	0·6, 0·9	0·2***	0·1, 0·3	0·7	0·5, 0·9	0·5	0·4, 0·7
Global/non-local										
Carbonated beverages	0·9	0·7, 1·1	1·1	0·8, 1·3	0·4**	0·3, 0·5	0·9	0·7, 1·2	0·9	0·6, 1·1
Packaged foods‡‡	4·8	4·5, 5·0	4·9	4·5, 5·3	4·6	4·2, 4·9	4·5	4·1, 4·9	5·1*	4·8, 5·5
Bakery products§§	2·5	2·2, 2·7	2·6	2·2, 3·0	2·2	1·9, 2·5	2·5	2·1, 2·9	2·4	2·1, 2·8
Ready-to-eat foods‖‖	1·2	1·0, 1·3	1·1	0·9, 1·4	1·3	1·1, 1·6	0·8	0·6, 1·1	1·5**	1·2, 1·8

GLV, green leafy vegetables.
Data were collected in January–April 2012. Results are survey-adjusted. Differences in food consumption between private- and public-school students and between boys and girls were tested using *t* tests.
*$P<0·05$, **$P<0·01$, ***$P<0·001$.
†Weekly food consumption values are presented as mean and 95 % CI.
‡Dairy includes milk and milk products.
§'Extra fat added to prepared food' includes butter, ghee and oil added to prepared food.
‖Indian snacks include *chaats*, *chooda*, etc.
¶Street foods include samosa, *kachori*, etc.
††Non-vegetarian foods include fish, poultry and mutton.
‡‡Packaged foods include biscuits, chips and chocolates.
§§Bakery products include bread, sandwiches, pizza, burgers and cakes.
‖‖Ready-to-eat foods include instant noodles, cereals, etc.

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added fat (OR = 3·25; 95 % CI 2·13, 4·97) and homemade sweets (OR = 2·57; 95 % CI 1·64, 4·01) were more likely to be consumed by those attending private schools than public schools. Alternatively, tea or coffee (OR = 0·28; 95 % CI 0·17, 0·46) was more likely to be consumed by those attending public schools than private schools. Eggs were more likely to be frequently consumed by boys (OR = 2·03; 95 % CI 1·39, 2·95), public-school students (OR = 0·32; 95 % CI 0·21, 0·49) and younger adolescents (OR = 0·81; 95 % CI 0·67, 0·98) than by girls, private-school students and older adolescents, respectively.

With regard to the mixed foods, street foods (OR = 1·88; 95 % CI 1·28, 2·76) were more likely to be frequently consumed by boys than girls. Non-vegetarian foods (OR = 0·20; 95 % CI 0·11, 0·36) and Indian snacks (OR = 0·64; 95 % CI 0·42, 0·99) were more likely to be consumed and fruit juice (OR = 2·12; 95 % CI 1·39, 3·24) was less likely to be consumed by public-schools adolescents than by private-school adolescents. Among global and non-local foods, ready-to-eat foods were more likely to be consumed by private-school adolescents (OR = 1·98; 95 % CI 1·29, 3·03), girls (OR = 0·46; 95 % CI 0·31, 0·68) and younger adolescents (OR = 0·71; 95 % CI 0·58, 0·87) than by public-school adolescents, boys and older adolescents, respectively. Private-school adolescents (OR = 0·54; 95 % CI 0·33, 0·87) and those belonging to the general caste (OR = 0·59; 95 % CI 0·35, 0·97) were less likely to consume carbonated beverages than were public-school adolescents and those belonging to OBC, ST and SC, respectively. Boys (OR = 0·63; 95 % CI 0·43, 0·92) and adolescents in higher-income households were less likely to frequently consume packaged foods (OR = 0·62; 95 % CI 0·41, 0·96) than girls and those in lower-income households, respectively. Results are consistent using multivariate linear regression (see online supplementary material, Supplemental Table 1).

Discussion

With urbanization and globalization, the access to, preferences for and consumption of foods and beverages may be changing in low- and middle-income countries. The present study investigated adolescents' consumption patterns in a remote mid-size city in South India and contextualized foods and beverages in three main categories: traditional foods, mixed foods and global/non-local foods. Overall, compared with dietary

Table 3 Intakes of traditional, mixed and global/non-local foods and beverages (d/week) among adolescents aged 13–16 years in Vijayapura, India (*n* 399). OR ratios and 95 % CI from ordered logistic regression models

	Traditional foods															
	GLV		Non-GLV		Fruit		Egg		Dairy		Added fat		Homemade sweets		Tea/coffee	
Variable	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Gender (ref. = Girl)																
Boy	1·04	0·72, 1·50	0·55**	0·38, 0·81	0·88	0·61, 1·27	2·03**	1·39, 2·95	1·02	0·68, 1·53	0·49**	0·33, 0·71	1·05	0·69, 1·59	1·11	0·69, 1·79
School type (ref. = Public school)																
Private	0·99	0·66, 1·50	1·30	0·84, 1·99	5·46***	3·50, 8·52	0·32***	0·21, 0·49	2·30**	1·41, 3·75	3·25***	2·13, 4·97	2·57***	1·64, 4·01	0·28***	0·17, 0·46
Age (years)	0·96	0·79, 1·15	0·93	0·77, 1·12	0·89	0·74, 1·08	0·81*	0·67, 0·98	1·07	0·87, 1·31	1·07	0·89, 1·30	0·96	0·78, 1·19	0·79	0·62, 1·01
Monthly family income (ref. = <INR 20 000)†																
≥INR 20 000	0·96	0·65, 1·51	1·26	0·82, 1·96	1·33	0·87, 2·03	0·88	0·58, 1·34	0·90	0·57, 1·42	1·04	0·68, 1·60	0·93	0·57, 1·49	1·30	0·75, 2·27
Caste (ref. = OBC and SC and ST)																
General	0·99	0·64, 1·52	1·32	0·84, 2·07	1·37	0·89, 2·13	1·21	0·78, 1·86	1·12	0·69, 1·80	0·79	0·50, 1·23	0·97	0·59, 1·58	0·97	0·56, 1·70
Religion (ref. = Hindu)																
Muslim and others	0·79	0·50, 1·25	0·77	0·48, 1·24	0·81	0·51, 1·29	0·90	0·56, 1·43	0·70	0·43, 1·15	1·16	0·72, 1·85	0·79	0·46, 1·35	1·14	0·62, 2·09

	Mixed foods								Global/non-local foods							
	Non-vegetarian foods		Indian snacks		Street foods		Fruit juices		Carbonated beverages		Packaged foods		Bakery products		Ready-to-eat foods	
Variable	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Gender (ref. = Girl)																
Boy	1·34	0·88, 2·04	1·13	0·77, 1·64	1·88**	1·28, 2·76	1·06	0·72, 1·57	1·03	0·69, 1·56	0·63*	0·43, 0·92	1·04	0·71, 1·50	0·46**	0·31, 0·68
School type (ref. = Public school)																
Private school	0·20***	0·11, 0·36	0·64**	0·42, 0·99	0·70	0·46, 1·09	2·12***	1·39, 3·24	0·54**	0·33, 0·87	0·80	0·53, 1·23	0·86	0·58, 1·29	1·98**	1·29, 3·03
Age (years)	0·93	0·75, 1·14	0·94	0·78, 1·14	1·13	0·94, 1·37	0·81*	0·67, 0·99	0·92	0·75, 1·13	0·92	0·75, 1·11	0·95	0·80, 1·14	0·71**	0·58, 0·87
Monthly family income (ref. = <INR 20 000)†																
≥INR 20 000	1·03	0·64, 1·66	1·13	0·52, 1·23	1·13	0·73, 1·74	1·03	0·66, 1·60	0·98	0·61, 1·57	0·62*	0·41, 0·96	0·94	0·62, 1·41	1·24	0·80, 1·92
Caste (ref. = OBC and SC and ST)																
General	1·11	0·68, 1·80	0·81	0·52, 1·23	0·64	0·41, 1·01	1·01	0·64, 1·60	0·59*	0·35, 0·97	1·12	0·71, 1·75	1·27	0·83, 1·93	1·17	0·74, 1·84
Religion (ref. = Hindu)																
Muslim and others	1·44	0·86, 2·42	0·90	0·56, 1·44	1·22	0·76, 1·95	0·95	0·58, 1·56	0·90	0·54, 1·50	1·43*	0·87, 2·35	0·97	0·62, 1·52	1·21	0·74, 1·98

GLV, green leafy vegetables; ref., reference category; OBC, Other Backward Caste; ST, Scheduled Tribe; SC, Scheduled Caste.
Data were collected in January–April 2012. Results are survey-adjusted.
$*P < 0·05$, $**P < 0·01$, $***P < 0·001$.
†$US 1 = 51·0 Indian Rupees (INR), April 2012. Family income was asked over a month.

guidelines, adolescents consumed energy-dense foods more frequently than recommended and consumed fruit, GLV, non-GLV and dairy less frequently than recommended[38]. Adolescents' exposure to global, non-local and traditional foods is showing resemblance to levels reported in urban areas. Still, dietary quality seems to be better in this remote mid-sized city than in Indian metropoles, with moderate intakes of GLV, fruits and dairy (~3·5–4 d/week) and low intake of homemade sweets (~0·6–2 d/week)[26,27,39].

The Dietary Guidelines of India recommend daily intake of GLV and fruits[38] while the WHO recommends a daily intake of 400 g of fruits and vegetables to prevent chronic diseases and micronutrient deficiencies[40]. In our study, only 29 % ate GLV and fruits daily while 10 % did so less than once monthly or not at all. A study in two Indian cities showed that all adolescents aged 12–14 years consumed GLV at least once weekly and those in the higher socio-economic group consumed GLV almost daily[25], so our population may be better off. Studies worldwide, including in India, have reported low fruit and vegetable intakes among adolescents from low-income households[26,41]. Data from across thirty-five countries indicated that adolescents ate fruit on average 2·8–5·0 d/week, vegetables 2·4–5·5 d/week and sweets 2·6–5·0 d/week[42]. In comparison, Vijayapura adolescents had less frequent consumption of fruit (0·8 to 6 d/week) and sweets (0·6 to 1·8 d/week) but similar frequency of GLV (1·5 to 6·2 d/week) and non-GLV (2·4 to 7·0 d/week). The majority of adolescents (91 %) in our study consumed homemade sweets less than once weekly, contrary to recent reports of increasing consumption of sweets among children and adolescents in Asia[39,43]. The infrequent weekly intake of homemade sweets may be due to their high cost and the traditional practice of making them mainly during festivals or special family occasions such as weddings.

In our study, the more frequent consumption of processed global/non-local foods among public-school students than among private-school students may be explained by the availability of low-cost versions of branded processed foods, produced to cater to low-income groups and to fit local tastes[22]. These unregulated cheaper and often lower-quality foods could worsen nutritionally poor diets[22]. Our findings align with reports from urban areas that biscuits and salted snacks are being eaten more over the past two decades and that low-cost fried and processed foods are a key feature of the nutrition transition in India[4,44,45]. Frequent consumption of processed foods has been reported to be associated with nutrition-related non-communicable diseases among adolescents[22,45,46]. Contrary to reports of increasing consumption of carbonated beverages documented among adolescents in Asia in the past few decades[39,43], the majority of adolescents (85 %) in our study consumed carbonated beverages less than once weekly. The low consumption of carbonated beverages may be due to their relatively higher cost (e.g. 200 ml Pepsi at INR 8 and 500 ml Pepsi at INR 20) when compared with the ready availability of cheaper alternatives for ≤INR 5 such as juice on street carts, ice candy, biscuit, chips, etc. that adolescents could purchase.

Food prices in relation to family income can affect a family's purchasing decisions. In our study, traditional but expensive foods including fruits, dairy, added fat and homemade sweets were more frequently consumed by private- than public-school adolescents. The National Family Health Surveys (NFHS 2)[47] and a study in Hyderabad, India[48] both reported higher intakes of milk and fruits among children of higher income groups. In our study, 41 % of adolescents attending public schools but only 22 % of those attending private schools consumed eggs daily or a few times weekly. Eggs (raw and boiled) are sold mainly on street carts placed outside centrally located public schools and markets in the city for INR 5–6 ($US 0.07–0.09) each (as of April 2012) that make them accessible to public-school students. The intake of eggs may be also be driven by religion or caste. Although eggs are often not consumed by some religious groups (e.g. Jains)[36], we did not find significant differences in egg intake by religion or caste. Adolescents drank tea and coffee frequently (~5 d/week), with 82 % of public-school adolescents and 60 % of private-school adolescents consuming daily. Only 63 % of adolescents consumed dairy daily and 22 % had dairy less than once weekly. Drinking tea or coffee cooked with milk does not provide the same nutritional benefits as consuming milk, known to be rich in protein and calcium. Drinking tea or coffee instead of milk is likely a result of cultural norms and the high cost of milk (INR 30–40 per litre as of April 2012), which could explain higher tea or coffee intake by public- than private-school adolescents.

In addition to food prices, religion, caste and gender norms are also relevant to consumption patterns in India. For the majority of people in India, particularly those of Hindu religion, food habits are driven by religious vegetarianism[36,37]. With increasing incomes, studies have reported increased intake of animal-source foods[3,49]. In addition, for much of history, people may have liked to eat non-vegetarian foods but were effectively vegetarian because of lack of access. In our study, public-school adolescents more frequently consumed non-vegetarian foods, Indian snacks and street foods compared with private-school adolescents after accounting for age, gender, caste and religion. More frequent intake of non-vegetarian foods among public- than private-school adolescents in our study, as also reported in Hyderabad[26], could be an indicator of changing food access and norms reflecting globalizing diets. More frequent egg and street food consumption by boys may be a result of gender and cultural norms that allow boys more access to foods believed to be strength-building, like eggs and meat, and to be away from home or outdoors more than girls. The cultural norms and religious taboos around eating eggs and meat may also be a barrier for girls more than for boys.

Our study has some limitations. Dietary assessment methods, including FFQ, may be limited by children's inadequate knowledge of and difficulty in estimating the foods they consume[50]. Still, by age 8–10 years, children can report their food intake as reliably as their parents[50]. Furthermore, minimal food recall difficulty is expected, as a weekly, not monthly or yearly, FFQ was used. There may be gender differences in perceiving or reporting food consumption. For example, boys may under-report adding fat to food because cultural norms have mothers in traditional Indian households typically serving children's food. Mothers would add extra fat to food while serving but may also follow this practice more so for boys than girls. More frequently adding fat to food among girls than boys could also be explained by the belief that consuming ghee will help girls build strength to sustain future childbirth. Another consideration is that our FFQ used only sixteen food groups and did not explicitly ask about some major food groups such as pulses and grains. The FFQ was designed to capture prominent traditional and global foods, and so was well suited to address the research topic of the study.

The current study presents several strengths and contributions. While many studies from India have focused on urban areas, our research was in a prototype remote city that is traditionally underdeveloped but undergoing urbanization and experiencing new exposure to non-local and global trends. This setting is particularly well suited to investigate adolescents' dietary patterns in a globalizing context. Our sample was representative of school-going adolescents from across the socio-economic spectrum in this setting. We have also proposed a way of categorizing foods and beverages as traditional, mixed and global/non-local that contextualizes the components of a diet in terms of the nutrition transition. Lastly, our study quantified differences in consumption according to gender, school type attended, and access to foods and beverages.

Conclusions

Adolescents' eating patterns in a globalizing Indian city reflect a combination of global/non-local and traditional foods, access and preferences. Adolescents' exposure to global, non-local and traditional foods is beginning to mirror urban levels reported in more metropolitan areas. Girls reported more frequent consumption of energy-dense traditional, mixed, and global or non-local foods and boys reported more frequent consumption of eggs and street foods. As global and non-local foods continue to emerge but have not yet overwhelmed the local culture in rural and urbanizing communities in low- and middle-income countries, it may be possible to intervene at this stage to promote healthy eating behaviours among the youth. An important direction for future research will be to understand emerging dietary patterns and preferences that can inform efforts to promote dietary diversity and healthful food consumption.

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Supplementary material

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