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Smartphone-based assessment of food environment, diet and obesity risk

Author
Hua, Jenna

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Smartphone-based Assessment of Food Environment, Diet and Obesity Risk

By

Jenna Hua

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Committee in charge:

Professor Robert Spear, Chair
Professor Edmund Seto
Professor Alan Hubbard

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Abstract

Smartphone-based Assessment of Food Environment, Diet and Obesity Risk

By

Jenna Hua

Doctor of Philosophy in Environmental Health Sciences

University of California, Berkeley

Professor Robert Spear, Chair

300 million adults and 16 million children in China are now obese. The rapid economic development, urbanization and associated environmental changes occurring in China are thought to be responsible for this growing obesity epidemic. My dissertation research has gradually developed into four interconnected parts which are presented in Chapter 1, 2, 3 and future work. First (Chapter 1), culturally specific food environment survey instruments were developed and used to document the longitudinal changes in food availability in six representative neighborhoods in Kunming via field audits. Second (Chapter 2), to pilot test our integrated methodology, a 12-person cohort was recruited in Kunming, and individual dietary behavior was modeled and topologies were proposed. Third (Chapter 3), to further test our methodology on a larger cohort aiming to examine the relationship between food environment and sugar-sweetened beverage consumption, we worked with Carolina Population Center on their China Beverage Validation Study in urban and rural Shanghai. Lastly (future work), to examine the health impacts of the changing food environment, a 300 adolescent cohort was recruited from two high schools in Kunming, and followed for two years. Their dietary, physical activity, mental, social and physical changes were assessed via traditional research surveys, smartphone-based activity tracking and Internet datamining. Preliminary results on the cohort's BMIs are presented.

For mom, dad, Jimmy and Carol

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Introduction

The United Nations predicts that by 2020, half of the world's population will be urban and that Asia alone will contain more than half of that population (1) Urbanization is changing the way people live at a pace faster than that experienced by industrialized nations such as the U.S. in the last century. These lifestyle changes have affected health-related behaviors such as diet and physical activity, which are major determinants of energy balance and obesity and other non-communicable diseases development. Among adults, more than one billion are overweight and at least 300 million are clinically obese (2, 3). Current obesity prevalence rates range from 5% in China, Japan and certain African nations to over 75% in urban Samoa (4). However, developing countries that have seemingly low obesity rates such as China have been experiencing steep increases in urban areas. Urbanization has resulted in significant changes in the built environment including the emergence of supermarket and fast food chains as the food industry responds to increasing demand for convenience foods. These changes have been referred to as the "nutrition transition" (4, 5). Related to demographic and epidemiologic transitions, the nutrition transition is a risk transition, in which shifts in diet occur with economic development, urbanization, and technology and cultural changes increase obesity risk. Not only is the transition characterized by diets high in saturated fats, sugar, animal source foods, and refined foods low in fiber -- the Western diet – but concurrent with the transition, are decreases in physical activity, and increases in sedentary activity, most notably through the introduction of motorized transport and television ownership, as well as cumulative exposures to various stressors of modern society.

Research on obesity in western industrialized nations such as the United States has begun to focus on environmental changes that have been taking place over the past 4-5 decades; however, relatively little research has been conducted in developing countries. While there is evidence to show that these environmental changes have decreased the accessibility of fresh produce and opportunities for physical activity (6), and have increased the accessibility of unhealthy processed and fast foods (7-9), less is known about the impact of these changes on obesity development, and the social, cultural and biological mechanisms that may explain how environmental changes affect obesity risk. Unless more rigorous research is conducted in these rapid urbanizing and developing countries, and effective intervention strategies are applied, obesity and other chronic disease rates are expected to rise.

Despite many obesity risk studies focused on energy balance, and the associations between obesity and food environments, most have been constrained by deficiencies in methodologies for assessing personal dietary and physical activity patterns, as well as food environment exposures. Current methodologies used in tracking diet and physical activity suffers from several limitations including physical activity and diet misclassification, recall bias, and usability and participant fatigue issues. Additionally, many food environment studies have overlooked the importance of personal perceptions on availability, accessibility, affordability, accommodation and acceptability of the food environment (10). For example, dietary assessment using 24-hour or 72-hour recall is inaccurate without a recall interview by a registered dietitian, which is extremely time-consuming and costly. On the other hand, food frequency questionnaires (FFQs) are underdeveloped for culturally diverse populations. Food environment research uses secondary databases obtained publicly or privately, and typically determines exposure based on establishments around home, school or work addresses; however, such databases largely do not exist for developing countries. Moreover, food environments around home, school or work do not fully capture where one shops for food or eats, or take into account a person's time-activity space or interpersonal interactions.

Most of the above challenges can be addressed with the advances in smartphone and personal sensing technologies. Both diet and physical activity patterns and their locations can be tracked continuously in real-time using the smartphone, and these records can be supplemented via Ecological Momentary Assessment (EMA) – a short survey programmed in the phone to capture an individual's at-the-moment self-reported emotions, perceptions and behaviors in their normal environment (11). Additionally, with the availability of large geospatial data that can be mined through Google and other Internet sources, there are now unprecedented opportunities for researchers to integrate objective measurement of actigraphy, time-location activity, and geospatial built and social environmental exposure metrics for assessing risk factors contributing to the obesity epidemic.

The goals of my dissertation research are to utilize and integrate technologies and available data sources to develop and validate new methodologies in assessing diet and physical activity patterns and built environment exposures, and to use these new methods to examine the relationships between personal food environment exposures, diets and obesity risk in a susceptible population in a rapidly urbanizing environment. If my goals are achieved, I will have generated new methods and data in personal sensing and food environment exposure assessment that allow us to better understand food environment's impact on personal dietary behavior, which can inform future research, provide insights into possible personalized interventions, and enhance our knowledge on food environment and its implication in China.

My dissertation research has gradually developed into four interconnected parts which are presented in Chapter 1, 2, 3 and future work. First (Chapter 1), culturally specific food environment survey instruments were developed and used to document the longitudinal changes in food availability in six representative neighborhoods in Kunming via field audits. Second (Chapter 2), to pilot test our integrated methodology, a 12-person cohort was recruited in Kunming, and individual dietary behavior was modeled and topologies were proposed. Third (Chapter 3), to further test our methodology on a larger cohort aiming to examine the relationship between food environment and sugar-sweetened beverage consumption, we worked with Carolina Population Center on their China Beverage Validation Study in urban and rural Shanghai. Lastly (future work), to examine the health impacts of the changing food environment, a 300 adolescent cohort was recruited from two high schools in Kunming, and followed for two years. Their dietary, physical activity, mental, social and physical changes were assessed via traditional research surveys, smartphone-based activity tracking and Internet datamining. Preliminary results on the cohort's BMIs are presented.

Chapter 1. Development and Evaluation of a food environment survey in three urban environments of Kunming, China

Background

The rates of obesity among children and adults in the United States are alarming [12,13] and are responsible for staggering medical costs [14]. Elsewhere, the World Health Organization has declared obesity a global epidemic [15]. Considerable research has been conducted on the complex etiology of obesity, with environmental factors now thought to play an important role in influencing physical activity and diet [16-18]. Given the rapid pace of environmental change, urban development, and Westernization that is occurring in second and third world countries, there is great urgency to better understand the effect of the built environment on obesity and its behavioral risk factors in developing regions of the world. Indeed, in China, obesity rates among children have tripled in just two decades, from 1982 to 2002, reaching rates comparable to those in Western countries [19]. While some well-established larger cities in China already have high rates of obesity [19,20], medium sized cities that are still rapidly developing and currently have relatively lower rates of obesity are opportune sites for place-based research to understand the associations between the changing built environment and obesity. According to epidemiological studies conducted in one such medium sized Chinese city, Kunming, in 2008, it was estimated that 26% of the adults were overweight [21]. Moreover, in Kunming, the childhood obesity rate in 2008 was 36% higher than it was in 1996, and three times higher than it was found to be in 1986 [22].

Chinese adolescents who grew up in the 1990s during a period of rapid social and environmental change had increasing access to Western fast food and exposure to new technologies and media that market such food, including the Internet and smartphones. Nearly all were born under China's one-child policy, and were the center of the attention of two generations, giving them the ability to concentrate on their education, but also enormous pressure to meet their parents' and grandparents' high expectations. At the same time, students at this age are highly susceptible to peer pressure [22-26], which influences their dietary patterns and other aspects of their behavior.

Numerous studies have reported associations between food-related aspects of the environment and obesity risk [27-31]. In the U. S. and other Western countries, this research has largely relied on the existence of business, land use, and tax record databases from governmental and commercial sources to characterize the food environment [28,32]. However, similar databases are not readily available for rapidly developing countries like China. Moreover, even if such databases were available, their validity would need to be assessed using field surveys.

Field survey instruments can be used to obtain detailed food environment data and to ground-truth food establishment databases. Such instruments allow for quantification of the number of food establishments in neighborhoods, as well as characterization of various aspects of the food offered by these establishments, including the availability and price of fresh and prepared foods that make up typical diets [33,34]. Field survey instruments need to be both reliable and valid. They need to be reliable in that ratings made by different surveyors need to be consistent. Also, among various validity measurements, construct validity is particularly important as it considers how the measures of the instrument relate to the overall theoretical hypotheses [35] – in our case, that the food environment is associated with weight status.

While reliable field survey instruments exist within the Western context [36-39], to our knowledge, no equivalent instruments currently exist to assess the food environment in China. Due to cultural differences in food availability and eating habits, survey instruments used in Western countries cannot be readily applied to China without modification. The development of a culturally appropriate and constructively valid survey instrument for characterizing the Chinese food environment is a critical step toward future studies on the evolution of food environments in a rapidly developing economy and its effects on the health of populations.

The objectives of this study are to: (1) develop a survey instrument for assessing the food environment in China; (2) assess its reliability in a rapidly developing Chinese city; (3) assess its construct validity for the hypothesis that the amount of fast food and packaged food in a Chinese community is positively associated with adolescent weight status; and (4) describe the density and types of food establishments in socioeconomically contrasting neighborhoods in such a city.

Methods

Survey instrument development

We developed two survey instruments: one to assess retail food stores and another to assess restaurants. To determine appropriate survey items, we reviewed the literature on food environment assessments via Google Scholar and PubMed, supplemented with a "snowballing" method to search for other relevant information. We found no existing tools appropriate for use in China, as the surveys that are used to assess food environment in United States were culturally inappropriate for the Chinese food environment, specifically the types of foods that are typically on restaurant menus and in food stores. However, the Nutrition Environment Measures Survey (NEMS) instrument used in the U.S. [36,39] provided ideas for conceptualizing the survey instruments, which we created with the assistance of our local Chinese collaborators at the Kunming Medical University. Both instruments (for store and restaurant assessment, see appendices) were designed so that they could be completed within 10 minutes for a single food establishment by surveyors working independently, without disturbing the store or restaurant staff. The survey items and rationale for their inclusion are described in Tables 1 and 2. The two instruments were pretested for wording and content at restaurants, grocery stores and wet markets (open markets where stalls of fresh and prepared foods are sold by different vendors) in Kunming, and then finalized for pilot testing in three socio-demographically contrasting neighborhoods.

Table 1 Items captured by the survey instrument for assessing stores

Item	Rationale/How measured
Date	Essential food establishment data that allows for identification, geocoding, and time stamping.
Survey start time, Survey end time	
Food establishment name	
Street address	
GPS reading	
Hours of operation	
Type of store	For classifying the stores (13 possible types). Categories are modified from those developed by the North American Industrial Classification System (NAICS) [40] used by the United States to classify food establishments. Specifically for Chinese context, even though both are selling cooked or prepared food, a deli is attached to a restaurant, and a take-out store is a stand-alone store. Check all that applied.
Wet market, supermarket, small market, convenience store, convenience store attached to a gas station, deli, take-out, bakery, street stand/cart, dessert/fruit juice, tobacco/alcohol shop and others	
Store size	Possibly a proxy for food variety. Estimated by assessing the length of a single floor tile and counting the number of perimeter tiles of each rectangular section of a store. (All stores had tiled floors)
Length and width	
Types of Items sold	For assessing the availability of basic food items. Nine basic food items were assessed. Food item categories were determined by in-person store visit and consultation with local collaborators.
Soy products (raw), packaged foods, frozen meals, fresh cooked/prepared foods, basic grain products, processed/preserved dried meat and seafood, cooking oil, cleaned/easy-to-cook/combo meals, and cold desserts/ice cream	
Indicator food items	For assessing the availability of specific food items that are indicative of either a healthy or unhealthy diet. Fourteen indicator items were assessed. If available, shelf space and product location were further assessed (see below)
Salty snack, sweet snack, sweet drinks, alcohol, milk/yogurt, bottled water, powdered drinks, tea, instant noodles, pastry/baked goods, tofu products (packaged snack), fruits, vegetables and fresh meat/poultry	
For indicator food item that is present:	Shelf space assesses whether the indicator item occupies a significant amount of shelf space (significant or not). If certain products occupy more than half of the shelf space, it is counted as significant.
Shelf space and product location	Product location assesses whether the location of the item is in the front, middle, or back of the store.

Table 2 Items captured by the survey instrument for assessing restaurants

Restaurant survey variables	Rationale/How measured
Date	Essential food establishment data that allows for identification, geocoding, and time-stamping
Survey start time, Survey end time	
Food establishment name	
Street address	
GPS reading	
Hours of operation	
Type of restaurant	Categorization the restaurant. 14 possible types. Check all that applied. A distinction was made between establishments that sold prepared foods: if they had 5 or more seats, they were defined as restaurants, otherwise defined as a store.
Sit-down, take-out, western fast food, café, Chinese fast food, street stand/cart, food court, deli, bakery, bar, tea house, dessert, juice bar and other	
Restaurant size	Seating capacity in number of persons or number of tables
Seating capacity	
Type of food served	Assess availability of certain types of foods that are common to this city. 11 types. Check all that applied.
Vegetarian, vegan, organic, dim-sum, seafood, noodles, regional cuisine, Muslim, buns/pancakes, deep-fried, and other	
Drinks	Assess availability of certain types of drinks that are common to this city. 10 types. Check all that applied.
None, soda, juice, alcohol, tea, coffee, bottled water, yogurt, flavored milk, and other	
Was a take-out menu available?	Yes/no
Was a flyer available?	Yes/no
Advertisement	Assesses whether the restaurant advertises their food. Check all that applied.
None, local TV station, phone directory, newspaper, and other	
Display of business license	Indication of potential food quality. Yes/no.
Website	Indication of new forms of advertising. Yes/no.
Nutrition information available	Yes/no
Signs encouraging overeating	e.g., all-you-can-eat, super-size, jumbo, extra-large descriptors on menu or signage. Yes/no
Promotions	e.g., low-carb, low-fat, low-cholesterol. Yes/no.
Portion size choices	Check if small, medium and large portions sizes are sold. Check all that applied
Price range	Range of pricing for vegetable dishes, meat dishes, and other dishes
Vegetable, meat, and others	

Study area

Kunming is a rapidly developing city that is the capital of Yunnan province, located in the southwest region of China neighboring Tibet, Laos, Vietnam and Burma. Yunnan province has an ethnically diverse population consisting of Han and numerous ethnic minority groups. Because of its geographic location and recently recognized potential to serve as an international logistics center, Kunming has begun to link China with other Southeast Asian countries and is undergoing faster and more dramatic urbanization and environmental change than Beijing or Shanghai did during their peak development periods. Moreover, recent studies suggest that the prevalence of adult overweight and childhood obesity is becoming an increasing problem in Kunming [26,41]. Unless effective intervention strategies are applied, obesity-related chronic disease rates are expected to increase dramatically [21,42].

Neighborhood Selection

Three neighborhoods varying in distance from the center of Kunming were selected. Like many other Chinese cities, Kunming has concentric ring roads, which radiate from the city center and divide the neighborhoods of the city. Similar to the spatial urban development patterns in many Chinese cities, Kunming was developed according to proximity to the city center. Our study's first neighborhood was situated within the first ring road, the second between the first ring road and the second ring road, and the third outside of the second ring road (Figure 1). These three neighborhoods vary in real estate prices, development histories, and land use characteristics (Table 3). In general, the more central areas of the city are older, with higher real estate and living costs, while the less costly outer areas consist of mixtures of urban slums, migrant worker areas, and newer developments that are rapidly replacing older communities. Because socio-demographic data at the neighborhood level was unavailable, we used the average neighborhood real estate prices as a proxy. In each neighborhood, the food environment assessments were carried out on a 1-km stretch of street with visibly high food establishment density. After areas in each neighborhood with high food establishment densities were identified by searching key terms (food establishments, restaurants, food stores, convenience stores, supermarkets and wet markets) at Google and Baidu Maps, 3 streets with highest food establishment densities were identified visually and ranked from first choice to third choice. Distances of 1-km were measured using built-in rulers in Google and Baidu Maps. Prior to conducting surveys, researchers visited the identified streets in each neighborhood to verify the existence and density of the food establishments, and made the final selection of a 1-km stretch of street in each neighborhood.

Figure 1 Neighborhood Locations

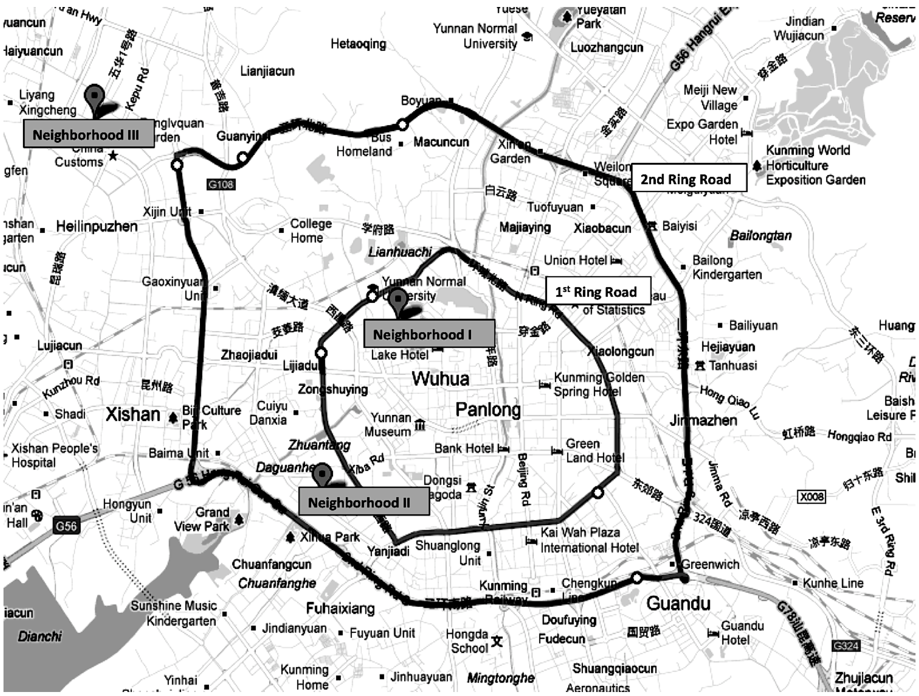


Table 3 Neighborhood Characteristics [32]

Neighborhoods	Location	Average Real Estate Price (RMB/m^2) in 2010	Development History	Primary Land Uses
Neighborhood I (Wenlin)	Within the 1st Ring	13,000	Oldest	Residential, higher education site nearby
Neighborhood II (Ankang)	Between the 1st and the 2nd Ring	9,000	Newer	Residential
Neighborhood III (Shangyuan)	Outside the 2nd Ring	7,500	Newest	Residential, higher educational institution nearby

Reliability

To assess the inter-rater reliability of the instrument, two pairs of trained student researchers, attempted to survey all food stores and restaurants on each of the pre-selected 1-km stretches of street in the three neighborhoods. Surveys were conducted on weekdays between 10 am and 6:30 pm in July of 2011, with the two pairs of researchers surveying different neighborhoods on a given day to blind each pair to the other pair's activities. If there was any discrepancy between the two researchers within a pair, both returned to the store or restaurant to make another observation and come to a mutual decision before completing the survey instrument. Having two researchers in a team permitted more efficient and accurate data collection in the field. The student researchers also measured the geographic location of each food establishment by using a GPS unit (Garmin 62S). This paper did not use the geographic location data collected; however, these data may be useful in the future to validate web-based secondary data sources on the food environment such as Google and Baidu Maps. The observations of the two pairs of researchers were compared using appropriate statistical methods as described below.

Evaluation/Validity

To evaluate and assess the construct validity of the instrument, measured heights and weights, as well as approximate home addresses of 575 adolescents from year 2011 were obtained from a local high school. These data were from the high school's routine annual physical assessments of students. The selected high school was located between the first ring and second ring road, but has a wide catchment for students, who lived in various regions of the city. Home addresses were identified by neighborhood, which allowed us to categorize each adolescent's home location in terms of the ring roads. Subjects with missing addresses were excluded from the analysis. Using both the data from the food environment surveys and this cohort's data, we determined the extent to which the prevalence of western-style fast food restaurants and convenience stores (both tending to sell high fat and high caloric foods) is associated with higher prevalence of adolescent overweight and obesity. Adolescents' weights, heights and approximate home addresses were recorded by the researchers without personal identifiers. Use of these de-identified data was approved by the Ethics Committees at Kunming Medical University and the University of California, Berkeley.

The weight statuses of the 575 adolescents were determined by calculating their body mass index (BMI) using their weight in kilograms divided by height in meters, squared. The BMIs were categorized into underweight, normal, overweight and obese. Because there was no single gold standard for BMI criteria for a Chinese population, we used five different BMI cutoffs to demonstrate different distributions of overweight and obese in the cohort. The five BMI cutoffs included those established by the Capital Institute of Pediatrics (CIP) and Working Group on Obesity in China (WGOC), International Obesity Task Force (IOTF), World Health Organization (WHO) and Center for Disease Control (CDC) [44-52]. Additionally, IOTF has two cutoffs, one specifically for Asians. Mean BMI and percentage of overweight adolescents were tabulated by different ring road locations for different genders and ages.

Data analysis

Differences in counts of different types of food establishments and numbers of overweight or obese by neighborhood were assessed via Fisher's exact test. For comparisons between dichotomous variables, chi-square test was used. The inter-rater reliability of categorical variables was assessed by calculating the percentage of agreement and Cohen's kappa statistic:

$$\% agreement = \left(A / N\right) \times 100$$

$$\kappa = \frac{\Pr\left(A\right) - \Pr\left(E\right)}{1 - \Pr\left(E\right)}$$

where A is the number of times an item was categorized similarly by the two teams, and N is the number of stores/restaurants survey by both teams; and kappa is the probability of agreement Pr(A), adjusted by the probability of chance agreement Pr(E). Differences in the means of continuous variables estimated by the two teams were assessed with Student's t-test. All tests used statistical significance level of p value less or equal to 0.05, and data analyses were conducted using STATA 11.2 (StataCorp, College Station, TX, 2012).

Results

Neighborhood comparison

A total of 273 food establishments including 163 restaurants and 110 retail stores were located on the 3 pre-selected 1-km stretches of street; data were obtained by both teams on 141 restaurants and 84 retail food stores, and these data were used to calculate inter-rater reliability. The unmatched 48 food establishments that were surveyed by only one of the teams were attributed to food establishments that were not open at the time of survey, as well as food establishments located at the intersection of the selected survey streets and adjacent streets. Sit-down restaurants accounted for almost 40% of restaurants, while take-out restaurants accounted for 21%. Fast food restaurants (both Western and Chinese) accounted for 19% of restaurants.

Among retail food stores, tobacco and alcohol shops accounted for nearly 25% of all stores, while take-out stores, convenience stores, and supermarkets accounted for 14%, 12% and 11% of all stores surveyed, respectively. In addition, there were just two wet markets (open markets that sell fresh produce and meats) in the three neighborhoods surveyed.

With only one street in each of the three neighborhoods sampled, our main objective was not to explore the relationship between neighborhood characteristics and food establishment counts. Nevertheless, we noted that the types and distributions of food establishments varied among the three neighborhoods (Tables 4 and 5). A restaurant or store could be classified into more than one category. For example, a sit-down restaurant selling western fast food would be classified as a sit-down restaurant and also a western fast food outlet. Neighborhood I (the oldest and most expensive neighborhood in the center of the city) had the highest restaurant count, while Neighborhood III (the newest and least expensive neighborhood on the city outskirts) had the second highest restaurant count. Interestingly, the neighborhood that had the highest restaurant count (Neighborhood I) also had the lowest store count. It was also observed that that in the city center, western-style fast food restaurants were prevalent (13 in Neighborhood I vs. 0 and 2 in Neighborhoods II and III respectively), while on the city outskirts, Chinese-style fast food restaurants were relatively more common than western-style fast food restaurants (9 in Neighborhood I vs. 15 and 7 in Neighborhoods II and III). Further, bars and cafes serving snacks/pastries were much more prevalent in Neighborhood I than in the other neighborhoods.

Table 4 Distribution of restaurants by neighborhood

Restaurant Type	Total Count[δ]	%	Neighborhood I Count	I %	II Count	II %	III Count	III %
Sit-down	95	39.3	34	29.3	24	44.4	37	51.4
Take-out	52	21.5	20	17.2	12	22.2	20	27.8
Chinese fast food	31	12.8	9	7.8	15	27.8	7	9.7
Western fast food	15	6.2	13	11.2	0	0	2	2.8
Café (snacks/pastries)	14	5.8	12	10.3	0	0	2	2.8
Other	13	5.4	9	7.8	1	1.9	3	4.2
Bar	12	5	12	10.3	0	0	0	0
Tea House	6	2.5	4	3.5	1	1.9	1	1.4
Bakery	2	0.8	2	1.7	0	0	0	0
Food court	1	0.4	1	0.9	0	0	0	0
Deli	1	0.4	0	0	1	1.9	0	0
Total	242	100	116	100	54	100	72	100

[δ] **Categories are not mutually exclusive and a restaurant/store may be counted in more than one category.**

Table 5 Distribution of retail food stores by neighborhood

Store Type	Total Count[δ]	%	Neighborhood I Count	I %	II Count	II %	III Count	III %
Tobacco & Alcohol	20	23.8	5	26.3	13	31	2	8.7
Take-out	12	14.3	0	0	8	19.1	4	17.4
Convenience store	10	11.9	5	26.3	3	7.1	2	8.7
Supermarket	9	10.7	1	5.3	4	9.5	4	17.4
Other	8	9.5	2	10.5	6	14.3	0	0
Bakery	6	7.1	2	10.5	3	7.1	1	4.4
Dessert/Fruit Juice	5	6	0	0	0	0	5	21.7
Small Market	4	4.8	2	10.5	1	2.4	1	4.4
Deli	4	4.8	0	0	2	4.8	2	8.7
Newspaper Stand, Street Stand/Cart	4	4.8	2	10.5	0	0	2	8.7
Wet Market	2	2.4	0	0	2	4.8	0	0
Total	84	100	19	100	42	100	23	100

[δ] **Categories are not mutually exclusive and a restaurant/store may be counted in more than one category.**

Characteristics of foods available

Selected characteristics of the most common foods offered by restaurants and stores are summarized in Tables 6 and 7. In restaurants, meat dishes tended to be more expensive than vegetable dishes, except at western fast food restaurants. Western fast food restaurants were more likely to offer deep-fried foods than Chinese sit-down, take-out, or even Chinese fast food restaurants. Interestingly, they were also more likely to offer dim-sum (bite-sized foods such as Chinese dumplings) than the other 3 common restaurant types. Chinese fast food consisted mainly of regional cuisine and noodle establishments. In terms of beverages, soda was available at most restaurants whereas bottled water was seldom available. Alcohol of various sorts was available at most restaurants except at sit-down restaurants. Most of the restaurants did not participate in any type of advertising although 3-13% had websites. Messages that encourage overeating such as “all-you-can-eat” promotions were visibly absent from the restaurants surveyed.

Table 6 Characteristics of four restaurant types

	Restaurant Type			
	Sit-down	**Take-out**	**Western fast food**	**Chinese fast food**
Number of establishments	100	54	16	34
Seating capacity, mean(SD) persons	81.6 (92.6)	57.0 (77.6)	96.4 (95.8)	103 (128)
Type of food served				
Vegetarian, Vegan, or Organic	1%	2%	6%	0%
Dim-sum	31%	28%	69%	24%
Seafood	17%	9%	6%	26%
Noodles	29%	35%	19%	38%
Regional cuisine	24%	20%	0%	44%
Muslim	1%	2%	0%	3%
Buns/pancakes	10%	13%	0%	32%
Deep-fried	22%	20%	38%	24%
Drinks				
None	15%	26%	0%	21%
Soda	74%	61%	100%	62%
Juice	75%	67%	88%	62%
Alcohol	6%	35%	75%	62%
Tea	47%	44%	75%	35%
Coffee	25%	20%	81%	6%
Bottled water	9%	11%	0%	12%
Yogurt	12%	6%	31%	12%
Flavored milk	15%	13%	38%	9%
Take out menu available	8%	11%	31%	3%
Flyer available	4%	0%	6%	6%
Advertisement				
None	92%	94%	75%	97%
Local TV station	4%	4%	6%	3%
Phone directory	4%	2%	6%	3%
Newspaper	1%	0%	0%	3%
Display of business license	88%	89%	75%	97%
Website	4%	4%	13%	3%
Nutrition information available	0%	0%	0%	0%
Signs encouraging overeating	0%	0%	0%	0%
Promotions	0%	0%	0%	0%
Portion size choices	37%	41%	25%	35%
Prices (lowest priced)				
Vegetable, mean (SD) RMB	2.31 (10.2)	0.93 (2.32)	8.25 (24.4)	1.13 (2.31)
Meat, mean (SD) RMB	3.71 (8.35)	2.50 (6.38)	5.75 (13.3)	2.24 (3.92)

Table 7 Characteristics of four food store types

	Food store type			
	Wet market	**Supermarket**	**Small Market**	**Convenience store**
Number of establishments	2	9	4	10
Store size, m^2	8100 (2121)	233 (360)	59.4 (42.6)	37.4 (48.0)
Types of items sold				
Soy products	100%	0%	0%	10%
Packaged foods	100%	67%	0%	30%
Frozen meals	0%	11%	0%	10%
Fresh cooked/prepared foods	100%	0%	0%	0%
Basic grain products	100%	56%	0%	20%
Processed/preserved dried meat and seafood	100%	33%	0%	20%
Cooking oil	100%	56%	0%	20%
Cleaned/easy-to-cook/combo meals	0%	0%	0%	0%
Cold dessert/ice cream	100%	78%	0%	30%
Indicator food items				
Salty snack	0%	100%	0%	60%
Sweet snack	0%	100%	0%	60%
Sweet drinks	100%	100%	0%	67%
Alcohol	0%	100%	0%	80%
Milk/yogurt	100%	89%	0%	50%
Bottled water	100%	89%	0%	70%
Powdered drinks	0%	67%	0%	70%
Tea	100%	44%	0%	10%
Instant noodles	0%	78%	0%	60%
Pastry/baked goods	100%	33%	0%	50%
Tofu products	100%	33%	0%	0%
Fruits	100%	0%	75%	0%
Vegetables	100%	0%	0%	0%
Fresh meat/poultry	100%	0%	0%	0%

The survey revealed the wide variety of food stores available in Kunming (Table 7). Wet markets were few in number but, when present, they typically carried fresh fruits and vegetables and meat. In contrast, neighborhood supermarkets and convenience stores mostly sold packaged and processed foods and beverages; few carried fresh fruits, vegetables and meats.

Reliability

Inter-rater reliability between the two survey teams for restaurant and store-related categorical variables is reported in Tables 8 and 9, respectively. In general, the percentage of agreement was high (>75%) for all categorical variables, and the average kappa statistics ranged from 0.162 to 0.648. Most kappa scores were between 0.4 to 0.6, indicating moderate agreement. The poorer kappa statistics tended to be associated with survey items that were not immediately observable (i.e., required questioning a person from the restaurant or store), such as whether the restaurant advertises or has a website. Thus, these person-reported surveys responses may reflect the varying degrees of knowledge of the restaurant staff versus managers or owners.

We found no statistically significant differences between teams for any of the continuous variables (Table 10).

Table 8 Inter-rater reliability for categorical items: restaurants

Restaurant	Team 1	Team 2	% Agreement	Kappa	SE
Type of Restaurant					
Sit-down	101	100	83.9	0.6	0.084
Take-out	82	54	73.4	0.5	0.077
Western fast food	6	16	93.0	0.5	0.073
Chinese fast food	5	34	79.7	0.2	0.051
Food court	1	1	100.0	1.0	0.084
Deli	4	1	97.9	0.4	0.067
Bakery	2	2	100.0	1.0	0.084
Bar	37	12	82.5	0.4	0.068
Tea House	2	6	95.8	0.2	0.072
Dessert	7	14	88.1	0.1	0.078
Other	11	14	88.1	0.3	0.083
Average	**23**	**23**	**89.3**	**0.5**	**0.075**
Type of Food Served					
Vegetarian	0	1	99.3	0.0	N/A
Dim-Sum	25	34	86.7	0.6	0.082
Seafood	22	17	88.1	0.5	0.083
Noodles	31	29	83.2	0.5	0.084
Regional cuisine	12	25	86.7	0.4	0.077
Muslim	3	2	97.9	0.4	0.082
Buns/Pancakes	18	12	93.0	0.6	0.082
Deep-fried foods	35	25	81.8	0.5	0.082
Other	18	30	67.8	0.1	0.080
Average	**18**	**19**	**87.2**	**0.4**	**0.081**
Drinks					
N/A	43	47	90.2	0.8	0.083
Soda	80	82	87.4	0.7	0.084
Juice	86	81	85.3	0.7	0.083
Alcohol	62	67	88.1	0.8	0.083
Tea	52	54	84.6	0.7	0.084
Coffee	31	29	88.8	0.7	0.084
Bottled Water	27	11	83.2	0.3	0.074
Yogurt	21	12	86.7	0.4	0.080
Flavored Milk	31	17	80.4	0.3	0.079
Other	8	3	93.7	0.2	0.074
Average	**44**	**40**	**86.9**	**0.5**	**0.081**
Takeout Menu	76	11	53.1	0.1	0.042
Flyers	41	6	75.3	0.2	0.050
Advertised					
N/A	115	134	82.5	0.3	0.069

Local phone directory	21	4	86.7	0.2	0.049
Newspaper	2	1	97.9	0.0	0.079
Local TV station	8	4	94.4	0.3	0.079
Other	6	4	93.0	0.0	0.082
Average	**30**	**29**	**90.9**	**0.2**	**0.072**
Business license	109	104	85.3	0.6	0.083
Website available	6	7	93.2	0.1	0.084
Nutrition information	1	0	99.3	0.0	N/A
Overeating	2	0	98.6	0.0	0.000
Special options	9	0	93.7	0.0	0.000
Portion choices					
N/A	98	104	83.2	0.6	0.083
Small	44	39	83.9	0.6	0.083
Medium	25	12	86.7	0.4	0.077
Large	43	39	81.8	0.6	0.083
Average	**53**	**49**	**83.9**	**0.5**	**0.082**

Table 9 Inter-rater reliability for categorical items: food stores

Food Store	Team 1	Team 2	% Agreement	Kappa	SE
Type of Store					
Wet Market	2	2	100.0	1.0	0.111
Supermarket	9	9	95.1	0.8	0.111
Small Market	3	4	96.3	0.6	0.110
Convenience store	2	10	87.7	0.1	0.080
Deli	4	4	100.0	1.0	0.111
Take-out	2	12	87.7	0.3	0.074
Bakery	6	6	100.0	1.0	0.111
Newspaper Stand, Street stand/cart	5	4	96.3	0.7	0.110
Dessert/Fruit Juice	5	5	100.0	1.0	0.111
Tobacco and Alcohol shop	13	20	86.4	0.6	0.107
Other	28	8	70.4	0.2	0.084
Average	7	8	**92.7**	**0.6**	**0.102**
Item Sold					
Tofu products	0	1	98.8	0.0	0.000
Packaged Foods	10	9	96.3	0.8	0.106
Frozen dumplings/meals	1	2	98.8	0.7	0.105
Fresh cooked prepared foods	0	2	97.5	0.0	0.000
Basic grain products	6	7	96.3	0.7	0.111
Processed, preserved dried meat and seafood	10	6	95.1	0.7	0.107
Cooking oil	9	7	97.5	0.9	0.110
Ice cream, cold dessert	11	18	86.4	0.5	0.106
Average	**6**	**7**	**95.8**	**0.5**	**0.081**

Table 10 Reliability statistics for restaurant and store continuous variables

	Team 1	Team 2	P
	Mean (SD)	**Mean (SD)**	
Restaurants			
Seating capacity, persons	62.4 (84.0)	62.6 (90.6)	0.99
Vegetable (lowest priced), RMB	1.41 (3.14)	1.72 (8.61)	0.68
Meat (lowest priced), RMB	3.76 (10.6)	2.87 (7.79)	0.42
Stores			
Store size, m^2	44.6 (111)	44.9 (136)	0.98

Adolescent BMI Distributions

The distribution of 575 adolescents' BMIs is illustrated in Figure 2 with mean BMI of 21.1 kg/m^2 and standard deviation of 3.2 kg/m^2. The percentage distribution of BMI categories for five different cutoffs is reported in Figure 3 and Appendices. Mean BMIs and percentages of overweight adolescents at categorized locations, adjusted for gender and age, are reported in Tables 11 and 12. More than 85% of the students were between ages 16 and 17. At age 16, IOTF Asian cutoffs generated the highest percentage (35.6% for male and 21.8% for female) of overweight (combined overweight and obese) adolescents; WGOC cutoffs generated 21.0% for males and 11.1% for females; IOTF regular cutoffs generated 19.8% for males and 9.9% for females; WHO cutoffs generated 20.9% for males and 9.9% for females, and CDC cutoffs generated the lowest percentage (18.6% for males and 9.5% for females). There was higher prevalence of overweight and obesity in males than females. In terms of underweight, CIP's below-5th-percentile cutoff and WHO cutoff generated 2.3% and 2.0% of underweight male and female adolescents, IOTF cutoff generated 6.2% for males and 12.3% for females, and CDC cutoff generated 5.1% for males and 3.6% for females.

Figure 2 BMI distributions of 575 students.

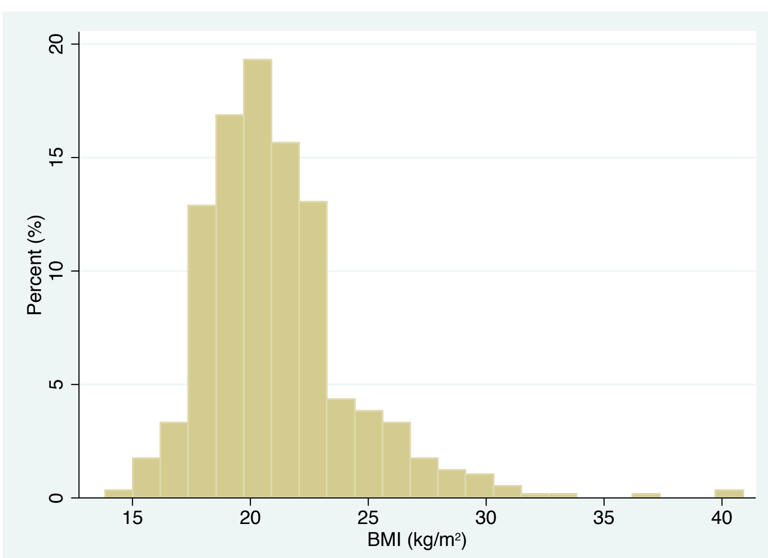
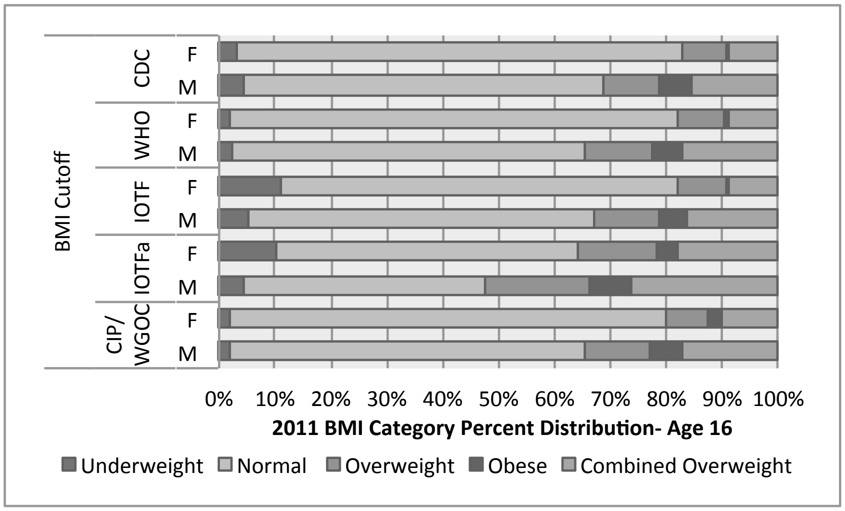
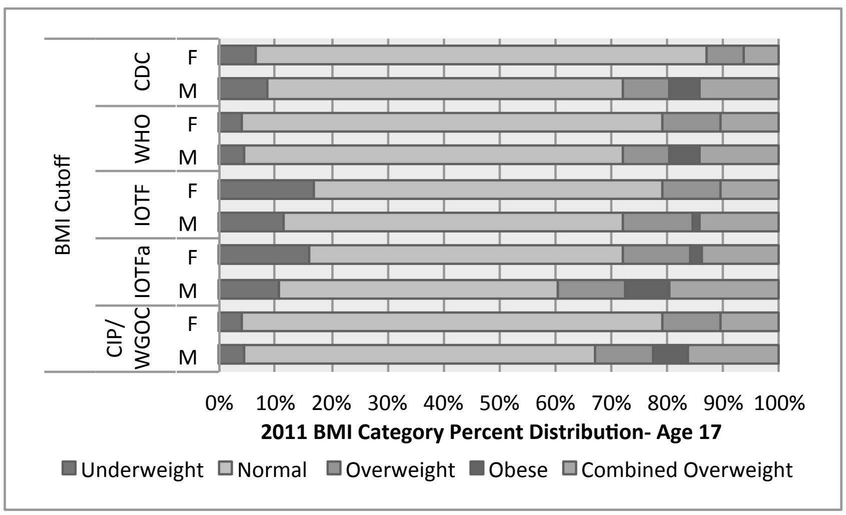
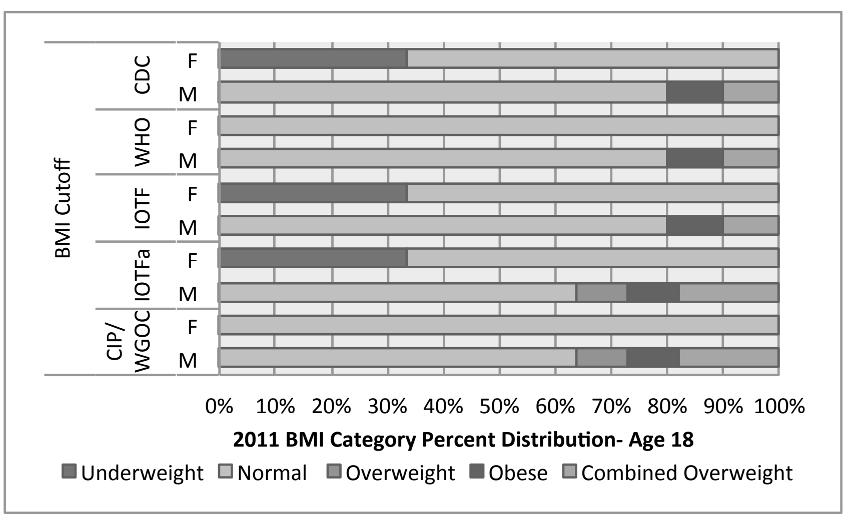


Figure 3 Percentage distributions of BMI categories among 5 different BMI cutoffs adjusting for gender and age for students aged 16 to 18.







Evaluation/Validity

Construct validity of the survey instruments is reported in Tables 11 and 12. There were 30 students with missing home addresses; therefore, a total of 545 students were included in the validity tabulation. In general, regardless of the cutoffs used, the percentages of overweight adolescents were highest for those who lived within the 1st ring. And, those who lived between the 1st and 2nd ring had higher percentages of overweight than those who lived outside the 2nd ring. Although the differences were small and only marginally statistically significant (Student' t-test p = 0.077 to 0.131 between within 1st and outside of 2nd ring groups depending on which cutoff is used), there was consistency with differences in mean BMI between categories for students aged 16 to 17. The mean BMIs of those who lived at three locations were 21.7, 21.4 and 21.3 kg/m^2 (SD 3.58, 3.97, and 3.83) for males, and 21.6, 20.5 and 20.8 kg/m^2 (SD 3.11, 2.78, and 3.55) for females, respectively. This was also consistent with the distribution of western-style fast food restaurants and convenience stores in three neighborhoods, with the neighborhood within the 1st ring having the highest count of western-style fast food restaurants and convenience stores illustrated in Table 4 and 5. This provides indication of validity that the survey is adequately sampling food environments relevant to adolescent obesity.

Table 11 Numbers and percentage of cohort and their average BMIs in different regions of the city adjusting for gender and age

Age, yr	Home Location											
	Within 1st Ring				Between the 1st and 2nd Ring				Outside the 2nd Ring			
	Male		Female		Male		Female		Male		Female	
	N (%)	Avg BMI (SD)	N (%)	Avg BMI (SD)	N (%)	Avg BMI (SD)	N (%)	Avg BMI (SD)	N (%)	Avg BMI (SD)	N (%)	Avg BMI (SD)
13	0	0	0	0	0	0	0	0	0	0	1 (0.5)	19.3 (N/A)
14	0	0	0	0	0	0	2 (2.6)	24.7 (3.08)	0	0	1 (0.5)	22.9 (N/A)
15	0	0	3 (8.3)	20.1 (1.51)	1 (1.5)	19.7 (N/A)	5 (6.5)	21.3 (3.50)	4 (3.0)	19.5 (1.46)	11 (5.6)	20.7 (1.82)
16	28 (71.8)	**21.7 (3.58)**	30 (83.3)	**21.6 (3.11)**	45 (68.2)	**21.4 (3.97)**	58 (75.3)	**20.5 (2.78)**	93 (70.5)	**21.3 (3.83)**	152 (77.9)	**20.8 (2.55)**
17	11 (28.2)	**21.9 (2.46)**	3 (8.3)	**19.4 (1.24)**	18 (27.3)	**21.7 (4.45)**	11 (14.3)	**21.5 (2.71)**	28 (21.2)	**21.3 (3.33)**	28 (14.4)	**20.7 (2.70)**
18 and above	0	0	0	0	2 (3.0)	22.8 (2.84)	1 (1.3)	17.4 (N/A)	7 (5.3)	23.8 (7.43)	2 (1.0)	19.3 (0.03)
Total	39 (100)	**21.8 (3.27)**	36 (100)	**21.3 (2.95)**	66 (100)	**21.5 (4.01)**	77 (100)	**20.8 (2.86)**	132 (100)	**21.4 (3.95)**	195 (100)	**20.8 (2.51)**

P**ercentage of** students aged 16-17 **and their average BMIs in different regions of the city** were **BOLD** as more than 85% of the students were between ages 16 and 17.

Table 12 Numbers and percentage of cohort that is overweight or obese in different regions of the city for various BMI cutoffs

Age 14												
Home Location	Within the 1st Ring				Between the 1st and 2nd Ring				Outside the 2nd Ring			
	N = 0		N = 0		N = 0		N = 2		N = 0		N = 1	
BMI Cutoffs	M	%	F	%	M	%	F	%	M	%	F	%
CIP/WGOC	0	0	0	0	0	0	1	50.0	0	0	0	0.0
IOTFa	0	0	0	0	0	0	2	100.0	0	0	1	100.0
IOTF	0	0	0	0	0	0	1	50.0	0	0	0	0.0
WHO	0	0	0	0	0	0	1	50.0	0	0	1	100.0
CDC	0	0	0	0	0	0	1	50.0	0	0	0	0.0
Age 15												
Home Location	Within the 1st Ring				Between the 1st and 2nd Ring				Outside the 2nd Ring			
	N = 0		N = 3		N = 1		N = 5		N = 3		N = 11	
BMI Cutoffs	M	%	F	%	M	%	F	%	M	%	F	%
CIP/WGOC	0	0	0	0	0	0	2	40.0	0	0	1	9.1
IOTFa	0	0	0	0	0	0	2	40.0	0	0	3	27.3
IOTF	0	0	0	0	0	0	1	20.0	0	0	1	9.1
WHO	0	0	0	0	0	0	2	40.0	0	0	1	9.1
CDC	0	0	0	0	0	0	1	20.0	0	0	1	9.1
Age 16												
Home Location	Within the 1st Ring				Between the 1st and 2nd Ring				Outside the 2nd Ring			
	N = 28		N = 30		N = 45		N = 58		N = 93		N = 152	
BMI Cutoffs	M	%	F	%	M	%	F	%	M	%	F	%
CIP/WGOC	6	21.4	7	23.3	7	15.6	6	10.3	22	23.7	14	9.2
IOTFa	11	39.3	9	30.0	15	33.3	15	25.9	31	33.3	28	18.4
IOTF	5	17.9	7	23.3	6	13.3	5	8.6	22	23.7	12	7.9
WHO	6	21.4	7	23.3	7	15.6	5	8.6	22	23.7	12	7.9
CDC	5	17.9	7	23.3	6	13.3	5	8.6	20	21.5	12	7.9
Age 17												
Home Location	Within the 1st Ring				Between the 1st and 2nd Ring				Outside the 2nd Ring			
	N = 11		N = 3		N = 18		N = 11		N = 28		N = 28	
BMI Cutoffs	M	%	F	%	M	%	F	%	M	%	F	%
CIP/WGOC	2	18.2	0	0	5	27.8	2	18.2	4	14.3	3	10.7
IOTFa	3	27.3	0	0	6	33.3	3	27.3	6	21.4	4	14.3
IOTF	2	18.2	0	0	5	27.8	2	18.2	3	10.7	3	10.7
WHO	2	18.2	0	0	5	27.8	2	18.2	3	10.7	3	10.7
CDC	2	18.2	0	0	5	27.8	2	18.2	3	10.7	1	3.6
Age 18 and above												
Home Location	Within the 1st Ring				Between the 1st and 2nd Ring				Outside the 2nd Ring			
	N = 0		N = 0		N = 2		N = 1		N = 7		N = 2	
BMI Cutoffs	M	%	F	%	M	%	F	%	M	%	F	%
CIP/WGOC	0	0	0	0	1	50.0	0	0	1	14.3	0	0
IOTFa	0	0	0	0	1	50.0	0	0	1	14.3	0	0
IOTF	0	0	0	0	0	0	0	0	1	14.3	0	0
WHO	0	0	0	0	0	0	0	0	1	14.3	0	0
CDC	0	0	0	0	0	0	0	0	1	14.3	0	0

Percentage of students aged 16-17 and their average BMIs in different regions of the city were **BOLD** as more than 85% of the students were between ages 16 and 17.

Discussion

The development and validation of culturally-specific food environment survey instruments is an important step towards the conduct of studies of changing food availability, access, and pricing in second and third world countries, where obesity rates are rising rapidly. Here, we present the results of an effort, motivated by the use of the NEMS instrument within the American context to study food environments, to develop and validate an instrument for surveying restaurants and food stores in a rapidly developing city in southwest China. Overall, both the restaurant and store food environment instruments were found to have excellent percentage of agreement and moderate kappa scores, as well as well-founded construct validity.

There are limitations to our survey. In particular, restriction to a 1-km stretch of street in only 3 neighborhoods is clearly not representative of all of China or even of all the neighborhoods of Kunming, and by limiting our surveys to 10 minutes, there were many aspects of the food environment that were not recorded. For example, we were unable to properly assess the prices of all food items. We were also unable to properly measure shelf space and instead, developed a rapid assessment technique that involved the counting of floor tiles that were measured at each store. However, our experience during rounds of pilot testing suggested that surveyor fatigue and store/restaurant's unwillingness to cooperate significantly impacted the survey qualities when the surveys were longer than 10 minutes. Despite these limitations, our study of three socio-demographically contrasting neighborhoods provides a fairly rich glimpse of the types of food environment changes that may be occurring as a result of ongoing globalization and the introduction of western-style fast food into other countries' food environments. Unhealthy qualities attributed to fast food were found in our study. In particular, high percentages of deep-fried foods, soda, and snack-like meals were found in restaurants and food stores, and prices of vegetables tended to be higher than those of meat products. Clearly, there is a need for more systematic longitudinal assessments of changing food environments in this cultural context, which could advance understanding of the influences of rapidly changing environments on non-communicable disease risk. Since the development of this instrument in 2011, we have conducted surveys in 2012 and 2013. While it is not the goal of this paper to describe longitudinal changes that may be occurring, as they are multi-faceted and complex, based on our preliminary analyses, the food environment instrument does seem to be sensitive in detecting certain key changes within neighborhoods such as changes in the numbers of sit-down and take-out restaurants, dessert shops, as well as convenience stores.

In contrast to the changes in the prevalence of certain foods that may be occurring with the proliferation of western fast food, some aspects of the food environment remain characteristically Chinese. For example, we found that traditional wet markets remain important places for people in the city to buy fresh fruits, vegetables and meat. In fact, none of the local supermarkets and convenience stores in our three neighborhoods sold these fresh foods. A point of concern is that supermarkets and convenience stores are ubiquitous, with one on nearly every street block, which makes packaged and processed foods and beverages more readily accessible than fresh food from the wet markets. We also observed that wet markets had limited operating hours. The wet market stalls are independently rented and operated, and hence may only be open during early morning and late afternoons, or only on certain days. This may affect food accessibility for some populations, such as workers and students. Further, the era of the wet market may be coming to an end. During our field study in Kunming we visited a few internationally owned ‘mega supermarkets.’ In the summer of 2011, there were three Wal-Mart and six Carrefour mega stores in the city. These mega stores all allocated a large proportion of their shelves to food products. Although we were not allowed by management to conduct our survey in their stores, we observed food delis that served many different types of cooked foods. Additionally, we observed aisle after aisle of packaged and fresh foods. Fresh fruits and vegetables were sold individually as well as in convenience packages – prewashed (Figure 4) and bundled for quick meal preparation. The prices were comparable to the wet markets, and the stores were packed with customers when we visited.

Figure 4 Vegetables sold in the wet market (left) compared to those sold in the mega-supermarket (right).

Our study is one of the few that present data on adolescent BMIs for middle-sized cities in western China. Adolescents who lived in the inner neighborhoods of Kunming tended to have higher percentage of overweight indicating the surveys were valid in assessing food environment – obesity relationships. Specifically, adolescents who live within the 1st ring tended to have higher western-style fast food and packaged food exposures or unhealthy food environment exposures than those who live between the 1st and 2nd ring and those who live outside the 2nd ring. While obesity is complex and affected by many factors such as built environment characteristics and socio-demographic status, even when unadjusted for confounding factors, differences in the food environment tended to be associated with observed differences in the rates of adolescent overweight and obese between neighborhoods. Additional research is needed to determine whether this association may be due to potential confounding factors (e.g., access to physical activity environments, environmental stress, etc.), rather than the food environment. As we consider future multivariate analyses of the associations between neighborhood-level differences and BMI, there may be value in considering BMI as a continuous variable in regression analyses to avoid loss of information through the tricotomization of BMI into underweight, normal, and overweight categories. Moreover, there would be considerable value in collecting actual data on dietary patterns as a mediator between the food environment and obesity. Ongoing research by our group aims to further explore the linkages between the food environment, dietary behavior, and weight status for adolescents. Nevertheless, our current findings are consistent with several studies that demonstrated that proximity to fast foods is positively associated with diet and higher BMI in Western contexts [23,42-50].

Different BMI cutoffs generated slight to moderate differences in the distributions of overweight and obese categories. IOTF Asian cutoff generated the highest percentages of overweight adolescents (35.6% for males and 21.8% for females) whereas CDC cutoffs only generated 18.6% for males and 9.5% for females, less than half of the IOTF Asian cutoff. In terms of underweight adolescents, CIP and WHO cutoffs generated around 2.0% of underweight males and females, whereas IOTF cutoff generated 6.2% for males and 12.3% for females, about three times and six times higher than the WHO percentage, respectively. Therefore, it is important for researchers to consider different cutoffs, and their use on particular populations. Choosing appropriate cutoffs will be extremely important in developing intervention strategies and making policy recommendations. Regardless of the BMI cutoffs used, however, we found the prevalence of overweight adolescents worrying, especially for male adolescents. Should these findings be reinforced by other larger studies in Chinese cities, action in the form of new obesity prevention strategies may be warranted to combat this problem.

Conclusions

The rates of overweight and obesity among Chinese adolescents deserves immediate attention, and requires the development of reliable, valid, and culturally-appropriate instruments to track risk factors for obesity. To our knowledge, this is the first food environment survey instrument developed to specifically assess changing food availability, accessibility and pricing in China. Moreover, this is one of the few studies that provide insights into rates of adolescent overweight/obesity in a middle-sized city in western China. This instrument can be used for conducting systematic longitudinal assessments of the changing food environment in rapidly developing Chinese cities where there is an urgent need to monitor changing disease risk.

Abbreviations

CIP, Capital Institute of Pediatrics; WGOC, Working Group on Obesity in China; IOTFa, International obesity task force Asian cutoff; IOTF, International Obesity Task Force; WHO, World Health Organization; CDC, Center for Disease Control

Chapter 2. Models of individual dietary behavior based on smartphone data: the influence of routine, physical activity, emotion and food environment

Introduction

Smartphone applications (apps) have made it possible to measure multiple aspects of a person's behavior, including physical activity, diet, emotion, and time-location patterns. Some of these software apps leverage the ability of hardware sensors (such as accelerometers and GPS) to collect measurements with relative ease and minimal subject burden, over long periods of time. In recent years, personal monitoring has become popular among individuals who wish to quantify their own behavior, not only with smartphone apps, but also with a variety of personal monitoring devices[53, 54]. Researchers interested in behavior change potentially have much to learn from these individuals, not only because of the tendency for there to be large amounts of behavioral data available for these individuals, but because the process by which these individuals learn from their data can inform behavioral constructs, such as self awareness, self efficacy, and decisional balance. Studying these individuals may inform behavioral theories such as classical and operant conditioning[55] and theoretical frameworks such as Bronfenbrenner's ecological framework for human development[56]. As more people use these personal devices and apps, there are opportunities to improve our understanding of how individuals learn from their monitoring data, recognizing that this learning is occurring naturally, outside of traditional psychological and cognitive science experimental settings.

Increasingly, studies of behavior change are recognizing the value of an "N of 1" approach, in which interventions are tailored to the individual [57]. This approach acknowledges subject uniqueness, and that interventions need to be effective first and foremost at the individual, rather than at the group level. The importance of tailoring interventions to the individual is gaining acceptance in other fields, e.g., personalized medicine [58], where studies of effectiveness of interventions at the individual level is a major departure from classic randomized clinical trials. Moreover, the "N of 1" approach is different from analytic approaches used in traditional epidemiology and public health. Such traditional approaches often identify associations between risk factors and outcomes, and are employed in large cohort studies to identify risk factors that are generalizable to the population being studied.

As a precursor to intervention studies aimed at assessing behavior change, methods are needed to characterize an individual's baseline behaviors before interventions are introduced. This characterization includes understanding the regularity of an individual's pattern of behavior, as well as either observable or hidden (latent) factors that might affect behavior. Such methods may also be of use to individuals who are self-monitoring as a way to synthesize and quantify the relationships between various behaviors they are tracking. Also, because no single behavioral model may be applicable to all persons, methods that allow for comparisons between alternative theories by fitting data to different models can be helpful in characterizing individuals.

This paper demonstrates individual-based modeling methods relevant to a person's eating behavior. Behavioral data were collected using a smartphone app that tracks diet, physical activity, emotion, and time-location patterns. Using these data, we evaluated four alternative hypotheses that potentially explain an individual's eating behavior–"typologies" of eating. The first hypothesis is that an individual follows a "routine", and that time of day is a good predictor of the type of meal this person will consume. The second hypothesis is that an individual follows an "energy balance" model, in which the person's diet is responsive to physical activity energy expenditure. The third hypothesis is that an individual follows an "emotional" model, and that the person's affective state alters eating behavior. The fourth hypothesis is that an individual is influenced by the surrounding "food environment", and a combination of this individual's GPS mobility tracking data and GIS food establishment data can be used to model the person's diet. To illustrate the value of an individual-based modeling approach, we compared the performance of individual-based models to a typical regression modeling approach in which a multivariate explanatory model was used to fit the pooled data from all monitored subjects.

By using mobile monitoring data to explore the different typologies described above we aim to address some of the complexity presented in previous conceptual models that describe the multitude of factors that affect obesity, which include unhealthy individual behaviors as well as environmental characteristics that may influence an individual's behavior [59]. While conceptual models and frameworks are useful in clarifying the linkages between various factors associated with obesity (e.g., the EnRG framework [60], the IoTF model [61] and SPOTLIGHT model [62]), our paper aims to illustrate how quantitative modeling approaches may be used to examine factors that affect an individual's diet patterns.

Methods

CalFit Chi and Dong Smartphone Application

We developed a software application called CalFit Chi and Dong (Chi means "to eat" and Dong means "to move" in Chinese) that runs on Android smartphones, and tracks diet, physical activity, emotion, and time-location patterns. For physical activity assessment, the app records 3-axis accelerometry data at 10 Hz, from which energy expenditure is computed using algorithms previously developed by our group [63, 64]. For time-location patterns, the app logs GPS data at 10-second intervals, from which the activity space of the phone's user can be mapped. To understand emotion, the app implements Ecological Momentary Assessment (EMA) [65, 66] – the phone rings during five times throughout the day. Each time the phone rings, it prompts the user to complete a short survey on the user's phone. A total of six questions are asked in the EMA survey (5-choice Likert ratings of happiness, stress, tiredness, and sadness; and two questions about where and with whom previous meals were consumed). On Samsung Galaxy Y phones, with no other apps running, the app can run for approximately 20 hours on a single battery charge. Data are encrypted and stored locally in the memory on the phone.

Additionally, the phone is used to assess diet. Study subjects are asked to use the video camera on their smartphones to record a voice-annotated video of each meal and snack they consume. Our approach is one of a number of emerging mobile phone-based approaches to diet assessment[67, 68]. During the recording, subjects verbally describe the contents of their meal (ingredients and quantities of food), which is recorded with the video. Later, two trained dietitians familiar with local diets review the contents of the videos, and code the portion sizes and food groups associated with each food consumed. Subjects' diet recordings were coded by both dietitians in order to assess inter-rater reliability. The coding accuracy of the dietitians was also assessed during training by having the dietitians code a previously prepared training video with known amounts of food items. All data are time-stamped by the clock on the phone, which allows the data to be merged.

Study Cohort

This research was conducted as part of a larger ongoing study investigating patterns of urban change within Kunming and their associations with changing dietary behaviors and risk factors for obesity. Kunming is the capital city of Yunnan province in southwestern China. Like many medium-sized cities in China, Kunming is rapidly developing. Studies have documented increasing obesity trends, which have outpaced those in larger Chinese cities [69, 70]. For this larger ongoing study, we hypothesize that obesity-related factors such as dietary behavior are associated with the food environment, which is supported by evidence from studies conducted in the U.S. [71-73]. The U.S.-based studies are relevant to China, particularly because in recent years, western-style fast food has become increasingly prevalent and heavily advertised within medium-sized Chinese cities.

A convenience sample of 12 subjects was recruited from among students at the Kunming Medical University and monitored. All participants completed a basic demographic and quality of life questionnaire. Participants received hands-on training on the use of the CalFit Chi and Dong app. Each participant received a study phone, and asked to carry the smartphone for two consecutive weeks during all waking hours, except for periods of bathing or swimming. They were asked to carry the phone in a neoprene waist pouch to improve the quality of accelerometry measurement. Subjects were trained on standard portion sizes, and how to use CalFit apps on study phones. Aside from in-person training during recruitment, each participant also received a written protocol with detailed instructions and a handout with common food items with standard portion sizes as a reminder. No services were provided for study phones; however, participants received reminder text messages (charging the phone, record dietary data, etc.) on their personal phones. Physical activity and EMA were monitored continuously over two weeks. However to reduce participant fatigue, we limited diet recording to only 6 days (3 days in each week). After each week of monitoring, we retrieved the phones, and downloaded the data. In some cases, this resulted in a 1-2 day gap in monitoring between the two weeks. The Institutional Review Boards at the University of California Berkeley and Kunming Medical University approved our study protocols (protocol number 2012-05-4352) and consent procedures. Study participants provided their written informed consents to participate in this study.

Data Analysis

Data from the phones were merged based on time-stamps. Because the different types of data were collected at different frequencies, we aggregated data as described below. In our study, our outcome is food portion size (in grams) consumed at each meal. Portion size is thought to be associated with obesity because it relates to latent variables such as hunger and satiety, which can change as a person ages, and possibly, because it is related to learned behaviors (e.g., taught to "clean your plate") [74-76]. For each recorded meal, trained dietitians familiar with local diets reviewed the videos, and coded the portion sizes of each food group consumed. Inter-rater reliability of the dietitians was assessed by comparing different dietitians coded portion sizes for specific food groups using the Student's t-test. We found no significant differences at the $p<0.05$ level between the dietitians. The coding accuracy was assessed by calculating the differences between coded and known amounts of food items in a prepared training video, as well as the percent errors. Similar to other studies [67, 77-81], on average, the differences between coded and known amounts of food items ranged between 8 to 20 grams, and percent errors ranged between 22 to 32%. To classify the timing of each person's meals, we used cutoffs of <=10 AM for "breakfast", >10 AM to <= 2 PM for "lunch", and >2 PM for "dinner". Only one participant recorded one occasion of snacking, which was categorized as part of the meal according to the cutoffs.

Accelerometry data were converted to energy expenditure using an algorithm that corrects for the orientation of the phone, computes activity counts along the vertical axis and horizontal plane, and finally, converts the activity counts into energy expenditure [63, 64]. Energy expenditure was then aggregated into 1-hour averages for each person. We analyzed energy expenditure in kcals during the same hour as each meal, and kcals before each meal (the average kcals of three hours before the meal).

To assess emotion, we averaged the Likert scores for each EMA question collected multiple times per day for each person. We performed Principal Components Analysis (PCA) on the average daily results of three questions related to emotion (happiness, stress, and tiredness), which resulted in two major components that explained over 82% of the variation. The first component loaded heavily on happiness, while the second orthogonal component loaded on tiredness. This resulted in two components representing the average daily emotion reported by each person.

To assess each person's exposure to different food environments, we used the GPS tracking data to look at the food environment within each person's activity space. First, we processed the data using a "Staypoint" algorithm [82]. The algorithm filters the GPS data by identifying those places where an individual stays for more than a specified amount of time. We chose a threshold of 10 minutes as a reasonable trade-off between producing too many locations (many of which may be unimportant because the individual simply passes by these places), and not missing potentially important short stops within a person's activity space (e.g., home, work, recreation, and the locations of transit stops and errands). For example, if a person spent 30 minutes at home, this would result in one Staypoint. In contrast, if a person is moving from one location to another, and does not spend more than 10 minutes at any given location, no Staypoint would be recorded.

In contrast to the U.S., for which various sources of GIS data for food environment analyses exist, food establishment data are difficult to obtain for China. For our study, we used Google map data, which offers a fairly comprehensive global database of establishments for cities, including Kunming. We developed a software application that automates the querying of food establishments using Google Places (https://developers.google.com/places). Google Places allows for searches on several keywords relevant to food establishments (bakery, bar, cafe, convenience store, food, grocery or supermarket, liquor store, meal delivery, meal takeaway, and restaurant). For each person's Staypoints, we used Google Places to search for the numbers of establishments within a 0.25 km radius (easy walking distance from places a person spends time during their day) using each keyword. We divided the number of establishments by the number of Staypoints visited each day to obtain a daily average number of food establishments per Staypoint for each person.

We examined four alternative models behavior as described in Table 1. Each model consisted of a linear regression model, in which the dependent variable, portion size of a meal, was explained by one or more possible explanatory factors. In the first model (routine), the portion size of each person's meal was estimated based on variables indicating whether the meal was a breakfast, lunch or dinner. In the second model (energy balance), portion size was estimated based on the energy expenditure at the same hour and the average of the 3 hours preceding the meal. In the third model (emotional), portion size was estimated based on the two principal components derived from the EMA questions. In the fourth model (food environment), portion size was estimated based on the average number of food establishments (of all types) encountered at each person's Staypoints. Table 1 lists the conceptual basis for each of these models and some supporting evidence. For each of these models, we fit each person's data separately, as well as fit the combined data from all persons. Additionally, for the combined data, we fit a full model, which included all explanatory variables from models 1-4. To further examine the association between food environment and food portion size, we ran separate full regression models using different types of food environment (e.g., bakeries, bars, cafes, etc.). Model goodness of fit was based on the coefficient of determination (R^2). For the models that based on the combined data from all individuals, we computed overall R^2 as well as the R^2 for each specific individual within the combined dataset to allow for comparisons to the individual-based models' coefficient of determinations. Finally, we also fit the data using a varying intercepts mixed effects model (lmer in lme4 for R), in which subject ID was a random effect in the model. The mixed effects model was specified similarly to the full model described before, with portion size as the outcome, and the timing of the meal, physical activity, EMA principal components, and the average number of food establishments per Staypoint as explanatory variables.

Table 1. Typological Models of Eating Behavior

Model	Hypothesis	Conceptual Basis
Routine	Portion size of each person's meal was estimated based on indicator variables indicating whether the meal was a breakfast, lunch or dinner	The concept of chronotypes – that there are time-based patterns in eating and obesity. e.g., Fleig and Randler used food logs and found differences in diet between morning vs. evening-oriented adolescents [83], and Schubert and Randler found that morningness was negatively associated with BMI in a cohort of German university students [84]
Energy Balance	Portion size was estimated based on the energy expenditure at the same hour and the average of the 3 hours preceding the meal	Exercise related to increase in carbohydrate and protein intake [85, 86]
Emotional	Portion size was estimated based on the two principal components derived from the EMA questions	Negative mood states may be associated with eating unhealthy foods [87]
Food Environment	Portion size was estimated based on the average number of food establishments encountered at each person's Staypoints	Neighborhood food environment associated with unhealthy eating [71-73]

Results

Descriptive statistics for the study population's characteristics, including summaries of smartphone-derived behavioral measures are presented in Table 2. The average age of study participants was 24.6 years old with a standard deviation of 3.06, and ranged between 18 and 31 years old. The average body mass index (BMI) was 21.0 kg/m^2 with a standard deviation of 3.69, and ranged between 17.0 to 30.5 kg/m^2. Based on the World Health Organization BMI cutoff[88], among the 12 participants, two (17%) were underweight; two (17%) were overweight, and the rest were of normal weight (66%). From the questionnaire, all were happy with their then current lives, all reported having adequate sleep time with an average of 7.5 hours per night, and believed exercise is important in their life.

Ample compliance with the phone-based behavioral assessment was observed for all participants. Across all individuals, 868 consumed food items were recorded. On average, subjects recorded 72 food items over the 6 days of diet assessment (the person who recorded the least, still recorded 56 food items). Generally, fruits, grains and dairy foods made up a larger share of their meals, while vegetables and proteins (including meat and beans) made up a relatively smaller portion of meals. Similarly, subjects complied with the use of the phones for accelerometry. On average, 218 hours of accelerometry were recorded for each participant. For the subject with the least monitoring, 180 hours of accelerometry were still collected. Finally, across all individuals, we recorded a total of 416 EMA responses and 35 responses on average per participant, with the least collected being 26 per participant. Participants on average recorded moderate levels of happiness, while stress, tiredness, and sadness were on average low. Responses to EMA questions spanned the entire range from scores of 0 to 4, indicating both variations between persons and between times for specific persons.

Table 2. Description of Study Subjects

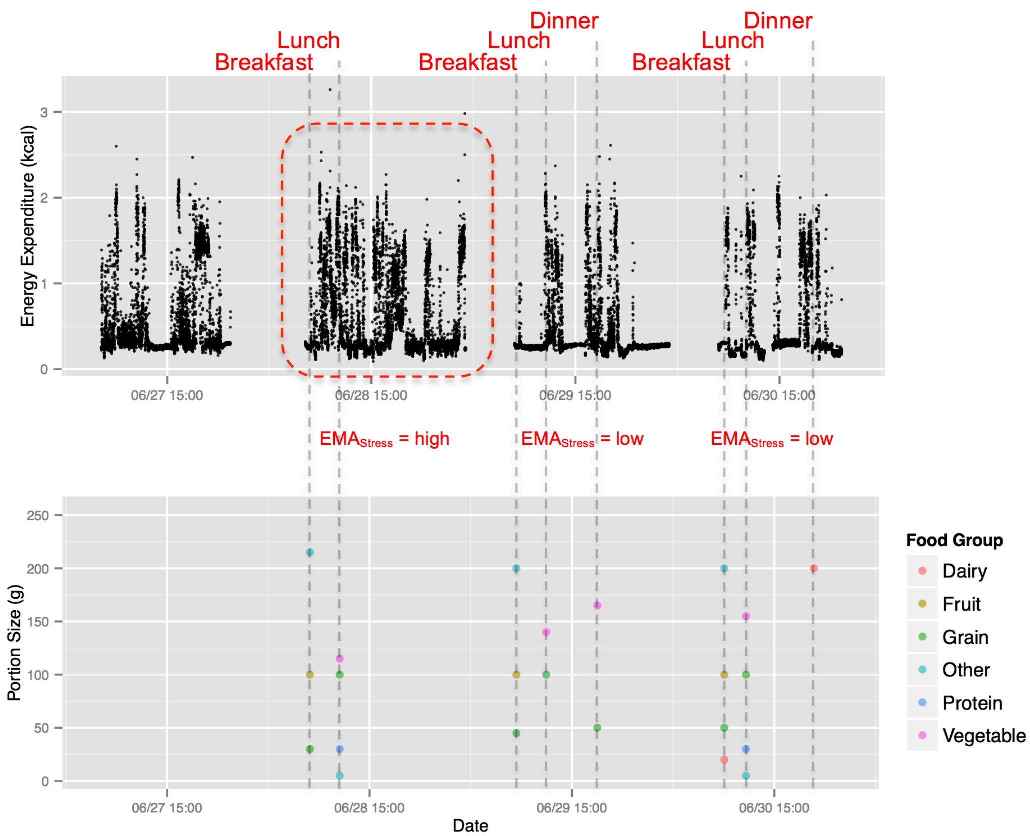
Characteristics	
Age, years (mean, SD, range)	24.6, 3.06, 18-31
Gender (% female)	66.7%
BMI, kg/m^2 (mean, SD, range)	21.0, 3.69, 17.0-30.5
Diet	
Total portion size per meal, g (mean, SD, range)	284, 178, 5 - 1203
Dairy portion size per meal, g (mean, SD, range)	178, 70, 20 - 250
Protein portion size per meal, g (mean, SD, range)	65, 53, 5 - 350
Grain portion size per meal, g (mean, SD, range)	114, 82, 7 - 500
Vegetable portion size per meal, g (mean, SD, range)	84, 72, 5 - 350
Fruit portion size per meal, g (mean, SD, range)	196, 202, 10 - 1028
Accelerometry	
Hourly Energy Expenditure, kcal (mean, SD, range)	27, 17, 4.7 - 132
Ecological Momentary Assessment	
Happiness Score (0 - 4) (mean, SD, range)	2.3, 1.3, 0 – 4
Stress Score (0 - 4) (mean, SD, range)	0.2, 0.5, 0 – 4
Tiredness Score (0 - 4) (mean, SD, range)	0.72, 1.0, 0 – 4
Sadness Score (0 - 4) (mean, SD, range)	0.25, 0.70, 0 - 4
Food Environment	
Number of Staypoints per person (mean, SD, range)	33, 20, 6 – 78
Number of food establishments 0.25 km of Staypoints (mean, SD, range)	1158, 1102, 91 - 3829

Based on the GPS data, we computed 400 Staypoints for all participants. On average there were 33 Staypoints per person, with 6 being the minimum. On average, each person encountered 1158 food establishments (based on a 0.25 km search centered on all of the person's Staypoints) over the 2 weeks of tracking, or approximately 83 establishments per day. There was a fairly large range of variability in food environment exposures between participants. There was a problem with Subject 2's GPS data, which did not allow us to assess their exposures to food environments. This individual was left in the analysis because of our low number of overall participants, and because the models that did not include food environment could still be examined for this subject.

Temporal Patterns in the Behavioral data

Clear diurnal patterns in both physical activity and diet data were observed in the two weeks of data. As an example, Fig. 1 illustrates a detailed time series of diet and energy expenditure data from one of the study participants. The dashed vertical lines indicate the times for breakfast, lunch and dinner meals for three consecutive days, aligned with the corresponding times of physical activity. Two of the 3 days (June 29 and 30, Friday and Saturday) had very similar patterns: a bout of physical activity immediately after breakfast, a period of relatively sedentary activity, followed by a bout of activity that surrounded the lunch meal. After lunch, there was another period of sedentary activity, until mid-afternoon, when there was another somewhat longer duration of physical activity that surrounded the dinner meal. Although June 27th (Wednesday) was not a day in which diet was assessed for this person, the pattern of physical activity was very similar to the two days just described. In contrast, June 28th (Thursday) was markedly different. There was fairly intensive activity throughout the day. While breakfast and lunch meals were recorded as normal, the dinner meal was not. The EMA stress level for this day was higher than that reported on the two following days. While there was a tendency for this person to follow a routine pattern of diet, there was also a tendency for physical activity and emotion to potentially affect this person's eating behavior.

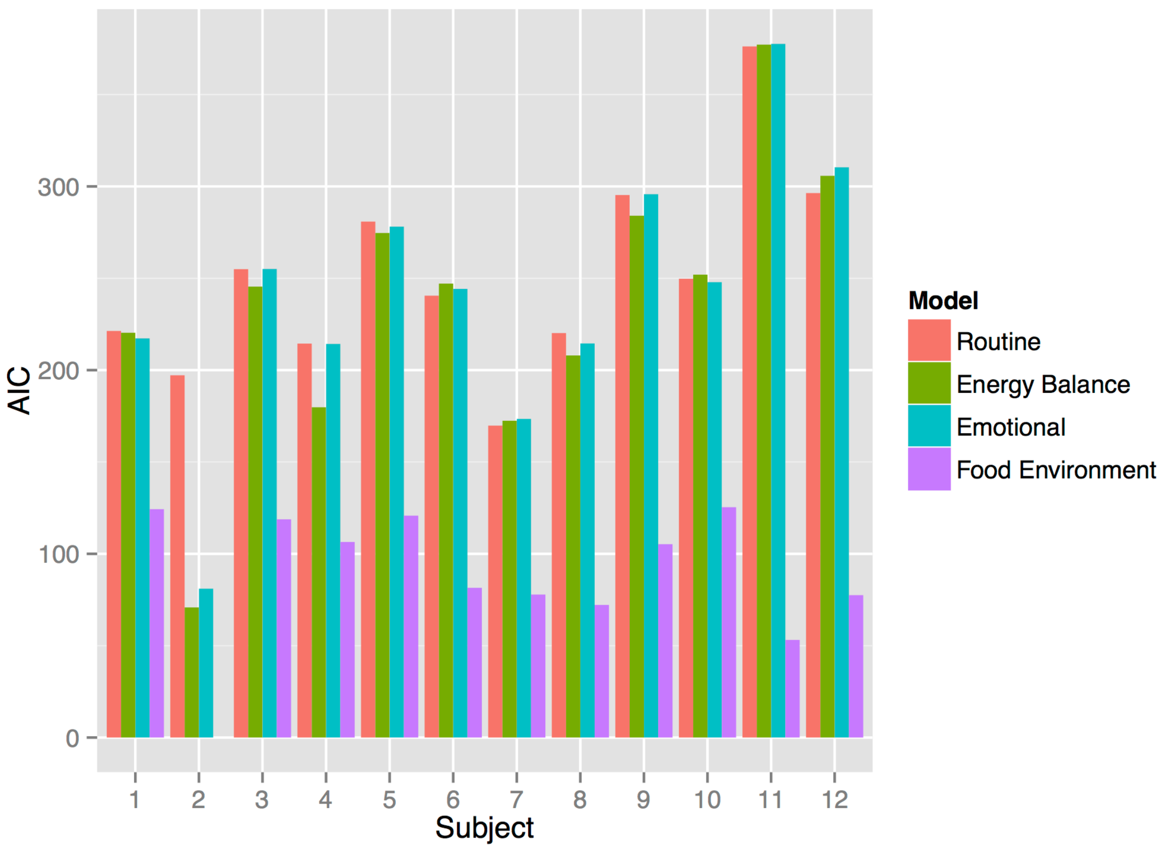
Fig. 1. Detailed smartphone-based diet, physical activity, and Ecological Momentary Assessment monitoring data for one subject for four days



Individual-based and Combined Models

Fig. 2 illustrates the R^2 results for the different typology models applied to each individual subject (See Supporting Information for details on model estimates). For this cohort, the routine model fit five individuals best. The food environment fit three individuals best. And, energy balance and emotion models each fit two individuals best. The food environment model not fit for Subject 2 because GPS data were not available for this person, perhaps because the participant turned off the GPS in the phone. Subject 2 was markedly different from others in that this person had the worst compliance, recording only 1 week of data. Subject 2 was the only obese subject in our study with a BMI of 30.

Fig. 2. AIC smartphone-based diets, physical activity, and Ecological Momentary Assessment monitoring data for one subject for four days



For four of the five subjects that the Routine model fit best, breakfast portion sizes tended to be smaller than dinner portions. On average the model estimated between 6.2 and 228 g difference for these subjects' breakfast and dinner portion sizes. For the remaining fifth individual, we found that lunchtime portion sizes tended to greater (model estimate of 206 g more) than dinnertime portions.

There was support for the influence of the food environment on certain individuals' diet patterns. The food environment explained a notable larger amount of variation in eating patterns compared to other hypothesized models for subjects 3 and 10. However, in the case of subject 8, the emotion model performed almost as well as the food environment model in explaining eating patterns.

Table 3 lists the coefficients of determination for all typology models applied to each individual. For comparison, the R^2 is provided for each individual when fit to a model that estimates coefficients across the combined dataset with all individuals. Generally, when any of the models were applied to the combined data, the models tended to fit relatively poorly to the individual compared to individual-based model. In contrast, when certain models were applied to individuals, the coefficients of determinations tended to be quite high. For example, the routine model explained over 47% of the variation in food portion sizes for subject 12, the energy balance model explained over 88% of the variation in portion sizes for subject 2, and the emotional model explained over 36% of the variation in portion sizes for subject 4.

Table 3. The Coefficients of Determination for Individual-based models and models with data from all subjects combined

	Typology Model							
	Routine		**Energy Balance**		**Emotional**		**Food Environment**	
Subject	**R^2**	**R^2 Combined Model**	**R^2**	**R^2 Combined Model**	**R^2**	**R^2 Combined Model**	**R^2**	**R^2 Combined Model**
1	0.055	<0.001	0.104	<0.001	0.244	<0.001	0.148	<0.001
2	0.203	0.069	0.889	<0.001	0.151	<0.001	-	-
3	0.186	<0.001	0.017	0.002	0.181	<0.001	0.300	<0.001
4	0.353	0.086	0.210	0.004	0.361	<0.001	0.049	0.041
5	0.036	<0.001	0.293	<0.001	0.158	<0.001	0.010	<0.001
6	0.412	0.059	0.152	<0.001	0.277	<0.001	0.103	<0.001
7	0.259	<0.001	0.103	<0.001	0.036	<0.001	<0.001	<0.001
8	0.070	<0.001	0.055	<0.001	0.333	<0.001	0.360	<0.001
9	0.120	0.091	0.093	0.013	0.101	0.004	0.102	<0.001
10	0.117	<0.001	0.007	<0.001	0.198	<0.001	0.300	<0.001
11	0.050	<0.001	0.016	<0.001	0.001	<0.001	<0.001	<0.001
12	0.476	0.142	0.211	<0.001	0.034	<0.001	<0.001	<0.001

There was insufficient monitoring data to fit a "full" multivariate model for each person, with all aspects of routine, energy balance, emotion, and food environment. However, it was possible to fit this multivariate model with data from all individuals combined. The full multivariate model produced an R^2 of 0.30. Controlling for all other factors (timing, physical activity, and emotion), the only significant predictor was the food environment variable (coefficient 0.32, 95% CI [0.16, 0.49]), indicating a 32% increase in portion sizes per food establishment encountered within 0.25 km of one's Staypoints.

The mixed effects model, which also controlled for timing, physical activity, and emotion, resulted in a similar coefficient estimate (0.21 95% CI [-0.17, 0.59]) for the food environment, which, however, was not statistically significant. Consistent with our individual-based modeling results, a considerable amount (45.2%) of residual variation was attributed to between subject random effects.

Comparison of Different Food Environment-based Models

Given the above findings indicating the importance of the food environment for this cohort, we examined the role of the individual food establishment types. We used the aforementioned full multivariate model on combined data from all individuals, substituting food establishments of all types, with specific types of establishments available from the Google Place keywords. The results of this analysis (Table 4) indicated that using all types of food tended to perform relatively well in predicting portion sizes. Only the keywords "café" (R^2=0.31), "meal takeaway" (R^2=0.31), and "restaurant" (R^2=0.31), performed slightly better. The first two are notable, in that they indicate some potential for environments with Western-style establishments to be associated with larger portion sizes. We also note that Google's "café" category tends to also include noodle shops and small Chinese fast food places. The effect sizes for café and meal takeaway establishments on portion sizes were also large (coefficients of 6.2 and 14.7, respectively).

Table 4. Comparison of Food Environment Variables[a]

Food establishment type	Coefficient	95% CI	R^2
All	0.323	0.158, 0.488	0.298
Bakery	5.266	1.363, 9.169	0.226
Bar	6.115	2.436, 9.794	0.261
Café	6.162	3.163, 9.160	0.310
Convenience store	1.750	0.526, 2.975	0.235
Food	0.334	0.164, 0.504	0.299
Grocery or supermarket	12.21	5.818, 18.60	0.292
Liquor store	10.30	1.537, 19.06	0.208
Meal delivery	14.39	4.551, 24.23	0.238
Meal takeaway	14.71	7.573, 21.84	0.311
Restaurant	0.453	0.232, 0.673	0.310

Each food environment variable is the number of establishments within 0.25 km of the subject's Staypoints.
[a] Full models adjusted for time of meal, physical activity, and emotion scores

Discussion

To our knowledge, this is the only study that has integrated multiple sensor and self-report measures obtained from smartphones to evaluate different typological models of diet behavior. In our study, we found that individual-based models tended to fit better than group models. The individual-based models allow for better tailoring of coefficients to specific persons. While our study focused on understanding eating behavior, this general approach of fitting models to repeated measures on individuals obtained from personal devices, sensors and apps might have broader uses in predicting patterns of behavior. Moreover, we have shown that by evaluating different typological behavioral models, we can potentially identify factors that are most relevant to an individual's diet pattern. Being able to predict as well as typify baseline behavior has potential uses for developing tailored interventions, and identifying deviations from baseline behavior over the course of an intervention.

Although we did not monitor many people, our study successfully measured multiple dimensions of individual behavior for each person using our smartphone app. Previous studies have focused on assessing one or two types of behaviors with phones. For example, a number of studies have focused only on tracking physical activity [89], while some have also included diet [90-92]. The addition of more people to this particular study would not necessarily help, as we found that individual-based models outperformed group models. Our intent with individual-based models was not to generalize findings across persons, as is the case with traditional regression approaches. While examining data from students was useful for illustrating the methodology of individual-based modeling, our finding of the importance of the food environment as a diet influence may not be generalizable outside of this particular study cohort.

There were challenges in with this dataset because the observation period was limited to two weeks, and seasonal and episodic changes in subjects' dietary consumptions and physical activities were not captured. An important direction for future work may be to incorporate longer term monitoring data to look not only at seasonal trends, but shifts in behavioral patterns and influences generally. Longer-term monitoring data would also allow for more sophisticated modeling that incorporate feedback dynamics.

Critical to smartphone-based behavioral assessment is the accuracy of the phone-based measures. We have previously evaluated the accuracy of phone-based accelerometry, and have found our CalFit algorithm to correlate well with measurements made by the Actigraph GT3X accelerometer in free-living studies (correlation coefficient of 0.932) [63]. As for phone-based diet assessments, other researchers have automated the processing of food images with some success [93-96], albeit largely in controlled experimental settings for a limited number of food items. In our study, we used a hybrid approach that mixes self-report, objective recording, and review by trained dietitians. Based on the amount of data collected in our study, our approach is a useful balance between subject burden, objectivity, and accurate measurement, which are typical challenges in diet assessment. Phone-based EMA has been useful in a variety of studies, including studies of emotion in youth [97], mood [68], drug-addiction and post-traumatic stress disorder [98], and sexual risk behavior [99].

Although there are daily variations in individuals' diets, we found that certain individuals tended to follow diet-related typologies or systematic classifications. Typologies are useful frameworks in clinical medicine and nursing for managing patient variability, and have been applied in various fields to categorize patients into treatment groups. For example, type 2 diabetes patients have been typed into "balanced", "problematic", "coasters", "discouraged", and "distressed" groups using quantitative methods [100], while patient and caregiver pairs have been typed into "patient oriented", "caregiver oriented", "collaboratively oriented", and "complementarily oriented" group using qualitative methods [101]. Typologies have also been useful in characterizing those who are likely to not adhere to prescribed medication due to "lack of knowledge", "psychosocial resistance", or "choice for quality of life" [102]. In each of these examples, there are practical implications associated with these types for patient management, tailoring of interventions, and reducing risk. While typologies have these practical benefits, we recognize that individuals are complex, may not fit into only one classification, or can change over time.

In our study we found that the routine model tended most of our subjects, however, the food environment tended to be most important influence across all subjects. We found that the spatial density of the food environment along one's Staypoints (places where an individual stayed for more than 10 minutes) was the only variable that was significant in the full model with pooled data from all subjects in explaining eating patterns. We found a positive effect. Specifically, greater access to food establishments was associated with consumption of larger food portions. While one should not generalize from our small sample of students, this finding is consistent with literature from large epidemiologic cohort studies conducted in the U.S. [72, 73]. In the Multi-Ethnic Study of Atherosclerosis (MESA) cohort, living near fast food establishments was found to be associated increased risk of eating fast food as well as decreased odds of eating a healthy diet. Similarly, in the longitudinal Coronary Artery Risk Development in Young Adults (CARDIA) study, neighborhood fast food exposure was also found to be associated with fast food consumption, particularly among low-income and male subjects. Unfortunately, Google Places did not offer "fast food" as a keyword search. We found however, that "café" and "meal takeaway" both performed well, and are related to fast food in the Chinese context, and were associated with larger diet portions.

A potential limitation of our food environment analysis is that it is ecologic in nature. We examined food environment only at the neighborhood-level, and did not gather data on the specific food establishments individuals visited. However, an ecologic approach has merits, not only for understanding macro-level factors that condition behavior, but also for examining individual activity patterns in the context of a combination of micro, meso, and macro environmental influences to inform composite or synergistic interventions to promote physical activity [103]. Moreover, neighborhood-level variables integrate nicely with community-based theories (e.g., theory of defensible space[104], theory of restorative environments [105], theory of behavioral settings [106, 107] and the theory of urban imageability [108]. Given our findings, these ecologic theories may also have relevance to understanding adult dietary behaviors in Chinese urban settings.

The research on food portion sizes may shed light on the potential interplay between macro-level factors and micro-level dietary choices. Based on the review by Ello-Martin, et al. [74], very young children are generally able to self-regulate their food intake based on hunger and satiety cues. However, by 4-5 years, they begin to lose this ability: when presented with larger portions, children tend to consume more. This may be the result of conditioning, as research has shown that children who are rewarded for cleaning their plates tend to consume more [109]. As adults, individuals provided with larger portion sizes also consume more, and yet, report similar levels of fullness after varying sized meals. Although it is unclear how these micro-level findings on portion size extrapolate to macro-level associations between food environment access and consumption, the aforementioned U.S.-based food environment studies, and our findings of a positive association between the macro-level food environment and micro-level portion sizes of diets from this small Chinese cohort, suggest that further research in this area is warranted.

Excluding the routine and ecologic food environment typology, there were slight tendencies for individuals to either fit the energy balance, or emotional models. For those who fit the routine model, further work might consider the use of chronotypes (i.e., “morningness” and “eveningness”) to improve our understanding time-related eating patterns [83, 84, 110]. Also, the theory of behavioral settings [106, 107] – that certain physical settings are associated with recurring patterns – may also lead to further understanding of the interplay between routine eating and place, especially given our findings related to the food environment.
For some individuals, the emotional model performed better than the routine model. The relationship between mood and diet has been explored in both experimental and natural studies. And there are likely feedbacks between mood and diet that we have not fully modeled in our study. Support for this type of model is based on early experimental work that has found that individuals given doses of caffeine report high levels vigor, clarity of mind, energy, etc., while doses of tryptophan tend to increase reports of lethargy and somnolence [111]. Moreover, there is considerable research that has linked negative mood states with a preference for relatively unhealthy foods, and conversely, positive mood with healthy foods [87].This literature suggests that future work with mobile phone assessments might go beyond quantifying portion size, to characterizing foods as unhealthy/healthy and its relationship to self-reported EMA of emotion.

Conclusions

In summary, a typological modeling approach can be useful in understanding individual dietary behaviors in our cohort. This approach may be applicable to the study of other human behaviors, particularly those that collect repeated measures on individuals. Smartphones and other personal devices are well suited to providing these repeated measures. The smartphone app and analytic methods are currently being applied to larger cohort studies of physical activity and diet behavior in two regions of China. These larger ongoing studies will be used to validate our findings of the importance of the food environment on Chinese diets, and to quantify the proportions of individuals that follow specific dietary typologies. Our study demonstrated individual-based modeling could be useful, and further research using larger datasets and typological approaches are needed for studying human behaviors.

Chapter 3. Smartphone-based assessment of food environment associations with sugar-sweetened beverage (SSB) intake in rural and urban Shanghai, China

Background

There has been significant upsurge in prevalence of overweight and obesity in China in recent decades [112]. China has had the second largest absolute increase in the number of overweight and obese people since 1980 – second only to the U.S.[113, 114]. The rising obesity epidemic in China is occurring at a time of fast economic development and built environment changes within the country, which is increasing the availability of energy-dense foods with added sugars, such as sugar-sweetened beverages (SSBs), and soft drinks in particular [115-119]. As Chinese are increasing exposed to these foods, there is concern whether this may lead to adoption of a Western lifestyle, including a greater energy-dense diet and less physical activity, which may ultimately contribute to an obesity epidemic.

Numerous studies have shown SSB consumption is associated increased risk of obesity, type II diabetes and cardiovascular disease [120-122]. Also, higher intake of SSBs has been suggested to be a marker of unhealthy diet as it is often linked to other adverse dietary behaviors and lifestyle habits [120, 123].

Dietary behaviors and lifestyle habits are determined by multiple individual, social and environmental factors [112, 124, 125]. Prior studies have suggested the importance of the food environment, including the presence of fast-food restaurants, convenience stores, grocery stores or supermarket and other food outlets, in influencing individuals' dietary behaviors and health outcomes [126, 127]. Research in areas of behavioral economics, social psychology and neuroscience have suggested that individuals automatically respond to contextual food cues through their dietary behaviors, and lack the ability to consistently overlook and withstand these cues, which then lead to increased consumption of unwanted calories [128-130]. Therefore, an individual's exposure to a food environment could be regarded as a potential environmental risk factor for SSB consumption and poor diet generally.

Our review of current literature suggested that there is considerable evidence for associations between SSB consumption and health outcomes such as obesity or type II diabetes, as well as the relationships between the food environment and the same health outcomes, but relatively less research on the relationships between the food environment and consumption of SSBs. For example, past studies have found associations between body mass index (BMI) and proximity to fast food restaurants, convenience stores, restaurants, grocery stores or supermarkets [131], and linkages of consumption of SSBs to various adverse health outcomes stated before. Many studies also lack data on participants' food consumption and physical activities despite these two factors are important in the energy balance equation [132].

A recent review of food environment and dietary intake studies revealed other limitations relevant to understanding the linkage between the food environment and SSB consumption within China [133, 134]. Most of studies have been conducted in the U.S., and very few in

China. Also, many of the studies focused on individuals' food environment exposures at the neighborhood level, and examined proximities of food establishments to individuals' home. However, individuals may shop for food or eat outside their residential areas, as their activity space can be much larger [132, 135]. Furthermore, most of those studies used self-reported dietary intake as outcome measures. Researchers also have tended to use brief, low-cost and burden dietary assessment instruments rather than more detailed instruments with less bias. In terms of assessing SSB take; most studies relied on single-item questions [136].

SSB consumption has increased globally [112]; however, there is seemingly a discrepancy between increased SSB sales and low consumption in China [137, 138], which implies that methodologies used may not be sufficient in assessing SSB intake. Recent advances in smartphone technology offer new possibilities to objectively capture multiple aspects of an individual's behavior such as diet, food environment, physical activity and time-location patterns [139]. As part of the China Beverage Validation Study, we developed and validated the use of a 3-day smartphone- assisted 24-hour recall (SA24-R) to assess beverage consumption [138], and evaluated the acceptability and feasibility of SA24-R [140] in a Chinese population in rural and urban Shanghai, China.

As few studies have systematically quantified and addressed the nutrition transition and changes in the built environment in China, and how these shifts relate to changes in food environment, diet, physical activity and obesity. The objective of this paper is to use smartphone-assisted diet and physical activity assessments and mobility tracking to examine the relationships between food environment exposures and SSB consumption in rural and urban Shanghai.

Methods

Study population and field data collection

As this is part of a larger study, details on the development and validity of 3-day SA24-R and acceptability and feasibility of smartphone usage in this cohort have been published [138, 140]. In short, 120 healthy adults aged 25-40 years were recruited from rural and urban Shanghai, China with roughly 1:1 rural to urban ratio to use SA24-R or a written-assisted recall (WA24-R) beverage consumption assessment, as well as gold standard 24-hr urine assessment. The first published paper from this study indicated that the total fluid intake assessed using SA24-R was more valid than WA24-R when comparing to the gold standard of 24-hour urine samples [138]. The dietary data used in this paper were obtained via SA24-R, and also included data on physical activity and food environment, which were collected via smartphones as well. In a second paper, the focus was on usability of the SA24-R: participants reported that the phones were easy to use and helped with their dietary recalls [140].

Participants were randomized to partake in SA24-R and WA24-R on two consecutive weeks. They were trained on how to use the study smartphone (Samsung Galaxy Y), and received a smartphone user manual made specifically for the study. They completed a demographic questionnaire administered by the study staff, and their weight and height were measured. BMI was calculated by using their weight divided by height squared, and similar to the two previously published paper stemmed from this study [138, 140] participants' BMIs were further categorized as normal if their BMIs were less than 25 kg/m^2, and overweight or obese if their BMIs were equal to or over 25 kg/m^2 [141].

Participants were instructed to take voice-annotated videos of everything they ate and drank on three consecutive days from Sunday to Tuesday during the week of SA24-R. Participants were provided a template script that was printed on credit card-sized plastic, which they could carry with the phone to help them remember to say their location, time and food or beverage they consumed, as well the portion sizes when they recorded their videos. The videos are automatically dated and time stamped by the phone. Next, trained interviewers conducted 24-hour recalls each evening from Sunday to Tuesday by reviewing the videos with the participants to prompt the recalls. All diet recall data were then coded and entered by trained study staff.

Participants were instructed to wear the smartphones on their waist in a small pouch during waking hours with a custom app called CalFit running continuously on the phone. CalFit is a smartphone-based system that provides objective measurements of a person's time-location patterns using the global positioning system and physical activity using the phone's accelerometer. CalFit was developed to run in the background on the smartphone without disrupting normal phone functions. The system has ample battery life to last an entire day, and can be recharged overnight. It enables the integrated collection of multiple aspects of behavior, environmental exposure, and outcome measurement that before required multiple instruments and post-hoc integration. It also has undergone extensive usability tests and validation against the Actigraph in two epidemiologic studies [142, 143].

Each participant carried a CalFit phone for 1 full week. The first and last days were not analyzed as they are biased by having to meet for deployment and retrieval. The CalFit phones recorded date, time, latitude, longitude, and accelerometry counts at 10-second intervals. Data were stored on the phone (wireless phone service is not required), and downloaded at the end of the week. The resulting physical activity measure for each participant was the average daily waking-hour energy expended in Kcal for each day. Methodologies used to assess physical activity and food environment have also been reported in a recently published study [139].

Among the recruited 120 participants, 117 agreed to participate, 3 did not meet the eligibility criteria due to medical conditions; 7 did not complete the study, and 6 had smartphone malfunction resulted in unusable data; consequently, 101 participants were included in the analysis.

Food environment exposure assessment

In this paper, personal food environment exposures were defined as the overall number of food establishments of a particular type along the individual's GPS track as measured by their phone. The cohort's GPS tracking is illustrated in Figure 1 with clear urban and rural activity clusters. Specifically, to compute the number of food establishments of a particular type along a participant's GPS track, a "Staypoint" algorithm [139] was run to identify locations this participant has spent at least 10 minutes. An example of a participant's GPS track (black dots) and staypoints (red circles) is shown in Figure 2. To protect the privacy of this participant, background street map is not shown.

Figure 1. Map of participants' GPS data

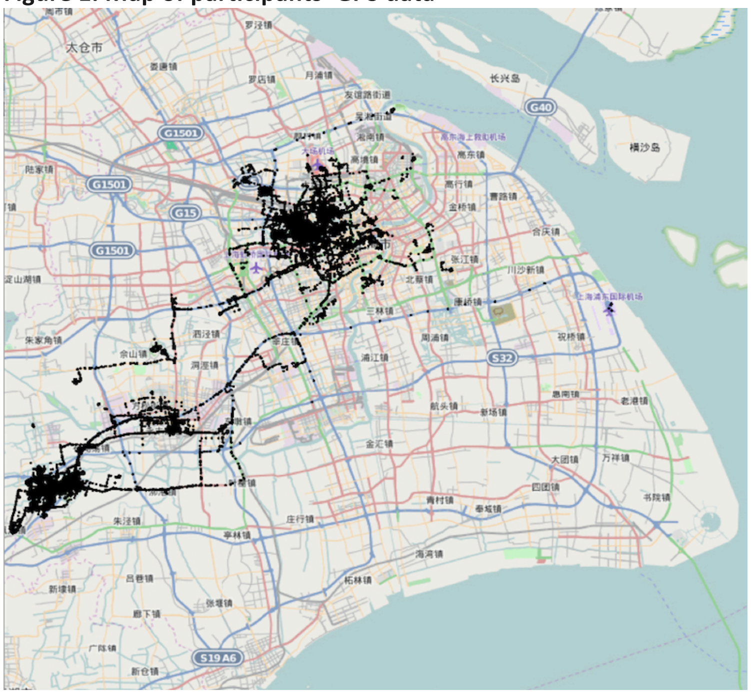
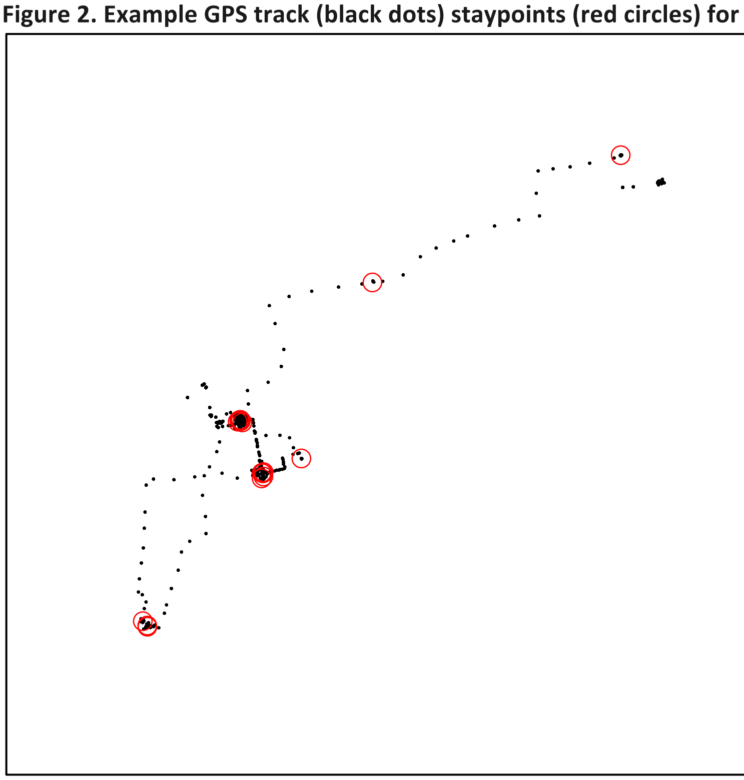


Figure 2. Example GPS track (black dots) staypoints (red circles) for one participant



To obtain food environment data for each of the identified staypoints, Google Places was used to search for information on names, addresses, geographic coordinates and types of food establishments are available for many places around the world. We created spatial buffers of 250 m (radius) from the center of each staypoint, then used Google Places to search on a number of different establishment categories within each of the buffers. Categories included bakery, bar, café, convenience store, grocery or supermarket, liquor store, meal delivery, meal takeaway, and restaurant, as well as "all types" of food-related establishments. For each participant, we generated averages of the number of each type of food establishment for all of his/her staypoints per day. These averages represent the typical food environment exposures participants encountered during the monitoring period. The 250 m buffer distance was chosen to capture the area of approximately 1-city block in Shanghai – the region of food options that a person could easily access at any point in time. As stated before, methodological details and rationale for the staypoint algorithm and food environment data extraction can be found in this recently published paper [139].

Moreover, we computed two other measures of the food environment that are based on concepts borrowed from the field of ecology. Both richness and Shannon's Diversity Index have been used in ecology to measure biodiversity [144]. In applying these to the food environment, we define "richness" as the number of different food establishment types. Shannon's Diversity Index accounts for both the number of different food establishment types as well as abundance for each type. Shannon's Diversity Index was calculated by first computing the proportion of food establishment type *i* relative to the total number of food establishment types (P_i), then multiplied by the natural logarithm of this proportion ($\ln P_i$), and the resulting product is summed across food establishment types, and multiplied by -1, illustrated in the following formula [144].

$$H = -\sum_{i=1}^{R} P_i \ln P_i$$

Statistical analyses

Variables

The outcome of interest, SSB consumption, was derived from 24-hour recalls as the mean SSB consumption over three days. SSBs included soda, sports drinks, sweetened fruit drinks, sweetened milk drinks, sweetened coffee and tea, and smoothies [138]. The mean SSB consumption in Kcal as a continuous variable was also converted to a dichotomous variable since approximately half of the cohort had no SSB consumption over the three recall days. In our analysis, we first used the dichotomous SSB consumption variable, and then we specifically looked at the participants who had consumed SSB over their recall days.

The independent variables of food environment exposures were derived from food environment exposure assessment described earlier, and these variables include different types of food establishments (bakery, bar, café, convenience store, grocery store or supermarket, liquor store, meal delivery, meal takeaway and restaurant), as well as "all types" (total counts of all food establishment types), richness and Shannon's Diversity Index.

The covariates considered in the analysis included site (rural/urban), age (21-26/27-31/32-36 years), sex (male/female), marital status (single/married), education level (no school or primary school/middle, high or technical schools/college, university or above), employment status (employed/not employed), smoking (never smoked/smoked or current smoker), sleep hours (hours slept) and total income (from all sources, in RMB) were collected in the demographic survey. BMI was calculated using anthropometric measurements of weight and height, and classified into two categories- normal/overweight or obese using the cut-offs described above. Average physical activity in Kcal was obtained from the phone accelerometry. Lastly, average daily energy intake in Kcal including food over three diet recall days was derived from 24-hour recall.

Descriptive statistics

Percentage distributions of participants' characteristics in the form of categorical variables were tabulated, and for continuous variables, including food environment characteristics, means, standard deviations, minimums and maximums were calculated.

Analyses

A total of 101 participants were included in the analyses. Logistic regression was used to explore the relationships between SSB consumption (dichotomous) and food environment exposures including "all types", richness and Shannon's Diversity Index, as well as exposures to individual food establishment types. We further explored the relationships between SSB drinkers (SSB consumption greater than 0 Kcal, continuous) and the same set of food environment exposures. As the SSB consumption for SSB drinkers was over-dispersed count data, negative binomial regression was used. Multicollinearity between independent variables was assessed by calculating variance inflation factors (VIF), and a VIF of less than 10 indicated that muticollinearity was not a concern among the variables [145]. To improve the overall fit of the full models, a backward stepwise selection with significance level for removal of 0.33 was used to build a reduced model. Significance level for removal of 0.33 was chosen to ensure that no important covariates were missed. We also explored multiplicative interactions between food environment exposure variables and the several covariates (age, sex, site, BMI, smoking status, employment status and child) in separate models. Hosmer-Lemeshow (H-L) test was used examine the goodness of fit for the models with the null hypothesis that the models were good fits for the data. To compare model fit, we used Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

To reiterate, six models were fitted for each food environment exposure variable to examine the relationships between SSB consumption and food environment- (i) full model with dichotomous SSB outcome, (ii) reduced model with dichotomous SSB outcome, (iii) full model plus interaction terms with SSB outcome, (ix) full model with continuous SSB outcome among SSB drinkers, (x) reduced model with continuous SSB outcome among SSB drinkers, and lastly

(xi) full model plus interaction terms with continuous SSB outcome among SSB drinkers. For each variable in the models, odds ratio (OR) or incident rate ratio (IRR), p-value and 95% confidence interval were presented in the results.

STATA version 11 (Stata Corporation, College Station, Texas) was used to perform all statistical analyses.

Results

Participants' characteristics are presented in Table 1 and 2. Among 101 participants included in the analyses, 50 (49.5%) were from rural Shanghai, and 51 (50.5%) were urban. The cohort was composed of 55.5% (56) female and 46.5% (45) male with average age of 29.7. 23% were overweight or obese with BMI greater or equal to 25 kg/m^2, and 33% were smokers.

In terms of SSB consumption during the 3-day dietary data collection, 48% of the participants reported no SSB consumption. The average SSB consumption was 69 Kcal for the entire cohort, and among SSB drinkers (52%), the average SSB consumption was 132 Kcal. The average energy consumption including food for the cohort was 1648 Kcal with standard deviation of 572 Kcal.

The food environment characteristics encountered on average by the participants are presented in Table 3. In general, participants were exposed to approximately 186 food establishments per day during the monitoring period. The individual counts do not sum up to the "all types" counts because an establishment may be e.g., both a restaurant and a meal-takeaway place. Participants were also exposed to about 25 convenience stores and 144 restaurants a day, and a richness score of 14.5 and Shannon Diversity Index of 2.86 indicating abundant and diverse food environment [144].

Table 1. Participant characteristics (categorical)

Participant Characteristics (Categorical)	n	%
Site		
Rural	50	49.5
Urban	51	50.5
Sex		
Female	56	55.45
Male	45	44.55
Age group		
21-26	18	17.82
27-31	54	53.47
32-36	29	28.71
BMI Category		
Normal	78	77.23
Overweight/Obese	23	22.77
Marital Status		
Single	32	31.68

Married	69	68.32
Child		
No	44	43.56
Yes	57	56.44
Education Level		
No school or primary school	7	6.93
Middle, high or technical school	41	40.59
College, University or above	53	52.48
Employed		
No	8	7.92
Yes	93	92.08
Ever smoked		
No	68	67.33
Yes	33	32.67
SSB consumption		
No	48	47.52
Yes	53	52.48

Table 2. Participant characteristics (continuous)

Participant Characteristics (Continuous)	Mean	Std. Dev.	Min	Max
Age	29.68	3.02	21	36
Sleep hour	8.10	1.00	6	11
Physical activity (Kcal)	0.42	0.08	0.27	0.76
BMI (kg/m^2)	22.53	3.56	15.02	34.16
Total income (RMB)	37546	31770	0	228000
Mean 3-day energy including food (Kcal)	1648.1	571.9	549.5	3180.9
Mean 3-day SSB consumption (Kcal)	69.02	125.82	0	812
Mean 3-day SSB consumption (Kcal) among SSB drinkers (n=53)	131.53	148.54	13.08	812

Table 3. Food environment characteristics (exposure/day)

Food Environment Characteristics	Mean	Std.Dev.	Min	Max
All types	185.84	236.59	0	953.33
Bakery	6.90	10.00	0	47.00
Bar	2.71	4.82	0	26.67
Café	4.12	6.59	0	40.83
Convenience store	25.43	31.73	0	138.00
Grocery or supermarket	2.87	3.90	0	24.50
Liquor store	0.07	0.25	0	1.83
Meal delivery	0.34	0.88	0	5.67
Meal takeaway	0.85	1.45	0	8.50
Restaurant	143.65	187.27	0	741.50
Richness	14.45	13.94	0	65.17
Shannon	2.86	2.45	0	10.92

The relationships between SSB drinker vs. non-drinker and food environment variables of "all types", richness and Shannon Diversity Index, as well as the relationship between these food environment variables and SSB consumption among SSB drinkers were presented in Table 4-9. All H-L tests generated a p-value greater than 0.05 suggesting null hypotheses cannot be rejected, and the models were good fit for the data. To compare between models, AIC and BIC values suggested that reduced models in general were the better fit of all models.

The associations of counts of all food establishments ("all types") and SSB consumption (drinkers vs. non-drinkers) are presented in Table 4. In the reduced model, the odds of being a SSB drinker was 4.6 times higher (OR = 4.6, 95% CI = 1.8; 11.6) for those having a college, university or above degree compared to those with less education. In the full model with interaction, the odds of being a SSB drinker was considerably lower for rural participants compared to urban participants (OR = 0.02, 95% CI = 0.001; 0.48). Single participants also had a lower odds of being a SSB drinker compared to married participants (OR = 0.02; 95% CI = 0.001; 0.29). Furthermore, the model with interaction terms suggested no significant interactions (coefficients all approximately 1 or non-significant) between exposure to all food establishments and covariates of interest. None of the models indicated that exposure to all food establishments generally, was associated with the odds of consuming SSB.

The associations between exposure to all food establishments and Kcal intake from SSB consumption among SSB drinkers are presented in Table 5. Similar to previously analysis of SSB drinkers vs. non-drinkers, with other variables are controlled for in the model, rural participants had a lower rate of Kcal intake from SSB consumption (IRR = 0.46, 95% CI = 0.23; 0.93) compared to urban participants. Incident rates for age groups 27-31 and 32-36 years were 1.90 (IRR = 1.90, 95% CI = 1.08; 3.35) and 2.09 (IRR = 2.09, 95% CI = 1.05; 4.06) times greater than the incident rate for the referent age group 21-26 years, indicating the older age groups of SSB drinkers consumed more Kcal than younger age group of SSB drinkers. Married SSB drinkers had 2.3 times greater incident rate of consuming more Kcal from SSB than single SSB drinkers. In addition, smoking SSB drinkers were expected to have an incident rate 2.32 times (IRR = 2.32, 95% CI = 1.10; 4.88) greater for SSB consumption than non- smoking SSB drinkers. Lastly, normal weight SSB drinkers were expected to have an incident rate 65% (IRR = 0.35, 95% CI = 0.12; 0.97) lower for Kcal from SSB consumption than overweight SSB drinkers. In the full model with interaction, there was a borderline significant association between exposure to all food environments and increased rate of Kcal intake from SSB consumption (IRR = 1.08, 95% CI 1.00; 1.16) among this subset of SSB drinkers.

The associations between richness of the food environment and SSB drinkers and non-drinkers are presented in Table 6. Similar trends were observed as counts of all types and SSB consumption for participants with college, university or above degrees, as well as participants' marriage statuses. Although a small difference, model with interaction terms suggested the relationship between richness of food environment and SSB consumption was different for participants with children versus participants without children. Among participants without children, the association between food environment richness and SSB drinking was OR 1.17, whereas among those with children, the association between food environment richness and

SSB drinking was higher (OR = 1.19).

The associations between richness of the food environment and Kcal intake from SSB consumption among SSB drinkers are presented in Table 7. Again, similar trends were observed for being an urban resident, age 27 years and above, married, having children and having a college, university or above degree. Also, in the reduced model, among SSB drinkers, there was a small positive association between food environment richness and Kcal intake from SSB consumption, controlling for other covariates (IRR = 1.01, 95% CI = 1.00; 1.01).

The relationship between Shannon's Diversity Index of the food environment and SSB consumption is presented in Table 8. Having a college, university or above degree or being a current smoker is associated with a greater odds of being a SSB drinker. However, no significant association was found between food environment diversity and an increased odds of being a SSB drinker.

The relationship between SSB consumption in Kcal among SSB drinkers and Shannon's Diversity Index of their food environment is shown in Table 9. Comparable associations were seen for being an urban resident, age 27 years and above, and married, as well as having children. In the models without interaction, a significant association was observed between food environment diversity and Kcal intake from SSB consumption.
The relationships between SSB consumption and other types of food establishment types can be found in the appendix. Other than similar trends described before in terms of age, education level and marriage status, as well as having children, an association was observed between counts of bakeries and SSB consumption, with an interaction with obesity: The odds ratio of overweight or obese participants was 0.96 times (OR = 0.96, 95% CI = 0.94; 0.99) the odds ratio of normal weight participants. This indicated that for normal weight participants, one unit increase in the count of bakery, the odds of being a SSB drinker is 1.17; and among overweight or obese participants, the odds ratio is 1.12.

The relationships between SSB consumption and other types of food establishment types can be found in the appendix. Similar trends described before in terms of age, education level, marriage status, as well as being a parent were observed. Significant associations were found between exposure to grocery stores/supermarkets, liquor stores, meal deliveries, meal takeaways and restaurants and SSB consumption and Kcal intake from SSB consumption. Moderation effects were also observed between participants' weight statuses, urbanicity, genders, and smoking statuses and different food environment exposures.

Table 4. SSB Consumption and All Types of Food Environment (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.57	0.54	0.10 - 3.40				**0.02**	**0.01**	**0.00 - 0.48**
Age 27-31	1.79	0.41	0.45 - 7.09				2.79	0.32	0.36 - 21.41
Age 32-36	1.97	0.40	0.40 - 9.70				1.54	0.72	0.15 - 15.58
Sex	1.13	0.85	0.33 - 3.80				0.77	0.76	0.14 - 4.21
Marriage	0.30	0.13	0.06 - 1.43	0.51	0.19	0.19 - 1.39	**0.02**	**0.01**	**0.00 - 0.29**
Child	1.02	0.98	0.27 - 3.79				0.42	0.34	0.07 - 2.50
Middle, High and Technical School	1.33	0.79	0.16 - 10.96				2.90	0.42	0.21 - 39.20
College, University or Above	8.88	0.08	0.74 - 106.28	**4.6**	**0.00**	**1.83 - 11.59**	**25.47**	**0.04**	**1.10 - 591.64**
Employment	0.97	0.98	0.15 - 6.27				6.52	0.38	0.10 - 422.27
Smoking	2.55	0.16	0.70 - 9.30	2.57	0.06	0.98 - 6.77	1.82	0.49	0.33 - 9.98
Sleep hours	1.11	0.69	0.67 - 1.84				1.14	0.66	0.64 - 2.04
Physical Activity	0.74	0.92	0.00 - 218.28				0.16	0.60	0.00 - 147.77
BMI	0.86	0.81	0.25 - 2.93				2.30	0.32	0.44 - 11.96
Total Income	1.00	0.87	1.00 - 1.00				1.00	0.90	1.00 - 1.00
Mean Daily Kcal	1.00	0.86	1.00 - 1.00				1.00	0.53	1.00 - 1.00
All Types	1.00	0.66	1.00 - 1.00				1.15	0.13	0.96 - 1.36
Age 21-26 X All types							1.00	.	1.00 - 1.00
Age 27-31 X All types							1.00	0.58	1.00 - 1.00
Age 32-36 X All types							1.00	0.20	1.00 - 1.00
Never Smoked X All types							1.00	.	1.00 - 1.00
Smoked X All types							1.00	0.41	1.00 - 1.00
Not Employed X All types							1.00	.	1.00 - 1.00
Employed X All types							0.87	0.13	0.73 - 1.04
No Child X All types							1.00	.	1.00 - 1.00
Child X All types							**1.00**	**0.01**	**1.00 - 1.00**
Female X All types							1.00	.	1.00 - 1.00
Male X All types							1.00	0.83	1.00 - 1.00
Rural X All types							1.00	.	1.00 - 1.00
Urban X All types							1.00	0.99	0.99 - 1.01
Normal Weight X All types							1.00	.	1.00 - 1.00

VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Overweight/Obese X All types							**1.00**	**0.03**	**1.00 - 1.00**
Log Likelihood	-59.59			-60.49			-49.02		
LR Chi2	20.59	0.19		18.78	<0.01		41.74	0.01	
AIC	1.52			1.28			1.60		
BIC	53.25			-4.94			69.03		
H-L GOF	5.25	0.73		2.87	0.58		9.66	0.29	

Statistically significant ($p<0.05$) results were **BOLD**.

Table 5. Mean SSB Consumption in Kcal and All Types of Food Environment (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	**0.42**	**0.02**	**0.20 - 0.89**	**0.46**	**0.03**	**0.23 - 0.93**	0.63	0.38	0.23 - 1.75
Age 27-31	**2.03**	**0.01**	**1.16 - 3.56**	**1.90**	**0.03**	**1.08 - 3.35**	**2.45**	**0.04**	**1.02 - 5.89**
Age 32-36	**2.22**	**0.02**	**1.11 - 4.43**	**2.09**	**0.04**	**1.05 - 4.16**	**6.09**	**0.02**	**1.28 - 29.07**
Sex	1.17	0.55	0.70 - 1.94				1.88	0.18	0.75 - 4.72
Marriage	**0.4**	**0.00**	**0.21 - 0.76**	**0.44**	**0.01**	**0.24 - 0.79**	0.62	0.23	0.29 - 1.34
Child	1.76	0.09	0.92 - 3.37	1.67	0.07	0.95 - 2.92	1.01	0.98	0.36 - 2.86
Middle, High and Technical School	1.99	0.47	0.31 - 12.58				0.00	0.08	0.00 - 60474772
College, University or Above	3.48	0.19	0.55 - 22.15	1.74	0.08	0.94 - 3.21	0.00	0.08	0.00 - 85254328
Employment	0.36	0.19	0.08 - 1.68	0.50	0.14	0.20 - 1.24	2.80E+62	0.08	0.00 - 8.15e+132
Smoking	1.76	0.06	0.98 - 3.18	1.62	0.09	0.93 - 2.83	**2.32**	**0.03**	**1.10 - 4.88**
Sleep hours	1.12	0.31	0.90 - 1.40				1.12	0.40	0.86 - 1.45
Physical Activity	3.07	0.46	0.15 - 61.53				2.33	0.56	0.13 - 41.30
BMI	0.62	0.07	0.37 - 1.05	0.62	0.08	0.36 - 1.06	**0.35**	**0.04**	**0.12 - 0.97**
Total Income	1.00	0.10	1.00 - 1.00	1.00	0.08	1.00 - 1.00	1.00	0.21	1.00 - 1.00
Mean Daily Kcal	1.00	0.22	1.00 - 1.00	1.00	0.16	1.00 - 1.00	1.00	0.26	1.00 - 1.00
All Types	1.00	0.07	1.00 - 1.00	1.00	0.12	1.00 - 1.00	1.08	0.07	1.00 - 1.16
Age 21-26 X All types							1.00	.	1.00 - 1.00
Age 27-31 X All types							1.00	0.54	1.00 - 1.00
Age 32-36 X All types							1.00	0.08	1.00 - 1.00
Never Smoked X All types							1.00	.	1.00 - 1.00
Smoked X All types							1.00	0.32	1.00 - 1.00

Not Employed X All types							1.00	.	1.00 - 1.00
Employed X All types							0.93	0.08	0.86 - 1.01
No Child X All types							1.00	.	1.00 - 1.00
Child X All types							1.00	0.87	1.00 - 1.00
Female X All types							1.00	.	1.00 - 1.00
Male X All types							1.00	0.26	1.00 - 1.00
Rural X All types							1.00	.	1.00 - 1.00
Urban X All types							1.00	0.25	0.99 - 1.00
Normal Weight X All types							1.00	.	1.00 - 1.00
Overweight/Obese X All types							1.00	0.18	1.00 - 1.00
lnalpha	0.45	0.00	0.31 - 0.65	0.47	0.00	0.33 - 0.68	0.36	0.00	0.25 - 0.53
Log Likelihood	-292.42			-293.58			-286.25		
LR Chi2	37.68	<0.01		35.39	<0.001		50.04	<0.01	
AIC	11.71			11.61			12.05		
BIC	25.84			12.26			45.24		

Statistically significant (p<0.05) results were **BOLD**.

Table 6. SSB Consumption and Richness of Food Environment (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.87	0.89	0.13 - 5.92				0.15	0.25	0.01 - 3.73
Age 27-31	1.92	0.36	0.48 - 7.70				3.74	0.27	0.36 - 38.86
Age 32-36	2.20	0.34	0.43 - 11.26				2.84	0.45	0.19 - 43.14
Sex	1.17	0.81	0.34 - 3.99				0.82	0.85	0.10 - 6.86
Marriage	0.31	0.15	0.07 - 1.51	0.41	0.10	0.14 - 1.20	**0.08**	**0.03**	**0.01 - 0.77**
Child	0.93	0.92	0.25 - 3.52				0.25	0.16	0.04 - 1.76
Middle, High and Technical School	1.29	0.81	0.16 - 10.55				2.13	0.54	0.19 - 23.64
College, University or Above	9.44	0.08	0.78 - 114.59	**7.10**	**0.00**	**2.19 - 23.07**	16.58	0.06	0.91 - 303.15
Employment	1.07	0.95	0.16 - 6.91				4.96	0.42	0.10 - 238.89
Smoking	2.73	0.13	0.74 - 10.09	2.60	0.05	0.99 - 6.88	0.74	0.78	0.09 - 5.98
Sleep hours	1.11	0.69	0.67 - 1.84				1.07	0.82	0.61 - 1.86
Physical Activity	1.00	1.00	0.00 - 323.75				0.12	0.54	0.00 - 107.44

BMI	0.80	0.72	0.23 - 2.77				2.40	0.33	0.41 - 14.21
Total Income	1.00	0.84	1.00 - 1.00				1.00	0.80	1.00 - 1.00
Mean Daily Kcal	1.00	0.78	1.00 - 1.00				1.00	0.72	1.00 - 1.00
Richness	0.99	0.27	0.99 - 1.00	1.00	0.20	0.99 - 1.00	1.17	0.18	0.93 - 1.47
Age 21-26 X Richness							1.00	.	1.00 - 1.00
Age 27-31 X Richness							0.99	0.41	0.98 - 1.01
Age 32-36 X Richness							1.00	0.84	0.98 - 1.03
Never Smoked X Richness							1.00	.	1.00 - 1.00
Smoked X Richness							1.02	0.14	0.99 - 1.04
Not Employed X Richness							1.00	.	1.00 - 1.00
Employed X Richness							0.86	0.20	0.68 - 1.08
No Child X Richness							1.00	.	1.00 - 1.00
Child X Richness							**1.02**	**0.05**	**1.00 - 1.04**
Female X Richness							1.00	.	1.00 - 1.00
Male X Richness							1.00	0.76	0.99 - 1.02
Rural X Richness							1.00	.	1.00 - 1.00
Urban X Richness							0.99	0.80	0.95 - 1.04
Normal Weight X Richness							1.00	.	1.00 - 1.00
Overweight/Obese X Richness							0.98	0.10	0.97 - 1.00
	-			-			-		
Log Likelihood	59.08			59.67			52.09		
LR Chi2	21.60	0.16		20.43	<0.001		35.58	0.06	
AIC	1.51			1.28			1.67		
BIC	52.24			-1.97			75.18		
H-L GOF	11.02	0.20		4.79	0.78		4.09	0.85	

Statistically significant (p<0.05) results were **BOLD**.

Table 7. Mean SSB Consumption in Kcal and Richness of Food Environment (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	**0.33**	**0.01**	**0.15 - 0.74**	**0.35**	**0.01**	**0.16 - 0.75**	0.79	0.74	0.20 - 3.10
Age 27-31	**1.99**	**0.01**	**1.14 - 3.46**	**1.92**	**0.02**	**1.11 - 3.33**	2.70	0.09	0.84 - 8.61
Age 32-36	**2.13**	**0.03**	**1.09 - 4.18**	**2.00**	**0.04**	**1.03 - 3.89**	2.79	0.30	0.39 - 19.85

Sex	1.18	0.50	0.72 - 1.94				0.71	0.62	0.18 - 2.79
Marriage	**0.40**	**0.00**	**0.21 - 0.75**	**0.42**	**0.00**	**0.23 - 0.75**	0.57	0.20	0.24 - 1.33
Child	**1.86**	**0.05**	**0.99 - 3.50**	**1.84**	**0.03**	**1.05 - 3.20**	**3.11**	**0.05**	**1.00 - 9.65**
Middle, High and Technical School	1.69	0.57	0.28 - 10.24				0.00	0.33	0.00 - 8837
College, University or Above	3.07	0.23	0.50 - 18.87	**1.79**	**0.05**	**0.99 - 3.22**	0.00	0.36	0.00 - 14225
Employment	0.42	0.26	0.09 - 1.88	0.55	0.18	0.23 - 1.33	9339	0.37	0.00 - 3.68e+12
Smoking	1.55	0.15	0.85 - 2.80	1.43	0.20	0.83 - 2.48	1.57	0.42	0.53 - 4.64
Sleep hours	1.10	0.36	0.89 - 1.37				1.06	0.61	0.84 - 1.34
Physical Activity	1.73	0.71	0.10 - 29.67				0.99	1.00	0.06 - 17.99
BMI	0.69	0.17	0.41 - 1.17	0.69	0.17	0.40 - 1.17	0.45	0.19	0.14 - 1.48
Total Income	1.00	0.11	1.00 - 1.00	1.00	0.12	1.00 - 1.00	1.00	0.15	1.00 - 1.00
Mean Daily Kcal	1.00	0.21	1.00 - 1.00	1.00	0.19	1.00 - 1.00	1.00	0.23	1.00 - 1.00
Richness	**1.00**	**0.02**	**1.00 - 1.01**	**1.01**	**0.02**	**1.00 - 1.01**	1.07	0.25	0.96 - 1.19
Age 21-26 X Richness							1.00	.	1.00 - 1.00
Age 27-31 X Richness							1.00	0.71	0.99 - 1.01
Age 32-36 X Richness							1.00	0.89	0.98 - 1.02
Never Smoked X Richness							1.00	.	1.00 - 1.00
Smoked X Richness							1.00	0.82	0.99 - 1.01
Not Employed X Richness							1.00	.	1.00 - 1.00
Employed X Richness							0.95	0.34	0.85 - 1.06
No Child X Richness							1.00	.	1.00 - 1.00
Child X Richness							0.99	0.12	0.98 - 1.00
Female X Richness							1.00	.	1.00 - 1.00
Male X Richness							1.00	0.53	0.99 - 1.02
Rural X Richness							1.00	.	1.00 - 1.00
Urban X Richness							0.99	0.36	0.98 - 1.01
Normal Weight X Richness							1.00	.	1.00 - 1.00
Overweight/Obese X Richness							1.01	0.35	0.99 - 1.02
lnalpha	0.43	0.00	0.30 - 0.63	0.45	0.00	0.31 - 0.64	0.37	0.00	0.26 - 0.54
Log Likelihood	-291.30			-292.21			-287.00		
LR Chi2	39.93	0.005		38.32	<0.001		48.53	<0.01	
AIC	11.67			11.55			12.08		

BIC	23.59			9.32			46.75		

Statistically significant (p<0.05) results were **BOLD**.

Table 8. SSB Consumption and Shannon Diversity Index of Food Environment (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.81	0.82	0.12 - 5.34				0.48	0.65	0.02 - 10.86
Age 27-31	1.89	0.37	0.47 - 7.52				4.56	0.24	0.35 - 58.92
Age 32-36	2.19	0.35	0.43 - 11.21				5.91	0.24	0.31 - 111.95
Sex	1.15	0.82	0.34 - 3.91				0.92	0.95	0.09 - 9.45
Marriage	0.32	0.16	0.07 - 1.54	0.44	0.12	0.16 - 1.24	0.16	0.08	0.02 - 1.28
Child	0.96	0.95	0.26 - 3.59				0.25	0.19	0.03 - 1.97
Middle, High and Technical School	1.33	0.79	0.16 - 10.91				1.75	0.64	0.16 - 18.98
College, University or Above	9.84	0.07	0.80 - 120.55	**6.92**	**0.00**	**2.11 - 22.70**	17.13	0.05	0.96 - 306.98
Employment	1.01	0.99	0.16 - 6.53				5.87	0.35	0.15 - 235.00
Smoking	2.76	0.13	0.75 - 10.23	**2.65**	**0.05**	**1.00 - 7.03**	0.47	0.52	0.05 - 4.69
Sleep hours	1.12	0.66	0.68 - 1.86				1.11	0.70	0.64 - 1.93
Physical Activity	1.20	0.95	0.00 - 387.43				0.13	0.56	0.00 - 126.98
BMI	0.80	0.72	0.23 - 2.77				2.09	0.45	0.31 - 13.89
Total Income	1.00	0.82	1.00 - 1.00				1.00	0.95	1.00 - 1.00
Mean Daily Kcal	1.00	0.78	1.00 - 1.00				1.00	0.81	1.00 - 1.00
Shannon	0.97	0.33	0.92 - 1.03	0.98	0.25	0.94 - 1.02	1.58	0.20	0.79 - 3.19
Age 21-26 X Shannon							1.00	.	1.00 - 1.00
Age 27-31 X Shannon							0.95	0.38	0.86 - 1.06
Age 32-36 X Shannon							0.98	0.76	0.86 - 1.12
Never Smoked X Shannon							1.00	.	1.00 - 1.00
Smoked X Shannon							1.11	0.08	0.99 - 1.25
Not Employed X Shannon							1.00	.	1.00 - 1.00
Employed X Shannon							0.63	0.21	0.30 - 1.29
No Child X Shannon							1.00	.	1.00 - 1.00
Child X Shannon							1.08	0.12	0.98 - 1.19
Female X Shannon							1.00	.	1.00 - 1.00
Male X Shannon							1.01	0.87	0.91 - 1.12

Rural X Shannon							1.00	.	1.00 - 1.00
Urban X Shannon							0.96	0.61	0.81 - 1.13
Normal Weight X Shannon							1.00	.	1.00 - 1.00
Overweight/Obese X All types							0.94	0.22	0.84 - 1.04
Log Likelihood	- 59.21			-59.81			- 52.22		
LR Chi2	21.35	0.17		20.15	<0.001		35.33	0.06	
AIC	1.51			1.28			1.67		
BIC	52.49			-1.69			75.44		
H-L GOF	10.85	0.21		8.87	0.35		7.32	0.50	

Statistically significant (p<0.05) results were **BOLD**.

Table 9. Mean SSB Consumption in Kcal and Shannon Diversity Index of Food Environment (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	**0.33**	**0.01**	**0.16 - 0.72**	**0.31**	**0.00**	**0.15 - 0.62**	0.60	0.45	0.15 - 2.29
Age 27-31	**1.98**	**0.02**	**1.14 - 3.45**	**1.88**	**0.02**	**1.09 - 3.23**	**3.56**	**0.05**	**1.00 - 12.69**
Age 32-36	**2.10**	**0.03**	**1.08 - 4.09**	1.77	0.08	0.93 - 3.34	3.23	0.24	0.45 - 23.32
Sex	1.21	0.45	0.74 - 1.97				0.47	0.28	0.12 - 1.86
Marriage	**0.43**	**0.01**	**0.23 - 0.80**	**0.45**	**0.01**	**0.25 - 0.80**	0.55	0.13	0.26 - 1.19
Child	1.81	0.06	0.97 - 3.36	**1.88**	**0.03**	**1.08 - 3.27**	3.07	0.06	0.97 - 9.66
Middle, High and Technical School	1.18	0.85	0.20 - 7.15				0.00	0.18	0.00 - 64.38
College, University or Above	2.20	0.39	0.36 - 13.44	1.63	0.09	0.92 - 2.87	0.00	0.22	0.00 - 116.42
Employment	0.61	0.51	0.13 - 2.73				9592	0.22	0.00 - 2.06e+10
Smoking	1.46	0.21	0.81 - 2.64				1.32	0.64	0.41 - 4.26
Sleep hours	1.11	0.34	0.90 - 1.36				1.02	0.86	0.81 - 1.28
Physical Activity	1.22	0.89	0.08 - 19.64				0.87	0.92	0.05 - 13.94
BMI	0.71	0.19	0.42 - 1.19	0.73	0.22	0.45 - 1.20	0.33	0.11	0.09 - 1.28
Total Income	1.00	0.16	1.00 - 1.00	1.00	0.16	1.00 - 1.00	1.00	0.29	1.00 - 1.00
Mean Daily Kcal	1.00	0.18	1.00 - 1.00	**1.00**	**0.05**	**1.00 - 1.00**	1.00	0.43	1.00 - 1.00
Shannon	**1.03**	**0.01**	**1.01 - 1.05**	**1.03**	**0.00**	**1.01 - 1.06**	1.29	0.16	0.91 - 1.84
Age 21-26 X Shannon							1.00	.	1.00 - 1.00
Age 27-31 X Shannon							0.98	0.44	0.93 - 1.03

Age 32-36 X Shannon							0.99	0.89	0.91 - 1.08
Never Smoked X Shannon							1.00	.	1.00 - 1.00
Smoked X Shannon							1.02	0.53	0.96 - 1.07
Not Employed X Shannon							1.00	.	1.00 - 1.00
Employed X Shannon							0.80	0.21	0.56 - 1.14
No Child X Shannon							1.00	.	1.00 - 1.00
Child X Shannon							0.96	0.15	0.91 - 1.01
Female X Shannon							1.00	.	1.00 - 1.00
Male X Shannon							1.04	0.29	0.97 - 1.11
Rural X Shannon							1.00	.	1.00 - 1.00
Urban X Shannon							0.99	0.84	0.94 - 1.05
Normal Weight X Shannon							1.00	.	1.00 - 1.00
Overweight/Obese X All types							1.04	0.22	0.98 - 1.11
lnalpha	0.42	0.00	0.29 - 0.61	0.45	0.00	0.31 - 0.64	0.36	0.00	0.25 - 0.53
	-			-			-		
Log Likelihood	290.55			292.08			286.20		
LR Chi2	41.43	<0.001		38.37	<0.001		50.14	0.001	
AIC	11.64			11.48			12.05		
BIC	22.09			1.33			45.15		

Statistically significant (p<0.05) results were **BOLD**.

Discussion

To our knowledge, this is the first study investigating the relationship between SSB consumption and exposure to the food environment in China. It is also the first study utilizing smartphone technology in food environment and physical activity tracking and dietary assessment. In addition, this study obtained detailed and quality SSB consumption, physical activity and weight status data, which were lacking in many prior studies [115].

It does not seem clear that food environment affects the odds of being a SSB drinker or not. However, our results suggest that exposure to the food environment indeed affects SSB drinkers' SSB consumption. Among SSB drinkers, those that are exposed to higher richness and diversity of the food environment tend to have higher Kcal intake from SSB consumption. Some have suggested that the abundance of food establishments provides both healthy and unhealthy food that could influence dietary behavior and obesity risk as people are exposed to such great provision of food with diverse nutritional quality on a regular basis [132, 146]. Also, the more grocery stores/supermarkets, meal takeaways or restaurants SSB drinkers encountered, the more SSB may be consumed. In contrary, previous studies suggested that living near supermarkets was associated with lower SSB consumption [147], and this might be due to the fact that many supermarkets and mega supermarkets such as Walmart and Carrefour are run by foreign entities and carry more Western foods. Negative association was observed between SSB consumption and exposure to liquor stores, likely due to the products liquor stores carry. Furthermore, the more meal deliveries participants encountered, the more likely they would drink SSB. Most of the meal deliveries and takeaways serve Chinese or Western fast food, and this was consistent with published literature that living near a fast food store is associated with higher SSB consumption [147, 148].

Different from previous studies, in our cohort, higher education is positively associated with being a SSB drinker, and consuming more SSB kcal if already a SSB drinker, whereas previous studies revealed that lower socioeconomic status was associated with higher odds of SSB consumption [149-151]. Rural participants had significantly lower odds of being SSB drinkers than urban participants. Also, among SSB drinkers, rural participants also have lower rate of consuming Kcal from SSB than urban participants. This is consistent with published studies, which indicated that urban areas had more large-sized supermarkets and Western fast food restaurants, in which SSBs were widely available [112, 152].

Being a parent seems to play a role in moderating SSB consumption depending on the types of food environment encountered. The effects of the food environment become stronger in terms of SSB consumption for participants with children. Although no children were in this study, strong evidence indicates that children and adolescents who consume more SSBs have higher body weights than those who drink fewer SSBs, and relatively moderate evidence for this association exists for adults [153]. Other than weight gain, higher consumption of SSBs is associated with developing metabolic syndrome and type II diabetes later in life [147]. This makes the role of parents in shaping their children's dietary habit potentially quite important, as children learn from their parents, and both desirable and undesirable dietary habits of the parents could be adopted by their children.

Weight status was also found to modify SSB consumption. Among SSB drinkers, normal weight individuals consumed lower Kcal from SSB than overweight or obese individuals. This suggests the importance of targeting interventions to reduce consumption of SSBs specifically to overweight or obese individuals. Prior studies suggested that awareness of weight status could result in systematic underreporting of SSB, which could weaken the associations of SSBs with food environment or weight gain [116]; however, two papers found no statistically significant differences between overweight versus normal weight participants in terms of reporting or the overall acceptability of smartphone use [138, 140]. The moderation effects of weight statuses change depending on the types of food establishment. For exposures to bakeries, convenience stores or meal deliveries, the odds of drinking SSBs was lower among overweight or obese participants than normal weight participants. However, for exposures to takeaway meal establishments, overweight SSB drinkers consume more SSBs than normal weight SSB drinkers.

Although our food environment measurements do not precisely indicate that individuals visited specific establishments and purchased SSBs from them, it is important to note general availability of SSBs within these types of establishments. For instance, bakeries in China generally sell both sweetened pastries or baked goods and SSBs, and overweight individuals may have different purchasing behaviors (purchasing only baked goods versus SSBs) than normal weight individuals. Again, takeaway meal establishments in China generally sell either Chinese or Western fast food. Like in the U.S., often SSBs may be combined with the meal. Normal-weight individuals may choose to forego the included SSBs or select non-SSB drinks.

In our cohort, married SSB drinkers had significantly higher rate of consuming Kcal from SSB compared to single SSB drinkers. Male SSB drinkers also had significantly higher rate than female drinkers. It was reported that SSB consumption was highest in men aged 20-39 years, and higher consumption in younger adults may in part be due to heavier marketing and advertising of SSBs to younger populations [152, 154].

Smoking SSB drinkers also had significantly higher rate of consuming Kcal from SSB compared to non- smoking SSB drinkers. Non-smoking SSB drinkers exposed to bars tended to have a higher rate of SSB consumption than smoking SSB drinkers. Perhaps smoking SSB drinkers would drink more alcohol at bars than non-smoking SSB drinkers. However, we did not include alcohol consumption in our models. Interestingly, smoking SSB drinkers exposed to liquor stores tend to have a higher consumption of SSB, while consumption tends to be lower for non-smoking SSB drinkers' who are exposed to liquor stores. It has been established that smoking in Asian countries is a global problem, and it was estimated that 60% of men in East Asia smoke. Similar to undesirable dietary factors such as high consumption of SSBs, it contributes to the mortality from cancers, cardiovascular and respiratory diseases [113, 155, 156].

This paper has several limitations. First, only 101 Chinese participants were included in the analysis, which limit its generalizability to larger population or cohort of other races or ethnicities. Second was the cross-sectional nature of the study as diet and beverage assessment were conducted for 3 days, and we were not able to assess seasonal changes or episodic consumption in SSBs. As the original study used a crossover design, and also reported in previously published studies, participants who did SA24-R second might experience fatigue and under reported their consumption [138, 140]. Third, we might have missed other potential interactions between food environment exposures and SSB consumption such as participants' income and alcohol consumption. There might be other interactions between the covariates, for example, BMI and age, BMI and daily energy consumption, hours of sleep and SSB consumption etc. Fourth, despite we had good sensitivity in our food environment data, as Google haven't been active in China in the last few years, this data might not be up to date and undercount certain food environment types, and this could lead to underestimate the effects of food environment. Lastly, instead of using participants' own phones, we distributed study phones to each participants, this could have been cumbersome for some participants, and led to participant fatigue and under-reporting.

It is essential to monitor food environment and indicator items such as SSBs that may contribute to adverse dietary behaviors and risk of obesity or chronic diseases. As most of the food establishments are regulated by local governments, there is a strong potential for further intervention to mitigate such environmental risk factors [128]. For example, despite resistance from the soda industry, soda tax to reduce SSB consumption have been developed and implemented in many regions and countries worldwide [122, 147]. Moreover, research on potential effectiveness of food and beverage taxes and subsidies suggested that raising prices in fast food prices would potentially impact weight outcomes by reducing consumption, and fruit and vegetable subsidies for low-income population may be effective in reducing obesity [157]. As smartphones and other mobile devices become smaller, faster, less expensive and more ubiquitous, it has the potential to provide researchers with valid, reliable and cost-effective data collection, as well as short-term or long-term detailed objective measures of physiologic, behavioral, social and environmental influences on personal health and daily function [158].

Conclusions

In summary, in a cohort of Chinese adults aged 21-40 years old living in rural and urban Shanghai, individuals' food environment exposures were found to influence their consumption of SSBs. Urban, older (aged 27-40), more educated, male gender and overweight participants had higher odds of consuming SSBs. Moderation effects were observed depending on participants' weight status, as well as in participants who have children versus without children. As this is the first and only study utilizing smartphones to assess the associations between food environment and SSB consumption, more research is needed to replicate current study findings. Due to the sample size and cross-sectional nature of the current study, future longitudinal study with larger sample size would improve current study results.

Future work

To further examine the health effects of food environment on diet and obesity risk, a 300 adolescent cohort was recruited from two high schools in Kunming in 2014, and followed for two years (2014 and 2015). As there is not enough time during my PhD study, I will continue to work on processing and analyze the data collected in my postdoctoral fellowship. In order to estimate the effects of socially-connected peers' behaviors on individuals' own diet, physical activity and stress, I plan to explore two alternative approaches: regression modeling and stochastic actor-based (SAB) modeling. I plan to build a set of structured multivariate equations to test the associations between exposure and outcome shown in my conceptual framework, as well as the associations between changes in physical activity, stress, and social networks. Preliminary results on the cohort's BMIs are presented in this section.

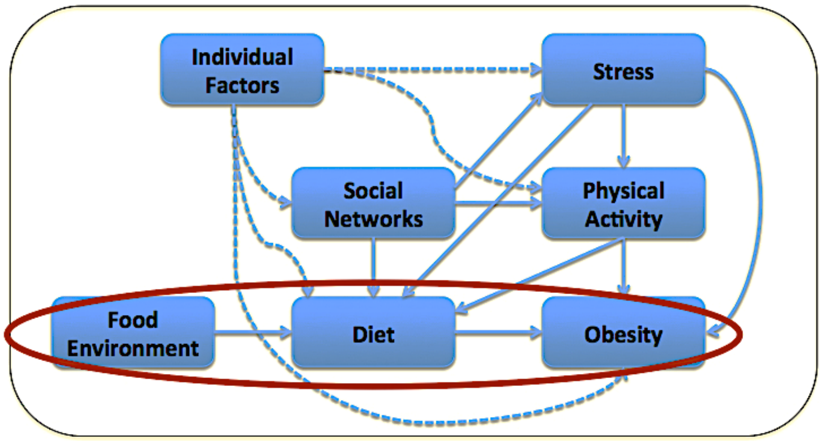
Background

Admission to a high school primarily depends on students' performance on entrance examination. Students attending a high school do not necessarily live near that high school. Thus, persons of various social demographic backgrounds can attend the same high school. Each high school class has approximately 40 students with roughly 1:1 male to female ratio. Unlike typical high schools in the U.S., Chinese high school students do not change classrooms, but stay with the same class students for all three years. This allows students attending the same class form relatively stronger social networks. Informed consent and assent were obtained from each student and his/her parent.

Students aged 15-18 have high adaptability to changing environments. Growing up in the 90s midst drastic social and environmental changes has given them increased access to Westernized fast food and exposures to new technologies and media. They grew up with the Internet, and many of them already have smartphones. Nearly all were born under China's one-child policy, and were the center of the attention of two generations, giving them the privilege to concentrate on their education, but also enormous pressure to meet their parents and grandparents' expectations. At the same time, students at this age are highly susceptible to peer pressure, which influences what they eat and other aspects of their behavior.

This research is based on an ecological model of health framework (conceptual diagram below), in which obesity is affected by various upstream social and built environmental determinants. The exposure pathway of interest is an individual's exposure to food environments, which mediates diet. Unhealthy food environments are defined as those with relatively higher densities of fast food restaurants and convenience stores, less diverse food options, higher availability of packaged food and food high in fat, salt and simple sugar, and lower availability of fresh fruits and vegetables. Additionally, this framework considers the structured effects of physical activity, stress, social influences, and individual-level confounders (age, SES, sex, smoking, etc.).

Conceptual diagram



Data Collection

Same as the pilot study described in Chapter 2, students carried smartphones that track their physical activity and GPS mobility patterns. GPS data from the phones would be combined with Google Map data on food establishments to quantify exposures to the food environment. Students used the phones to record voice-annotated videos of their meals for dietary assessment. The phones also were used to conduct EMA to assess self-reported stress and social interactions. Students used the phones for two 1-week periods in two years. Students' weights and heights were measured, and BMIs were calculated.

Basic socio-demographics including gender, age, parental education level and household income, smoking, meals ate at home of the students were collected via a questionnaire during recruitment. Information on students and their households' health status and other individual level environmental factors such as media exposure were also collected. Data on stress was collected by using Cohen's Stress Index [159].

The purpose of collecting data and enumerating students' social networks is to assess how social ties may influence dietary and physical activity behaviors. As recent research has suggested, obesity seems likely to spread among family and friends via some form of social influence [160-163], it is important to control for the influence of social ties on individual health behaviors and outcomes in order to determine the health effects that the food environment alone has. To do so, all students were part of strong networks. Following the network design of the well-known US-based National Longitudinal Study of Adolescent Health (Add Health) [164], upon recruitment and at two time points of data collection, each student identified five of their closest male friends and five of their closest female friends, and what they had done with each of their identified friend in the previous week in order to recognize the strength of ties between the students and identify the key players or the degree of centralities students exhibit.

Preliminary Results- Adolescent obesity in Kunming

Students' BMIs were calculated using their weight in kilograms divided by height in meters, squared. The BMIs were categorized into underweight, normal, overweight and obese. Using the same cutoffs as in Chapter 1, because there was no single gold standard for BMI criteria for a Chinese population, five different BMI cutoffs to demonstrate different distributions of overweight and obese in the cohort. The five BMI cutoffs included those established by the Capital Institute of Pediatrics (CIP) and Working Group on Obesity in China (WGOC), International Obesity Task Force (IOTF and IOTFa, Asian specific), World Health Organization (WHO) and Center for Disease Control (CDC) [44-53].

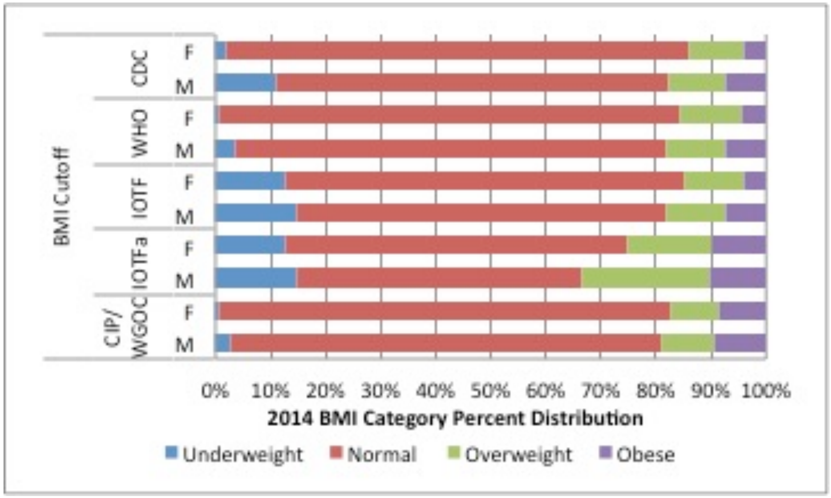
The distributions of the cohort's BMIs in 2014 and 2015 are illustrated in the following tables and figures. The mean BMI of the cohort in 2014 and 2015 were 21.4 kg/m^2 with standard deviation of 3.92 kg/m^2 and 21.6 kg/m^2 with standard deviation of 3.87 kg/m^2, and these were similar to the BMIs of another cohort of adolescents reported in Chapter 1.

Different cutoffs generated different percentages of each BMI category. For 2014, IOTF Asian cutoffs generated the highest percentage (33.6% for male and 25.3% for female) of overweight (combined overweight and obese) adolescents; WGOC cutoffs generated 19.0% for males and 17.2% for females; IOTF regular cutoffs generated 18.3% for males and 14.9% for females; WHO cutoffs generated 18.3% for males and 15.5% for females, and CDC cutoffs generated the lowest percentage (17.5% for males and 13.8% for females). In terms of underweight, IOTF cutoffs (both regular and Asian-specific) generated 14.6% underweight males and 12.6% underweight females. CDC cutoffs generated 11.0% for males and 1.7% for females; WHO cutoffs generated 3.7% and 0.6%, and WGOC cutoff generated 2.3% and 2.0%.

There were clear differences between the percentages of BMI categories of males and females regardless of cutoffs used, as well as between the two years. There was higher prevalence of overweight and obese, as well as underweight males than females. Between 2014 and 2015, the percentages of underweight have increased in both males and females. However, in terms of the percentages of overweight and obese males and females, the percentages increased more than 10% in males using WGOC cutoffs, whereas the percentages decreased in females. This difference is likely contributed by females becoming more aware of their body image.

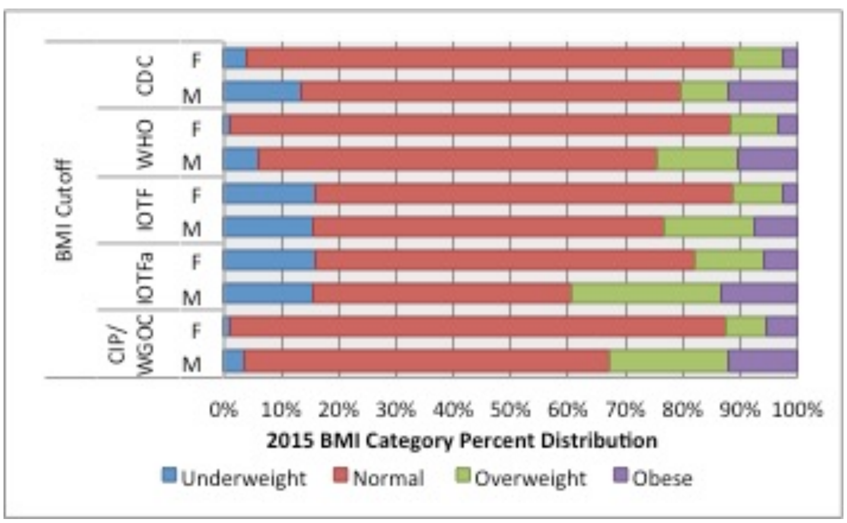
BMI distribution 2014

2014 Year1										
BMI Category	BMI Cutoff									
	CIP/WGOC		IOTFa		IOTF		WHO		CDC	
	M	F	M	F	M	F	M	F	M	F
Underweight	2.9	0.6	14.6	12.6	14.6	12.6	3.7	0.6	11.0	1.7
Normal	78.1	82.2	51.8	62.1	67.2	72.4	78.1	83.9	71.5	84.5
Overweight	9.5	8.6	23.4	15.5	11.0	10.9	11.0	10.9	10.2	9.8
Obese	9.5	8.6	10.2	9.8	7.3	4.0	7.3	4.6	7.3	4.0
Combined Overweight	19.0	17.2	33.6	25.3	18.3	14.9	18.3	15.5	17.5	13.8



BMI distribution 2015

2015 Year2										
BMI Category	BMI Cutoff									
	CIP/WGOC		IOTFa		IOTF		WHO		CDC	
	M	F	M	F	M	F	M	F	M	F
Underweight	3.7	1.2	15.7	16.0	15.7	16.0	6.0	1.2	13.4	4.1
Normal	63.4	86.4	44.8	66.3	61.2	72.8	69.4	87.0	66.4	84.6
Overweight	20.9	7.1	26.1	11.8	15.7	8.9	14.2	8.3	8.2	8.9
Obese	11.9	5.3	13.4	5.9	7.5	2.4	10.5	3.6	11.9	2.4
Combined Overweight	32.8	12.4	39.6	17.8	23.1	11.3	24.6	11.8	20.2	11.3



Conclusion

In summary, my dissertation research has four interrelated parts, which are presented in Chapter 1, 2, 3 and future work. First (Chapter 1), culturally specific food environment survey instruments were developed and used to document the longitudinal changes in food availability in six representative neighborhoods in Kunming via field audits. These instruments can be used for conducting systematic longitudinal assessments of the changing food environment in rapidly developing Chinese cities where there is an urgent need to monitor changing disease risk.

Second (Chapter 2), to pilot test our integrated methodology, a 12-person cohort was recruited in Kunming, and individual dietary behavior was modeled and topologies were proposed. Typological modeling approach can be useful in understanding individual dietary behaviors in our cohort. This approach may be applicable to the study of other human behaviors, particularly those that collect repeated measures on individuals. Our study demonstrated individual-based modeling could be useful, and further research using larger datasets and typological approaches are needed for studying human behaviors.

Third (Chapter 3), to further test our methodology on a larger cohort aiming to examine the relationship between food environment and sugar-sweetened beverage consumption, we worked with Carolina Population Center on their China Beverage Validation Study in urban and rural Shanghai. Our study results suggested that individuals' food environment exposures do influence their consumption of sugar-sweetened beverages, and disparities existed between urban and rural, different gender, education levels, smoking status and weight status.

Lastly (future work), to examine the health impacts of the changing food environment, a 300 adolescent cohort was recruited from two high schools in Kunming, and followed for two years. Methodologies tested in previous chapters would be used to analyze the data collected, help understand the study results, and develop potential intervention strategies in mitigating any adverse health impacts stemmed from the changing food environment.

References

1. UNFPA. The State of World Population 2001: Footprints and Milestones: Population and Environmental Change. 2001.
2. Hossain P, Kawar B, M. EN. Obesity and diabetes in the developing world--a growing challenge Erratum in: N Engl J Med 2007 Mar 1;356(9):973. 2007;356 (3):213-5.
3. World Health Organization. Obesity and Overweight [Fact Sheet] 2003 [cited 2012 May 28]. Available from: http://www.who.int/hpr/NPH/docs/gs_obesity.pdf
4. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 2004;28 (Suppl 3):S2-9.
5. Troutt DD. The thin red line: How the poor still pay more (Unpublished report). West Coast Regional Office, Consumers Union of the U.S., Inc., 1992.
6. Black JL, Macinko J. Neighborhoods and obesity. Nutr Rev 2008;66(1):2-20. Review.
7. Lopez R. Urban sprawl and risk for being overweight or obese. Am J Public Health. 2004;94(9):1574-9.
8. Lovasi GS, Hutson MA, Guerra M, Neckerman KM. Built environments and obesity in disadvantaged populations. Epidemiol Rev. 2009;31:7-20.
9. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: a systematic review. Health & place. 2012;18(5):1172-87. Epub 2012/06/22. doi: 10.1016/j.healthplace.2012.05.006. PubMed PMID: 22717379.
10. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Annual review of clinical psychology. 2008;4:1-32. Epub 2008/05/30. PubMed PMID: 18509902.
11. Shu ZK LY. Prevalence of Overweight and Central Obesity and the Relationship with Cardiovascular Diseases among Rural Residents in Kunming. Modern Preventative Medicine. 2010;37(19).
12. Ogden CL, Carroll MD, Kit BK, Flegal KM: Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. JAMA 2012, 307(5):483–490.
13. Flegal KM, Carroll MD, Kit BK, Ogden CL: Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. JAMA 2012, 307(5):491–497.
14. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W: Annual medical spending attributable to obesity: payer-and service-specific estimates. Health Aff 2009, 28(5):w822–831.
15. World Health Organization (WHO): Controlling the global obesity epidemic- The challenge; 2012.
16. Durand CP, Andalib M, Dunton GF, Wolch J, Pentz MA: A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning. Obes Rev 2011, 12(5):e173–182.
17. Frank LD, Saelens BE, Powell KE, Chapman JE: Stepping towards causation: do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity? Soc Sci Med 2007, 65(9):1898–1914.
18. Larson N, Story M: A review of environmental influences on food choices. Ann Behav Med 2009, 38(Suppl 1):S56–73.
19. Ji CY, Cheng TO: Epidemic increase in overweight and obesity in Chinese children from 1985 to 2005. Int J Cardiol 2009, 132(1):1–10.

20. Chen S, Binns CW, Zhang Y: The importance of definition in diagnosing obesity: a review of studies of children in china. Asia Pac J Public Health 2012, 24(2):248–262.
21. Cai L, Shu ZK, Lu YC, Tao J, Yan F, Ye YH, Zhang P: Prevalence of Overweight and Central Obesity and the Relationship with Cardiovascular Diseases among Rural Residents in Kunming. Mod Preventative Med 2010, 37(19):3601-3609.
22. Zhu K, Pu B, Xu X: Epidemiological survey on simple obesity in 0 ~ 7 years old children in Kunming city. Chin J Public Health 2008, 16:280–284.
23. Chen CM: Overview of obesity in Mainland China. Obes Rev 2008, 9(Suppl 1):14–21.
24. Fletcher A, Bonell C, Sorhaindo A: You are what your friends eat: systematic review of social network analyses of young people's eating behaviors and bodyweight. J Epidemiol Community Health 2011, 65(6):548–555.
25. Li Y, Schouten EG, Hu X, Cui Z, Luan D, Ma G: Obesity prevalence and time trend among youngsters in China, 1982-2002. Asia Pac J Clin Nutr 2008, 17(1):131–137.
26. Qiu H, Zhang MR, Li ZK, Ma Y, Yang Z, Shen L, Liu Y, Tian R: Study on the epidemiological characteristics of overweight and obesity in Kunming. Chin Prim Health Care 2009, 23(4):68–70.
27. Block JP, Christakis NA, O'Malley AJ, Subramanian SV: Proximity to food establishments and body mass index in the Framingham Heart Study offspring cohort over 30 years. Am J Epidemiol 2011, 174(10):1108–1114.
28. Fleischhacker SE, Evenson KR, Rodriguez DA, Ammerman AS: A systematic review of fast food access studies. Obes Rev 2011, 12(5):e460–471.
29. Holsten JE: Obesity and the community food environment: a systematic review. Public Health Nutr 2009, 12(3):397–405.
30. Wang M, Kim S, Gonzalez A, MacLeod K, Winkleby M: Socioeconomic and food-related physical characteristics of the neighbourhood environment are associated with body mass index. J Epidemiol Commun Health 2007, 61(6):491–498.
31. Morland K, Diez Roux AV, Wing S: Supermarkets, other food stores, and obesity: the atherosclerosis risk in communities study. Am J Preventive Med 2006, 30(4):333–339.
32. Bader MD, Ailshire JA, Morenoff JD, House JS: Measurement of the local food environment: a comparison of existing data sources. Am J Epidemiol 2010, 171(5):609–617.
33. Gustafson A, Hankins S, Jilcott S: Measures of the Consumer Food Store Environment: A Systematic Review of the Evidence 2000–2011. J Commun Health 2012, 37(4):897-911.
34. Kelly B, Flood VM, Yeatman H: Measuring local food environments: an overview of available methods and measures. Health Place 2011, 17(6):1284–1293.
35. Lytle LA: Measuring the food environment: state of the science. Am J Preventive Med 2009, 36(4 Suppl):S134–144.
36. Glanz K, Sallis JF, Saelens BE, Frank LD: Nutrition Environment Measures Survey in stores (NEMS-S): development and evaluation. Am J Preventive Med 2007, 32(4):282–289.
37. Hosler AS, Dharssi A: Reliability of a survey tool for measuring consumer nutrition environment in urban food stores. J Public Health Manag Pract 2011, 17(5):E1–8.
38. Ohri-Vachaspati P, Leviton LC: Measuring food environments: a guide to available instruments. J Public Health Manag Pract 2010, 24(6):410–426.
39. Saelens BE, Glanz K, Sallis JF, Frank LD: Nutrition Environment Measures Study in restaurants (NEMS-R): development and evaluation. Am J Preventive Med 2007, 32(4):273–281.

40. Office of Management and Budget (OMB): In North American Industry Classification System, 2007 [http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007]
41. Zhu K, Pu B, Xu X: Epidemiological survey on simple obesity in 0 ~ 7 years old children in Kunming city. Chin J Child Health Care 2008, 16(6):696–698.
42. Liu WMLJ, Guo BZ: The Changing Trend of Detection Rate of Collective Obesity in Children under 7 in Kunming from 2002 to 2007. J Kunming Med University 2011, 3:73–75.
43. Zhang H: Four-Neighborhood Comparison Survey. In. Kunming, Yunnan, China: Yunnan University of Finance and Economics; 2011.
44. Ji CY: Report on childhood obesity in China (1)–body mass index reference for screening overweight and obesity in Chinese school-age children. Biomedical Environ Sci 2005, 18(6):390–400.
45. International Association for the Study of Obesity: Extended International (IOTF) Body Mass Index Cut-offs for Thinness, Overweight and Obesity in Children [http://www.iaso.org/resources/aboutobesity/child-obesity/newchildcutoffs/]
46. Cole TJ, Lobstein T: Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatric Obesity 2012, 7(4):284–294.
47. World Health Organization (WHO): Growth reference 5-19 Years, BMI-for-age (5-19 years), 2007 [http://www.who.int/growthref/who2007_bmi_for_age/en/index.html]
48. Butte NF, Garza C, de Onis M: Evaluation of the feasibility of international growth standards for school-aged children and adolescents. J Nutr 2007, 137(1):153–157.
49. Center for Disease Control and Prevention and National Center for Health Statistics: Clinical Growth Charts, 2009 [http://www.cdc.gov/growthcharts/clinical_charts.htm]
50. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, Wei R, Curtin LR, Roche AF, Johnson CL: CDC Growth Charts for the United States: methods and development. Vital Health Stat Series 11, Data National Health Surv 2000, 2002(246):1–190.
51. Li H, Ji CY, Zong XN, Zhang YQ: [Body mass index growth curves for Chinese children and adolescents aged 0 to 18 years]. Zhonghua Er Ke Za Zhi Chin J Pediatr 2009, 47(7):493–498.
52. Li H, Ji CY, Zong XN, Zhang YQ: Height and weight standardized growth charts for Chinese children and adolescents aged 0 to 18 years. Zhonghua Er Ke Za Zhi Chin J Pediatr 2009, 47(7):487–492.
53. Swan M. Sensor mania! the internet of things, wearable computing, objective metrics, and the quantified self 2.0. Journal of Sensor and Actuator Networks. 2012;1(3):217-53.
54. Rivera-Pelayo V, Zacharias V, Müller L, Braun S. A framework for applying quantified self approaches to support reflective learning. Mobile Learning. 2012.
55. McSweeney FK, Murphy ES. The Wiley-Blackwell handbook of operant and classical conditioning [text]. Hoboken: Wiley,; 2014. Available from: Wiley Online Library. Restricted to UC campuses http://dx.doi.org/10.1002/9781118468135.
56.Bronfenbrenner u. Measuring environment across the life span : emerging methods and concepts. 1st ed. Friedman SL, Wachs TD, editors. Washington, DC: American Psychological Association; 1999. xvii, 419 p. p.
57. Collins LM, Murphy SA, Bierman KL. A conceptual framework for adaptive preventive interventions. Prevention science : the official journal of the Society for Prevention Research. 2004;5(3):185-96. PubMed PMID: 15470938; PubMed Central PMCID: PMC3544191.

58. Lillie EO, Patay B, Diamant J, Issell B, Topol EJ, Schork NJ. The n-of-1 clinical trial: the ultimate strategy for individualizing medicine? Personalized medicine. 2011;8(2):161-73. doi: 10.2217/pme.11.7. PubMed PMID: 21695041; PubMed Central PMCID: PMC3118090.
59. Lakerveld J, Glonti K, Rutter H. Individual and contextual correlates of obesity-related behaviours and obesity: the SPOTLIGHT project. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2016;17 Suppl 1:5-8. doi: 10.1111/obr.12384. PubMed PMID: 26879108.
60. Kremers SP, de Bruijn GJ, Visscher TL, van Mechelen W, de Vries NK, Brug J. Environmental influences on energy balance-related behaviors: a dual-process view. Int J Behav Nutr Phys Act. 2006;3:9. doi: 10.1186/1479-5868-3-9. PubMed PMID: 16700907; PubMed Central PMCID: PMCPMC1481572.
61. Kumanyika S, Jeffery RW, Morabia A, Ritenbaugh C, Antipatis VJ, Public Health Approaches to the Prevention of Obesity Working Group of the International Obesity Task F. Obesity prevention: the case for action. Int J Obes Relat Metab Disord. 2002;26(3):425-36. doi: 10.1038/sj.ijo.0801938. PubMed PMID: 11896500.
62. Lakerveld J, Brug J, Bot S, Teixeira PJ, Rutter H, Woodward E, et al. Sustainable prevention of obesity through integrated strategies: The SPOTLIGHT project's conceptual framework and design. BMC Public Health. 2012;12:793. doi: 10.1186/1471-2458-12-793. PubMed PMID: 22985293; PubMed Central PMCID: PMCPMC3490949.
63. Donaire-Gonzalez D, de Nazelle A, Seto E, Mendez M, Nieuwenhuijsen MJ, Jerrett M. Comparison of physical activity measures using mobile phone-based CalFit and Actigraph. J Med Internet Res. 2013;15(6):e111. Epub 2013/07/31. doi: 10.2196/jmir.2470. PubMed PMID: 23896156; PubMed Central PMCID: PMC3713904.
64. Seto E, Martin E, Yang A, Yan P, Gravina R, Lin I, et al. Opportunistic Strategies for Lightweight Signal Processing for Body Sensor Networks. PETRAE conference, workshop on Light-weight Signal Processing for Computationally Intensive BSN Applications; Samos, Greece2010.
65. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Annu Rev Clin Psychol. 2008;4:1-32.
66. Stone AA, Shiffman SS, DeVries MW. Ecological momentary assessment. In: Kahneman D, Diener E, Schwarz N, editors. Well-being: The foundations of hedonic psychology. New York, NY, US: Russell Sage Foundation; 1999. p. 26-39.
67. Jon Noronha EH, Haoqi Zhang , Krzysztof Z. Gajos editor Platemate: crowdsourcing nutritional analysis from food photographs. Proceedings of the 24th annual ACM symposium on User interface software and technology; 2011 October 16-19, 2011; Santa Barbara, California, USA
68. Courvoisier DS, Eid M, Lischetzke T, Schreiber WH. Psychometric properties of a computerized mobile phone method for assessing mood in daily life. Emotion. 2010;10(1):115.
69. Zhu K, Pu B, Xu X-l. Epidemiological survey on simple obesity in 0~ 7 years old children in Kunming city. Chin J Child Health Care. 2008;16(6):696-8.
70. Qiu H, Zhang M-r, Li Z-k. Study on the Epidemiological Characteristics of Overweight and Obesity in Kunming. Chinese Primary Health Care. 2009;4:037.
71. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: a systematic review. Health & place. 2012;18(5):1172-87. doi:

10.1016/j.healthplace.2012.05.006. PubMed PMID: 22717379; PubMed Central PMCID: PMC3684395.
72. Boone-Heinonen J, Gordon-Larsen P, Kiefe CI, Shikany JM, Lewis CE, Popkin BM. Fast food restaurants and food stores: longitudinal associations with diet in young to middle-aged adults: the CARDIA study. Archives of internal medicine. 2011;171(13):1162-70. doi: 10.1001/archinternmed.2011.283. PubMed PMID: 21747011; PubMed Central PMCID: PMC3178268.
73. Moore LV, Diez Roux AV, Nettleton JA, Jacobs DR, Franco M. Fast-food consumption, diet quality, and neighborhood exposure to fast food: the multi-ethnic study of atherosclerosis. American journal of epidemiology. 2009;170(1):29-36. doi: 10.1093/aje/kwp090. PubMed PMID: 19429879; PubMed Central PMCID: PMC2733038.
74. Ello-Martin JA, Ledikwe JH, Rolls BJ. The influence of food portion size and energy density on energy intake: implications for weight management. The American journal of clinical nutrition. 2005;82(1 Suppl):236S-41S. PubMed PMID: 16002828.
75. Ledikwe JH, Ello-Martin JA, Rolls BJ. Portion sizes and the obesity epidemic. The Journal of nutrition. 2005;135(4):905-9. PubMed PMID: 15795457.
76. Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. American journal of public health. 2002;92(2):246-9. PubMed PMID: 11818300; PubMed Central PMCID: PMC1447051.
77. Ayala GX. An experimental evaluation of a group- versus computer-based intervention to improve food portion size estimation skills. Health Educ Res. 2006;21(1):133-45. doi: 10.1093/her/cyh049. PubMed PMID: 16100228; PubMed Central PMCID: PMCPMC3724534.
78. T. Hernandez LW, D. Kuehn, K. Rubotzky, P. Moser-Veillon, S. Godwin, C. Thompson, C. Wang. Portion size estimation and expectation of accuracy. J Food Comp Anal. 2006;(19 (suppl)):pp. S14–S21.
79. Godwin SL, Chambers Et, Cleveland L. Accuracy of reporting dietary intake using various portion-size aids in-person and via telephone. J Am Diet Assoc. 2004;104(4):585-94. doi: 10.1016/j.jada.2004.01.006. PubMed PMID: 15054344.
80. Williamson DA, Allen HR, Martin PD, Alfonso AJ, Gerald B, Hunt A. Comparison of digital photography to weighed and visual estimation of portion sizes. J Am Diet Assoc. 2003;103(9):1139-45. doi: 10.1053/jada.2003.50567. PubMed PMID: 12963941.
81. Lucas F NM, Villeminot S, Kaaks R, Clavel-Chapelon F. Estimation of food portion size using photographs: Relative validity, strengths, weaknesses and recommendations. J Hum Nutr Diet 1995;8:65-74.
82. Montoliu R, Gatica-Perez D, editors. Discovering human places of interest from multimodal mobile phone data. Proceedings of the 9th International Conference on Mobile and Ubiquitous Multimedia; 2010: ACM.
83. Fleig D, Randler C. Association between chronotype and diet in adolescents based on food logs. Eat Behav. 2009;10(2):115-8. doi: Doi 10.1016/J.Eatbeh.2009.03.002. PubMed PMID: WOS:000275021600006.
84. Schubert E, Randler C. Association between chronotype and the constructs of the Three-Factor-Eating-Questionnaire. Appetite. 2008;51(3):501-5. doi: Doi 10.1016/J.Appet.2008.03.018. PubMed PMID: WOS:000259930900013.

85. Thompson DA, Wolfe LA, Eikelboom R. Acute effects of exercise intensity on appetite in young men. Med Sci Sports Exerc. 1988;20(3):222-7. PubMed PMID: 3386499.
86. Verger P, Lanteaume MT, Louis-Sylvestre J. Free food choice after acute exercise in men. Appetite. 1994;22(2):159-64. doi: 10.1006/appe.1994.1015. PubMed PMID: 8037440.
87. Christensen L. Effects of eating behavior on mood: a review of the literature. The International journal of eating disorders. 1993;14(2):171-83. PubMed PMID: 8401550.
88. WHO. Global Database on Body Mass Index 2014. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.
89. O'Reilly GA, Spruijt-Metz D. Current mHealth technologies for physical activity assessment and promotion. American journal of preventive medicine. 2013;45(4):501-7. doi: 10.1016/j.amepre.2013.05.012. PubMed PMID: 24050427; PubMed Central PMCID: PMC4199827.
90. Carter MC, Burley VJ, Nykjaer C, Cade JE. 'My Meal Mate' (MMM): validation of the diet measures captured on a smartphone application to facilitate weight loss. The British journal of nutrition. 2013;109(3):539-46. doi: 10.1017/S0007114512001353. PubMed PMID: 22717334.
91. Hebden L, Cook A, van der Ploeg HP, Allman-Farinelli M. Development of smartphone applications for nutrition and physical activity behavior change. JMIR research protocols. 2012;1(2):e9. doi: 10.2196/resprot.2205. PubMed PMID: 23611892; PubMed Central PMCID: PMC3626164.
92. Hughes DC, Andrew A, Denning T, Hurvitz P, Lester J, Beresford S, et al. BALANCE (Bioengineering Approaches for Lifestyle Activity and Nutrition Continuous Engagement): developing new technology for monitoring energy balance in real time. Journal of diabetes science and technology. 2010;4(2):429-34. PubMed PMID: 20307404; PubMed Central PMCID: PMC2864179.
93. Six BL, Schap TE, Zhu FM, Mariappan A, Bosch M, Delp EJ, et al. Evidence-based development of a mobile telephone food record. Journal of the American Dietetic Association. 2010;110(1):74-9.
94. Zhu F, Bosch M, Woo I, Kim S, Boushey CJ, Ebert DS, et al. The use of mobile devices in aiding dietary assessment and evaluation. Selected Topics in Signal Processing, IEEE Journal of. 2010;4(4):756-66.
95. Kong F, Tan J. DietCam: Automatic dietary assessment with mobile camera phones. Pervasive and Mobile Computing. 2012;8(1):147-63.
96. Woo I, Ostmo K, Kim S, Ebert DS, Delp EJ, Boushey CJ. Automatic portion estimation and visual refinement in mobile dietary assessment. Computational Imaging. 2010;8(7533):1.
97. Silk JS, Forbes EE, Whalen DJ, Jakubcak JL, Thompson WK, Ryan ND, et al. Daily emotional dynamics in depressed youth: A cell phone ecological momentary assessment study. Journal of experimental child psychology. 2011;110(2):241-57.
98. Fletcher RR, Tam S, Omojola O, Redemske R, Fedor S, Moshoka JM, editors. Mobile application and wearable sensors for use in cognitive behavioral therapy for drug addiction and PTSD. Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2011 5th International Conference on; 2011: IEEE.
99. Hensel DJ, Fortenberry JD, Harezlak J, Craig D. The feasibility of cell phone based electronic diaries for STI/HIV research. BMC medical research methodology. 2012;12(1):75.

100. Fisher L, Chesla CA, Skaff MA, Gilliss C, Kanter RA, Lutz CP, et al. Disease management status: a typology of Latino and Euro-American patients with type 2 diabetes. Behavioral medicine. 2000;26(2):53-66. doi: 10.1080/08964280009595752. PubMed PMID: 11147290.
101. Buck HG, Kitko L, Hupcey JE. Dyadic heart failure care types: qualitative evidence for a novel typology. The Journal of cardiovascular nursing. 2013;28(6):E37-46. doi: 10.1097/JCN.0b013e31827fcc4c. PubMed PMID: 23388704; PubMed Central PMCID: PMC3655126.
102. Shaw RJ, Palmer L, Blasey C, Sarwal M. A typology of non-adherence in pediatric renal transplant recipients. Pediatric transplantation. 2003;7(6):489-93. PubMed PMID: 14870900.
103. King AC, Stokols D, Talen E, Brassington GS, Killingsworth R. Theoretical approaches to the promotion of physical activity: forging a transdisciplinary paradigm. American journal of preventive medicine. 2002;23(2 Suppl):15-25. PubMed PMID: 12133734.
104. Newman O. Defensible space; crime prevention through urban design. New York,: Macmillan; 1972. xvii, 264 p. p.
105. Kaplan S. The Restorative Benefits of Nature - toward an Integrative Framework. J Environ Psychol. 1995;15(3):169-82. doi: Doi 10.1016/0272-4944(95)90001-2. PubMed PMID: WOS:A1995TC98400002.
106. Barker RG. Ecological psychology; concepts and methods for studying the environment of human behavior. Stanford, Calif.,: Stanford University Press; 1968. vi, 242 p. p.
107. Schoggen P, Barker RG, Fox KA. Behavior settings : a revision and extension of Roger G. Barker's Ecological psychology. Stanford, Calif.: Stanford University Press; 1989. xii, 419 p.
108. Lynch K. The image of the city. Cambridge Mass.: Technology Press; 1960. 194 p. p.
109. Birch LL, Mcphee L, Shoba BC, Steinberg L, Krehbiel R. Clean up Your Plate - Effects of Child Feeding Practices on the Conditioning of Meal Size. Learn Motiv. 1987;18(3):301-17. doi: Doi 10.1016/0023-9690(87)90017-8. PubMed PMID: WOS:A1987J858100005.
110. Gruber R, Wiebe S, Coffey EB, Elgie B, Frenette S, Robert M, et al. The Association between Chronotype and Sleep Patterns in Children. Sleep. 2010;33:A80-A. PubMed PMID: WOS:000208208000232.
111. Leathwood PD, Pollet P. Diet-induced mood changes in normal populations. Journal of psychiatric research. 1982;17(2):147-54. PubMed PMID: 6764931.
112. Liao C, Tan Y, Wu C, Wang S, Yu C, Cao W, et al. City Level of Income and Urbanization and Availability of Food Stores and Food Service Places in China. (1932-6203 (Electronic)). doi: D - NLM: PMC4777357 EDAT- 2016/03/05 06:00 MHDA- 2016/07/28 06:00 CRDT- 2016/03/04 06:00 PHST- 2016 [ecollection] PHST- 2015/09/07 [received] PHST- 2015/12/14 [accepted] PHST- 2016/03/03 [epublish] AID - 10.1371/journal.pone.0148745 [doi] AID - PONE-D-15-39444 [pii] PST - epublish.
113. Ezzati M, Riboli E. Behavioral and dietary risk factors for noncommunicable diseases. (1533-4406 (Electronic)).
114. Stevens GA, Singh Gm Fau - Lu Y, Lu Y Fau - Danaei G, Danaei G Fau - Lin JK, Lin Jk Fau - Finucane MM, Finucane Mm Fau - Bahalim AN, et al. National, regional, and global trends in adult overweight and obesity prevalences. (1478-7954 (Electronic)). doi: D - NLM: PMC3543235.
115. Economos CD, Hatfield DP, King AC, Ayala GX, Pentz MA. Food and physical activity environments: an energy balance approach for research and practice. (1873-2607 (Electronic)).

116. Malik VS, Willett Wc Fau - Hu FB, Hu FB. Global obesity: trends, risk factors and policy implications. (1759-5037 (Electronic)).
117. Astrup A, Dyerberg J Fau - Selleck M, Selleck M Fau - Stender S, Stender S. Nutrition transition and its relationship to the development of obesity and related chronic diseases. (1467-789X (Electronic)).
118. Popkin BM, Nielsen SJ. The sweetening of the world's diet. (1071-7323 (Print)).
119. Rivera JA, Barquera S Fau - Gonzalez-Cossio T, Gonzalez-Cossio T Fau - Olaiz G, Olaiz G Fau - Sepulveda J, Sepulveda J. Nutrition transition in Mexico and in other Latin American countries. (0029-6643 (Print)).
120. Malik VS, Popkin BM, Bray GA, Despres JP, Hu FB. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. Circulation. 2010;121(11):1356-64. doi: 10.1161/CIRCULATIONAHA.109.876185. PubMed PMID: 20308626; PubMed Central PMCID: PMCPMC2862465.
121. Odegaard AO, Koh Wp Fau - Arakawa K, Arakawa K Fau - Yu MC, Yu Mc Fau - Pereira MA, Pereira MA. Soft drink and juice consumption and risk of physician-diagnosed incident type 2 diabetes: the Singapore Chinese Health Study. (1476-6256 (Electronic)). doi: D - NLM: PMC2842218 EDAT- 2010/02/18 06:00 MHDA- 2010/04/03 06:00 CRDT- 2010/02/18 06:00 PHST- 2010/02/16 [aheadofprint] AID - kwp452 [pii] AID - 10.1093/aje/kwp452 [doi] PST - ppublish.
122. Hu FB, Malik VS. Sugar-sweetened beverages and risk of obesity and type 2 diabetes: epidemiologic evidence. (1873-507X (Electronic)). doi: D - NLM: NIHMS182110D - NLM: PMC2862460 EDAT- 2010/02/09 06:00 MHDA- 2010/07/02 06:00 CRDT- 2010/02/09 06:00 PHST- 2009/12/07 [received] PHST- 2010/01/23 [revised] PHST- 2010/01/30 [accepted] PHST- 2010/02/06 [aheadofprint] AID - S0031-9384(10)00060-0 [pii] AID - 10.1016/j.physbeh.2010.01.036 [doi] PST - ppublish.
123. Schulze MB, Manson Je Fau - Ludwig DS, Ludwig Ds Fau - Colditz GA, Colditz Ga Fau - Stampfer MJ, Stampfer Mj Fau - Willett WC, Willett Wc Fau - Hu FB, et al. Sugar-sweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. (1538-3598 (Electronic)).
124. Vesnaver E, Keller HH. Social influences and eating behavior in later life: a review. (2155-1200 (Electronic)).
125. Ford PB, Dzewaltowski DA. Disparities in obesity prevalence due to variation in the retail food environment: three testable hypotheses. (0029-6643 (Print)).
126. Duran AC, de Almeida SL, Latorre MD, Jaime PC. The role of the local retail food environment in fruit, vegetable and sugar-sweetened beverage consumption in Brazil. Public Health Nutr. 2015:1-10. doi: 10.1017/S1368980015001524. PubMed PMID: 26054646.
127. Babey Sh Fau - Jones M, Jones M Fau - Yu H, Yu H Fau - Goldstein H, Goldstein H. Bubbling over: soda consumption and its link to obesity in California.
128. Cohen DA, Babey SH. Contextual influences on eating behaviours: heuristic processing and dietary choices. Obes Rev. 2012;13(9):766-79. doi: 10.1111/j.1467-789X.2012.01001.x. PubMed PMID: 22551473; PubMed Central PMCID: PMCPMC3667220.
129. Levitsky DA. The non-regulation of food intake in humans: hope for reversing the epidemic of obesity. (0031-9384 (Print)).

130. Levitsky DA, Obarzanek E Fau - Mrdjenovic G, Mrdjenovic G Fau - Strupp BJ, Strupp BJ. Imprecise control of energy intake: absence of a reduction in food intake following overfeeding in young adults. (0031-9384 (Print)).
131. Block JP, Christakis Na Fau - O'Malley AJ, O'Malley Aj Fau - Subramanian SV, Subramanian SV. Proximity to food establishments and body mass index in the Framingham Heart Study offspring cohort over 30 years. (1476-6256 (Electronic)). doi: D - NLM: PMC3208142 EDAT- 2011/10/04 06:00 MHDA- 2011/12/23 06:00 CRDT- 2011/10/04 06:00 PHST- 2011/09/30 [aheadofprint] AID - kwr244 [pii] AID - 10.1093/aje/kwr244 [doi] PST - ppublish.
132. Michimi A, Wimberly MC. The food environment and adult obesity in US metropolitan areas. Geospat Health. 2015;10(2):368. doi: 10.4081/gh.2015.368. PubMed PMID: 26618317.
133. Ni Mhurchu C, Vandevijvere S Fau - Waterlander W, Waterlander W Fau - Thornton LE, Thornton Le Fau - Kelly B, Kelly B Fau - Cameron AJ, Cameron Aj Fau - Snowdon W, et al. Monitoring the availability of healthy and unhealthy foods and non-alcoholic beverages in community and consumer retail food environments globally. (1467-789X (Electronic)).
134. Wang R, Shi L. Access to food outlets and children's nutritional intake in urban China: a difference-in-difference analysis. (1824-7288 (Electronic)). doi: D - NLM: PMC3480924 EDAT- 2012/07/04 06:00 MHDA- 2013/03/13 06:00 CRDT- 2012/07/04 06:00 PHST- 2011/12/11 [received] PHST- 2012/06/15 [accepted] PHST- 2012/06/30 [aheadofprint] AID - 1824-7288-38-30 [pii] AID - 10.1186/1824-7288-38-30 [doi] PST - epublish.
135. Chaix B, Bean K Fau - Daniel M, Daniel M Fau - Zenk SN, Zenk Sn Fau - Kestens Y, Kestens Y Fau - Charreire H, Charreire H Fau - Leal C, et al. Associations of supermarket characteristics with weight status and body fat: a multilevel analysis of individuals within supermarkets (RECORD study). (1932-6203 (Electronic)). doi: D - NLM: PMC3319546 EDAT- 2012/04/13 06:00 MHDA- 2012/08/22 06:00 CRDT- 2012/04/13 06:00 PHST- 2011/06/28 [received] PHST- 2012/02/07 [accepted] PHST- 2012/04/04 [epublish] AID - 10.1371/journal.pone.0032908 [doi] AID - PONE-D-11-12082 [pii] PST - ppublish.
136. Kirkpatrick SI, Reedy J, Butler EN, Dodd KW, Subar AF, Thompson FE, et al. Dietary assessment in food environment research: a systematic review. (1873-2607 (Electronic)). doi: D - NLM: NIHMS542051D - NLM: PMC4558887 EDAT- 2013/12/21 06:00 MHDA- 2014/08/27 06:00 CRDT- 2013/12/21 06:00 PHST- 2013/05/28 [received] PHST- 2013/07/16 [revised] PHST- 2013/08/27 [accepted] AID - S0749-3797(13)00524-2 [pii] AID - 10.1016/j.amepre.2013.08.015 [doi] PST - ppublish.
137. Adair LS, Popkin BM. Are child eating patterns being transformed globally? (1071-7323 (Print)).
138. Smith LP, Hua J, Seto E, Du S, Zang J, Zou S, et al. Development and validity of a 3-day smartphone assisted 24-hour recall to assess beverage consumption in a Chinese population: a randomized cross-over study. Asia Pac J Clin Nutr. 2014;23(4):678-90. doi: 10.6133/apjcn.2014.23.4.10. PubMed PMID: 25516327; PubMed Central PMCID: PMCPMC4270062.
139. Seto E, Hua J, Wu L, Shia V, Eom S, Wang M, et al. Models of Individual Dietary Behavior Based on Smartphone Data: The Influence of Routine, Physical Activity, Emotion, and Food Environment. (1932-6203 (Electronic)). doi: D - NLM: PMC4822823 EDAT- 2016/04/07 06:00 MHDA- 2016/04/07 06:00 CRDT- 2016/04/07 06:00 PHST- 2016 [ecollection] PHST- 2015/10/01

[received] PHST- 2016/03/23 [accepted] PHST- 2016/04/06 [epublish] AID - 10.1371/journal.pone.0153085 [doi] AID - PONE-D-15-41955 [pii] PST - epublish.
140. Zang J, Song J, Wang Z, Yao C, Ma J, Huang C, et al. Acceptability and feasibility of smartphone-assisted 24 h recalls in the Chinese population. Public Health Nutr. 2015:1-6. doi: 10.1017/S1368980015000907. PubMed PMID: 25857612; PubMed Central PMCID: PMCPMC4600407.
141. Global Database on Body Mass Index: an interactive surveillance tool for monitoring nutrition transition [Internet]. 2013.
142. Donaire-Gonzalez D, de Nazelle A Fau - Seto E, Seto E Fau - Mendez M, Mendez M Fau - Nieuwenhuijsen MJ, Nieuwenhuijsen Mj Fau - Jerrett M, Jerrett M. Comparison of physical activity measures using mobile phone-based CalFit and Actigraph. (1438-8871 (Electronic)). doi: D - NLM: PMC3713904 OTO - NOTNLM.
143. de Nazelle A, Seto E Fau - Donaire-Gonzalez D, Donaire-Gonzalez D Fau - Mendez M, Mendez M Fau - Matamala J, Matamala J Fau - Nieuwenhuijsen MJ, Nieuwenhuijsen Mj Fau - Jerrett M, et al. Improving estimates of air pollution exposure through ubiquitous sensing technologies. (1873-6424 (Electronic)). doi: D - NLM: NIHMS446477D - NLM: PMC3600144 EDAT- 2013/02/19 06:00 MHDA- 2013/04/26 06:00 CRDT- 2013/02/19 06:00 PHST- 2012/10/12 [received] PHST- 2012/12/18 [revised] PHST- 2012/12/26 [accepted] PHST- 2013/02/13 [aheadofprint] AID - S0269-7491(13)00008-0 [pii] AID - 10.1016/j.envpol.2012.12.032 [doi] PST - ppublish.
144. Magurran AE. Meausuring Biological Diversity: Blackwell; 2004.
145. Education UIfDRa. Lesson 3 Logistic Regression Diagnostics [cited 2016 7/1]. Available from: http://www.ats.ucla.edu/stat/stata/webbooks/logistic/chapter3/statalog3.htm.
146. Swinburn BA, Caterson I Fau - Seidell JC, Seidell Jc Fau - James WPT, James WP. Diet, nutrition and the prevention of excess weight gain and obesity. (1368-9800 (Print)).
147. Mazarello Paes V, Hesketh K, O'Malley C, Moore H, Summerbell C, Griffin S, et al. Determinants of sugar-sweetened beverage consumption in young children: a systematic review. Obes Rev. 2015;16(11):903-13. doi: 10.1111/obr.12310. PubMed PMID: 26252417.
148. Holsten JE. Obesity and the community food environment: a systematic review. (1368-9800 (Print)).
149. Han E Fau - Han E, Powell Lm Fau - Powell LM. CONSUMPTION PATTERNS OF SUGAR SWEETENED BEVERAGES IN THE UNITED STATES. (2212-2672 (Print)).
150. Lobstein T. Reducing consumption of sugar-sweetened beverages to reduce the risk of childhood overweight and obesity- Biological, behavioural and contextual rationale: World Health Organization; 2014 [cited 2016 7/1]. Available from: http://www.who.int/elena/bbc/ssbs_childhood_obesity/en/.
151. Pabayo R, Spence Jc Fau - Cutumisu N, Cutumisu N Fau - Casey L, Casey L Fau - Storey K, Storey K. Sociodemographic, behavioural and environmental correlates of sweetened beverage consumption among pre-school children. (1475-2727 (Electronic)).
152. Li L, Shen T, Wen LM, Wu M, He P, Wang Y, et al. Lifestyle factors associated with childhood obesity: a cross-sectional study in Shanghai, China. BMC Res Notes. 2015;8:6. doi: 10.1186/s13104-014-0958-y. PubMed PMID: 25595610; PubMed Central PMCID: PMCPMC4305265.

153. Trumbo PR, Rivers CR. Systematic review of the evidence for an association between sugar-sweetened beverage consumption and risk of obesity. (1753-4887 (Electronic)).
154. Singh GM, Micha R, Khatibzadeh S, Shi P, Lim S, Andrews KG, et al. Global, Regional, and National Consumption of Sugar-Sweetened Beverages, Fruit Juices, and Milk: A Systematic Assessment of Beverage Intake in 187 Countries. PLoS One. 2015;10(8):e0124845. doi: 10.1371/journal.pone.0124845. PubMed PMID: 26244332; PubMed Central PMCID: PMCPMC4526649.
155. Nakamura K, Huxley R Fau - Ansary-Moghaddam A, Ansary-Moghaddam A Fau - Woodward M, Woodward M. The hazards and benefits associated with smoking and smoking cessation in Asia: a meta-analysis of prospective studies. (1468-3318 (Electronic)).
156. Gu D, Kelly Tn Fau - Wu X, Wu X Fau - Chen J, Chen J Fau - Samet JM, Samet Jm Fau - Huang J-f, Huang Jf Fau - Zhu M, et al. Mortality attributable to smoking in China. (1533-4406 (Electronic)).
157. Powell LM, Chriqui JF, Khan T, Wada R, Chaloupka FJ. Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: a systematic review of prices, demand and body weight outcomes. Obes Rev. 2013;14(2):110-28. doi: 10.1111/obr.12002. PubMed PMID: 23174017; PubMed Central PMCID: PMCPMC3556391.
158. King AC, Glanz K, Patrick K. Technologies to measure and modify physical activity and eating environments. (1873-2607 (Electronic)).
159. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. Journal of health and social behavior. 1983;24(4):385-96. Epub 1983/12/01. PubMed PMID: 6668417.
160. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. Erratum in: N Engl J Med 2007 Mar 1;356(9):973. 2007;357(4):370-9. Epub 2007/07/27. doi: 10.1056/NEJMsa066082. PubMed PMID: 17652652.
161. Pachucki MA, Jacques PF, Christakis NA. Social network concordance in food choice among spouses, friends, and siblings. Am J Public Health. 2011;101(11):2170-7. Epub 2011/09/24. doi: 10.2105/AJPH.2011.300282. PubMed PMID: 21940920; PubMed Central PMCID: PMC3222397.
162. Valente TW, Fujimoto K, Chou CP, Spruijt-Metz D. Adolescent affiliations and adiposity: a social network analysis of friendships and obesity. The Journal of adolescent health : official publication of the Society for Adolescent Medicine. 2009;45(2):202-4. Epub 2009/07/25. doi: 10.1016/j.jadohealth.2009.01.007. PubMed PMID: 19628148; PubMed Central PMCID: PMC2747768.
1163. Christakis NA, Fowler JH. Social contagion theory: examining dynamic social networks and human behavior. Statistics in medicine. 2012. Epub 2012/06/20. doi: 10.1002/sim.5408. PubMed PMID: 22711416.
164. Center CP. ADD Health. http://wwwcpcuncedu/projects/addhealth Accessed 12/1/2012.

Bibliography

1. UNFPA. The State of World Population 2001: Footprints and Milestones: Population and Environmental Change. 2001.
2. Hossain P, Kawar B, M. EN. Obesity and diabetes in the developing world--a growing challenge Erratum in: N Engl J Med 2007 Mar 1;356(9):973. 2007;356 (3):213-5.
3. World Health Organization. Obesity and Overweight [Fact Sheet] 2003 [cited 2012 May 28]. Available from: http://www.who.int/hpr/NPH/docs/gs_obesity.pdf
4. Popkin BM, Gordon-Larsen P. The nutrition transition: worldwide obesity dynamics and their determinants. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 2004;28 (Suppl 3):S2-9.
5. Troutt DD. The thin red line: How the poor still pay more (Unpublished report). West Coast Regional Office, Consumers Union of the U.S., Inc., 1992.
6. Black JL, Macinko J. Neighborhoods and obesity. Nutr Rev 2008;66(1):2-20. Review.
7. Lopez R. Urban sprawl and risk for being overweight or obese. Am J Public Health. 2004;94(9):1574-9.
8. Lovasi GS, Hutson MA, Guerra M, Neckerman KM. Built environments and obesity in disadvantaged populations. Epidemiol Rev. 2009;31:7-20.
9. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: a systematic review. Health & place. 2012;18(5):1172-87. Epub 2012/06/22. doi: 10.1016/j.healthplace.2012.05.006. PubMed PMID: 22717379.
10. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Annual review of clinical psychology. 2008;4:1-32. Epub 2008/05/30. PubMed PMID: 18509902.
11. Shu ZK LY. Prevalence of Overweight and Central Obesity and the Relationship with Cardiovascular Diseases among Rural Residents in Kunming. Modern Preventative Medicine. 2010;37(19).
12. Ogden CL, Carroll MD, Kit BK, Flegal KM: Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. JAMA 2012, 307(5):483–490.
13. Flegal KM, Carroll MD, Kit BK, Ogden CL: Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. JAMA 2012, 307(5):491–497.
14. Finkelstein EA, Trogdon JG, Cohen JW, Dietz W: Annual medical spending attributable to obesity: payer-and service-specific estimates. Health Aff 2009, 28(5):w822–831.
15. World Health Organization (WHO): Controlling the global obesity epidemic- The challenge; 2012.
16. Durand CP, Andalib M, Dunton GF, Wolch J, Pentz MA: A systematic review of built environment factors related to physical activity and obesity risk: implications for smart growth urban planning. Obes Rev 2011, 12(5):e173–182.
17. Frank LD, Saelens BE, Powell KE, Chapman JE: Stepping towards causation: do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity? Soc Sci Med 2007, 65(9):1898–1914.
18. Larson N, Story M: A review of environmental influences on food choices. Ann Behav Med 2009, 38(Suppl 1):S56–73.
19. Ji CY, Cheng TO: Epidemic increase in overweight and obesity in Chinese children from 1985 to 2005. Int J Cardiol 2009, 132(1):1–10.

20. Chen S, Binns CW, Zhang Y: The importance of definition in diagnosing obesity: a review of studies of children in china. Asia Pac J Public Health 2012, 24(2):248–262.
21. Cai L, Shu ZK, Lu YC, Tao J, Yan F, Ye YH, Zhang P: Prevalence of Overweight and Central Obesity and the Relationship with Cardiovascular Diseases among Rural Residents in Kunming. Mod Preventative Med 2010, 37(19):3601-3609.
22. Zhu K, Pu B, Xu X: Epidemiological survey on simple obesity in 0 ~ 7 years old children in Kunming city. Chin J Public Health 2008, 16:280–284.
23. Chen CM: Overview of obesity in Mainland China. Obes Rev 2008, 9(Suppl 1):14–21.
24. Fletcher A, Bonell C, Sorhaindo A: You are what your friends eat: systematic review of social network analyses of young people's eating behaviors and bodyweight. J Epidemiol Community Health 2011, 65(6):548–555.
25. Li Y, Schouten EG, Hu X, Cui Z, Luan D, Ma G: Obesity prevalence and time trend among youngsters in China, 1982-2002. Asia Pac J Clin Nutr 2008, 17(1):131–137.
26. Qiu H, Zhang MR, Li ZK, Ma Y, Yang Z, Shen L, Liu Y, Tian R: Study on the epidemiological characteristics of overweight and obesity in Kunming. Chin Prim Health Care 2009, 23(4):68–70.
27. Block JP, Christakis NA, O'Malley AJ, Subramanian SV: Proximity to food establishments and body mass index in the Framingham Heart Study offspring cohort over 30 years. Am J Epidemiol 2011, 174(10):1108–1114.
28. Fleischhacker SE, Evenson KR, Rodriguez DA, Ammerman AS: A systematic review of fast food access studies. Obes Rev 2011, 12(5):e460–471.
29. Holsten JE: Obesity and the community food environment: a systematic review. Public Health Nutr 2009, 12(3):397–405.
30. Wang M, Kim S, Gonzalez A, MacLeod K, Winkleby M: Socioeconomic and food-related physical characteristics of the neighbourhood environment are associated with body mass index. J Epidemiol Commun Health 2007, 61(6):491–498.
31. Morland K, Diez Roux AV, Wing S: Supermarkets, other food stores, and obesity: the atherosclerosis risk in communities study. Am J Preventive Med 2006, 30(4):333–339.
32. Bader MD, Ailshire JA, Morenoff JD, House JS: Measurement of the local food environment: a comparison of existing data sources. Am J Epidemiol 2010, 171(5):609–617.
33. Gustafson A, Hankins S, Jilcott S: Measures of the Consumer Food Store Environment: A Systematic Review of the Evidence 2000–2011. J Commun Health 2012, 37(4):897-911.
34. Kelly B, Flood VM, Yeatman H: Measuring local food environments: an overview of available methods and measures. Health Place 2011, 17(6):1284–1293.
35. Lytle LA: Measuring the food environment: state of the science. Am J Preventive Med 2009, 36(4 Suppl):S134–144.
36. Glanz K, Sallis JF, Saelens BE, Frank LD: Nutrition Environment Measures Survey in stores (NEMS-S): development and evaluation. Am J Preventive Med 2007, 32(4):282–289.
37. Hosler AS, Dharssi A: Reliability of a survey tool for measuring consumer nutrition environment in urban food stores. J Public Health Manag Pract 2011, 17(5):E1–8.
38. Ohri-Vachaspati P, Leviton LC: Measuring food environments: a guide to available instruments. J Public Health Manag Pract 2010, 24(6):410–426.
39. Saelens BE, Glanz K, Sallis JF, Frank LD: Nutrition Environment Measures Study in restaurants (NEMS-R): development and evaluation. Am J Preventive Med 2007, 32(4):273–281.

40. Office of Management and Budget (OMB): In North American Industry Classification System, 2007 [http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2007]
41. Zhu K, Pu B, Xu X: Epidemiological survey on simple obesity in 0 ~ 7 years old children in Kunming city. Chin J Child Health Care 2008, 16(6):696–698.
42. Liu WMLJ, Guo BZ: The Changing Trend of Detection Rate of Collective Obesity in Children under 7 in Kunming from 2002 to 2007. J Kunming Med University 2011, 3:73–75.
43. Zhang H: Four-Neighborhood Comparison Survey. In. Kunming, Yunnan, China: Yunnan University of Finance and Economics; 2011.
44. Ji CY: Report on childhood obesity in China (1)–body mass index reference for screening overweight and obesity in Chinese school-age children. Biomedical Environ Sci 2005, 18(6):390–400.
45. International Association for the Study of Obesity: Extended International (IOTF) Body Mass Index Cut-offs for Thinness, Overweight and Obesity in Children [http://www.iaso.org/resources/aboutobesity/child-obesity/newchildcutoffs/]
46. Cole TJ, Lobstein T: Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatric Obesity 2012, 7(4):284–294.
47. World Health Organization (WHO): Growth reference 5-19 Years, BMI-for-age (5-19 years), 2007 [http://www.who.int/growthref/who2007_bmi_for_age/en/index.html]
48. Butte NF, Garza C, de Onis M: Evaluation of the feasibility of international growth standards for school-aged children and adolescents. J Nutr 2007, 137(1):153–157.
49. Center for Disease Control and Prevention and National Center for Health Statistics: Clinical Growth Charts, 2009 [http://www.cdc.gov/growthcharts/clinical_charts.htm]
50. Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, Wei R, Curtin LR, Roche AF, Johnson CL: CDC Growth Charts for the United States: methods and development. Vital Health Stat Series 11, Data National Health Surv 2000, 2002(246):1–190.
51. Li H, Ji CY, Zong XN, Zhang YQ: [Body mass index growth curves for Chinese children and adolescents aged 0 to 18 years]. Zhonghua Er Ke Za Zhi Chin J Pediatr 2009, 47(7):493–498.
52. Li H, Ji CY, Zong XN, Zhang YQ: Height and weight standardized growth charts for Chinese children and adolescents aged 0 to 18 years. Zhonghua Er Ke Za Zhi Chin J Pediatr 2009, 47(7):487–492.
53. Swan M. Sensor mania! the internet of things, wearable computing, objective metrics, and the quantified self 2.0. Journal of Sensor and Actuator Networks. 2012;1(3):217-53.
54. Rivera-Pelayo V, Zacharias V, Müller L, Braun S. A framework for applying quantified self approaches to support reflective learning. Mobile Learning. 2012.
55. McSweeney FK, Murphy ES. The Wiley-Blackwell handbook of operant and classical conditioning [text]. Hoboken: Wiley,; 2014. Available from: Wiley Online Library. Restricted to UC campuses http://dx.doi.org/10.1002/9781118468135.
56.Bronfenbrenner u. Measuring environment across the life span : emerging methods and concepts. 1st ed. Friedman SL, Wachs TD, editors. Washington, DC: American Psychological Association; 1999. xvii, 419 p. p.
57. Collins LM, Murphy SA, Bierman KL. A conceptual framework for adaptive preventive interventions. Prevention science : the official journal of the Society for Prevention Research. 2004;5(3):185-96. PubMed PMID: 15470938; PubMed Central PMCID: PMC3544191.

58. Lillie EO, Patay B, Diamant J, Issell B, Topol EJ, Schork NJ. The n-of-1 clinical trial: the ultimate strategy for individualizing medicine? Personalized medicine. 2011;8(2):161-73. doi: 10.2217/pme.11.7. PubMed PMID: 21695041; PubMed Central PMCID: PMC3118090.
59. Lakerveld J, Glonti K, Rutter H. Individual and contextual correlates of obesity-related behaviours and obesity: the SPOTLIGHT project. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2016;17 Suppl 1:5-8. doi: 10.1111/obr.12384. PubMed PMID: 26879108.
60. Kremers SP, de Bruijn GJ, Visscher TL, van Mechelen W, de Vries NK, Brug J. Environmental influences on energy balance-related behaviors: a dual-process view. Int J Behav Nutr Phys Act. 2006;3:9. doi: 10.1186/1479-5868-3-9. PubMed PMID: 16700907; PubMed Central PMCID: PMCPMC1481572.
61. Kumanyika S, Jeffery RW, Morabia A, Ritenbaugh C, Antipatis VJ, Public Health Approaches to the Prevention of Obesity Working Group of the International Obesity Task F. Obesity prevention: the case for action. Int J Obes Relat Metab Disord. 2002;26(3):425-36. doi: 10.1038/sj.ijo.0801938. PubMed PMID: 11896500.
62. Lakerveld J, Brug J, Bot S, Teixeira PJ, Rutter H, Woodward E, et al. Sustainable prevention of obesity through integrated strategies: The SPOTLIGHT project's conceptual framework and design. BMC Public Health. 2012;12:793. doi: 10.1186/1471-2458-12-793. PubMed PMID: 22985293; PubMed Central PMCID: PMCPMC3490949.
63. Donaire-Gonzalez D, de Nazelle A, Seto E, Mendez M, Nieuwenhuijsen MJ, Jerrett M. Comparison of physical activity measures using mobile phone-based CalFit and Actigraph. J Med Internet Res. 2013;15(6):e111. Epub 2013/07/31. doi: 10.2196/jmir.2470. PubMed PMID: 23896156; PubMed Central PMCID: PMC3713904.
64. Seto E, Martin E, Yang A, Yan P, Gravina R, Lin I, et al. Opportunistic Strategies for Lightweight Signal Processing for Body Sensor Networks. PETRAE conference, workshop on Light-weight Signal Processing for Computationally Intensive BSN Applications; Samos, Greece2010.
65. Shiffman S, Stone AA, Hufford MR. Ecological momentary assessment. Annu Rev Clin Psychol. 2008;4:1-32.
66. Stone AA, Shiffman SS, DeVries MW. Ecological momentary assessment. In: Kahneman D, Diener E, Schwarz N, editors. Well-being: The foundations of hedonic psychology. New York, NY, US: Russell Sage Foundation; 1999. p. 26-39.
67. Jon Noronha EH, Haoqi Zhang , Krzysztof Z. Gajos editor Platemate: crowdsourcing nutritional analysis from food photographs. Proceedings of the 24th annual ACM symposium on User interface software and technology; 2011 October 16-19, 2011; Santa Barbara, California, USA
68. Courvoisier DS, Eid M, Lischetzke T, Schreiber WH. Psychometric properties of a computerized mobile phone method for assessing mood in daily life. Emotion. 2010;10(1):115.
69. Zhu K, Pu B, Xu X-l. Epidemiological survey on simple obesity in 0~ 7 years old children in Kunming city. Chin J Child Health Care. 2008;16(6):696-8.
70. Qiu H, Zhang M-r, Li Z-k. Study on the Epidemiological Characteristics of Overweight and Obesity in Kunming. Chinese Primary Health Care. 2009;4:037.
71. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: a systematic review. Health & place. 2012;18(5):1172-87. doi:

10.1016/j.healthplace.2012.05.006. PubMed PMID: 22717379; PubMed Central PMCID: PMC3684395.
72. Boone-Heinonen J, Gordon-Larsen P, Kiefe CI, Shikany JM, Lewis CE, Popkin BM. Fast food restaurants and food stores: longitudinal associations with diet in young to middle-aged adults: the CARDIA study. Archives of internal medicine. 2011;171(13):1162-70. doi: 10.1001/archinternmed.2011.283. PubMed PMID: 21747011; PubMed Central PMCID: PMC3178268.
73. Moore LV, Diez Roux AV, Nettleton JA, Jacobs DR, Franco M. Fast-food consumption, diet quality, and neighborhood exposure to fast food: the multi-ethnic study of atherosclerosis. American journal of epidemiology. 2009;170(1):29-36. doi: 10.1093/aje/kwp090. PubMed PMID: 19429879; PubMed Central PMCID: PMC2733038.
74. Ello-Martin JA, Ledikwe JH, Rolls BJ. The influence of food portion size and energy density on energy intake: implications for weight management. The American journal of clinical nutrition. 2005;82(1 Suppl):236S-41S. PubMed PMID: 16002828.
75. Ledikwe JH, Ello-Martin JA, Rolls BJ. Portion sizes and the obesity epidemic. The Journal of nutrition. 2005;135(4):905-9. PubMed PMID: 15795457.
76. Young LR, Nestle M. The contribution of expanding portion sizes to the US obesity epidemic. American journal of public health. 2002;92(2):246-9. PubMed PMID: 11818300; PubMed Central PMCID: PMC1447051.
77. Ayala GX. An experimental evaluation of a group- versus computer-based intervention to improve food portion size estimation skills. Health Educ Res. 2006;21(1):133-45. doi: 10.1093/her/cyh049. PubMed PMID: 16100228; PubMed Central PMCID: PMCPMC3724534.
78. T. Hernandez LW, D. Kuehn, K. Rubotzky, P. Moser-Veillon, S. Godwin, C. Thompson, C. Wang. Portion size estimation and expectation of accuracy. J Food Comp Anal. 2006;(19 (suppl)):pp. S14–S21.
79. Godwin SL, Chambers Et, Cleveland L. Accuracy of reporting dietary intake using various portion-size aids in-person and via telephone. J Am Diet Assoc. 2004;104(4):585-94. doi: 10.1016/j.jada.2004.01.006. PubMed PMID: 15054344.
80. Williamson DA, Allen HR, Martin PD, Alfonso AJ, Gerald B, Hunt A. Comparison of digital photography to weighed and visual estimation of portion sizes. J Am Diet Assoc. 2003;103(9):1139-45. doi: 10.1053/jada.2003.50567. PubMed PMID: 12963941.
81. Lucas F NM, Villeminot S, Kaaks R, Clavel-Chapelon F. Estimation of food portion size using photographs: Relative validity, strengths, weaknesses and recommendations. J Hum Nutr Diet 1995;8:65-74.
82. Montoliu R, Gatica-Perez D, editors. Discovering human places of interest from multimodal mobile phone data. Proceedings of the 9th International Conference on Mobile and Ubiquitous Multimedia; 2010: ACM.
83. Fleig D, Randler C. Association between chronotype and diet in adolescents based on food logs. Eat Behav. 2009;10(2):115-8. doi: Doi 10.1016/J.Eatbeh.2009.03.002. PubMed PMID: WOS:000275021600006.
84. Schubert E, Randler C. Association between chronotype and the constructs of the Three-Factor-Eating-Questionnaire. Appetite. 2008;51(3):501-5. doi: Doi 10.1016/J.Appet.2008.03.018. PubMed PMID: WOS:000259930900013.

85. Thompson DA, Wolfe LA, Eikelboom R. Acute effects of exercise intensity on appetite in young men. Med Sci Sports Exerc. 1988;20(3):222-7. PubMed PMID: 3386499.
86. Verger P, Lanteaume MT, Louis-Sylvestre J. Free food choice after acute exercise in men. Appetite. 1994;22(2):159-64. doi: 10.1006/appe.1994.1015. PubMed PMID: 8037440.
87. Christensen L. Effects of eating behavior on mood: a review of the literature. The International journal of eating disorders. 1993;14(2):171-83. PubMed PMID: 8401550.
88. WHO. Global Database on Body Mass Index 2014. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.
89. O'Reilly GA, Spruijt-Metz D. Current mHealth technologies for physical activity assessment and promotion. American journal of preventive medicine. 2013;45(4):501-7. doi: 10.1016/j.amepre.2013.05.012. PubMed PMID: 24050427; PubMed Central PMCID: PMC4199827.
90. Carter MC, Burley VJ, Nykjaer C, Cade JE. 'My Meal Mate' (MMM): validation of the diet measures captured on a smartphone application to facilitate weight loss. The British journal of nutrition. 2013;109(3):539-46. doi: 10.1017/S0007114512001353. PubMed PMID: 22717334.
91. Hebden L, Cook A, van der Ploeg HP, Allman-Farinelli M. Development of smartphone applications for nutrition and physical activity behavior change. JMIR research protocols. 2012;1(2):e9. doi: 10.2196/resprot.2205. PubMed PMID: 23611892; PubMed Central PMCID: PMC3626164.
92. Hughes DC, Andrew A, Denning T, Hurvitz P, Lester J, Beresford S, et al. BALANCE (Bioengineering Approaches for Lifestyle Activity and Nutrition Continuous Engagement): developing new technology for monitoring energy balance in real time. Journal of diabetes science and technology. 2010;4(2):429-34. PubMed PMID: 20307404; PubMed Central PMCID: PMC2864179.
93. Six BL, Schap TE, Zhu FM, Mariappan A, Bosch M, Delp EJ, et al. Evidence-based development of a mobile telephone food record. Journal of the American Dietetic Association. 2010;110(1):74-9.
94. Zhu F, Bosch M, Woo I, Kim S, Boushey CJ, Ebert DS, et al. The use of mobile devices in aiding dietary assessment and evaluation. Selected Topics in Signal Processing, IEEE Journal of. 2010;4(4):756-66.
95. Kong F, Tan J. DietCam: Automatic dietary assessment with mobile camera phones. Pervasive and Mobile Computing. 2012;8(1):147-63.
96. Woo I, Ostmo K, Kim S, Ebert DS, Delp EJ, Boushey CJ. Automatic portion estimation and visual refinement in mobile dietary assessment. Computational Imaging. 2010;8(7533):1.
97. Silk JS, Forbes EE, Whalen DJ, Jakubcak JL, Thompson WK, Ryan ND, et al. Daily emotional dynamics in depressed youth: A cell phone ecological momentary assessment study. Journal of experimental child psychology. 2011;110(2):241-57.
98. Fletcher RR, Tam S, Omojola O, Redemske R, Fedor S, Moshoka JM, editors. Mobile application and wearable sensors for use in cognitive behavioral therapy for drug addiction and PTSD. Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2011 5th International Conference on; 2011: IEEE.
99. Hensel DJ, Fortenberry JD, Harezlak J, Craig D. The feasibility of cell phone based electronic diaries for STI/HIV research. BMC medical research methodology. 2012;12(1):75.

100. Fisher L, Chesla CA, Skaff MA, Gilliss C, Kanter RA, Lutz CP, et al. Disease management status: a typology of Latino and Euro-American patients with type 2 diabetes. Behavioral medicine. 2000;26(2):53-66. doi: 10.1080/08964280009595752. PubMed PMID: 11147290.
101. Buck HG, Kitko L, Hupcey JE. Dyadic heart failure care types: qualitative evidence for a novel typology. The Journal of cardiovascular nursing. 2013;28(6):E37-46. doi: 10.1097/JCN.0b013e31827fcc4c. PubMed PMID: 23388704; PubMed Central PMCID: PMC3655126.
102. Shaw RJ, Palmer L, Blasey C, Sarwal M. A typology of non-adherence in pediatric renal transplant recipients. Pediatric transplantation. 2003;7(6):489-93. PubMed PMID: 14870900.
103. King AC, Stokols D, Talen E, Brassington GS, Killingsworth R. Theoretical approaches to the promotion of physical activity: forging a transdisciplinary paradigm. American journal of preventive medicine. 2002;23(2 Suppl):15-25. PubMed PMID: 12133734.
104. Newman O. Defensible space; crime prevention through urban design. New York,: Macmillan; 1972. xvii, 264 p. p.
105. Kaplan S. The Restorative Benefits of Nature - toward an Integrative Framework. J Environ Psychol. 1995;15(3):169-82. doi: Doi 10.1016/0272-4944(95)90001-2. PubMed PMID: WOS:A1995TC98400002.
106. Barker RG. Ecological psychology; concepts and methods for studying the environment of human behavior. Stanford, Calif.,: Stanford University Press; 1968. vi, 242 p. p.
107. Schoggen P, Barker RG, Fox KA. Behavior settings : a revision and extension of Roger G. Barker's Ecological psychology. Stanford, Calif.: Stanford University Press; 1989. xii, 419 p.
108. Lynch K. The image of the city. Cambridge Mass.: Technology Press; 1960. 194 p. p.
109. Birch LL, Mcphee L, Shoba BC, Steinberg L, Krehbiel R. Clean up Your Plate - Effects of Child Feeding Practices on the Conditioning of Meal Size. Learn Motiv. 1987;18(3):301-17. doi: Doi 10.1016/0023-9690(87)90017-8. PubMed PMID: WOS:A1987J858100005.
110. Gruber R, Wiebe S, Coffey EB, Elgie B, Frenette S, Robert M, et al. The Association between Chronotype and Sleep Patterns in Children. Sleep. 2010;33:A80-A. PubMed PMID: WOS:000208208000232.
111. Leathwood PD, Pollet P. Diet-induced mood changes in normal populations. Journal of psychiatric research. 1982;17(2):147-54. PubMed PMID: 6764931.
112. Liao C, Tan Y, Wu C, Wang S, Yu C, Cao W, et al. City Level of Income and Urbanization and Availability of Food Stores and Food Service Places in China. (1932-6203 (Electronic)). doi: D - NLM: PMC4777357 EDAT- 2016/03/05 06:00 MHDA- 2016/07/28 06:00 CRDT- 2016/03/04 06:00 PHST- 2016 [ecollection] PHST- 2015/09/07 [received] PHST- 2015/12/14 [accepted] PHST- 2016/03/03 [epublish] AID - 10.1371/journal.pone.0148745 [doi] AID - PONE-D-15-39444 [pii] PST - epublish.
113. Ezzati M, Riboli E. Behavioral and dietary risk factors for noncommunicable diseases. (1533-4406 (Electronic)).
114. Stevens GA, Singh Gm Fau - Lu Y, Lu Y Fau - Danaei G, Danaei G Fau - Lin JK, Lin Jk Fau - Finucane MM, Finucane Mm Fau - Bahalim AN, et al. National, regional, and global trends in adult overweight and obesity prevalences. (1478-7954 (Electronic)). doi: D - NLM: PMC3543235.
115. Economos CD, Hatfield DP, King AC, Ayala GX, Pentz MA. Food and physical activity environments: an energy balance approach for research and practice. (1873-2607 (Electronic)).

116. Malik VS, Willett Wc Fau - Hu FB, Hu FB. Global obesity: trends, risk factors and policy implications. (1759-5037 (Electronic)).
117. Astrup A, Dyerberg J Fau - Selleck M, Selleck M Fau - Stender S, Stender S. Nutrition transition and its relationship to the development of obesity and related chronic diseases. (1467-789X (Electronic)).
118. Popkin BM, Nielsen SJ. The sweetening of the world's diet. (1071-7323 (Print)).
119. Rivera JA, Barquera S Fau - Gonzalez-Cossio T, Gonzalez-Cossio T Fau - Olaiz G, Olaiz G Fau - Sepulveda J, Sepulveda J. Nutrition transition in Mexico and in other Latin American countries. (0029-6643 (Print)).
120. Malik VS, Popkin BM, Bray GA, Despres JP, Hu FB. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. Circulation. 2010;121(11):1356-64. doi: 10.1161/CIRCULATIONAHA.109.876185. PubMed PMID: 20308626; PubMed Central PMCID: PMCPMC2862465.
121. Odegaard AO, Koh Wp Fau - Arakawa K, Arakawa K Fau - Yu MC, Yu Mc Fau - Pereira MA, Pereira MA. Soft drink and juice consumption and risk of physician-diagnosed incident type 2 diabetes: the Singapore Chinese Health Study. (1476-6256 (Electronic)). doi: D - NLM: PMC2842218 EDAT- 2010/02/18 06:00 MHDA- 2010/04/03 06:00 CRDT- 2010/02/18 06:00 PHST- 2010/02/16 [aheadofprint] AID - kwp452 [pii] AID - 10.1093/aje/kwp452 [doi] PST - ppublish.
122. Hu FB, Malik VS. Sugar-sweetened beverages and risk of obesity and type 2 diabetes: epidemiologic evidence. (1873-507X (Electronic)). doi: D - NLM: NIHMS182110D - NLM: PMC2862460 EDAT- 2010/02/09 06:00 MHDA- 2010/07/02 06:00 CRDT- 2010/02/09 06:00 PHST- 2009/12/07 [received] PHST- 2010/01/23 [revised] PHST- 2010/01/30 [accepted] PHST- 2010/02/06 [aheadofprint] AID - S0031-9384(10)00060-0 [pii] AID - 10.1016/j.physbeh.2010.01.036 [doi] PST - ppublish.
123. Schulze MB, Manson Je Fau - Ludwig DS, Ludwig Ds Fau - Colditz GA, Colditz Ga Fau - Stampfer MJ, Stampfer Mj Fau - Willett WC, Willett Wc Fau - Hu FB, et al. Sugar-sweetened beverages, weight gain, and incidence of type 2 diabetes in young and middle-aged women. (1538-3598 (Electronic)).
124. Vesnaver E, Keller HH. Social influences and eating behavior in later life: a review. (2155-1200 (Electronic)).
125. Ford PB, Dzewaltowski DA. Disparities in obesity prevalence due to variation in the retail food environment: three testable hypotheses. (0029-6643 (Print)).
126. Duran AC, de Almeida SL, Latorre MD, Jaime PC. The role of the local retail food environment in fruit, vegetable and sugar-sweetened beverage consumption in Brazil. Public Health Nutr. 2015:1-10. doi: 10.1017/S1368980015001524. PubMed PMID: 26054646.
127. Babey Sh Fau - Jones M, Jones M Fau - Yu H, Yu H Fau - Goldstein H, Goldstein H. Bubbling over: soda consumption and its link to obesity in California.
128. Cohen DA, Babey SH. Contextual influences on eating behaviours: heuristic processing and dietary choices. Obes Rev. 2012;13(9):766-79. doi: 10.1111/j.1467-789X.2012.01001.x. PubMed PMID: 22551473; PubMed Central PMCID: PMCPMC3667220.
129. Levitsky DA. The non-regulation of food intake in humans: hope for reversing the epidemic of obesity. (0031-9384 (Print)).

130. Levitsky DA, Obarzanek E Fau - Mrdjenovic G, Mrdjenovic G Fau - Strupp BJ, Strupp BJ. Imprecise control of energy intake: absence of a reduction in food intake following overfeeding in young adults. (0031-9384 (Print)).
131. Block JP, Christakis Na Fau - O'Malley AJ, O'Malley Aj Fau - Subramanian SV, Subramanian SV. Proximity to food establishments and body mass index in the Framingham Heart Study offspring cohort over 30 years. (1476-6256 (Electronic)). doi: D - NLM: PMC3208142 EDAT- 2011/10/04 06:00 MHDA- 2011/12/23 06:00 CRDT- 2011/10/04 06:00 PHST- 2011/09/30 [aheadofprint] AID - kwr244 [pii] AID - 10.1093/aje/kwr244 [doi] PST - ppublish.
132. Michimi A, Wimberly MC. The food environment and adult obesity in US metropolitan areas. Geospat Health. 2015;10(2):368. doi: 10.4081/gh.2015.368. PubMed PMID: 26618317.
133. Ni Mhurchu C, Vandevijvere S Fau - Waterlander W, Waterlander W Fau - Thornton LE, Thornton Le Fau - Kelly B, Kelly B Fau - Cameron AJ, Cameron Aj Fau - Snowdon W, et al. Monitoring the availability of healthy and unhealthy foods and non-alcoholic beverages in community and consumer retail food environments globally. (1467-789X (Electronic)).
134. Wang R, Shi L. Access to food outlets and children's nutritional intake in urban China: a difference-in-difference analysis. (1824-7288 (Electronic)). doi: D - NLM: PMC3480924 EDAT- 2012/07/04 06:00 MHDA- 2013/03/13 06:00 CRDT- 2012/07/04 06:00 PHST- 2011/12/11 [received] PHST- 2012/06/15 [accepted] PHST- 2012/06/30 [aheadofprint] AID - 1824-7288-38-30 [pii] AID - 10.1186/1824-7288-38-30 [doi] PST - epublish.
135. Chaix B, Bean K Fau - Daniel M, Daniel M Fau - Zenk SN, Zenk Sn Fau - Kestens Y, Kestens Y Fau - Charreire H, Charreire H Fau - Leal C, et al. Associations of supermarket characteristics with weight status and body fat: a multilevel analysis of individuals within supermarkets (RECORD study). (1932-6203 (Electronic)). doi: D - NLM: PMC3319546 EDAT- 2012/04/13 06:00 MHDA- 2012/08/22 06:00 CRDT- 2012/04/13 06:00 PHST- 2011/06/28 [received] PHST- 2012/02/07 [accepted] PHST- 2012/04/04 [epublish] AID - 10.1371/journal.pone.0032908 [doi] AID - PONE-D-11-12082 [pii] PST - ppublish.
136. Kirkpatrick SI, Reedy J, Butler EN, Dodd KW, Subar AF, Thompson FE, et al. Dietary assessment in food environment research: a systematic review. (1873-2607 (Electronic)). doi: D - NLM: NIHMS542051D - NLM: PMC4558887 EDAT- 2013/12/21 06:00 MHDA- 2014/08/27 06:00 CRDT- 2013/12/21 06:00 PHST- 2013/05/28 [received] PHST- 2013/07/16 [revised] PHST- 2013/08/27 [accepted] AID - S0749-3797(13)00524-2 [pii] AID - 10.1016/j.amepre.2013.08.015 [doi] PST - ppublish.
137. Adair LS, Popkin BM. Are child eating patterns being transformed globally? (1071-7323 (Print)).
138. Smith LP, Hua J, Seto E, Du S, Zang J, Zou S, et al. Development and validity of a 3-day smartphone assisted 24-hour recall to assess beverage consumption in a Chinese population: a randomized cross-over study. Asia Pac J Clin Nutr. 2014;23(4):678-90. doi: 10.6133/apjcn.2014.23.4.10. PubMed PMID: 25516327; PubMed Central PMCID: PMCPMC4270062.
139. Seto E, Hua J, Wu L, Shia V, Eom S, Wang M, et al. Models of Individual Dietary Behavior Based on Smartphone Data: The Influence of Routine, Physical Activity, Emotion, and Food Environment. (1932-6203 (Electronic)). doi: D - NLM: PMC4822823 EDAT- 2016/04/07 06:00 MHDA- 2016/04/07 06:00 CRDT- 2016/04/07 06:00 PHST- 2016 [ecollection] PHST- 2015/10/01

[received] PHST- 2016/03/23 [accepted] PHST- 2016/04/06 [epublish] AID - 10.1371/journal.pone.0153085 [doi] AID - PONE-D-15-41955 [pii] PST - epublish.
140. Zang J, Song J, Wang Z, Yao C, Ma J, Huang C, et al. Acceptability and feasibility of smartphone-assisted 24 h recalls in the Chinese population. Public Health Nutr. 2015:1-6. doi: 10.1017/S1368980015000907. PubMed PMID: 25857612; PubMed Central PMCID: PMCPMC4600407.
141. Global Database on Body Mass Index: an interactive surveillance tool for monitoring nutrition transition [Internet]. 2013.
142. Donaire-Gonzalez D, de Nazelle A Fau - Seto E, Seto E Fau - Mendez M, Mendez M Fau - Nieuwenhuijsen MJ, Nieuwenhuijsen Mj Fau - Jerrett M, Jerrett M. Comparison of physical activity measures using mobile phone-based CalFit and Actigraph. (1438-8871 (Electronic)). doi: D - NLM: PMC3713904 OTO - NOTNLM.
143. de Nazelle A, Seto E Fau - Donaire-Gonzalez D, Donaire-Gonzalez D Fau - Mendez M, Mendez M Fau - Matamala J, Matamala J Fau - Nieuwenhuijsen MJ, Nieuwenhuijsen Mj Fau - Jerrett M, et al. Improving estimates of air pollution exposure through ubiquitous sensing technologies. (1873-6424 (Electronic)). doi: D - NLM: NIHMS446477D - NLM: PMC3600144 EDAT- 2013/02/19 06:00 MHDA- 2013/04/26 06:00 CRDT- 2013/02/19 06:00 PHST- 2012/10/12 [received] PHST- 2012/12/18 [revised] PHST- 2012/12/26 [accepted] PHST- 2013/02/13 [aheadofprint] AID - S0269-7491(13)00008-0 [pii] AID - 10.1016/j.envpol.2012.12.032 [doi] PST - ppublish.
144. Magurran AE. Meausuring Biological Diversity: Blackwell; 2004.
145. Education UIfDRa. Lesson 3 Logistic Regression Diagnostics [cited 2016 7/1]. Available from: http://www.ats.ucla.edu/stat/stata/webbooks/logistic/chapter3/statalog3.htm.
146. Swinburn BA, Caterson I Fau - Seidell JC, Seidell Jc Fau - James WPT, James WP. Diet, nutrition and the prevention of excess weight gain and obesity. (1368-9800 (Print)).
147. Mazarello Paes V, Hesketh K, O'Malley C, Moore H, Summerbell C, Griffin S, et al. Determinants of sugar-sweetened beverage consumption in young children: a systematic review. Obes Rev. 2015;16(11):903-13. doi: 10.1111/obr.12310. PubMed PMID: 26252417.
148. Holsten JE. Obesity and the community food environment: a systematic review. (1368-9800 (Print)).
149. Han E Fau - Han E, Powell Lm Fau - Powell LM. CONSUMPTION PATTERNS OF SUGAR SWEETENED BEVERAGES IN THE UNITED STATES. (2212-2672 (Print)).
150. Lobstein T. Reducing consumption of sugar-sweetened beverages to reduce the risk of childhood overweight and obesity- Biological, behavioural and contextual rationale: World Health Organization; 2014 [cited 2016 7/1]. Available from: http://www.who.int/elena/bbc/ssbs_childhood_obesity/en/.
151. Pabayo R, Spence Jc Fau - Cutumisu N, Cutumisu N Fau - Casey L, Casey L Fau - Storey K, Storey K. Sociodemographic, behavioural and environmental correlates of sweetened beverage consumption among pre-school children. (1475-2727 (Electronic)).
152. Li L, Shen T, Wen LM, Wu M, He P, Wang Y, et al. Lifestyle factors associated with childhood obesity: a cross-sectional study in Shanghai, China. BMC Res Notes. 2015;8:6. doi: 10.1186/s13104-014-0958-y. PubMed PMID: 25595610; PubMed Central PMCID: PMCPMC4305265.

153. Trumbo PR, Rivers CR. Systematic review of the evidence for an association between sugar-sweetened beverage consumption and risk of obesity. (1753-4887 (Electronic)).
154. Singh GM, Micha R, Khatibzadeh S, Shi P, Lim S, Andrews KG, et al. Global, Regional, and National Consumption of Sugar-Sweetened Beverages, Fruit Juices, and Milk: A Systematic Assessment of Beverage Intake in 187 Countries. PLoS One. 2015;10(8):e0124845. doi: 10.1371/journal.pone.0124845. PubMed PMID: 26244332; PubMed Central PMCID: PMCPMC4526649.
155. Nakamura K, Huxley R Fau - Ansary-Moghaddam A, Ansary-Moghaddam A Fau - Woodward M, Woodward M. The hazards and benefits associated with smoking and smoking cessation in Asia: a meta-analysis of prospective studies. (1468-3318 (Electronic)).
156. Gu D, Kelly Tn Fau - Wu X, Wu X Fau - Chen J, Chen J Fau - Samet JM, Samet Jm Fau - Huang J-f, Huang Jf Fau - Zhu M, et al. Mortality attributable to smoking in China. (1533-4406 (Electronic)).
157. Powell LM, Chriqui JF, Khan T, Wada R, Chaloupka FJ. Assessing the potential effectiveness of food and beverage taxes and subsidies for improving public health: a systematic review of prices, demand and body weight outcomes. Obes Rev. 2013;14(2):110-28. doi: 10.1111/obr.12002. PubMed PMID: 23174017; PubMed Central PMCID: PMCPMC3556391.
158. King AC, Glanz K, Patrick K. Technologies to measure and modify physical activity and eating environments. (1873-2607 (Electronic)).
159. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. Journal of health and social behavior. 1983;24(4):385-96. Epub 1983/12/01. PubMed PMID: 6668417.
160. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. Erratum in: N Engl J Med 2007 Mar 1;356(9):973. 2007;357(4):370-9. Epub 2007/07/27. doi: 10.1056/NEJMsa066082. PubMed PMID: 17652652.
161. Pachucki MA, Jacques PF, Christakis NA. Social network concordance in food choice among spouses, friends, and siblings. Am J Public Health. 2011;101(11):2170-7. Epub 2011/09/24. doi: 10.2105/AJPH.2011.300282. PubMed PMID: 21940920; PubMed Central PMCID: PMC3222397.
162. Valente TW, Fujimoto K, Chou CP, Spruijt-Metz D. Adolescent affiliations and adiposity: a social network analysis of friendships and obesity. The Journal of adolescent health : official publication of the Society for Adolescent Medicine. 2009;45(2):202-4. Epub 2009/07/25. doi: 10.1016/j.jadohealth.2009.01.007. PubMed PMID: 19628148; PubMed Central PMCID: PMC2747768.
1163. Christakis NA, Fowler JH. Social contagion theory: examining dynamic social networks and human behavior. Statistics in medicine. 2012. Epub 2012/06/20. doi: 10.1002/sim.5408. PubMed PMID: 22711416.
164. Center CP. ADD Health. http://wwwcpcuncedu/projects/addhealth Accessed 12/1/2012.
165. Boone-Heinonen J, Gordon-Larsen P, Kiefe CI, Shikany JM, Lewis CE, Popkin BM: Fast food restaurants and food stores: longitudinal associations with diet in young to middle-aged adults: the CARDIA study. *Arch Intern Med* 2011, 171(13):1162–1170.
166. Moore LV, Diez Roux AV, Nettleton JA, Jacobs DR, Franco M: Fast-food consumption, diet quality, and neighborhood exposure to fast food: the multi-ethnic study of atherosclerosis. *Am J Epidemiol* 2009, 170(1):29–36.

167. Hickson DA, Diez Roux AV, Smith AE, Tucker KL, Gore LD, Zhang L, Wyatt SB: Associations of fast food restaurant availability with dietary intake and weight among African Americans in the Jackson Heart Study, 2000-2004. *Am J Public Health* 2011, 101(Suppl 1):S301–309.
168. Jennings A, Welch A, Jones AP, Harrison F, Bentham G, van Sluijs EM, Griffin SJ, Cassidy A: Local food outlets, weight status, and dietary intake: associations in children aged 9-10 years. *Am J Prev Med* 2011, 40(4):405–410.
169. Timperio A, Ball K, Roberts R, Campbell K, Andrianopoulos N, Crawford D: Children's fruit and vegetable intake: associations with the neighbourhood food environment. *Preventive Med* 2008, 46(4):331–335.
170. Charreire H, Casey R, Salze P, Simon C, Chaix B, Banos A, Badariotti D, Weber C, Oppert JM: Measuring the food environment using geographical information systems: a methodological review. *Public Health Nutr* 2010, 13(11):1773–1785.
171. McKinnon RA, Reedy J, Morrissette MA, Lytle LA, Yaroch AL: Measures of the food environment: a compilation of the literature, 1990-2007. *Am J Prev Med* 2009, 36(4 Suppl):S124–133.

Appendices

Restaurant survey (Chapter 1)
Store survey (Chapter 1)
Percentage distribution of BMI categories among 5 different BMI cutoffs adjusting for gender and age (Chapter 1)
Model coefficients and confidence intervals (Chapter 2)
Model outputs (Chapter 3)

2011 昆明饮食环境调查 Kunming Food Environment
餐馆问卷 Restaurant Survey V3-8302011

调查员首字母 Observer Initials: ________ 餐馆编号 Restaurant ID: R _____________ – ___________
邻里/小区 Neighborhood 餐馆 Restaurant

日期 Date: ____ /____/ _______ 调查开始时间 Survey Start Time:__________ AM/PM
DD/ MM/ YYYY

餐馆名 Restaurant name: _____________________ 餐馆电话 Restaurant Phone: ______________

餐馆地址 Restaurant Address: ________________________________

GPS定点 Waypoint: ________________________________

位置(GPS 读数) Location(based on GPS reading): ________________ _________________
纬度 Lat (Ex. N37.52025) 经度 Long (Ex. E122.1759)

营业时间 Hours of Operation: ____________ AM/PM 至 TO _________________ AM/PM
开门 Open 关门 Close

1) 餐馆种类(可多选) Type of Restaurant (check as many as apply):

- ☐ 堂食 Sit-down
- ☐ 外带 Take-out
- ☐ 西式快餐 Western fast food
- ☐ 咖啡馆 Café
- ☐ 中式快餐/点心 Chinese fast food/snacks
- ☐ 路边摊/路边小吃车 Street stand/cart
- ☐ 小吃城/美食街 Food court
- ☐ 餐馆中的熟食柜 Deli
- ☐ 面包店 Bakery
- ☐ 酒吧 Bar
- ☐ 茶馆 Tea House
- ☐ 甜点 Dessert
- ☐ 果汁店/水吧 Juice Bar
- ☐ 其它 Other: ______________

2) 餐馆规模 Size of Restaurant:
座位数(就餐人数) Seating Capacity (number of persons) _____________
或 OR 餐桌数 Number of Tables ____________________

3) 食物种类(可多选) Type of Food Served (check as many as apply)

- ☐ 素食餐 Vegetarian
- ☐ 维根餐 Vegan
- ☐ 有机食品 Organic
- ☐ 点心 Dim-Sum
- ☐ 水产品 Seafood
- ☐ 面条 Noodles
- ☐ 地方食品 Regional cuisine
- ☐ 清真 Muslim
- ☐ 包子/馒头/粑粑/饵块 Buns/Pancakes
- ☐ 煎炸 Deep-fried
- ☐ 其它 Other: ______________

4) 饮料(可多选) Drinks (check all that apply)

- ☐ 无 N/A
- ☐ 碳酸饮料 Soda
- ☐ 果汁 Juice
- ☐ 酒 Alcohol
- ☐ 茶Tea
- ☐ 咖啡 Coffee
- ☐ 瓶装水 Bottled Water
- ☐ 酸奶 Yogurt
- ☐ 牛奶 Flavored Milk
- ☐ 其它Other: ____________________

5) 是否有现成的外卖菜单? Takeout Menu Available? ☐是 Yes ☐ 否 No

6) 宣传页? Flyers? ☐ 是 Yes ☐否 No

7) 广告方式（可多选） Advertised (check all that apply):

- ☐ 无 N/A
- ☐ 本地电话簿 Local Phone Directory
- ☐ 报纸 Newspaper
- ☐ 本地电视台 Local TV Station
- ☐ 其它Other: __________________

8) 是否展示营业执照? Display of Business License? ☐是 Yes ☐ 否 No

9) 是否有网页 Website Available? ☐ 是 Yes ☐ 否 No

10) 是否有营养素含量标识? Nutrition Information Available? ☐是 Yes ☐ 否 No

11) 餐馆是否有海报/菜单标示鼓励多吃或暴饮暴食? (列如: 自助餐, 超大, 加大, 盛宴等字样或描述) Do signs/displays encourage overeating? (Ex. All-you-can-eat, super-size, jumbo, extra-large, feast descriptors on menu or signage) ☐是 Yes ☐ 否 No

12) 餐馆是否有其它特殊的食品选项/促销? (列如: 低碳, 低脂肪, 低胆固醇等) Does the restaurant have other special meal options/promotion? (Ex. low-carb, low-fat, low-cholesterol) ☐ 是 Yes ☐否 No

13) 食品量选择(可多选) Meal portion choices (check all that apply):

☐无选项 N/A ☐小 Small ☐中 Medium ☐大 Large

14) 价格范围(元) Price Range (RMB):

素菜 Vegetable: _______________ 混菜 Meat: ________________ 其它 Other: ____________

15) 餐馆自设车位 Access - Restaurant Own Parking? ☐有 Yes ☐ 无 No

16) 选择符合选项(可多选)：PLEASE CHECK IF APPLICABLE:

- ☐ 获得餐馆名片 Obtained restaurant's business card
- ☐ 获得餐馆菜单 Obtained a copy of the menu
- ☐ 给菜单拍照 Took a picture of the menu

17) 餐馆电话 Restaurant Phone: ____________________________

18) 餐馆愿意配合 Whether the restaurant is willing to corporate? ☐是 ☐否

2011昆明饮食环境调查 Kunming Food Environment
商店问卷 Store Survey V5-09012011

调查员首字母 Observer Initials: _______ 商店编号 Store ID: S _____________ – ___________
邻里/小区 Neighborhood 商店 Store

日期 Date: ____ /____/ _______ 调查开始时间 Survey Start Time: __________AM/PM
DD/ MM/ YYYY

商店名 Store name: _________________________ 商店电话 Store Phone: ________________

商店地址 Store Address: __________________________________

GPS 定点 Waypoint: _____________________________________

位置(GPS 读数) Location(based on GPS reading): _________________ __________________
纬度 Lat (Ex. N37.52025) 经度 Long (Ex. E122.1759)

营业时间 Hours of Operation: _____________ AM/PM 至 TO __________________ AM/PM
开门 Open 关门 Close

商店种类(可多选) Type of Stores (check as many as apply):

- ☐ 农贸市场 Wet market
- ☐ 超市(中大规模) Supermarket (wide variety, of moderate to large size)
- ☐ 小市场(卖新鲜产品，水果或肉类)Small market (sells fresh produce, fruits and/or meats)
- ☐ 便利食品店(主要卖不容易腐烂的食品) Convenience foods store (sells mostly non-perishable products)
- ☐ 加油站附属的便利店 Convenience store attached to a gas station
- ☐ 熟食柜 Deli
- ☐ 外带 Take-out
- ☐ 面包店 Bakery
- ☐ 报刊亭/路边摊/路边小吃车 Newspaper stand, Street stand/cart
- ☐ 甜点/果汁 Dessert/Fruit Juice
- ☐ 进口食品店 Imported food store
- ☐ 烟酒店 Tobacco and Alcohol shop
- ☐ 其它 Other ________________________________

商店大小 Store Size: 长 Length:__________________米M 宽Width:_________________ 米M
如果是算地板砖，注释单块砖的长宽 if counting tiles, indicate the length and width of one tile
单块砖长 Length of a single tile: ____________米M 单块砖数量 Number of tiles: ________
单块砖宽 Width of a single tile: _____________米M 单块砖数量 Number of tiles: ________

售卖种类 ITEMS SOLD

☐ 豆制品 Tofu Products ☐ 罐装食品 Packaged Foods(Canned Foods or food in a jar) ☐ 速冻食品(速冻饺子,馒头,汤圆)Frozen Dumplings, Frozen Meals ☐ 新鲜熟食 Fresh Cooked Prepared Foods	☐ 基本谷物 Basic Grain Products ☐ 腌制食品,烤肉,水产品 Processed, Preserved, Dried Meat and Seafood ☐ 油 Oil ☐ 净菜 Cleaned, Easy-to-cook, Combo Meals ☐ 冰淇淋，冰甜点 Ice cream, Cold Dessert

在售产品 Availability	货架数量重视程度 Occupied Significant Shelf Space	产品位置 Product Location
咸零食 Salty Snack ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
甜零食 Sweet Snack ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
甜饮料 Sweet Drinks ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
酒 Alcohol ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
牛奶/酸奶 Milk/Yogurt ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
瓶装水 Bottled Water ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
粉状饮料 Powdered Drinks ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
茶叶 Tea ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
方便面 Instant Noodles ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
烘焙食品/面包 Pastry/Baked goods ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
豆腐类 Tofu Products ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
水果 Fruits ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
蔬菜 Vegetables ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back
鲜肉,家禽,水产品 Fresh Meat, Poultry, and Seafood ☐ 有 Yes ☐ 无 No	☐ 重视 Significant ☐ 不重视 Insignificant	☐ 前Front ☐ 中Middle ☐ 后 Back

Percentage distribution of BMI categories among 5 different BMI cutoffs adjusting for gender and age

BMI Category	BMI Cutoff																			
	CIP/WGOC				IOTFa				IOTF				WHO				CDC			
	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%
Age 13																				
Underweight	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0
Normal	0	N/A	1	100.0	0	N/A	1	100.0	0	N/A	1	100.0	0	N/A	1	100.0	0	N/A	1	100.0
Overweight	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0
Obese	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0
Combined Overweight	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0
Total	0	N/A	1	100.0	0	N/A	1	100.0	0	N/A	1	100.0	0	N/A	1	100.0	0	N/A	1	100.0
Age 14																				
Underweight	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0
Normal	0	N/A	2	66.7	0	N/A	0	0.0	0	N/A	2	66.7	0	N/A	1	33.3	0	N/A	2	66.7
Overweight	0	N/A	0	0.0	0	N/A	2	66.7	0	N/A	1	33.3	0	N/A	2	66.7	0	N/A	1	33.3
Obese	0	N/A	1	33.3	0	N/A	1	33.3	0	N/A	0	0.0	0	N/A	0	0.0	0	N/A	0	0.0
Combined Overweight	0	N/A	1	33.3	0	N/A	3	100.0	0	N/A	1	33.3	0	N/A	2	66.7	0	N/A	1	33.3
Total	0	N/A	3	100.0	0	N/A	3	100.0	0	N/A	3	100.0	0	N/A	3	100.0	0	N/A	3	100.0
Age 15																				
Underweight	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Normal	5	100.0	18	85.7	5	100.0	16	76.2	5	100.0	19	90.5	5	100.0	18	85.7	5	100.0	19	90.5
Overweight	0	0.0	3	14.3	0	0.0	4	19.0	0	0.0	2	9.5	0	0.0	3	14.3	0	0.0	2	9.5
Obese	0	0.0	0	0.0	0	0.0	1	4.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Combined Overweight	0	0.0	3	14.3	0	0.0	5	23.8	0	0.0	2	9.5	0	0.0	3	14.3	0	0.0	2	9.5
Total	5	100.0	21	100.0	5	100.0	21	100.0	5	100.0	21	100.0	5	100.0	21	100.0	5	100.0	21	100.0
Age 16																				
Underweight	4	**2.3**	5	**2.0**	11	**6.2**	31	**12.3**	11	**6.2**	31	**12.3**	5	**2.8**	5	**2.0**	9	**5.1**	9	**3.6**
Normal	135	76.7	219	86.9	103	58.2	166	65.9	131	74.0	196	77.8	135	76.3	222	88.1	135	76.3	219	86.9

Percentage distribution of BMI categories among 5 different BMI cutoffs adjusting for gender and age

Overweight	25	14.2	21	8.3	45	25.4	43	17.1	25	14.1	24	9.5	26	14.7	23	9.1	21	11.9	22	8.7
Obese	12	6.8	7	2.8	18	10.2	12	4.8	10	5.6	1	0.4	11	6.2	2	0.8	12	6.8	2	0.8
Combined Overweight	37	**21.0**	28	**11.1**	63	**35.6**	55	**21.8**	35	**19.8**	25	**9.9**	37	**20.9**	25	**9.9**	33	**18.6**	24	**9.5**
Total	176	100.0	252	100.0	177	100.0	252	100.0	177	100.0	252	100.0	177	100.0	252	100.0	177	100.0	252	100.0
Age 17																				
Underweight	3	**5.4**	2	**4.7**	8	**13.1**	8	**18.6**	8	**13.1**	8	**18.6**	3	**4.9**	2	**4.7**	6	**9.8**	3	**7.0**
Normal	42	75.0	36	83.7	38	62.3	28	65.1	43	70.5	30	69.8	48	78.7	36	83.7	45	73.8	37	86.0
Overweight	7	12.5	5	11.6	9	14.8	6	14.0	9	14.8	5	11.6	6	9.8	5	11.6	6	9.8	3	7.0
Obese	4	7.1	0	0.0	6	9.8	1	2.3	1	1.6	0	0.0	4	6.6	0	0.0	4	6.6	0	0.0
Combined Overweight	11	**19.6**	5	**11.6**	15	**24.6**	7	**16.3**	10	**16.4**	5	**11.6**	10	**16.4**	5	**11.6**	10	**16.4**	3	**7.0**
Total	56	100.0	43	100.0	61	100.0	43	100.0	61	100.0	43	100.0	61	100.0	43	100.0	61	100.0	43	100.0
Age 18 and above																				
Underweight	0	0.0	0	0.0	0	0.0	1	33.3	0	0.0	1	33.3	0	0.0	0	0.0	0	0.0	1	33.3
Normal	7	77.8	3	100.0	7	77.8	2	66.7	8	88.9	2	66.7	8	88.9	3	100.0	8	88.9	2	66.7
Overweight	1	11.1	0	0.0	1	11.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Obese	1	11.1	0	0.0	1	11.1	0	0.0	1	11.1	0	0.0	1	11.1	0	0.0	1	11.1	0	0.0
Combined Overweight	2	22.2	0	0.0	2	22.2	0	0.0	1	11.1	0	0.0	1	11.1	0	0.0	1	11.1	0	0.0
Total	9	100.0	3	100.0	9	100.0	3	100.0	9	100.0	3	100.0	9	100.0	3	100.0	9	100.0	3	100.0

Model coefficients and confidence intervals

Table 1. Routine model coefficients and confidence intervals

Routine Models				
	Variable Name	**Estimate**	**95% CI**	
Combined data all subjects	Intercept	302.89	265.74	340.03
	Breakfast indicator	-67.84	-123.46	-12.22
	Lunch indicator	6.2	-48.79	61.18
Individual 1	Intercept	241.4	146.78	336.02
	Breakfast indicator	-32.83	-156.72	91.06
	Lunch indicator	17.77	-110.35	145.88
Individual 2	Intercept	423.33	236.89	609.78
	Breakfast indicator	-177.9	-400.75	44.94
	Lunch indicator	-111.33	-347.17	124.5
Individual 3	Intercept	151.67	0.09	303.25
	Breakfast indicator	176.19	-30.38	382.76
	Lunch indicator	148.33	-66.03	362.7
Individual 4	Intercept	445	294.99	595.01
	Breakfast indicator	-256	-478.5	-33.5
	Lunch indicator	-204.8	-427.3	17.7
Individual 5	Intercept	508.83	301.55	716.12
	Breakfast indicator	-100.71	-374.92	173.5
	Lunch indicator	-77.67	-370.81	215.48
Individual 6	Intercept	363.33	243.12	483.55
	Breakfast indicator	-228.33	-445.05	-11.62
	Lunch indicator	137.67	-63.49	338.82

Individual 7	Intercept	193.8	107.01	280.59
	Breakfast indicator	-108.8	-271.17	53.57
	Lunch indicator	29.77	-83.86	143.4
Individual 8	Intercept	220	122.21	317.79
	Breakfast indicator	62.5	-166.83	291.83
	Lunch indicator	70	-84.61	224.61
Individual 9	Intercept	299.09	214.9	383.28
	Breakfast indicator	-111.09	-261.69	39.51
	Lunch indicator	1.62	-133.38	136.62
Individual 10	Intercept	253.75	91.89	415.61
	Breakfast indicator	-123.75	-321.99	74.49
	Lunch indicator	-38.75	-241.66	164.16
Individual 11	Intercept	333.71	232.64	434.79
	Breakfast indicator	-6.21	-173.83	161.4
	Lunch indicator	-98.71	-283.25	85.82
Individual 12	Intercept	227.22	131.99	322.46
	Breakfast indicator	-99.37	-243.35	44.62
	Lunch indicator	205.63	61.65	349.62

Table 2. Energy balance model coefficients and confidence intervals

Energy Balance Models				
	Variable Name	**Estimate**	**95% CI**	
Combined data all subjects	Intercept	300.83	228.34	373.33
	kcal same hr	-17.05	-96.74	62.65
	kcal average of 3 hrs before	-16.7	-125.65	92.25

Individual 1	Intercept	110.48	-96.74	317.7
	kcal same hr	83.43	-146.29	313.14
	kcal average of 3 hrs before	168.06	-143.68	479.79
Individual 2	Intercept	-503.83	-1096.2	88.53
	kcal same hr	727.83	255.11	1200.55
	kcal average of 3 hrs before	220.2	-255.73	696.14
Individual 3	Intercept	345.84	-30.89	722.57
	kcal same hr	-23.51	-343.88	296.85
	kcal average of 3 hrs before	-112.78	-591.78	366.22
Individual 4	Intercept	282.53	-113.27	678.32
	kcal same hr	-191.24	-565.41	182.93
	kcal average of 3 hrs before	248.41	-254.13	750.96
Individual 5	Intercept	118.17	-174.79	411.13
	kcal same hr	528.41	-141.75	1198.57
	kcal average of 3 hrs before	374.11	11.67	736.56
Individual 6	Intercept	69.08	-341.73	479.88
	kcal same hr	75.22	-268.06	418.5
	kcal average of 3 hrs before	577.41	-180.07	1334.89
Individual 7	Intercept	181.76	14.84	348.68
	kcal same hr	116.39	-120.19	352.98
	kcal average of 3 hrs before	-135.25	-513.25	242.75
Individual 8	Intercept	343.92	81.21	606.63
	kcal same hr	-17.76	-324.47	288.95
	kcal average of 3 hrs before	-128.69	-459.75	202.36
Individual 9	Intercept	320.37	147.26	493.49
	kcal same hr	56.1	-246.38	358.58

	kcal average of 3 hrs before	-152.53	-383.33	78.27
Individual 10	Intercept	211.41	-63.29	486.1
	kcal same hr	-39.67	-289.11	209.77
	kcal average of 3 hrs before	11.54	-453.17	476.24
Individual 11	Intercept	278.61	-22.77	580
	kcal same hr	84.62	-209.91	379.14
	kcal average of 3 hrs before	-58.43	-660.96	544.1
Individual 12	Intercept	174.48	-110.7	459.65
	kcal same hr	196.06	-12.88	405.01
	kcal average of 3 hrs before	-154.4	-470.88	162.08

Table 3. Emotion model coefficients and confidence intervals

Emotion Models				
	Variable Name	**Estimate**	**95% CI**	
Combined data all subjects	Intercept	281.84	257.95	305.74
	PC1 (happiness)	-5.81	-24.03	12.42
	PC2 (tiredness)	-1.04	-27.42	25.34
Individual 1	Intercept	267.49	209.93	325.06
	PC1 (happiness)	-95.37	-187.67	-3.06
	PC2 (tiredness)	73.61	-32.88	180.1
Individual 2	Intercept	-922.45	-4855.6	3010.7
	PC1 (happiness)	972.59	-2232.21	4177.4
	PC2 (tiredness)	1416.61	NA	NA
Individual 3	Intercept	262.1	83.69	440.5
	PC1	21.71	-143.68	187.11

	(happiness)			
	PC2 (tiredness)	276.39	-58.84	611.63
Individual 4	Intercept	-81.68	-420.57	257.2
	PC1 (happiness)	319.79	50.58	589
	PC2 (tiredness)	-19.65	-235.02	195.73
Individual 5	Intercept	553.21	325.38	781.04
	PC1 (happiness)	94.57	-126.59	315.74
	PC2 (tiredness)	81.74	-41.24	204.72
Individual 6	Intercept	350.39	234.66	466.12
	PC1 (happiness)	-29.62	-246.48	187.23
	PC2 (tiredness)	-380.49	-720.13	-40.86
Individual 7	Intercept	171.91	39.31	304.51
	PC1 (happiness)	-45.12	-216.43	126.2
	PC2 (tiredness)	-31.78	-182.8	119.25
Individual 8	Intercept	138.65	28.27	249.02
	PC1 (happiness)	-81.64	-167.95	4.66
	PC2 (tiredness)	-5.9	-92.81	81
Individual 9	Intercept	224.29	113.23	335.35
	PC1 (happiness)	25.78	-118.78	170.34
	PC2 (tiredness)	62.31	-44.84	169.46
Individual 10	Intercept	203.48	129.59	277.37
	PC1 (happiness)	48.85	-4.15	101.84
	PC2 (tiredness)	-98.84	-307.72	110.04
Individual 11	Intercept	298.44	56.36	540.52
	PC1 (happiness)	-7.1	-178.29	164.09
	PC2 (tiredness)	1.15	-119.53	121.84

Individual 12	Intercept	392.95	-1270.34	2056.25
	PC1 (happiness)	-84.94	-948.24	778.37
	PC2 (tiredness)	3.49	-649.79	656.78

Table 4. Food environment model coefficients and confidence intervals

Food Environment Models				
	Variable Name	**Estimate**	**95% CI**	
Combined data all subjects	Intercept	180.89	129.18	232.61
	# food establishments within 0.25km	0.31	0.15	0.46
Individual 1	Intercept	68.57	-192.4	329.53
	# food establishments within 0.25km	0.49	-0.46	1.43
Individual 3	Intercept	-357.96	-1217.08	501.16
	# food establishments within 0.25km	1.3	-0.47	3.07
Individual 4	Intercept	187.47	35.81	339.13
	# food establishments within 0.25km	0.22	-0.74	1.18
Individual 5	Intercept	624.52	-693.99	1943.04
	# food establishments within 0.25km	-0.27	-2.74	2.19
Individual 6	Intercept	289.99	-802.37	1382.34
	# food establishments within 0.25km	0.8	-2.46	4.06
Individual 7	Intercept	168.25	-191.84	528.34

	# food establishments within 0.25km	0.29	-33.14	33.73
Individual 8	Intercept	401.71	-41.59	845.01
	# food establishments within 0.25km	-0.39	-1.1	0.33
Individual 9	Intercept	350.44	53.68	647.2
	# food establishments within 0.25km	-0.92	-3.63	1.8
Individual 10	Intercept	-27.14	-228.14	173.85
	# food establishments within 0.25km	82.86	-20.25	185.96
Individual 11	Intercept	217.5	11.1	423.9
	# food establishments within 0.25km	64.86	NA	NA
Individual 12	Intercept	138.33	11.07	265.6
	# food establishments within 0.25km	49.51	NA	NA

Table 5. Full model coefficients and confidence intervals

Full Model				
	Variable Name	**Estimate**	**95% CI**	
	Intercept	272.42	152.42	392.43
	Breakfast indicator	-57.45	-150.08	35.17
	Lunch indicator	56.89	-33.46	147.23
	kcal same hr	-88.92	-217.28	39.44
	kcal average of 3 hrs before	-67.44	-223.37	88.49
	PC1 (happiness)	1.05	-32.31	34.41
	PC2 (tiredness)	4.78	-58.64	68.21
	# food establishments within 0.25km	0.32	0.16	0.49

Model Outputs

Table 1. SSB Consumption and Bakery (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.52	0.46	0.09 - 2.94				0.14	0.11	0.01 - 1.58
Age 27-31	1.73	0.43	0.44 - 6.73				3.86	0.18	0.53 - 28.28
Age 32-36	1.93	0.41	0.40 - 9.40				1.21	0.87	0.13 - 11.16
Sex	1.12	0.86	0.33 - 3.77				0.61	0.55	0.12 - 3.15
Marriage	0.30	0.13	0.06 - 1.42	0.51	0.19	0.19 - 1.39	**0.05**	**0.01**	**0.01 - 0.50**
Child	1.05	0.94	0.29 - 3.86				0.56	0.50	0.10 - 3.02
Middle, High and Technical School	1.35	0.78	0.16 - 11.12				2.82	0.41	0.24 - 33.27
College, University or Above	8.83	0.08	0.74 - 105.31	**4.6**	**0.00**	**1.83 - 11.59**	**26.16**	**0.04**	**1.22 - 560.77**
Employment	0.96	0.97	0.15 - 6.26				0.60	0.70	0.04 - 8.28
Smoking	2.52	0.16	0.69 - 9.19	2.57	0.06	0.98 - 6.77	1.80	0.49	0.33 - 9.72
Sleep hours	1.11	0.68	0.67 - 1.86				1.06	0.84	0.60 - 1.86
Physical Activity	0.73	0.92	0.00 - 219.82				0.24	0.68	0.00 - 200.40
BMI	0.86	0.81	0.25 - 2.94				3.27	0.16	0.62 - 17.13
Total Income	1.00	0.89	1.00 - 1.00				1.00	0.86	1.00 - 1.00
Mean Daily Kcal	1.00	0.88	1.00 - 1.00				1.00	0.85	1.00 - 1.00
Bakery	1.00	0.79	0.99 - 1.01				1.17	0.32	0.86 - 1.59
Age 21-26 X Bakery							1.00	.	1.00 - 1.00
Age 27-31 X Bakery							0.99	0.31	0.96 - 1.01
Age 32-36 X Bakery							1.02	0.22	0.99 - 1.06
Never Smoked X Bakery							1.00	.	1.00 - 1.00
Smoked X Bakery							1.02	0.30	0.99 - 1.05
Not Employed X Bakery							1.00	.	1.00 - 1.00
Employed X Bakery							1.00	.	1.00 - 1.00
No Child X Bakery							1.00	.	1.00 - 1.00
Child X Bakery							**1.04**	**0.03**	**1.00 - 1.07**

Female X Bakery							1.00	.	1.00 - 1.00
Male X Bakery							1.01	0.44	0.99 - 1.03
Rural X Bakery							1.00	.	1.00 - 1.00
Urban X Bakery							0.85	0.29	0.62 - 1.15
Normal Weight X Bakery							1.00	.	1.00 - 1.00
Overweight/Obese X Bakery							**0.96**	**0.01**	**0.94 - 0.99**
Log Likelihood	-59.65			-60.49			-49.69		
LR Chi2	20.47	0.2		18.78	<0.001		39.1	0.02	
AIC	1.52			1.28			1.63		
BIC	53.37			-4.94			66.82		
H-L GOF	5.24	0.73		2.87	0.58		7.94	0.44	

Statistically significant (p<0.05) results were **BOLD**.

Table 2. Mean SSB Consumption in Kcal and Bakery (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	0.54	0.07	0.28 - 1.05	0.56	0.07	0.30 - 1.05	0.81	0.61	0.35 - 1.84
Age 27-31	**2.13**	**0.01**	**1.20 - 3.77**	**1.97**	**0.02**	**1.11 - 3.49**	1.98	0.06	0.97 - 4.03
Age 32-36	**2.25**	**0.02**	**1.11 - 4.56**	**2.11**	**0.04**	**1.05 - 4.27**	2.98	0.08	0.88 - 10.12
Sex	1.17	0.55	0.69 - 1.99				1.82	0.12	0.86 - 3.87
Marriage	**0.45**	**0.01**	**0.24 - 0.85**	**0.48**	**0.01**	**0.26 - 0.86**	0.70	0.30	0.35 - 1.37
Child	1.60	0.16	0.83 - 3.07	1.55	0.13	0.88 - 2.74	1.27	0.54	0.59 - 2.71
Middle, High and Technical School	1.69	0.58	0.26 - 10.84				0.84	0.85	0.13 - 5.24
College, University or Above	3.00	0.25	0.46 - 19.41	1.75	0.08	0.94 - 3.29	1.28	0.80	0.19 - 8.52
Employment	0.42	0.27	0.09 - 1.97	0.52	0.17	0.21 - 1.31	0.69	0.63	0.16 - 3.06
Smoking	**1.8**	**0.05**	**0.99 - 3.28**	1.63	0.09	0.93 - 2.86	**2.29**	**0.02**	**1.13 - 4.61**
Sleep hours	1.11	0.35	0.89 - 1.39				1.04	0.77	0.80 - 1.35
Physical Activity	3.75	0.41	0.16 - 86.99				3.00	0.46	0.16 - 54.61
BMI	0.6	0.06	0.35 - 1.03	0.6	0.07	0.35 - 1.04	0.48	0.11	0.20 - 1.18
Total Income	1.00	0.11	1.00 - 1.00	1.00	0.07	1.00 - 1.00	1.00	**0.03**	**1.00 - 1.00**
Mean Daily Kcal	1.00	0.18	1.00 - 1.00	1.00	0.13	1.00 - 1.00	1.00	0.10	1.00 - 1.00

Bakery	1.00	0.22	1.00 - 1.01	1.00	0.31	1.00 - 1.01	1.12	0.12	0.97 - 1.29
Age 21-26 X Bakery							1.00	.	1.00 - 1.00
Age 27-31 X Bakery							1.00	0.88	0.99 - 1.01
Age 32-36 X Bakery							0.99	0.12	0.98 - 1.00
Never Smoked X Bakery							1.00	.	1.00 - 1.00
Smoked X Bakery							0.99	0.18	0.98 - 1.00
Not Employed X Bakery							1.00	.	1.00 - 1.00
Employed X Bakery							1.00	.	1.00 - 1.00
No Child X Bakery							1.00	.	1.00 - 1.00
Child X Bakery							0.99	0.24	0.98 - 1.00
Female X Bakery							1.00	.	1.00 - 1.00
Male X Bakery							0.99	0.26	0.98 - 1.01
Rural X Bakery							1.00	.	1.00 - 1.00
Urban X Bakery							0.90	0.16	0.79 - 1.04
Normal Weight X Bakery							1.00	.	1.00 - 1.00
Overweight/Obese X Bakery							1.01	0.36	0.99 - 1.02
lnalpha	0.47	0.00	0.32 - 0.67	0.48	0.00	0.34 - 0.69	0.37	0.00	0.26 - 0.54
Log Likelihood	-293.36			-294.38			-286.72		
LR Chi2	35.82	<0.01		33.78	<0.001		49.09	0.001	
AIC	11.75			11.64			12.07		
BIC	27.70			13.87			42.22		

Statistically significant (p<0.05) results were **BOLD**.

Table 3. SSB Consumption and Bar (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.82	0.82	0.15 - 4.59				0.56	0.59	0.07 - 4.70
Age 27-31	2.24	0.27	0.54 - 9.36				1.47	0.68	0.24 - 9.06
Age 32-36	2.08	0.38	0.40 - 10.66				1.40	0.74	0.19 - 10.52
Sex	1.17	0.80	0.34 - 4.07				1.94	0.45	0.35 - 10.75
Marriage	0.38	0.24	0.08 - 1.91	0.47	0.15	0.17 - 1.31	0.17	0.09	0.02 - 1.35

Child	0.80	0.74	0.21 - 3.08				0.57	0.50	0.11 - 2.88
Middle, High and Technical School	1.24	0.84	0.15 - 10.08				1.65	0.66	0.18 - 15.56
College, University or Above	9.05	0.08	0.75 - 108.75	**7.01**	**0.00**	**2.43 - 20.26**	13.99	0.06	0.90 - 216.46
Employment	0.86	0.88	0.13 - 5.58				1.00	1.00	0.09 - 10.73
Smoking	2.88	0.12	0.76 - 10.90	**2.82**	**0.04**	**1.06 - 7.53**	3.72	0.15	0.61 - 22.72
Sleep hours	1.05	0.85	0.63 - 1.75				1.07	0.83	0.59 - 1.93
Physical Activity	0.65	0.88	0.00 - 202.29				0.72	0.92	0.00 - 531.11
BMI	0.89	0.85	0.26 - 3.06				2.19	0.32	0.47 - 10.11
Total Income	1.00	0.90	1.00 - 1.00				1.00	0.85	1.00 - 1.00
Mean Daily Kcal	1.00	0.73	1.00 - 1.00				1.00	0.85	1.00 - 1.00
Bar	0.98	0.09	0.96 - 1.00	0.98	0.08	0.97 - 1.00	1.11	0.58	0.77 - 1.59
Age 21-26 X Bar							1.00	.	1.00 - 1.00
Age 27-31 X Bar							1.06	0.33	0.94 - 1.19
Age 32-36 X Bar							1.05	0.46	0.93 - 1.18
Never Smoked X Bar							1.00	.	1.00 - 1.00
Smoked X Bar							1.01	0.88	0.91 - 1.12
Not Employed X Bar							1.00	.	1.00 - 1.00
Employed X Bar							1.00	.	1.00 - 1.00
No Child X Bar							1.00	.	1.00 - 1.00
Child X Bar							1.05	0.08	0.99 - 1.12
Female X Bar							1.00	.	1.00 - 1.00
Male X Bar							0.94	0.27	0.83 - 1.05
Rural X Bar							1.00	.	1.00 - 1.00
Urban X Bar							0.88	0.47	0.61 - 1.25
Normal Weight X Bar							1.00	.	1.00 - 1.00
Overweight/Obese X Bar							0.89	0.07	0.79 - 1.01
Log Likelihood	-58.13			-58.86			-51.98		
LR Chi2	23.52	0.10		22.05	<0.001		34.52	0.06	
AIC	1.49			1.27			1.68		
BIC	50.32			-3.59			71.40		

H-L GOF	5.46	0.71		4.53	0.72		9.10	0.33	

Statistically significant (p<0.05) results were **BOLD**.

Table 4. Mean SSB Consumption in Kcal and Bar (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	**0.44**	**0.03**	**0.21 - 0.91**	**0.42**	**0.02**	**0.20 - 0.85**	0.69	0.36	0.32 - 1.51
Age 27-31	1.67	0.10	0.90 - 3.07	1.62	0.12	0.88 - 2.98	1.28	0.47	0.65 - 2.51
Age 32-36	**2.11**	**0.04**	**1.04 - 4.29**	1.97	0.06	0.97 - 3.99	1.86	0.23	0.68 - 5.04
Sex	1.32	0.29	0.79 - 2.22	1.38	0.21	0.83 - 2.31	**2.37**	**0.02**	**1.17 - 4.80**
Marriage	**0.42**	**0.01**	**0.22 - 0.79**	**0.46**	**0.01**	**0.25 - 0.84**	0.52	0.06	0.26 - 1.04
Child	1.66	0.12	0.87 - 3.18	1.48	0.22	0.79 - 2.76	1.21	0.65	0.54 - 2.72
Middle, High and Technical School	1.38	0.73	0.22 - 8.78				1.39	0.76	0.17 - 11.56
College, University or Above	2.55	0.33	0.39 - 16.43	1.68	0.10	0.91 - 3.09	1.64	0.65	0.19 - 14.16
Employment	0.52	0.42	0.11 - 2.48				0.52	0.44	0.10 - 2.74
Smoking	1.63	0.11	0.89 - 3.00	1.52	0.17	0.84 - 2.76	**2.83**	**0.00**	**1.45 - 5.52**
Sleep hours	1.10	0.38	0.88 - 1.38				1.11	0.50	0.83 - 1.48
Physical Activity	1.79	0.72	0.08 - 40.70				3.65	0.41	0.16 - 80.78
BMI	**0.59**	**0.05**	**0.35 - 1.00**	**0.59**	**0.05**	**0.35 - 0.99**	**0.41**	**0.03**	**0.18 - 0.93**
Total Income	1.00	0.07	1.00 - 1.00	1.00	0.06	1.00 - 1.00	1.00	0.13	1.00 - 1.00
Mean Daily Kcal	1.00	0.18	1.00 - 1.00	1.00	0.09	1.00 - 1.00	1.00	0.28	1.00 - 1.00
Bar	1.01	0.10	1.00 - 1.02	1.01	0.08	1.00 - 1.02	1.13	0.10	0.98 - 1.30
Age 21-26 X Bar							1.00	.	1.00 - 1.00
Age 27-31 X Bar							1.03	0.19	0.99 - 1.08
Age 32-36 X Bar							1.00	0.93	0.94 - 1.06
Never Smoked X Bar							1.00	.	1.00 - 1.00
Smoked X Bar							**0.96**	**0.05**	**0.93 - 1.00**
Not Employed X Bar							1.00	.	1.00 - 1.00
Employed X Bar							1.00	.	1.00 - 1.00
No Child X Bar							1.00	.	1.00 - 1.00
Child X Bar							1.00	0.85	0.97 - 1.03
Female X Bar							1.00	.	1.00 - 1.00
Male X Bar							0.96	0.07	0.92 - 1.00

Rural X Bar							1.00	.	1.00 - 1.00
Urban X Bar							0.90	0.13	0.78 - 1.03
Normal Weight X Bar							1.00	.	1.00 - 1.00
Overweight/Obese X Bar							1.01	0.66	0.97 - 1.04
lnalpha	0.45	0.00	0.32 - 0.66	0.47	0.00	0.33 - 0.68	0.37	0.00	0.26 - 0.54
Log Likelihood	-292.66			-293.62			-287.06		
LR Chi2	37.21	0.002		35.29	<0.001		48.41	0.002	
AIC	11.72			11.61			12.08		
BIC	26.32			12.35			42.90		

Statistically significant (p<0.05) results were **BOLD**.

Table 5. SSB Consumption and Cafe (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.69	0.67	0.13 - 3.80				0.31	0.28	0.04 - 2.55
Age 27-31	1.95	0.35	0.48 - 7.84				2.34	0.36	0.38 - 14.37
Age 32-36	2.09	0.37	0.42 - 10.48				3.44	0.25	0.43 - 27.78
Sex	1.11	0.86	0.33 - 3.80				1.64	0.53	0.36 - 7.52
Marriage	0.29	0.13	0.06 - 1.41	0.41	0.10	0.14 - 1.20	0.16	0.07	0.02 - 1.16
Child	0.96	0.95	0.26 - 3.55				0.53	0.44	0.11 - 2.62
Middle, High and Technical School	1.41	0.75	0.17 - 11.42				1.69	0.64	0.19 - 15.36
College, University or Above	8.62	0.09	0.72 - 102.87	**5.67**	**0.00**	**2.12 - 15.17**	12.24	0.07	0.80 - 187.90
Employment	1.00	1.00	0.16 - 6.39				1.95	0.58	0.18 - 21.18
Smoking	2.51	0.17	0.68 - 9.26	2.52	0.06	0.95 - 6.70	1.95	0.39	0.42 - 9.05
Sleep hours	1.12	0.65	0.68 - 1.86				1.12	0.69	0.65 - 1.93
Physical Activity	0.77	0.93	0.00 - 228.74				0.61	0.88	0.00 - 424.69
BMI	0.81	0.74	0.24 - 2.80				1.04	0.96	0.23 - 4.79
Total Income	1.00	0.85	1.00 - 1.00				1.00	0.69	1.00 - 1.00
Mean Daily Kcal	1.00	0.81	1.00 - 1.00				1.00	0.79	1.00 - 1.00
Cafe	0.99	0.22	0.98 - 1.00	0.99	0.18	0.98 - 1.00	1.19	0.57	0.66 - 2.13
Age 21-26 X Cafe	0.20	0.62	0.00 - 127.33	0.76	0.65	0.24 - 2.43	1.00	.	1.00 - 1.00

Age 27-31 X Cafe							1.00	0.99	0.95 - 1.05
Age 32-36 X Cafe							0.99	0.85	0.94 - 1.05
Never Smoked X Cafe							1.00	.	1.00 - 1.00
Smoked X Cafe							1.01	0.78	0.96 - 1.05
Not Employed X Cafe							1.00	.	1.00 - 1.00
Employed X Cafe							0.88	0.64	0.51 - 1.51
No Child X Cafe							1.00	.	1.00 - 1.00
Child X Cafe							1.05	0.08	0.99 - 1.11
Female X Cafe							1.00	.	1.00 - 1.00
Male X Cafe							0.97	0.23	0.91 - 1.02
Rural X Cafe							1.00	.	1.00 - 1.00
Urban X Cafe							0.96	0.74	0.76 - 1.21
Normal Weight X Cafe							1.00	.	1.00 - 1.00
Overweight/Obese X Cafe							0.97	0.26	0.93 - 1.02
Log Likelihood	-58.92			-59.55			-54.16		
LR Chi2	21.93	0.15		20.66	<0.001		31.45	0.14	
AIC	1.50			1.28			1.71		
BIC	51.91			-2.20			79.32		
H-L GOF	7.51	0.48		5.82	0.56		9.81	0.28	

Statistically significant (p<0.05) results were **BOLD**.

Table 6. Mean SSB Consumption in Kcal and Cafe (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	**0.45**	**0.04**	**0.21 - 0.98**	**0.43**	**0.03**	**0.20 - 0.90**	0.85	0.70	0.37 - 1.95
Age 27-31	**2.04**	**0.01**	**1.16 - 3.58**	**1.95**	**0.02**	**1.12 - 3.41**	1.56	0.32	0.64 - 3.77
Age 32-36	**2.45**	**0.02**	**1.18 - 5.06**	**2.47**	**0.01**	**1.19 - 5.11**	2.37	0.13	0.78 - 7.16
Sex	1.42	0.21	0.82 - 2.46	1.45	0.19	0.84 - 2.50	1.89	0.10	0.88 - 4.04
Marriage	**0.43**	**0.01**	**0.23 - 0.82**	**0.45**	**0.01**	**0.25 - 0.83**	0.72	0.39	0.34 - 1.53
Child	1.51	0.21	0.79 - 2.87	1.40	0.29	0.75 - 2.60	1.22	0.66	0.50 - 2.95
Middle, High and Technical School	1.45	0.69	0.23 - 9.28				0.78	0.82	0.09 - 6.48

College, University or Above	2.86	0.27	0.44 - 18.57	**1.98**	**0.04**	**1.03 - 3.80**	1.18	0.88	0.14 - 10.11
Employment	0.49	0.36	0.10 - 2.30	0.59	0.27	0.23 - 1.49	0.81	0.81	0.14 - 4.57
Smoking	**1.91**	**0.03**	**1.05 - 3.48**	**1.87**	**0.04**	**1.04 - 3.34**	**2.44**	**0.02**	**1.17 - 5.09**
Sleep hours	1.05	0.65	0.85 - 1.31				1.04	0.76	0.80 - 1.36
Physical Activity	2.78	0.52	0.12 - 62.78				4.18	0.36	0.20 - 87.92
BMI	**0.56**	**0.03**	**0.33 - 0.95**	**0.57**	**0.04**	**0.33 - 0.98**	**0.35**	**0.01**	**0.16 - 0.77**
Total Income	1.00	0.09	1.00 - 1.00	**1.00**	**0.05**	**1.00 - 1.00**	1.00	0.06	1.00 - 1.00
Mean Daily Kcal	1.00	0.20	1.00 - 1.00	1.00	0.14	1.00 - 1.00	1.00	0.25	1.00 - 1.00
Cafe	1.01	0.17	1.00 - 1.01	1.01	0.15	1.00 - 1.01	1.09	0.13	0.97 - 1.23
Age 21-26 X Cafe							1.00	.	1.00 - 1.00
Age 27-31 X Cafe							1.01	0.67	0.98 - 1.03
Age 32-36 X Cafe							0.99	0.71	0.96 - 1.03
Never Smoked X Cafe							1.00	.	1.00 - 1.00
Smoked X Cafe							1.00	0.98	0.98 - 1.02
Not Employed X Cafe							1.00	.	1.00 - 1.00
Employed X Cafe							1.00	.	1.00 - 1.00
No Child X Cafe							1.00	.	1.00 - 1.00
Child X Cafe							0.99	0.35	0.96 - 1.01
Female X Cafe							1.00	.	1.00 - 1.00
Male X Cafe							1.00	0.90	0.97 - 1.03
Rural X Cafe							1.00	.	1.00 - 1.00
Urban X Cafe							0.91	0.11	0.82 - 1.02
Normal Weight X Cafe							1.00	.	1.00 - 1.00
Overweight/Obese X Cafe							1.01	0.17	0.99 - 1.03
lnalpha	0.46	0.00	0.32 - 0.67	0.47	0.00	0.33 - 0.67	0.39	0.00	0.27 - 0.57
Log Likelihood	-293.18			-293.54			-288.49		
LR Chi2	36.18	0.003		35.46	<0.001		45.57	0.003	
AIC	11.74			11.64			12.13		
BIC	27.35			16.15			45.75		

Statistically significant (p<0.05) results were **BOLD**.

Table 7. SSB Consumption and Convenience Store (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.44	0.38	0.07 - 2.71				**0.03**	**0.02**	**0.00 - 0.51**
Age 27-31	1.68	0.46	0.43 - 6.60				3.17	0.28	0.39 - 25.87
Age 32-36	1.88	0.44	0.38 - 9.22				1.28	0.84	0.12 - 13.70
Sex	1.11	0.87	0.33 - 3.71				0.73	0.73	0.12 - 4.34
Marriage	0.30	0.13	0.06 - 1.41	0.51	0.19	0.19 - 1.39	**0.03**	**0.01**	**0.00 - 0.34**
Child	1.09	0.90	0.30 - 3.96				0.41	0.34	0.07 - 2.54
Middle, High and Technical School	1.42	0.75	0.17 - 11.60				2.57	0.47	0.20 - 32.94
College, University or Above	8.95	0.08	0.75 - 106.28	**4.6**	**0.00**	**1.83 - 11.59**	18.43	0.06	0.87 - 389.56
Employment	0.93	0.94	0.14 - 6.06				1.35	0.87	0.04 - 44.20
Smoking	2.51	0.16	0.69 - 9.16	2.57	0.06	0.98 - 6.77	1.69	0.56	0.29 - 9.82
Sleep hours	1.13	0.63	0.68 - 1.88				1.12	0.70	0.63 - 1.98
Physical Activity	0.79	0.94	0.00 - 219.97				0.32	0.74	0.00 - 299.90
BMI	0.86	0.81	0.25 - 2.92				2.44	0.30	0.46 - 12.99
Total Income	1.00	0.88	1.00 - 1.00				1.00	0.92	1.00 - 1.00
Mean Daily Kcal	1.00	0.93	1.00 - 1.00				1.00	0.55	1.00 - 1.00
Convenience Store	1.00	0.85	1.00 - 1.00				1.09	0.71	0.68 - 1.76
Age 21-26 X Convenience Store	0.20	0.63	0.00 - 126.72	0.59	0.33	0.20 - 1.72	1.00	.	1.00 - 1.00
Age 27-31 X Convenience Store							1.00	0.53	0.99 - 1.01
Age 32-36 X Convenience Store							1.01	0.21	1.00 - 1.02
Never Smoked X Convenience Store							1.00	.	1.00 - 1.00
Smoked X Convenience Store							1.01	0.27	0.99 - 1.02
Not Employed X Convenience Store							1.00	.	1.00 - 1.00
Employed X Convenience Store							0.91	0.69	0.56 - 1.46
No Child X Convenience Store							1.00	.	1.00 - 1.00
Child X Convenience Store							**1.01**	**0.02**	**1.00 - 1.03**
Female X Convenience Store							1.00	.	1.00 - 1.00
Male X Convenience Store							1.00	0.72	0.99 - 1.01
Rural X Convenience Store							1.00	.	1.00 - 1.00
Urban X Convenience Store							1.01	0.78	0.96 - 1.05
Normal Weight X Convenience Store							1.00	.	1.00 - 1.00
Overweight/Obese X Convenience Store							**0.99**	**0.04**	**0.98 - 1.00**

	-		-		-	
Log Likelihood	59.67		60.49		49.34	
LR Chi2	20.44	0.20	18.78	<0.001	41.08	0.02
AIC	1.52		1.28		1.61	
BIC	53.41		-4.94		69.68	
H-L GOF	3.07	0.93	2.87	0.58	5.99	0.65

Statistically significant (p<0.05) results were **BOLD**.

Table 8. Mean SSB Consumption in Kcal and Convenience Store (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	0.5	0.06	0.24 - 1.04	0.65	0.14	0.36 - 1.16	1.18	0.76	0.42 - 3.27
Age 27-31	**2.11**	**0.01**	**1.19 - 3.75**	**1.95**	**0.02**	**1.09 - 3.48**	**3.68**	**0.01**	**1.37 - 9.85**
Age 32-36	**2.24**	**0.03**	**1.10 - 4.55**	**2.11**	**0.04**	**1.03 - 4.31**	**7.36**	**0.02**	**1.34 - 40.48**
Sex	1.19	0.52	0.70 - 2.01				1.97	0.16	0.77 - 5.01
Marriage	**0.42**	**0.01**	**0.22 - 0.81**	**0.47**	**0.02**	**0.25 - 0.87**	0.76	0.52	0.34 - 1.74
Child	1.62	0.15	0.84 - 3.14	1.55	0.14	0.87 - 2.77	0.87	0.81	0.28 - 2.70
Middle, High and Technical School	1.86	0.52	0.28 - 12.25				0.00	0.17	0.00 - 8.46e+11
College, University or Above	3.29	0.22	0.50 - 21.69	1.81	0.07	0.96 - 3.44	0.00	0.17	0.00 - 1.15e+12
Employment	0.38	0.23	0.08 - 1.84	0.53	0.18	0.21 - 1.34	2.11e+28	0.17	0.00 - 1.06e+69
Smoking	**1.81**	**0.05**	**0.99 - 3.30**	1.64	0.09	0.93 - 2.89	2.03	0.07	0.95 - 4.36
Sleep hours	1.10	0.39	0.88 - 1.37				1.05	0.70	0.83 - 1.33
Physical Activity	2.91	0.50	0.13 - 64.16				2.28	0.56	0.14 - 36.90
BMI	0.61	0.07	0.35 - 1.04	**0.57**	**0.04**	**0.34 - 0.99**	0.43	0.10	0.16 - 1.17
Total Income	1.00	0.11	1.00 - 1.00	1.00	0.07	1.00 - 1.00	1.00	0.47	1.00 - 1.00
Mean Daily Kcal	1.00	0.25	1.00 - 1.00	1.00	0.15	1.00 - 1.00	1.00	0.23	1.00 - 1.00
Convenience Store	1.00	0.26	1.00 - 1.00				1.37	0.14	0.90 - 2.07
Age 21-26 X Convenience Store							1.00	.	1.00 - 1.00
Age 27-31 X Convenience Store							1.00	0.21	0.99 - 1.00
Age 32-36 X Convenience Store							**0.99**	**0.05**	**0.99 - 1.00**
Never Smoked X Convenience Store							1.00	.	1.00 - 1.00
Smoked X Convenience Store							1.00	0.41	0.99 - 1.00

Not Employed X Convenience Store							1.00	.	1.00 - 1.00
Employed X Convenience Store							0.75	0.17	0.49 - 1.14
No Child X Convenience Store							1.00	.	1.00 - 1.00
Child X Convenience Store							1.00	0.99	1.00 - 1.00
Female X Convenience Store							1.00	.	1.00 - 1.00
Male X Convenience Store							1.00	0.22	0.99 - 1.00
Rural X Convenience Store							1.00	.	1.00 - 1.00
Urban X Convenience Store							**0.98**	**0.05**	**0.96 - 1.00**
Normal Weight X Convenience Store							1.00	.	1.00 - 1.00
Overweight/Obese X Convenience Store							1.00	0.34	1.00 - 1.01
lnalpha	0.47	0.00	0.32 - 0.67	0.49	0.00	0.34 - 0.71	0.37	0.00	0.25 - 0.53
Log Likelihood	-293.48			-294.91		-286.39			
LR Chi2	35.57	0.003		32.72	<0.001	49.76	0.002		
AIC	11.75			11.62		12.05			
BIC	27.95			10.96		45.52			

Statistically significant (p<0.05) results were **BOLD**.

Table 9. SSB Consumption and Grocery/Supermarket (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.63	0.59	0.12 - 3.34				**0.08**	**0.05**	**0.01 - 1.05**
Age 27-31	1.84	0.39	0.46 - 7.36				3.78	0.22	0.46 - 31.19
Age 32-36	2.06	0.38	0.41 - 10.42				1.12	0.92	0.10 - 12.08
Sex	1.16	0.82	0.34 - 3.97				0.50	0.48	0.08 - 3.32
Marriage	0.30	0.13	0.06 - 1.44	0.43	0.11	0.15 - 1.22	**0.11**	**0.03**	**0.01 - 0.82**
Child	0.92	0.90	0.24 - 3.44				0.45	0.38	0.08 - 2.68
Middle, High and Technical School	1.32	0.80	0.16 - 10.74				1.72	0.65	0.17 - 17.77
College, University or Above	9.00	0.08	0.75 - 107.99	**6.06**	**0.00**	**2.16 - 17.04**	**18.39**	**0.05**	**0.98 - 345.24**
Employment	1.05	0.96	0.16 - 6.87				1.62	0.74	0.10 - 27.57
Smoking	2.97	0.11	0.78 - 11.25	**2.90**	**0.04**	**1.07 - 7.80**	0.91	0.92	0.13 - 6.37
Sleep hours	1.10	0.70	0.67 - 1.83				1.06	0.85	0.60 - 1.86

Physical Activity	0.89	0.97	0.00 - 277.94				0.09	0.46	0.00 - 57.91
BMI	0.77	0.68	0.22 - 2.70				1.79	0.47	0.37 - 8.79
Total Income	1.00	0.85	1.00 - 1.00				1.00	0.89	1.00 - 1.00
Mean Daily Kcal	1.00	0.82	1.00 - 1.00				1.00	0.87	1.00 - 1.00
Grocery/Supermarket	0.99	0.22	0.96 - 1.01	0.99	0.17	0.96 - 1.01	1.03	0.86	0.72 - 1.49
Age 21-26 X Grocery/Supermarket	0.24	0.67	0.00 - 162.55	0.71	0.56	0.23 - 2.22	1.00	.	1.00 - 1.00
Age 27-31 X Grocery/Supermarket							0.96	0.26	0.89 - 1.03
Age 32-36 X Grocery/Supermarket							1.08	0.18	0.97 - 1.19
Never Smoked X Grocery/Supermarket							1.00	.	1.00 - 1.00
Smoked X Grocery/Supermarket							1.11	0.06	1.00 - 1.24
Not Employed X Grocery/Supermarket							1.00	.	1.00 - 1.00
Employed X Grocery/Supermarket							0.84	0.33	0.59 - 1.19
No Child X Grocery/Supermarket							1.00	.	1.00 - 1.00
Child X Grocery/Supermarket							1.07	0.15	0.98 - 1.17
Female X Grocery/Supermarket							1.00	.	1.00 - 1.00
Male X Grocery/Supermarket							1.06	0.18	0.98 - 1.15
Rural X Grocery/Supermarket							1.00	.	1.00 - 1.00
Urban X Grocery/Supermarket							1.10	0.18	0.96 - 1.27
Normal Weight X Grocery/Supermarket							1.00	.	1.00 - 1.00
Overweight/Obese X Grocery/Supermarket							0.95	0.19	0.87 - 1.03
Log Likelihood	-58.97			-59.61			-52.38		
LR Chi2	21.82	0.15		20.56	<0.001		35.00	0.07	
AIC	1.50			1.28			1.67		
BIC	52.02			-2.09			75.76		
H-L GOF	5.57	0.70		5.65	0.69		11.38	0.18	

Statistically significant (p<0.05) results were **BOLD**.

Table 10. Mean SSB Consumption in Kcal and Grocery/Supermarket (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	**0.43**	**0.02**	**0.22 - 0.86**	**0.38**	**0.00**	**0.21 - 0.70**	0.55	0.25	0.20 - 1.53

Age 27-31	**1.96**	**0.02**	**1.13 - 3.41**	**1.77**	**0.04**	**1.03 - 3.04**	**2.56**	**0.02**	**1.13 - 5.78**
Age 32-36	**2.06**	**0.04**	**1.04 - 4.07**	1.74	0.09	0.91 - 3.31	3.59	0.06	0.96 - 13.41
Sex	1.15	0.58	0.70 - 1.90				0.75	0.50	0.32 - 1.75
Marriage	**0.4**	**0.00**	**0.21 - 0.75**	**0.39**	**0.00**	**0.21 - 0.71**	**0.44**	**0.04**	**0.21 - 0.95**
Child	**1.97**	**0.04**	**1.02 - 3.78**	**2.07**	**0.01**	**1.18 - 3.64**	**2.33**	**0.03**	**1.08 - 5.03**
Middle, High and Technical School	2.27	0.38	0.37 - 14.07	2.73	0.28	0.45 - 16.68	0	0.10	0.00 - 4.54
College, University or Above	4.24	0.12	0.67 - 26.76	4.65	0.10	0.74 - 29.25	0.00	0.12	0.00 - 8.32
Employment	0.32	0.14	0.07 - 1.46	0.29	0.10	0.06 - 1.27	11602	0.11	0.14 - 954263410
Smoking	1.41	0.28	0.76 - 2.60				1.74	0.21	0.73 - 4.17
Sleep hours	1.11	0.33	0.90 - 1.38				1.06	0.59	0.85 - 1.33
Physical Activity	2.15	0.60	0.12 - 39.35				1.21	0.90	0.07 - 20.79
BMI	0.70	0.17	0.41 - 1.18	0.75	0.27	0.45 - 1.25	0.39	0.11	0.12 - 1.23
Total Income	1.00	0.06	1.00 - 1.00	**1.00**	**0.02**	**1.00 - 1.00**	1.00	0.07	1.00 - 1.00
Mean Daily Kcal	1.00	0.14	1.00 - 1.00	**1.00**	**0.03**	**1.00 - 1.00**	1.00	0.43	1.00 - 1.00
Grocery/Supermarket	**1.01**	**0.02**	**1.00 - 1.02**	**1.01**	**0.01**	**1.00 - 1.02**	**1.7**	**0.05**	**1.00 - 2.91**
Age 21-26 X Grocery/Supermarket							1.00	.	1.00 - 1.00
Age 27-31 X Grocery/Supermarket							0.99	0.61	0.96 - 1.02
Age 32-36 X Grocery/Supermarket							0.98	0.55	0.93 - 1.04
Never Smoked X Grocery/Supermarket							1.00	.	1.00 - 1.00
Smoked X Grocery/Supermarket							0.99	0.79	0.95 - 1.04
Not Employed X Grocery/Supermarket							1.00	.	1.00 - 1.00
Employed X Grocery/Supermarket							0.6	0.07	0.35 - 1.04
No Child X Grocery/Supermarket							1.00	.	1.00 - 1.00
Child X Grocery/Supermarket							0.98	0.31	0.95 - 1.01
Female X Grocery/Supermarket							1.00	.	1.00 - 1.00
Male X Grocery/Supermarket							1.01	0.68	0.96 - 1.06
Rural X Grocery/Supermarket							1.00	.	1.00 - 1.00
Urban X Grocery/Supermarket							0.99	0.68	0.95 - 1.04
Normal Weight X Grocery/Supermarket							1.00	.	1.00 - 1.00
Overweight/Obese X Grocery/Supermarket							1.04	0.35	0.96 - 1.12
lnalpha	0.43	0.00	0.30 - 0.63	0.45	0.00	0.31 - 0.65	0.37	0.00	0.26 - 0.54
Log Likelihood	-291.3			-292.3			-286.88		

LR Chi2	39.94	<0.001		37.93	<0.001		48.78	0.002	
AIC	11.67			11.56			12.07		
BIC	23.59			9.71			46.5		

Statistically significant (p<0.05) results were **BOLD**.

Table 11. SSB Consumption and Liquor Store (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.48	0.37	0.10 - 2.38				0.38	0.28	0.07 - 2.18
Age 27-31	1.82	0.39	0.46 - 7.21				1.12	0.89	0.22 - 5.57
Age 32-36	1.94	0.41	0.40 - 9.48				1.38	0.71	0.24 - 7.90
Sex	1.06	0.93	0.31 - 3.58				1.59	0.51	0.40 - 6.36
Marriage	0.29	0.12	0.06 - 1.38	0.51	0.19	0.19 - 1.39	0.25	0.14	0.04 - 1.56
Child	1.09	0.89	0.30 - 3.99				0.56	0.43	0.13 - 2.35
Middle, High and Technical School	1.41	0.75	0.17 - 11.50				1.38	0.77	0.16 - 11.86
College, University or Above	9.33	0.08	0.77 - 113.06	**4.6**	**0.00**	**1.83 - 11.59**	9.48	0.09	0.71 - 126.23
Employment	0.94	0.95	0.15 - 6.13				1.16	0.89	0.15 - 8.88
Smoking	2.49	0.17	0.69 - 9.08	2.57	0.06	0.98 - 6.77	2.01	0.35	0.46 - 8.76
Sleep hours	1.14	0.60	0.69 - 1.90				1.03	0.92	0.58 - 1.82
Physical Activity	0.62	0.87	0.00 - 191.56				0.28	0.69	0.00 - 134.52
BMI	0.83	0.77	0.24 - 2.86				0.98	0.98	0.26 - 3.76
Total Income	1.00	0.82	1.00 - 1.00				1.00	0.89	1.00 - 1.00
Mean Daily Kcal	1.00	0.91	1.00 - 1.00				1.00	0.95	1.00 - 1.00
Liquor Store	0.91	0.54	0.67 - 1.23				0.00	0.99	0.00 - .
Age 21-26 X Liquor Store							1.00	.	1.00 - 1.00
Age 27-31 X Liquor Store							1.00	.	1.00 - 1.00
Age 32-36 X Liquor Store							1.00	.	1.00 - 1.00
Never Smoked X Liquor Store							1.00	.	1.00 - 1.00
Smoked X Liquor Store							1.00	.	1.00 - 1.00

Not Employed X Liquor Store							1.00	.	1.00 - 1.00
Employed X Liquor Store							1.00	.	1.00 - 1.00
No Child X Liquor Store							1.00	.	1.00 - 1.00
Child X Liquor Store							1164519	0.99	0.00 - .
Female X Liquor Store							1.00	.	1.00 - 1.00
Male X Liquor Store							0.04	0.99	0.00 - 1.72e+261
Rural X Liquor Store							1.00	.	1.00 - 1.00
Urban X Liquor Store							12165116	0.99	0.00 - .
Normal Weight X Liquor Store							1.00	.	1.00 - 1.00
Overweight/Obese X Liquor Store							1.00	.	1.00 - 1.00
Log Likelihood	- 59.50			- 60.49			-50.97		
LR Chi2	20.77	0.19		18.78	<0.001		26.71	0.11	
AIC	1.52			1.28			1.78		
BIC	53.07			-4.94			59.41		
H-L GOF	3.20	0.92		2.87	0.58		7.19	0.52	

Statistically significant (p<0.05) results were **BOLD**.

Table 12. Mean SSB Consumption in Kcal and Liquor Store (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	0.69	0.22	0.39 - 1.25	0.72	0.21	0.42 - 1.21	0.60	0.11	0.32 - 1.12
Age 27-31	**2.23**	**0.00**	**1.31 - 3.82**	**2.13**	**0.01**	**1.25 - 3.64**	**2.18**	**0.00**	**1.28 - 3.72**
Age 32-36	**2.21**	**0.02**	**1.13 - 4.32**	**2.08**	**0.03**	**1.08 - 4.00**	**2.2**	**0.02**	**1.11 - 4.36**
Sex	1.11	0.67	0.68 - 1.82				0.93	0.77	0.55 - 1.56
Marriage	**0.5**	**0.02**	**0.28 - 0.89**	**0.52**	**0.02**	**0.30 - 0.89**	**0.3**	**0.00**	**0.15 - 0.59**
Child	1.61	0.12	0.88 - 2.92	1.58	0.09	0.93 - 2.67	**2.58**	**0.00**	**1.34 - 4.98**
Middle, High and Technical School	1.37	0.72	0.25 - 7.54				2.51	0.29	0.46 - 13.78
College, University or Above	2.59	0.28	0.47 - 14.39	**1.86**	**0.04**	**1.03 - 3.36**	5.21	0.06	0.92 - 29.43
Employment	0.50	0.34	0.12 - 2.08	0.59	0.21	0.25 - 1.36	0.26	0.07	0.06 - 1.13
Smoking	**1.74**	**0.04**	**1.03 - 2.92**	**1.64**	**0.05**	**1.01 - 2.66**	1.67	0.11	0.90 - 3.09
Sleep hours	1.09	0.41	0.89 - 1.33				1.15	0.18	0.94 - 1.40

Physical Activity	1.69	0.72	0.10 - 29.19				1.21	0.91	0.05 - 28.23
BMI	**0.55**	**0.02**	**0.34 - 0.91**	**0.56**	**0.02**	**0.34 - 0.91**	**0.56**	**0.05**	**0.31 - 1.00**
Total Income	**1.00**	**0.05**	**1.00 - 1.00**	**1.00**	**0.04**	**1.00 - 1.00**	1.00	0.13	1.00 - 1.00
Mean Daily Kcal	1.00	0.07	1.00 - 1.00	1.00	0.07	1.00 - 1.00	1.00	0.25	1.00 - 1.00
Liquor Store	**0.79**	**0.00**	**0.70 - 0.88**	**0.78**	**0.00**	**0.70 - 0.87**	0.54	0.66	0.04 - 8.25
Age 21-26 X Liquor Store							1.00	.	1.00 - 1.00
Age 27-31 X Liquor Store							11.73	0.14	0.45 - 308.88
Age 32-36 X Liquor Store							1.00	.	1.00 - 1.00
Never Smoked X Liquor Store							1.00	.	1.00 - 1.00
Smoked X Liquor Store							**8.41**	**0.02**	**1.46 - 48.53**
Not Employed X Liquor Store							1.00	.	1.00 - 1.00
Employed X Liquor Store							1.00	.	1.00 - 1.00
No Child X Liquor Store							1.00	.	1.00 - 1.00
Child X Liquor Store							**0.12**	**0.02**	**0.02 - 0.68**
Female X Liquor Store							1.00	.	1.00 - 1.00
Male X Liquor Store							2.02	0.09	0.90 - 4.56
Rural X Liquor Store							1.00	.	1.00 - 1.00
Urban X Liquor Store							**0.12**	**0.02**	**0.02 - 0.70**
Normal Weight X Liquor Store							1.00	.	1.00 - 1.00
Overweight/Obese X Liquor Store							0.96	0.97	0.08 - 11.44
lnalpha	0.39	0.00	0.27 - 0.57	0.4	0.00	0.28 - 0.58	0.35	0.00	0.24 - 0.51
Log Likelihood	-288.33			-288.84			-285.16		
LR Chi2	45.88	<0.001		44.86	<0.001		52.22	<0.001	
AIC	11.56			11.43			12.01		
BIC	17.64			2.79			35.13		

Statistically significant (p<0.05) results were **BOLD**.

Table 13. SSB Consumption and Meal Delivery (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.24	0.11	0.04 - 1.35	0.25	0.08	0.05 - 1.19	0.15	0.06	0.02 - 1.05

Age 27-31	1.90	0.40	0.43 - 8.48				1.64	0.55	0.33 - 8.21
Age 32-36	2.12	0.39	0.38 - 11.91				1.63	0.60	0.26 - 10.28
Sex	0.86	0.82	0.24 - 3.11				0.64	0.55	0.15 - 2.71
Marriage	0.30	0.15	0.06 - 1.53	0.35	0.10	0.10 - 1.24	**0.13**	**0.05**	**0.02 - 1.00**
Child	1.12	0.86	0.29 - 4.31				1.31	0.74	0.28 - 6.17
Middle, High and Technical School	1.60	0.67	0.18 - 13.90				2.59	0.41	0.27 - 25.18
College, University or Above	**13.98**	**0.05**	**1.05 - 186.43**	**7.89**	**0.00**	**2.16 - 28.91**	**20.31**	**0.03**	**1.32 - 313.19**
Employment	0.76	0.78	0.11 - 5.20				1.15	0.90	0.13 - 10.35
Smoking	2.86	0.13	0.73 - 11.13	2.71	0.06	0.98 - 7.50	1.56	0.55	0.37 - 6.59
Sleep hours	1.27	0.39	0.74 - 2.17				1.39	0.30	0.75 - 2.57
Physical Activity	2.57	0.75	0.01 - 945.47				2.56	0.77	0.00 - 1,330.13
BMI	0.71	0.60	0.20 - 2.53				1.16	0.84	0.28 - 4.77
Total Income	1.00	0.97	1.00 - 1.00				1.00	0.26	1.00 - 1.00
Mean Daily Kcal	1.00	0.96	1.00 - 1.00				1.00	0.66	1.00 - 1.00
Meal Delivery	**1.28**	**0.01**	**1.05 - 1.55**	**1.27**	**0.02**	**1.04 - 1.55**	1.07	0.64	0.80 - 1.43
Age 21-26 X Meal Delivery							1.00	.	1.00 - 1.00
Age 27-31 X Meal Delivery							2.74	0.46	0.19 - 38.98
Age 32-36 X Meal Delivery							1.00	.	1.00 - 1.00
Never Smoked X Meal Delivery							1.00	.	1.00 - 1.00
Smoked X Meal Delivery							1.00	.	1.00 - 1.00
Not Employed X Meal Delivery							1.00	.	1.00 - 1.00
Employed X Meal Delivery							1.00	.	1.00 - 1.00
No Child X Meal Delivery							1.00	.	1.00 - 1.00
Child X Meal Delivery							1.00	.	1.00 - 1.00
Female X Meal Delivery							1.00	.	1.00 - 1.00
Male X Meal Delivery							1.00	.	1.00 - 1.00
Rural X Meal Delivery							1.00	.	1.00 - 1.00
Urban X Meal Delivery							1.00	.	1.00 - 1.00
Normal Weight X Meal Delivery							1.00	.	1.00 - 1.00
Overweight/Obese X Meal Delivery							1.00	.	1.00 - 1.00
	-			-			-		
Log Likelihood	54.40			55.24			45.87		
LR Chi2	30.97	0.01		29.29	<0.001		24.27	0.11	

AIC	1.41		1.21		1.85	
BIC	42.88		-6.22		51.05	
H-L GOF	4.88	0.77	3.19	0.78	4.91	0.77

Statistically significant ($p<0.05$) results were **BOLD**.

Table 14. Mean SSB Consumption in Kcal and Meal Delivery (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	0.57	0.10	0.30 - 1.10	0.65	0.14	0.36 - 1.16	0.74	0.37	0.38 - 1.43
Age 27-31	**2.06**	**0.01**	**1.16 - 3.68**	**1.95**	**0.02**	**1.09 - 3.48**	1.76	0.12	0.87 - 3.58
Age 32-36	**2.24**	**0.03**	**1.09 - 4.59**	**2.11**	**0.04**	**1.03 - 4.31**	1.75	0.22	0.72 - 4.29
Sex	1.17	0.58	0.68 - 2.01				0.84	0.60	0.44 - 1.61
Marriage	**0.45**	**0.01**	**0.24 - 0.85**	**0.47**	**0.02**	**0.25 - 0.87**	0.55	0.06	0.29 - 1.03
Child	1.61	0.17	0.82 - 3.14	1.55	0.14	0.87 - 2.77	**2.18**	**0.04**	**1.04 - 4.54**
Middle, High and Technical School	1.82	0.54	0.27 - 12.12				1.94	0.48	0.31 - 12.10
College, University or Above	3.35	0.22	0.49 - 22.61	1.81	0.07	0.96 - 3.44	3.22	0.21	0.51 - 20.29
Employment	0.38	0.24	0.08 - 1.88	0.53	0.18	0.21 - 1.34	0.30	0.14	0.06 - 1.48
Smoking	1.76	0.07	0.95 - 3.24	1.64	0.09	0.93 - 2.89	1.52	0.19	0.81 - 2.87
Sleep hours	1.11	0.39	0.88 - 1.39				1.06	0.65	0.83 - 1.34
Physical Activity	3.04	0.49	0.13 - 72.10				1.96	0.69	0.07 - 56.34
BMI	0.6	0.06	0.35 - 1.03	**0.57**	**0.04**	**0.34 - 0.99**	0.69	0.21	0.38 - 1.23
Total Income	1.00	0.08	1.00 - 1.00	1.00	0.07	1.00 - 1.00	1	0.08	1.00 - 1.00
Mean Daily Kcal	1.00	0.19	1.00 - 1.00	1.00	0.15	1.00 - 1.00	1.00	0.10	1.00 - 1.00
Meal Delivery	1.02	0.39	0.98 - 1.05				0.98	0.73	0.87 - 1.10
Age 21-26 X Meal Delivery							1.00	.	1.00 - 1.00
Age 27-31 X Meal Delivery							1.02	0.72	0.91 - 1.14
Age 32-36 X Meal Delivery							1.03	0.76	0.85 - 1.24
Never Smoked X Meal Delivery							1.00	.	1.00 - 1.00
Smoked X Meal Delivery							1.02	0.79	0.87 - 1.19
Not Employed X Meal Delivery							1.00	.	1.00 - 1.00

Employed X Meal Delivery							1.00	.	1.00 - 1.00
No Child X Meal Delivery							1.00	.	1.00 - 1.00
Child X Meal Delivery							0.91	0.08	0.82 - 1.01
Female X Meal Delivery							1.00	.	1.00 - 1.00
Male X Meal Delivery							1.08	0.24	0.95 - 1.24
Rural X Meal Delivery							1.00	.	1.00 - 1.00
Urban X Meal Delivery							1.00	.	1.00 - 1.00
Normal Weight X Meal Delivery							1.00	.	1.00 - 1.00
Overweight/Obese X Meal Delivery							0.95	0.64	0.79 - 1.16
lnalpha	0.47	0.00	0.33 - 0.68	0.49	0.00	0.34 - 0.71	0.42	0.00	0.29 - 0.61
Log Likelihood	-293.75			-294.91			-290.61		
LR Chi2	35.05	0.004		32.72	<0.001		41.32	0.01	
AIC	11.76			11.62			12.21		
BIC	28.48			10.96			46.03		

Statistically significant (p<0.05) results were **BOLD**.

Table 15. SSB Consumption and Meal Takeaway (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.38	0.27	0.07 - 2.10				**0.1**	**0.04**	**0.01 - 0.89**
Age 27-31	1.81	0.40	0.46 - 7.16				5.99	0.09	0.76 - 47.43
Age 32-36	2.01	0.39	0.41 - 10.00				2.88	0.37	0.29 - 28.54
Sex	1.04	0.95	0.31 - 3.54				0.72	0.71	0.13 - 3.98
Marriage	0.29	0.12	0.06 - 1.38	0.51	0.19	0.19 - 1.39	**0.09**	**0.02**	**0.01 - 0.70**
Child	1.10	0.88	0.30 - 4.00				0.53	0.49	0.09 - 3.27
Middle, High and Technical School	1.46	0.72	0.18 - 12.01				1.32	0.83	0.11 - 16.02
College, University or Above	9.53	0.08	0.79 - 114.57	**4.6**	**0.00**	**1.83 - 11.59**	12.44	0.10	0.64 - 240.39
Employment	0.87	0.89	0.13 - 5.79				1.06	0.96	0.08 - 14.03
Smoking	2.61	0.15	0.71 - 9.55	2.57	0.06	0.98 - 6.77	2.92	0.22	0.53 - 16.07
Sleep hours	1.15	0.59	0.70 - 1.90				1.19	0.56	0.67 - 2.13

Physical Activity	1.10	0.97	0.00 - 329.34				0.32	0.74	0.00 - 285.90
BMI	0.79	0.72	0.23 - 2.75				1.69	0.53	0.33 - 8.71
Total Income	1.00	0.87	1.00 - 1.00				1.00	0.51	1.00 - 1.00
Mean Daily Kcal	1.00	0.96	1.00 - 1.00				1.00	0.99	1.00 - 1.00
Meal Takeaway	1.03	0.42	0.96 - 1.10				0.51	0.13	0.22 - 1.21
Age 21-26 X Meal Takeaway							1.00	.	1.00 - 1.00
Age 27-31 X Meal Takeaway							0.88	0.16	0.74 - 1.05
Age 32-36 X Meal Takeaway							1.30	0.23	0.84 - 2.01
Never Smoked X Meal Takeaway							1.00	.	1.00 - 1.00
Smoked X Meal Takeaway							1.09	0.69	0.72 - 1.63
Not Employed X Meal Takeaway							1.00	.	1.00 - 1.00
Employed X Meal Takeaway							1.00	.	1.00 - 1.00
No Child X Meal Takeaway							1.00	.	1.00 - 1.00
Child X Meal Takeaway							**1.29**	**0.03**	**1.03 - 1.61**
Female X Meal Takeaway							1.00	.	1.00 - 1.00
Male X Meal Takeaway							0.94	0.58	0.76 - 1.16
Rural X Meal Takeaway							1.00	.	1.00 - 1.00
Urban X Meal Takeaway							2.14	0.08	0.90 - 5.09
Normal Weight X Meal Takeaway							1.00	.	1.00 - 1.00
Overweight/Obese X Meal Takeaway							**0.67**	**0.04**	**0.45 - 0.99**
	-			-			-		
Log Likelihood	59.37			60.49			48.49		
LR Chi2	21.04	0.18		18.78	<0.001		41.48	0.01	
AIC	1.51			1.28			1.61		
BIC	52.80			-4.94			64.44		
H-L GOF	6.46	0.60		2.87	0.58		4.17	0.84	

Statistically significant (p<0.05) results were **BOLD**.

Table 16. Mean SSB Consumption in Kcal and Meal Takeaway (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	0.61	0.15	0.32 - 1.19	0.65	0.14	0.36 - 1.16	1.43	0.34	0.68 - 3.00

Age 27-31	**2.1**	**0.02**	**1.10 - 4.01**	**1.95**	**0.02**	**1.09 - 3.48**	**2.69**	**0.00**	**1.36 - 5.30**
Age 32-36	**2.27**	**0.03**	**1.06 - 4.83**	**2.11**	**0.04**	**1.03 - 4.31**	**5.07**	**0.00**	**1.97 - 13.08**
Sex	1.23	0.47	0.70 - 2.16				1.61	0.16	0.83 - 3.13
Marriage	**0.45**	**0.02**	**0.23 - 0.88**	**0.47**	**0.02**	**0.25 - 0.87**	0.76	0.43	0.38 - 1.51
Child	1.52	0.22	0.78 - 2.96	1.55	0.14	0.87 - 2.77	1.30	0.48	0.63 - 2.71
Middle, High and Technical School	1.58	0.64	0.24 - 10.53				0.59	0.54	0.11 - 3.18
College, University or Above	2.91	0.27	0.43 - 19.57	1.81	0.07	0.96 - 3.44	0.88	0.89	0.15 - 5.15
Employment	0.44	0.32	0.09 - 2.18	0.53	0.18	0.21 - 1.34	1.05	0.94	0.24 - 4.55
Smoking	**1.85**	**0.05**	**0.99 - 3.45**	1.64	0.09	0.93 - 2.89	1.64	0.16	0.83 - 3.25
Sleep hours	1.07	0.55	0.86 - 1.34				1.04	0.71	0.84 - 1.28
Physical Activity	2.78	0.54	0.11 - 71.35				2.06	0.63	0.11 - 39.80
BMI	**0.57**	**0.05**	**0.33 - 0.99**	**0.57**	**0.04**	**0.34 - 0.99**	**0.47**	**0.02**	**0.25 - 0.87**
Total Income	1.00	0.10	1.00 - 1.00	1.00	0.07	1.00 - 1.00	**1.00**	**0.02**	**1.00 - 1.00**
Mean Daily Kcal	1.00	0.20	1.00 - 1.00	1.00	0.15	1.00 - 1.00	**1.00**	**0.00**	**1.00 - 1.00**
Meal Takeaway	1.00	0.95	0.98 - 1.03				**1.63**	**0.02**	**1.07 - 2.48**
Age 21-26 X Meal Takeaway							1.00	.	1.00 - 1.00
Age 27-31 X Meal Takeaway							0.96	0.21	0.90 - 1.02
Age 32-36 X Meal Takeaway							**0.86**	**0.00**	**0.78 - 0.95**
Never Smoked X Meal Takeaway							1.00	.	1.00 - 1.00
Smoked X Meal Takeaway							0.89	0.07	0.78 - 1.01
Not Employed X Meal Takeaway							1.00	.	1.00 - 1.00
Employed X Meal Takeaway							1.00	.	1.00 - 1.00
No Child X Meal Takeaway							1.00	.	1.00 - 1.00
Child X Meal Takeaway							0.95	0.16	0.88 - 1.02
Female X Meal Takeaway							1.00	.	1.00 - 1.00
Male X Meal Takeaway							1.03	0.35	0.97 - 1.10
Rural X Meal Takeaway							1.00	.	1.00 - 1.00
Urban X Meal Takeaway							**0.61**	**0.02**	**0.40 - 0.91**
Normal Weight X Meal Takeaway							1.00	.	1.00 - 1.00
Overweight/Obese X Meal Takeaway							**1.16**	**0.00**	**1.06 - 1.27**
lnalpha	0.48	0.00	0.33 - 0.69	0.49	0.00	0.34 - 0.71	0.34	0.00	0.23 - 0.49
Log Likelihood	-294.13			-294.91			-284.17		

LR Chi2	34.27	0.005		32.72	<0.001		54.2	<0.001	
AIC	11.78			11.62			11.97		
BIC	29.25			10.96			37.12		

Statistically significant (p<0.05) results were **BOLD**.

Table 17. SSB Consumption and Restaurant (Observation = 101)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	OR	P-val	95% CI	OR	P-val	95% CI	OR	P-val	95% CI
Site	0.57	0.53	0.10 - 3.29				**0.02**	**0.01**	**0.00 - 0.38**
Age 27-31	1.80	0.40	0.45 - 7.16				3.05	0.29	0.39 - 23.99
Age 32-36	1.98	0.40	0.40 - 9.72				2.31	0.49	0.22 - 24.50
Sex	1.13	0.85	0.33 - 3.81				0.88	0.88	0.16 - 4.73
Marriage	0.30	0.13	0.06 - 1.42	0.51	0.19	0.19 - 1.39	**0.02**	**0.00**	**0.00 - 0.27**
Child	1.01	0.98	0.27 - 3.79				0.42	0.36	0.07 - 2.63
Middle, High and Technical School	1.34	0.79	0.16 - 10.98				5.75	0.24	0.31 - 107.20
College, University or Above	8.93	0.08	0.75 - 107.00	**4.6**	**0.00**	**1.83 - 11.59**	**63.28**	**0.02**	**1.83 - 2189**
Employment	0.96	0.97	0.15 - 6.20				5.82	0.35	0.15 - 229.77
Smoking	2.54	0.16	0.70 - 9.27	2.57	0.06	0.98 - 6.77	2.46	0.30	0.45 - 13.44
Sleep hours	1.11	0.70	0.66 - 1.84				1.21	0.54	0.66 - 2.19
Physical Activity	0.73	0.91	0.00 - 216.46				0.21	0.65	0.00 - 196.61
BMI	0.86	0.81	0.25 - 2.94				2.02	0.41	0.38 - 10.63
Total Income	1.00	0.86	1.00 - 1.00				1.00	0.90	1.00 - 1.00
Mean Daily Kcal	1.00	0.87	1.00 - 1.00				1.00	0.60	1.00 - 1.00
Restaurant	1.00	0.66	1.00 - 1.00				1.45	0.06	0.99 - 2.14
Age 21-26 X Restaurant							1.00	.	1.00 - 1.00
Age 27-31 X Restaurant							1.00	0.57	1.00 - 1.00
Age 32-36 X Restaurant							1.00	0.26	1.00 - 1.00
Never Smoked X Restaurant							1.00	.	1.00 - 1.00
Smoked X Restaurant							1.00	0.61	1.00 - 1.00
Not Employed X Restaurant							1.00	.	1.00 - 1.00
Employed X Restaurant							0.69	0.06	0.47 - 1.02
No Child X Restaurant							1.00	.	1.00 - 1.00

Child X Restaurant							**1.00**	**0.01**	**1.00 - 1.00**
Female X Restaurant							1.00	.	1.00 - 1.00
Male X Restaurant							1.00	1.00	1.00 - 1.00
Rural X Restaurant							1.00	.	1.00 - 1.00
Urban X Restaurant							1.00	0.88	0.99 - 1.01
Normal Weight X Restaurant							1.00	.	1.00 - 1.00
Overweight/Obese X Restaurant							**1.00**	**0.03**	**1.00 - 1.00**
	-			-			-		
Log Likelihood	59.59			60.49			47.59		
LR Chi2	20.60	0.19		18.78	<0.001		44.59	0.01	
AIC	1.52			1.28			1.58		
BIC	53.25			-4.94			66.17		
H-L GOF	5.28	0.73		2.87	0.58		3.93	0.86	

Statistically significant (p<0.05) results were **BOLD**.

Table 18. Mean SSB Consumption in Kcal and Restaurant (Observation = 53)

	Full Model			Reduced Model			Full Model with Interaction		
VARIABLES	IRR	P-val	95% CI	IRR	P-val	95% CI	IRR	P-val	95% CI
Site	**0.42**	**0.02**	**0.20 - 0.89**	**0.46**	**0.03**	**0.23 - 0.92**	0.54	0.21	0.21 - 1.41
Age 27-31	**2.00**	**0.02**	**1.14 - 3.52**	**1.88**	**0.03**	**1.07 - 3.32**	2.23	0.07	0.94 - 5.30
Age 32-36	**2.23**	**0.02**	**1.12 - 4.44**	**2.09**	**0.04**	**1.05 - 4.16**	**6.19**	**0.02**	**1.32 - 28.95**
Sex	1.17	0.54	0.70 - 1.95				1.74	0.24	0.70 - 4.36
Marriage	**0.4**	**0.00**	**0.21 - 0.76**	**0.43**	**0.01**	**0.24 - 0.79**	0.59	0.17	0.28 - 1.25
Child	1.78	0.08	0.93 - 3.40	1.68	0.07	0.96 - 2.94	1.07	0.89	0.38 - 3.06
Middle, High and Technical School	1.98	0.47	0.31 - 12.48				**0.00**	**0.05**	**0.00 - 0.21**
College, University or Above	3.44	0.19	0.54 - 21.87	1.73	0.08	0.94 - 3.19	**0.00**	**0.05**	**0.00 - 0.32**
Employment	0.36	0.20	0.08 - 1.69	0.50	0.14	0.20 - 1.25	1.45E+98	0.05	3.58 - 5.85e+195
Smoking	1.79	0.05	0.99 - 3.22	1.64	0.08	0.94 - 2.86	**2.45**	**0.02**	**1.18 - 5.10**
Sleep hours	1.13	0.29	0.90 - 1.40				1.15	0.31	0.88 - 1.49
Physical Activity	3.02	0.47	0.15 - 60.09				2.12	0.61	0.11 - 39.14
BMI	0.6	0.06	0.36 - 1.02	0.61	0.07	0.36 - 1.04	**0.31**	**0.02**	**0.11 - 0.85**
Total Income	1.00	0.11	1.00 - 1.00	1.00	0.09	1.00 - 1.00	1.00	0.20	1.00 - 1.00

Mean Daily Kcal	1.00	0.22	1.00 - 1.00	1.00	0.17	1.00 - 1.00	1.00	0.25	1.00 - 1.00
Restaurant	1.00	0.07	1.00 - 1.00	1.00	0.11	1.00 - 1.00	**1.15**	**0.04**	**1.01 - 1.31**
Age 21-26 X Restaurant							1.00	.	1.00 - 1.00
Age 27-31 X Restaurant							1.00	0.68	1.00 - 1.00
Age 32-36 X Restaurant							1.00	0.09	1.00 - 1.00
Never Smoked X Restaurant							1.00	.	1.00 - 1.00
Smoked X Restaurant							1.00	0.35	1.00 - 1.00
Not Employed X Restaurant							1.00	.	1.00 - 1.00
Employed X Restaurant							**0.87**	**0.05**	**0.76 - 1.00**
No Child X Restaurant							1.00	.	1.00 - 1.00
Child X Restaurant							1.00	0.86	1.00 - 1.00
Female X Restaurant							1.00	.	1.00 - 1.00
Male X Restaurant							1.00	0.37	1.00 - 1.00
Rural X Restaurant							1.00	.	1.00 - 1.00
Urban X Restaurant							1.00	0.44	0.99 - 1.00
Normal Weight X Restaurant							1.00	.	1.00 - 1.00
Overweight/Obese X Restaurant							1.00	0.13	1.00 - 1.00
lnalpha	0.45	0.00	0.31 - 0.65	0.47	0.00	0.33 - 0.67	0.36	0.00	0.25 - 0.53
Log Likelihood	-292.35			-293.53			-286.22		
LR Chi2	37.83	0.002		35.47	<0.001		50.1	0.001	
AIC	11.71			11.61			12.05		
BIC	25.69			12.17			45.19		

Statistically significant (p<0.05) results were **BOLD**.