# Diet, Obesity, and Diabetes in Suburban Nepal
# A Community-Based Study

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**Abstract**

Diet, Obesity, and Diabetes in Suburban Nepal – A community-based Study

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**Background:** Obesity and type-2 diabetes are among the top five risk factors for cardiovascular (CVD) deaths in the world, and their prevalence is rising in Nepal. These diseases result from the interaction of genetic, environmental and nutritional factors. Reducing obesity and diabetes through nutritional modification holds great promise as a strategy to prevent CVD deaths.

**Objectives:** This dissertation aimed to assess relative validity and reproducibility of a food frequency questionnaire (FFQ); use the FFQ data to derive major dietary patterns; and to investigate the relationship of the derived dietary patterns with overweight, obesity, and type-2 diabetes in a suburban community of Nepal.

**Methods**: This cross-sectional study was conducted among 1,073 community-based adult participants (18 years of age or older) of the Dhulikhel Heart Study (DHS) in Dhulikhel, central Nepal. We recruited a subset of the DHS (n = 121); administered a 115-item FFQ twice over a three months interval; and collected six 24-hour dietary recalls (HDR). We used Spearman correlation coefficients between weekly servings of 22 food groups estimated by the two FFQs to test reproducibility, and weekly servings of the food groups estimated by the FFQs was compared to an average of six 24 HDR to test the relative validity. Dietary patterns were derived using principal component analysis on the FFQ data from 1,073 DHS participants. International body mass index (BMI) cut-offs were used to define overweight as BMI of 25 kg/m$^2$ or higher, and obesity as BMI of 30kg/$m^2$ or higher. Type 2 diabetes was defined as glycated hemoglobin (HbA1c) of 6.5% or higher. The blood sample was available for 479 participants. We utilized generalized estimating equation (GEE) with multivariate logistic regression (household as cluster) to examine the association of the derived dietary patterns with overweight, obesity, and diabetes adjusting for demographic (age, sex, ethnicity, religion, marital status, income and education), and CVD risk factors (alcohol consumption, smoking, physical activity, and systolic blood pressure).

**Results:** All crude Spearman coefficients for validity were greater than 0.3 except for dairy products, chips and fries, sausages/burgers, and pizzas/pastas. The de-attenuated Spearman correlation ranged from 0.19 (sausage/burgers) to 0.72 (sweet foods). The reproducibility Spearman correlations for all food groups were greater than 0.5, with the exception of oil (0.41). Four dietary patterns were derived: mixed, fast food, refined grain-meat-alcohol, and solid fats-diary. The refined grain-meat-alcohol pattern was positively associated with overweight (OR 1.19, 95% CI: 1.03 – 1.39; p-value=0.02) after adjusting for demographic and CVD risk factors. The association between fast food and overweight/obesity was significantly modified by age (p=0.01). In adults 40 years of age or older, the fast food pattern was positively associated with obesity after controlling for demographic and traditional risk factors (OR 1.69, 95% CI: 1.19 - 2.39; p-value=0.003). None of the food patterns were significantly associated with type-2 diabetes.

**Conclusions:** The FFQ that was designed for the DHS was found to be reliable and valid for assessing the intake of food groups in Nepal. Our results suggest that refined grains-meat-alcohol intake is associated with higher prevalence of overweight. Fast food intake is associated with higher prevalence of obesity in older adults (40 years or above). The findings were inconclusive for diabetes. This study adds to the existing literature by identifying dietary pattern and their relationships with overweight and obesity in suburban Nepal, an understudied population in a low-resource setting.

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**Dedication**

To my father, Narayan Mani Shrestha, who nurtured me and believed in my convictions that made me the person I am today.

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# Chapter 1
# Introduction

## BURDEN OF OBESITY AND DIABETES

The burden of non-communicable diseases (NCDs) such as cardiovascular disease (CVD), diabetes, cancer, and chronic obstructive pulmonary disease, is on the rise in low- and middle- income countries.[2] CVD is the leading cause of morbidity, mortality, and disability in South Asian regions where 20% of the world's population reside.[3] Obesity and diabetes mellitus are among the top five risk factors for cardiovascular deaths in the world.[4] Obesity increases the risk of myocardial infarction, heart failure, stroke and kidney failure[5] and dramatically increases the risk of type 2 diabetes mellitus,[6,7] whereas type 2 diabetes is a major risk factor for blindness, renal failure and lower limb amputation in addition to coronary heart disease and stroke.[8]

More than 1.1 billion of the world's adults are overweight, and 312 million of them are obese.[9] The increasing rate of obese population along with population growth, aging, urbanization, and physical inactivity has contributed to an increase in the prevalence of type 2 diabetes. An estimated 171 million adults greater than 20 years of age were diabetic in the world in 2000, and this is expected to more than double by 2030.[10] The burden of stroke, ischemic heart disease, and diabetes in terms of disability adjusted life years has increased almost 100% from 1990 to 2010 in Nepal (Figure 1).[1] A few population-based studies have estimated obesity and diabetes prevalence in Nepal. Shrestha et al. (2006) reported 19% prevalence of diabetes among adults (≥ 40 years) residing in urban Kathmandu.[11] A survey in the eastern region of Nepal reported 6.7% prevalence of diabetes and 32% prevalence of obesity among adults of 20 years or older.[12] Obesity increased in Nepalese women (15 to 45 years old) from 1.6% in 1996 to

10% in 2006.[13] The first nationally representative study, the Nepal Non-Communicable Disease Risk Factor Survey (NCDRFS), was conducted in 2007 among 15 to 64 years old adults and reported 7% overweight, 1.7% obesity, and 10.8% self-reported diabetes.[14] The second NCDRFS survey was conducted in 2011 and reported the prevalence of overweight at 17.7 %, obesity at 4 % and diabetes (glucose level of 126 mg/dL or higher) at 3.6%.[15]

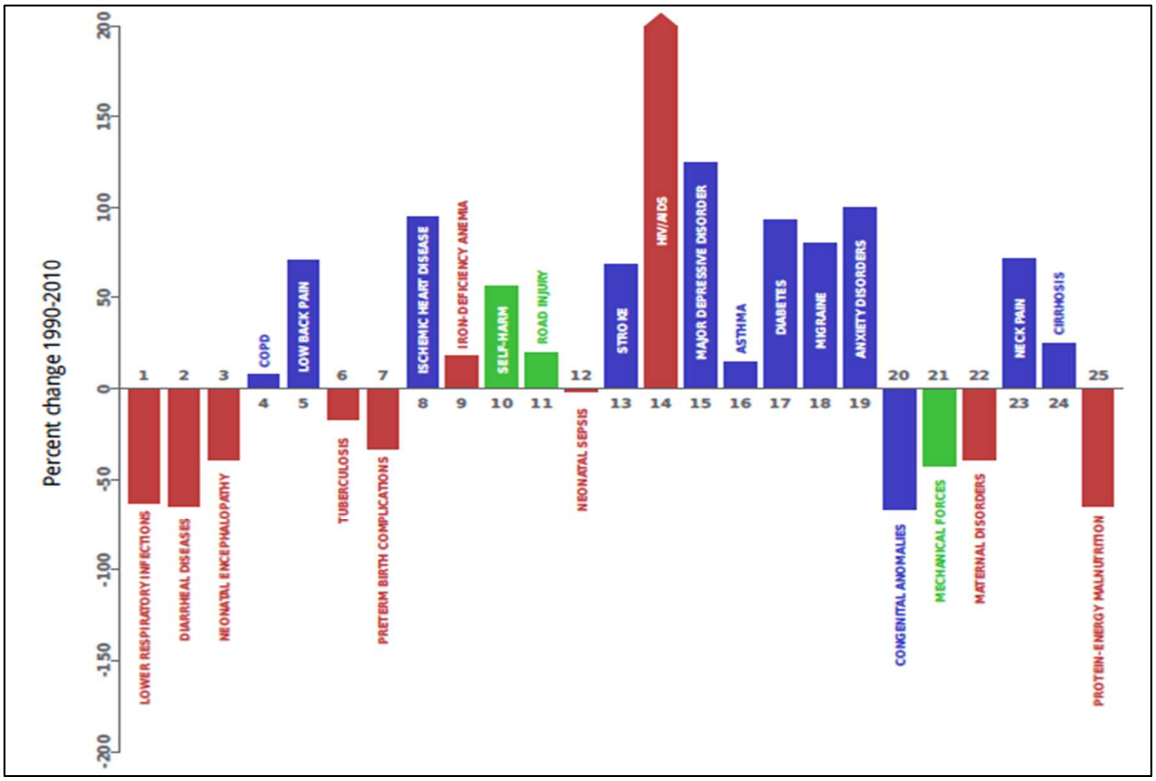


Figure 1. Leading causes of Disability Adjusted Life years (DALTYs and percent change 1990 to 2010 for Nepal
No 8: Ischemic Heart Disease; No 13: Stroke; No 17: Diabetes
Source: IHME, Global burden of disease profile – Nepal (2010)[1]

## DIETARY PATTERNS IN RELATION TO OBESITY AND DIABETES

Obesity and diabetes result from the interaction of genetic susceptibility factors, modifiable environmental, and nutritional factors.[16] Reducing obesity and diabetes through nutritional modification holds great promise as a strategy to prevent CVDs. The relationship of diet with the incidence of obesity and type 2 diabetes have been focused on intake of individual nutrients such as fiber, carbohydrates, and protein.[17, 18] However, these dietary factors alone probably explain only part of the effect of diet. Additives, contaminants, and unknown compounds including the physical properties as well as interactions between nutrients affect metabolism of glucose.[18] Thus, the examination of effects of food consumption has emerged as a useful tool for evaluating associations between diet and health. It has been suggested that the overall dietary pattern may affect health more than individual food and nutrients.[18] In addition, identification of dietary patterns may provide insight into the consumption of foods allowing for the translation of findings into pragmatic public health recommendations.

Many studies in the literature have previously documented associations between specific patterns of food intake and health. Dietary patterns have been found to be associated with the risk of chronic diseases such as cancer,[19-22] metabolic syndrome,[23-25] and cardiovascular diseases.[26-28] Dietary patterns consistent with recommended national dietary guidelines (fruits, vegetables, whole grains, low fat dairy, lean meats and poultry) have also been associated with lower risk of mortality.[29,30] Although studies involving dietary intake in developing countries are scarce, many studies from developed countries have investigated dietary patterns.

The Health Professionals' Follow-up Study,[27] a prospective cohort study of more than 50,000 male health professionals (40-75 years) of the United States, identified two major dietary patterns named ''prudent'' (including vegetables, fruits, legumes, whole grains, and fish) and ''western'' (including processed meat, red meat, butter, high-fat dairy products, eggs, and refined grain) in 2001. The western pattern was associated with increased risk of diabetes[31,32] and obesity.[27] Similar dietary patterns were found in the Nurses Health Study (NHS) in 2004.[33] The NHS reported inverse association of the prudent pattern with BMI[33] and a positive association of diabetes with western-like pattern (sugar-sweetened soft drinks, refined grains, diet soft drinks, and processed meat but low in wine, coffee, cruciferous vegetables, and yellow vegetables).[34] Newby et al. (2003) reported that the diet characterized by low-fat dairy, grains, and fruit was inversely associated with changes in BMI and waist circumference in the participants of Baltimore Longitudinal Study of Aging.[35] Similarly, dietary pattern highly loaded with meat was inversely associated with BMI[36] and type 2 diabetes[37] among Hawaiian women.

In the participants of the Swedish Mammography Cohort (2004), three major dietary patterns labeled healthy (high in vegetables, fruits, fish, poultry, tomato, cereal, and low-fat dairy products), western (processed meat, meat, refined grains, sweets, and fried potatoes), and drinker (beer, wine, liquor, and snacks) were reported.[38] An analysis after 9 years of follow-up showed that increasing intake of the healthy pattern foods was associated with decreased BMI[39]. The Finnish Mobile Clinic Health Examination Survey reported that a prudent dietary pattern characterized by high consumption of fruits and vegetables is associated with a reduced risk for type 2 diabetes.[40] The fruit, vegetables, and dairy pattern was inversely associated with BMI and waist circumference; whereas the meat, potatoes and sweet foods pattern was positively associated with glycated hemoglobin among British women.[41] The traditional pattern characterized by meat, potatoes, white bread, and sausage was inversely associated with BMI among 30 to 60 years old Danish men; and the sweet-traditional pattern (candy, baked items, meat, butter, soft drinks, jam, potatoes) was inversely associated with BMI among Danish women.[42] Likewise, high intake of fresh fruits and low intake of soft drinks, beer, poultry, legumes and bread was associated with decreased odds of diabetes among participants of European Prospective Investigation into Cancer and Nutrition study.[43] The Melbourne Collaborative Cohort Study reported that the dietary pattern characterized by salad and cooked vegetables was inversely associated with diabetes whereas meat and fatty food pattern increased diabetes risk.[44]

In Asia, the Singapore Chinese Health Study revealed that higher intake of vegetables, fruits, and soy foods was inversely associated with risk of incident type 2 diabetes in Chinese men and women.[45] And also, Sun J et al. (2014) reported inverse association of western pattern (red meat, flour, light veg, grains, beans, soybeans, potato, peanuts, sunflowers, fresh milk) with central obesity in Chinese men of 50 years or older.[46] Similarly, consuming vegetables, potatoes, seaweeds, fruits, and soybean products was associated with lower risk of diabetes,[47] whereas Japanese traditional pattern characterized by high intakes of rice, miso soup, and soy products, as well as the western pattern characterized by high intakes of meat, fat and oil, seasoning, processed meat and egg were both associated with increased risk of obesity among Japanese men and women.[48] Korea health and genome survey among 40-69 years women identified a positive association between central obesity and western diet pattern (bread, breakfast, cereal, pizza, hamburger, snack, egg, dairy products, coffee, carbonated drinks, and tea).[49] The meat-fat dietary pattern was also associated with increased obesity risk among 30-70 years old Korean population.[50] The greater odds of obesity was reported for higher consumption of western dietary pattern (refined grains, red meat, butter, processed meat, high-fat dairy, sweets, fast foods, soft drinks) among 40 - 60 years old Iranian women.[51] In Lebanon, the refined grains, desserts, and fast food patterns were associated with higher odds of type 2 diabetes, whereas the traditional Lebanese pattern (fruits, vegetables, low fat milk, olive oil, whole bread, and Arabic sweets) was inversely associated with the odds of type 2 diabetes.[52]

In Nepal, seven major dietary patterns were identified among 200 males and females of 30 years and older residing in Kathmandu and Dhulikhel: pattern 1 (fruit, dairy products, nuts, caffeine, processed food, fats, and sweets); pattern 2 (meat and fish); pattern 3 (roots, tubers, pulses, and bread/noodles); pattern 4 (cereal and vegetables); pattern 5 (deep fried foods), pattern 6 (green leafy vegetables); and pattern 7 (milk and dairy). Deep fried food pattern was positively associated with diabetes whereas cereal and vegetable pattern was associated with decreased odds of diabetes.[53]

Dietary intake plays a significant role in the prevention and management of hyperglycemia as well as obesity. Evidence from epidemiological studies suggests that dietary patterns are important predictors of the risk of type 2 diabetes and obesity; and emphasizes the importance of good preventive dietary practices. Specifically, studies have reported that dietary patterns high in fiber-rich food items such as vegetables, fruits, whole grains, plus white meat like poultry and fish have protective effects against the incidence of diabetes and obesity. However, dietary patterns rich in processed meat, red meat, refined grains, and fats are associated with higher risk of obesity and diabetes. The heterogeneity of the studies and the data driven approach to dietary pattern derivation, however, make comparisons and the interpretation difficult. Thus, more research is needed to explore the association of food intake patterns with the development of obesity and diabetes in order to draw conclusions for a specific population. Furthermore, it is necessary to take into account a priori knowledge of other elements of study such as relevant confounders and interactions to explore the causal associations of diet factor scores with obesity and type 2 diabetes.

## MEASUREMENT OF DIET

Measurement of diet has always been challenging because of its complexity and variability. Food frequency questionnaires (FFQ) are often the method of choice to assess dietary exposure for large-scale epidemiological studies. There are two main reasons: compared to other methods, FFQs measure habitual long-term dietary intake, and they are relatively inexpensive to administer.[54] The underlying principle of food frequency approach is that average long-term diet is conceptually important exposure rather than intake on a few specific days. Therefore, it may be advantageous to sacrifice precise intake measurements obtainable on one or few days in exchange for more crude information relating to an extended period of time.[54]

FFQs have been shown to be an appropriate method for assessing diet in a wide variety of epidemiologic settings.[18] Although FFQs are not considered appropriate for estimating actual nutrient intake in quantitative terms, they can be used for relative ranking of intake and for categorizing persons according to intake. Moreover, it is typically easier to describe one's usual frequency of consuming a food than what foods were eaten at any specific meal in the past. In addition, the data collected from the FFQs can be used for identifying major dietary patterns.[45,55]

Random and systematic errors can arise in FFQ estimates not representing the actual usual diet,[56] which can bias the associations of epidemiological studies.[57] Random and systematic within person errors that are unrelated to disease status tend to bias relative risk towards the null.[58] Furthermore, FFQs tend to be culture-specific; they can perform differently among various demographic groups and sub-cultures. Thus, it is important that to assess the reproducibility and validity of a FFQ to increase its utility for quantifying dietary intake. The validity and reproducibility of food-frequency questionnaires has been examined in many studies. The FFQ validation studies have been conducted in about thirty different countries, with most originating in the United States. The FFQs have been designed to assess food groups as well as nutrients. They have been used to measure group or population levels of intakes, absolute intakes, rank individuals, and generate patterns of food[59].

It is acknowledged that there is no perfect measure of dietary intake.[54] Given that neither method is perfect, it is crucial that the errors of both methods be as independent as possible to avoid spuriously high estimates of validity.[60] A systematic review of food frequency questionnaires showed that 75% of studies validated a FFQ against another dietary method and 19% against a biomarker. Twelve per cent of studies were reports of a FFQ validation against another method, e.g. doubly labeled water, energy expenditure studies, or interviews.[61]

Reproducibility refers to consistency of questionnaire measurements on more than one administration to the same persons at different times, realizing that conditions are never identical on repeated administration. Cade et al. (2002) conducted a systematic review of the studies testing reproducibility of food frequency questionnaires.[61] The most common method, used in 90% of studies, for assessing reproducibility was the correlation coefficient. The time interval between repeat administrations of the food-frequency questionnaires in the review ranged from 2 hours to 15 years and the correlations were somewhat higher for repeat administrations one month or less apart compared with those administered six months to one year apart.[61]

**THE CONTEXT OF NEPAL**

The Federal Democratic Republic of Nepal is a landlocked country located in South Asia with a population of 27 million.[62] It is home to 100 registered population groups, who speak about 92 different languages and dialects.[63] It is one of the poorest nations in the world with about 25.2% of the population living below the national poverty line.[64] Nepal ranks 157th out of 187 countries using the Human Development Index (HDI), which takes into account education, health, and income, as a measure of well-being.[65] Dhulikhel is the administrative center of Kavrepalanchowk district, situated 30 km southeast of Kathmandu (figure 2). It is the smallest town of Nepal with population of 16,263.[62]


**Figure 2. Map of Nepal showing Dhulikhel**
Source: maps.google.com

Most Nepalese eat two meals a day at around 9am and 6pm with a number of small snacks and tea in between. Eating always takes place in the home and visiting restaurants happens seldom except in cities. The cultural and geographic diversity of

Nepal provides ample space for a variety of cuisines based on ethnicity, soil and climate.[66] Nevertheless *dal-bhat-tarkari* is eaten throughout the country. *Dal* is a soup made of lentils and spices. It is served over boiled grain, *bhat*-- usually rice but sometimes, another grain with vegetable curry, *tarkari*. Typical condiments are a small amount of extremely spicy *chutney* or *achaar*).[53]

Nepal is also undergoing dietary changes similarly to the typical high-fat high-sugar and high-meat consumption of the West. We expect the dietary change to increase unless policies are adopted to discourage this pattern. This rapid change in diet is creating a situation where under-nutrition and over-nutrition exist side by side.[14.67] There are currently no national strategies to prevent and control obesity and diabetes in Nepal. The country is still developing policies to address nutritional problems related to poverty and the problems related to excess have begun to increase as well. So, it is important for Nepal to classify its own dietary patterns because of the unique dietary cultures and its impact on dietary excess and deficit.[68,69]

**RATIONALE OF THE STUDY**

The prevalence of obesity and diabetes has increased in many developing countries, including Nepal.[8,70,12,13] Remarkably little data exist about dietary patterns despite evidence that there is rise in obesity and type 2 diabetes in Nepal.[13] And, there are no national strategies to prevent and control obesity and diabetes.

Dietary pattern analysis is important for identifying those who may be at nutritional risk in order to provide appropriate interventions. In Nepal, it is necessary to emphasize the need to consider prevention and low-cost strategies to deal with the concentration of obesity and type 2 diabetes. The policy makers in the country however do not have data on the existing prevalence of dietary changes and its contribution to obesity and type 2 diabetes, particularly in urban areas. For low-income country like Nepal, the availability of data on the dietary patterns contributing to over-nutrition will provide information to understand how to improve dietary intake.

This study addresses a key issue for identifying the dietary shifts in the Nepalese population and its associations with obesity and type 2 diabetes. Development of food and nutrition health policies for the country where problems of dietary excess and deficit coexist side by side represents a new and pressing agenda. The prevailing policies to address problems of deficit are quite different from those needed to address the problems of excess. This study will provide information and evidence in order to develop national level policy and strategy to combat the problems of excess such as obesity, diabetes, and other nutrition related NCDs.

The proposed research presents an innovative and important step in advancing obesity and diabetes prevention strategies in Nepal. To our knowledge, no large community-based study has been conducted measuring dietary patterns and examining its associations with obesity and type 2 diabetes in Nepalese people. As a result of this gap of knowledge, there currently are minimal, if any, policies and programs for addressing dietary modification related to chronic diseases. Therefore, this study will help to guide further research and formulate a new approach to dietary recommendations in this population by identifying unhealthy dietary patterns in the population and quantifying their associations with obesity and type 2 diabetes. This information can be provided as evidence to develop obesity and diabetes control and prevention strategies in Nepal as well as in other lower income countries. Additionally, the study provides a new validated dietary assessment tool for measuring dietary intake in the Nepalese population.

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# Chapter 2
# Reproducibility and Relative Validity of Food Group Intake in a Food Frequency Questionnaire Developed for the Dhulikhel Heart Study

**ABSTRACT**

**Background**: About one-fourth of Nepalese adults are estimated to be overweight or obese. No studies have examined the risk factors for obesity, especially pertaining to diet, in Nepal.

**Objective**: The present study aimed to identify dietary patterns in a suburban Nepalese community and to assess their association with overweight and obesity prevalence.

**Methods:** This cross-sectional study utilized data from the 1,073 adults (18 years or older) participating in the baseline survey of the Dhulikhel Heart Study. We derived major dietary patterns from the dietary intake using a validated food frequency questionnaire by using principal component analysis. Overweight was defined as BMI of 25 kg/m$^2$ or higher and obesity was defined as BMI of 30kg/m$^2$ or higher. Weight was measured using an Omron Model HBF-400 scale and recorded to the nearest 0.1 pounds. Height was measured using a standard tape with participants standing against a wall and recorded to the nearest 0.1cm. Statistical analysis was conducted using the generalized estimating equation (GEE) with multivariate logistic regression (with household as cluster) adjusting for age, sex, ethnicity, religion, marital status, income, education, alcohol consumption, smoking, physical activity, and systolic blood pressure.

**Results:** Four dietary patterns were derived: mixed, fast food, refined grain-meat-alcohol, and solid fats-diary.  The refined grain-rice-alcohol pattern was positively associated with overweight (aOR 1.19, 95% CI: 1.03 – 1.39; p =0.02) after adjusting for demographic and traditional cardiovascular risk factors. We found a significant interaction between age and the fast food pattern in association with obesity (p=0.01) and overweight (p=0.01). In adults of 40 years or older, the fast food pattern was positively associated with obesity controlling for demographic and traditional risk factors (aOR 1.69, 95% CI: 1.19- 2.39; p-value = 0.003)

**Conclusions:** Our results suggest that refined grains-meat-alcohol intake is associated with higher prevalence of overweight in adults; and fast food intake is associated with higher prevalence of obesity in older adults (40 years or above) in suburban Nepalese adults.

## BACKGROUND

Food frequency questionnaires (FFQ) are widely used in epidemiologic research of chronic diseases to characterize the dietary intake of study participants. FFQs are appealing because they measure usual or long-term intake, which is a more relevant metric for the study of chronic disease than are actual measures of recent diet. Moreover, they are inexpensive and quick to administer.[1] FFQs have been shown to be an appropriate method for assessing diet in a wide variety of epidemiologic settings.[2]

Although FFQs cannot measure actual diet intake, they can be used for categorizing persons accurately according to intake and for identifying subjects at the extremes of intake. The data collected from the FFQs can be also used for identifying major dietary patterns.[3,4] Numerous FFQs have been shown to perform well in ranking subjects by nutrient intake, but few studies have assessed their ability to measure consumption of individual food items or food groups.[5] Accurate measurement of foods is important because they may be independently related to disease outcomes via nutritive and nonnutritive components; or through interaction of nutrients within a food. Observed associations between foods and disease may also strengthen the causality attributable to a nutrient common to those food items. In addition, relationships between foods and disease can generate hypotheses about nutrients or other dietary components not previously considered as risk factors. The examination of food intake in relation to disease outcome is also important because foods relate most directly to the formulation of dietary recommendations.

Nevertheless, random and systematic errors can arise in FFQ estimates not representing the actual usual diet[6] which can underestimate the associations of epidemiological studies.[7] It is crucial to estimate the validity and reliability of a FFQ for study results to enhance the interpretation of estimated diet–disease associations and to improve the translation of such associations into dietary recommendations.[8,9] The performance of a FFQ is sensitive to the culture and ethnic background of the study population. Thus, the validity and reliability for a FFQ needs to be evaluated for studies conducted in different study populations.[10]

In recent years, epidemiological studies in Nepal have shown an increasing trend in prevalence of CVD and its risk factors.[11] The Dhulikhel Heart Study (DHS) was conducted to further investigate dietary relationships, among the other causes of high rates of CVD. As part of DHS, we administered a new FFQ (115 items) designed specifically to capture the dietary practices of the study participants. In the present study, we aimed to describe the validity and reproducibility of this FFQ for assessing food group intake.

## METHODS AND MATERIALS

### Subjects

The present study was conducted within the framework of the DHS, a prospective cohort study conducted in residents of Dhulikhel town of central Nepal, to determine prevalence of cardiovascular diseases and to identify its modifiable and non-modifiable risk factors. Participants in the DHS were identified using a random selection process of residents in all households. We recruited a sample of 121 cohort members (from the first 121 household enrolled in the DHS), aged 18 years or above, for participation in a dietary assessment validation study. Sample size was determined by considering a power of 90 percent and a minimum expected correlation coefficient of 0.3 at 5% level of significance and 10 percent attrition rate.[12] The research ethical committee of Nepal Health Research Council and the University of Washington approved the study.

### Assessment of dietary intake

***Food frequency questionnaire:*** Usual dietary intake was assessed using a 115-item semi-quantitative food frequency questionnaire. The food items in the questionnaire were selected from a previously existing FFQ (used in the pilot study) designed by a Nepali nurse in 2009. It was subsequently modified utilizing two 24-hour dietary recalls conducted among a convenience sample of 7 subjects from Kathmandu. The food list was updated based on the commonly consumed items stated in the dietary recalls. The FFQ was then piloted on 56 subjects in Dhulikhel in 2013. Subjects were asked if they had consumed any food item more than twice a week that was not included in the FFQ. Those food items were added to the questionnaire.

Trained interviewers recorded the usual food intake in the past year using electronic tablet-based food frequency questionnaire. The FFQ required about 40 minutes to complete. The FFQ contained questions on the average consumption frequency during the past year for 115 commonly consumed food items. Subjects could indicate their answers in times per day, per week, per month, per year, or as never. The questionnaire was supplemented with color photographs of four differently sized portions of foods developed by a professional photographer under controlled conditions including distance, angles, light and presentation. The food items that did not have natural units or applicable household measures were photographed. Subjects chose one of the amounts presented in the photographs. Different sizes of glasses or bowls were presented to estimate the amount of liquids. Other items were asked as a number of specified units (slice, number, spoon, etc.).

***24-hour dietary recall (HDR)****:* Three trained interviewers interviewed the participants to record the 24-HDRs. It required about 25 minutes to complete the interview. In the first section, activities of the previous day were taken to refresh the participant's memory. Then, the interviewers asked the participants about everything they ate or drank the previous day from the first meal to the last meal. A quick list of time and place of meals were taken, followed by more detailed information on each food including specific brands, ingredients, and/or recipes. Food portion sizes were estimated using the color photographs of different portion sizes and/or household measures such as spoon, bowl etc. If a subject reported eating a personal recipe, complete information on each individual item was asked.

For the validation study, the FFQ was administered twice to the same person three to four months apart for reproducibility. Relative validity was evaluated by comparing the number of weekly servings from a food group estimated from the FFQ with the weekly estimate from an average of six 24-HDR assessments, performed every month for six months. All the interviews were performed at the subjects' home. The data collection was conducted from April 2014 to February 2015.

**Statistical analysis**

The general characteristics of the participants were summarized using percentage and means (standard deviations). The servings of food per week were calculated and means (standard deviations) and medians were presented. The 115 food items in the FFQ were grouped into the 7 food groups: (1) grains and lentils, (2) fats, (3) fruits and vegetables, (4) meat and dairy, (5) western foods (6) packaged food, and (7) high sugar food. The categorization of 115 food items within the 7 food groups and sub groups is presented in Appendix 1. The FFQ was supplemented with a colored photograph of 4 different portion sizes. The amounts presented in the portion size photographs represented: ½ of average serving size; an average serving size; 1 and ½ of average serving size, and twice the average serving size. The number of servings per week was then calculated by multiplying the serving size with frequency of eating per week. The availability of fruits and vegetables are seasonal in Nepal. So, the number of servings for fruits and vegetables were calculated on an average based on the seasonal consumption. The months when the fruits and vegetables are available[13] are presented in Appendix 2. For the 24 HDR, we used the average number of servings per food group from the six 24-HDR. We converted it to weekly number of servings by multiplying it by 7.

Spearman correlation coefficients between the numbers of servings per week for the seven food groups and sub groups based on the FFQs and those based on the 24-HDR were used as measures of the relative validity. The reproducibility was expressed as Spearman correlation coefficients between the numbers of servings per week estimates for the seven food groups based on the first and the second FFQ. The Spearman's correlation coefficient was calculated between ranked variables by converting the weekly number of servings calculated from the two methods (FFQ vs. 24 HDR for relative validity and 1st FFQ vs. 2nd FFQ for reproducibility) to rank in the ascending order.

Random within-person variation error in the measurement of one or both variables being compared tends to reduce correlation coefficients towards zero.[14] Correcting the observed correlation for the attenuation effect of random within-person error provides a value similar to that obtained with a large number of replicates.[1] Thus, we de-attenuated the correlations to adjust for within-person variance using the ratio of within-to between-person variance measured from the 24-HDR.

**RESULTS**

Out of 121 participants who agreed to participate in the validation study, we excluded those subjects who did not complete two FFQs (n = 5) and those who did not complete multiple 24-hour dietary recalls (n = 13). Some participants however did not complete all six 24-HDR. The mean number of 24HDR was 5.6.

A comparison of the study population and the Dhulikhel Heart Study sample population on which data were collected during the first wave of the study (December 2014-January 2015) is presented in 2-1. The age, ethnicity, education, marital status, smoking status and BMI of the study participants were similar to the DHS population. There were more female participants in the current study.

**Table 2-1. Characteristics of validation study participants and the Dhulikhel Heart Study sample**

| Characteristics | Validation study (n =116) | | Dhulikhel Heart Study (n=1,073) | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| **Age in years, mean (SD)** | 40.0 (15.9) | | 40.3 (16.4) | |
| **Sex** | | | | |
| Male | 37 | 31.9 | 446 | 41.6 |
| Female | 79 | 68.1 | 627 | 58.4 |
| **Ethnicity** | | | | |
| Brahmin/ Chhetri | 26 | 22.4 | 298 | 27.8 |
| Newar | 74 | 63.8 | 527 | 49.1 |
| Magar/Tamang | 11 | 9.5 | 194 | 18.1 |
| Other | 5 | 4.3 | 54 | 5.0 |
| **Education** | | | | |
| No education | 30 | 24.4 | 340 | 31.7 |
| Less than high school | 58 | 47.2 | 478 | 44.6 |
| High school or more | 35 | 28.5 | 225 | 23.8 |
| **Marital Status** | | | | |
| Married | 83 | 71.6 | 784 | 73.1 |
| Single | 25 | 21.6 | 225 | 21.0 |
| Widowed/separated/Divorced | 8 | 6.9 | 64 | 5.9 |
| **Current Smoker** | 33 | 28.5 | 347 | 32.3 |
| **BMI (kg/m$^2$)** | | | | |
| Below 18.5 | 2 | 1.7 | 69 | 6.5 |
| 18.5 - 24.9 | 66 | 56.9 | 610 | 57.0 |
| 25.0 - 29.9 | 40 | 34.5 | 303 | 28.4 |
| 30.0 kg/m$^2$ and | 8 | 6.9 | 87 | 8.1 |

The mean and median intake of 7 food groups measured by six 24-hour dietary recalls and two FFQs are shown in Table 2-2. The mean servings per week of the FFQs were higher than the 24 HDR for refined lentils, oil, vegetables, sausage/burgers, and moderately sweetened beverages. In contrast, lower frequency consumption was observed in the FFQs compared to 24 HDR for whole grains, butter/ghee, and processed cereals. In comparison with the first FFQ, the second FFQ underestimated the consumption of vegetables and highly sweetened beverage; and overestimated pizzas/pastas.

**Table 2-2. Servings per week of food groups estimated by six 24-hour dietary recalls and 2 food frequency questionnaires developed for the Dhulikhel Heart Study**

| | | FFQ1 (n = 116) | | FFQ2 (n = 116) | | 24 HDR (n=103) | |
|---|---|---|---|---|---|---|---|
| | **Food groups** | **Mean (SD)** | **Median** | **Mean (SD)** | **Median** | **Mean (SD)** | **Median** |
| 1 | **Grains and Lentils** | | | | | | |
| | Whole grains | 1.71 (2.01) | 0.92 | 1.69 (1.67) | 1.00 | 3.75 (8.25) | 0.00 |
| | Refined grains | 20.61 (7.21) | 21.43 | 19.94 (7.03) | 17.96 | 20.38 (9.59) | 19.25 |
| | Whole lentils | 3.03 (3.20) | 2.00 | 2.81 (2.57) | 1.94 | 2.59 (5.53) | 0.00 |
| | Refined lentils | 8.45 (5.66) | 7.02 | 7.53 (4.96) | 7.01 | 5.62 (4.01) | 5.25 |
| 2 | **Fats** | | | | | | |
| | Oil | 11.73 (5.49) | 12.33 | 12.63 (8.29) | 10.52 | 10.14 (4.52) | 9.76 |
| | Butter/Ghee | 1.04 (1.76) | 0.46 | 1.04 (2.24) | 0.23 | 4.59 (10.78) | 0.00 |
| | Fatty foods | 5.25 (5.45) | 4.07 | 5.84 (12.09) | 3.21 | 5.44 (5.85) | 15.31 |
| 3 | **Fruits and Vegetables** | | | | | | |
| | Vegetables | 30.75 (22.01) | 28.65 | 25.14 (14.14) | 24.92 | 23.28 (18.86) | 18.38 |
| | Fruits | 18.17 (13.84) | 14.65 | 17.44 (8.06) | 16.39 | 19.32 (18.69) | 24.50 |
| | Starchy vegetables | 10.10 (6.04) | 9.99 | 9.57 (5.65) | 7.15 | 11.07 (7.94) | 16.33 |
| 4 | **Meat and milk** | | | | | | |
| | Meat | 4.74 (4.92) | 3.50 | 4.71 (4.13) | 3.53 | 4.23 (4.48) | 3.50 |
| | Milk | 1.38 (4.21) | 0.00 | 0.69 (2.32) | 0.00 | 1.78 (3.15) | 0.00 |
| | Dairy products | 0.65 (1.43) | 0.13 | 0.40 (0.74) | 0.07 | 0.58 (2.77) | 0.00 |
| 5 | **Western food** | | | | | | |
| | Chips and fries | 1.07 (1.67) | 0.33 | 1.07 (1.63) | 0.41 | 0.89 (3.22) | 0.00 |
| | Sausages/burgers | 0.40 (1.48) | 0.00 | 0.31 (1.30) | 0.00 | 0.18 (1.24 | 0.00 |
| | Pizzas/pastas | 0.03 (0.09) | 0.00 | 0.06 (0.20) | 0.00 | 0.13 (0.60) | 0.00 |
| 6 | **Packaged food** | | | | | | |
| | Processed cereals | 4.12 (3.90) | 3.11 | 4.31 (3.36) | 3.97 | 7.17 (6.10) | 5.83 |
| | Noodles | 2.43 (2.57) | 1.69 | 2.19 (2.02) | 1.46 | 2.24 (2.23) | 1.40 |
| | Salty snacks | 1.96 (2.58) | 0.96 | 1.87 (2.19) | 1.23 | 1.50 (2.88) | 0.00 |
| 7 | **Sweet foods** | | | | | | |
| | High sweetened beverage | 1.79 (3.81) | 0.46 | 1.31 (2.07) | 0.46 | 1.36 (2.67) | 0.00 |
| | Moderately sweetened beverage | 20.23 (11.37) | 21.06 | 20.77 (13.12) | 21.06 | 13.56 (4.56) | 13.53 |
| | Sweet foods | 2.32 (3.38) | 2.00 | 2.07 (2.80) | 1.06 | 1.29 (2.28) | 0.00 |

The crude and de-attenuated Spearman correlation coefficient was calculated to assess the validity of FFQs on food groups (Table 2-3). All crude associations comparing the first FFQ and 24 HDR were greater than 0.3 except for dairy products, sausage/burgers, and pizzas/pastas. The de-attenuated Spearman correlation coefficients ranged from 0.19 (sausage/burgers) to 0.72 (sweet foods). While comparing the second FFQ and 24 HDR, all the crude correlation coefficients were greater than 0.3, except for chips/fries, moderately sweet beverages, and pizzas/pasta. The de-attenuated correlation coefficient was highest for processed cereals (0.82) and the lowest for the moderately sweetened beverage (0.29).

**Table 2-3. Spearman correlation coefficients of the servings per week of the food group intakes estimated using six 24 HDR and FFQs developed for the DHS**

| | FFQ1 and 24 HDR | | FFQ2 and HDR | |
|---|---|---|---|---|
| **Food groups** | **Crude** | **De-attenuated** | **Crude** | **De-attenuated** |
| | n =103 | | n = 103 | |
| **Grains and Lentils** | **0.50** | **0.53** | **0.57** | **0.60** |
| Whole grains | 0.53 | 0.57 | 0.49 | 0.52 |
| Refined grains | 0.31 | 0.33 | 0.42 | 0.44 |
| Whole lentils | 0.63 | 0.65 | 0.43 | 0.44 |
| Washed lentils | 0.46 | 0.54 | 0.57 | 0.67 |
| **Fats** | **0.59** | **0.61** | **0.57** | **0.59** |
| Oil | 0.43 | 0.56 | 0.36 | 0.47 |
| Butter/Ghee | 0.60 | 0.61 | 0.62 | 0.62 |
| Fatty foods | 0.42 | 0.50 | 0.43 | 0.50 |
| **Fruits and Vegetables** | **0.70** | **0.74** | **0.62** | **0.65** |
| Vegetables | 0.62 | 0.66 | 0.62 | 0.65 |
| Fruits | 0.60 | 0.62 | 0.48 | 0.50 |
| Potatoes | 0.65 | 0.69 | 0.67 | 0.71 |
| **Meat and milk** | **0.47** | **0.58** | **0.45** | **0.56** |
| Meat | 0.42 | 0.51 | 0.46 | 0.55 |
| Milk | 0.51 | 0.67 | 0.38 | 0.50 |
| Dairy products | 0.29 | 0.30 | 0.32 | 0.33 |
| **Western food** | **0.39** | **0.79** | **0.25** | **0.50** |
| Chips and fries | 0.29 | 0.57 | 0.13* | 0.43 |
| Sausages/burgers | 0.18* | 0.19 | 0.30 | 0.30 |
| Pizzas/pastas | 0.22 | 0.32 | 0.29 | 0.43 |
| **Packaged food** | **0.55** | **0.75** | **0.57** | **0.77** |
| Processed cereals | 0.54 | 0.70 | 0.62 | 0.82 |
| Noodles | 0.53 | 0.54 | 0.62 | 0.64 |
| Salty snacks | 0.31 | 0.41 | 0.31 | 0.41 |
| **Sweet foods** | **0.41** | **0.51** | **0.30** | **0.37** |
| High sweetened beverage | 0.31 | 0.44 | 0.38 | 0.54 |
| Moderately sweetened beverage | 0.36 | 0.39 | 0.27 | 0.29 |
| Sweet foods | 0.58 | 0.72 | 0.50 | 0.62 |

*P-value > 0.05

Bold numbers are correlation coefficient for larger food groups

The Spearman correlation coefficient of the two FFQs is shown in Table 2-4. The correlations varied from 0.41 (oil) to 0.81 (vegetables). The correlations for all food groups were greater than 0.5, with the exception of oil.

**Table 2-4. Spearman correlation coefficient for food groups between the two FFQs developed for the DHS**

| | Food groups | FFQ1 and FFQ2 Crude (n = 116) |
|---|---|---|
| 1 | **Grains and Lentils** | **0.77** |
| | Whole grains | 0.64 |
| | Refined grains | 0.68 |
| | Whole lentils | 0.69 |
| | Washed lentils | 0.81 |
| 2 | **Fats** | **0.57** |
| | Oil | 0.41 |
| | Butter/Ghee | 0.82 |
| | Fatty foods | 0.94 |
| 3 | **Fruits and Vegetables** | **0.80** |
| | Vegetables | 0.81 |
| | Fruits | 0.76 |
| | Potatoes | 0.85 |
| 4 | **Meat and milk** | **0.62** |
| | Meat | 0.56 |
| | Milk | 0.69 |
| | Dairy products | 0.59 |
| 5 | **Western food** | **0.56** |
| | Chips and fries | 0.51 |
| | Sausages/burgers | 0.62 |
| | Pizzas/pastas | 0.54 |
| 6 | **Packaged food** | **0.73** |
| | Processed cereals | 0.68 |
| | Noodles | 0.77 |
| | Salty snacks | 0.63 |
| 7 | **Sweet foods** | **0.65** |
| | High sweetened beverage | 0.51 |
| | Moderately sweetened beverage | 0.65 |
| | Sweet foods | 0.80 |

P-value <0.001 for all coefficients
Bold numbers are correlation coefficient for larger food groups

## DISCUSSION

The food frequency questionnaire for the DHS was designed to capture the usual intake of major foods among population in Dhulikhel. a suburban community in central Nepal. The present study showed that the FFQ provide a fair estimate of food groups taken in the past year, in relation to the standard reference of an average of six 24 HDR. The observed correlation between the two FFQs was good demonstrating the reproducibility of the FFQ for the major food groups.

The results of FFQs usually reflect higher estimates for most food groups than the reference method,[15] particularly if the FFQ exceeds 100 items,[16] as does our study. Our FFQ overestimated refined lentils, oil, vegetables, sausage/burgers, and moderately sweetened beverages. Other FFQ validity studies have shown both over and underestimation of the same food groups.[17-20] Liquid oils are used during food preparation, so it is difficult for an individual to estimate the actual amount of oil consumed. In Nepal, many vegetables are cooked in combination with potato, onion, and tomato. So, overestimation may be due to measurement errors introduced by differences in conceptualization of the portion size of each item in a mixed vegetable dish. The overestimate of vegetables intake may also be accounted for by the seasonal variation of supply of these foods. The FFQ only asked for the consumption of vegetables during the peak season.

Moderately sweetened beverage (mostly tea) was over estimated in the FFQ. Tea is a part of social life in Nepal. It is offered in almost any social gatherings as well as in informal meetings, and refusing the tea is considered offensive to the host. So, over estimation may have resulted due to high social desirability of the drink. Some food groups such as butter/ghee and processed cereals were underestimated in the FFQ.

Mostly, the ghee was consumed with the packaged noodles, which was well captured in the 24 HDR, but was misreported in the FFQ.

The results of relative validity testing in the present study showed main food group correlations that were very similar to those noted in a Spanish population (median: 0,57; range: 0.29 to 0.72)[21]; Swedish population (median: 0.50; range: 0.15 to 0.69)[9], a Iranian population (median: 0.44; range: 0.03 to 0.79)[20] ; and Japanese cohort (median: 0.35; range: 0.07 to 0.81).[8] Vegetables had high correlation coefficient and are consumed frequently in this population. More commonly consumed foods had shown the highest correlations in other studies.[6,9,17,19,22] Weak correlations are mostly seen when the frequency of consumption is low and the within-person variability is high.[19] The infrequent consumption of western food and soft drinks in Dhulikhel, which are expensive and are eaten on special occasions, may be the reason for the lower correlation of these foods. Surprisingly, the correlation for refined and moderately sweetened beverages (mostly tea) was low despite being consumed frequently. A possible explanation for this might be that these beverages are likely to be consumed more than once a day with large differences in portion sizes, which may have resulted in measurement error in estimating the drink.

Adjusting for de-attenuating the correlation between different measurement methods for within person variation caused an increase in almost all groups, which is due to the relative size of within-person and between-person variation in the intake of food groups in our study subjects. Foods consumed regularly (e.g., grains, vegetables, fruits) had lower within-person variation in weekly consumption and also tended to have higher observed correlation coefficients[1] and the deattenuation affected them less. In contrast, irregularly consumed foods (e.g. pastas/pizzas, salty snacks, soft drinks) tended to exhibit high within-person variance, greatly attenuating the observed correlations.

The Spearman correlation between the two FFQs ranged from 0.41 to 0.81. The studies that have examined the reproducibility of intake measurements for specific food groups on dietary questionnaires, correlation coefficients in the range of 0.4 to 0.7 are most common.[10,17,23,24] Other studies have also used percent agreement to assess reproducibility,[20,25,26] but these are more difficult to compare because better agreement can be achieved by questionnaires with fewer response categories. In this study, we assessed the reproducibility at an interval of 3 to 4 months. Reproducibility tests are based on the assumption that diets did not change between the two questionnaires.[27] According to a comprehensive review, the time interval in published reports ranges from 2 hours to 15 years.[5] The observed reproducibility in this study may be less affected by the actual changes in eating habit since the time interval between them was about 3 months and the subjects are not likely to remember and repeat the responses from one time to the next.

To our knowledge, this is the first study to examine the relative validity and reproducibility of a food frequency questionnaire designed to assess dietary intake of Nepalese population. The study included six 24-hour dietary recalls administered in person, which reduced the daily and seasonal variations in our study population. In addition, we calculated the de-attenuated correlation coefficient, which removed the random errors from intra-person variations. This theoretically provides a value similar to that obtained with a large number of replicates.[14] The inclusion of the food group intake in the assessment allows analysis of dietary intake, which may subsequently guide the resulting recommendations aimed at establishing healthful eating patterns. Furthermore, the assessment of dietary intake in different seasons of the year, and the fact that participants entered the study at different times enabled us to obtain a more complete view of habitual diets. Sources of errors using the 24 HDR are its reliance on memory, the lack of adequate food descriptive detail, and quantification of portion sizes used.[28] To facilitate the recall of the food and quantification of portion size, we used the photographs of food and portion sizes in household utensils. Because of the similar distributions in socio demographic characteristics of the participant in the present study and the cohort population, the present results can be generalized to the DHS cohort.

Our study does have some limitations. While the weighted dietary record is the gold standard used to evaluate the relative validity of a FFQ, it is more demanding and may cause individuals to change diet.[1,29] About a third of the population was illiterate in DHS So, we conducted six 24 HDR as reference measurement because literacy is necessary for keeping dietary records, which is considered to assess the diet better. However, we acknowledge that six days of diet recall will not adequately represent usual intake for food groups that are consumed less frequently. So, the average of six 24-HDR may imperfectly capture these foods. Consequently, caution should be taken to interpret the validity of these food groups.[30] A limitation in the use of correlation coefficient to evaluate the validity is that the correlations are a function of between person variations in food intakes in the population under study. So, the observed correlations will be higher for foods with greater between-person variation. Although this limits the generalizability of the correlations, the capacity to assess diet-disease relationships is in part a function of between-person variation.[1] The small sample size of the present study kept us from categorizing subjects according to their sex, BMI, and physical activity.

In conclusion, this 115-item FFQ developed for the DHS facilitates accurate ranking of individuals according to levels of their food group intake and seems to be an acceptable tool for assessing the intake of food groups, based on its reasonable relative validity and reproducibility correlations. The instrument is useful for the epidemiological research of diet as a risk factor for CVD and other chronic disease in Dhulikhel and central Nepal.

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# Chapter 3

# Food Patterns Measured by Principal Component Analysis and Obesity in the Nepalese Adult


## ABSTRACT

**Background**: About one-fourth of Nepalese adults are estimated to be overweight or obese. No studies have examined the risk factors for obesity, especially pertaining to diet, in Nepal.

**Objective**: The present study aimed to identify dietary patterns in a suburban Nepalese community and assess their association with overweight and obesity prevalence.

**Methods:** This cross-sectional study utilized data from the 1,073 adults (18 years or older) participating in the baseline survey of the Dhulikhel Heart Study. We derived major dietary patterns from the dietary intake using a validated food frequency questionnaire by using principal component analysis. Overweight was defined as BMI of 25 kg/m$^2$ or higher and obesity was defined as BMI of 30kg/m$^2$ or higher. Weight was measured using an Omron Model HBF-400 scale and recorded to the nearest 0.1 pounds. Height was measured using a standard tape with participants standing against a wall and recorded to the nearest 0.1cm. Statistical analysis was conducted using the generalized estimating equation (GEE) with multivariate logistic regression (with household as cluster) adjusting for age, sex, ethnicity, religion, marital status, income, education, alcohol consumption, smoking, physical activity, and systolic blood pressure.

**Results:** Four dietary patterns were derived: mixed, fast food, refined grain-meat-alcohol, and solid fats-diary.  The refined grain-rice-alcohol pattern was positively associated with overweight (aOR 1.19, 95% CI: 1.03 – 1.39; p =0.02) after adjusting for demographic and traditional cardiovascular risk factors. We found a significant interaction between age and the fast food pattern in association with obesity (p=0.01) and overweight (p=0.01). In adults of 40 years or older, the fast food pattern was positively associated with obesity controlling for demographic and traditional risk factors (aOR 1.69, 95% CI: 1.19- 2.39; p-value = 0.003)

**Conclusions:** Our results suggest that refined grains-meat-alcohol intake is associated with higher prevalence of overweight, and fast food intake is associated with higher prevalence of obesity in older adults (40 years or above) in suburban Nepalese adults.

## BACKGROUND

Obesity is a multifactorial chronic disease that develops from an interaction of the environment and genotype.[1,2] Obese adults are at an increased risk of the major diseases such as hypertension, type 2 diabetes, cardiovascular disease, and certain cancers.[3,4] Both developed and developing countries face the obesity epidemic among adults as well as children[5,6]. The data on obesity and non-communicable diseases in Nepal is limited. In 2013, the world health organization (WHO) STEPS survey reported 18% overweight and 4% obesity among the Nepalese adults (15-45 years)[7] whereas a population based study in the eastern region reported higher prevalence (32.5%) of overweight.[8]

Diet is one of the most important factors in the development of obesity.[9] Despite numerous studies, the nutritional etiology of obesity remains unclear and controversial, especially in relation to macronutrient composition.[10-12] Inconsistent research findings can be attributable to the traditional single-nutrient approach commonly used in nutritional epidemiologic research. The traditional approach is limited because of the biological interaction and collinearly between nutrients[13] and inability to detect small health effects from single nutrients.[14]

In response to the limitation of the traditional approach to evaluating food intake, dietary pattern analysis has emerged as a comprehensive alternative or supplemental method to understanding diet-disease relationship.[15] The dietary pattern analysis identifies a set of correlated foods and computes a score for each set according to the frequency of intake of the foods. The scores then are used as replacement for the food variables.[15] Dietary patterns defined with the use of either dietary index, factor analysis, or cluster analysis were previously reported to be associated with obesity in developed countries.[16] Several epidemiological studies have reported that dietary patterns high in fruits, vegetables, and fiber, and low in high-fat dairy products, sweets, and processed meat were associated with a reduced risk of obesity.[17-19] However, evidence is still limited, and most studies have been conducted in Western populations.

The objectives of this study are to identify the major dietary patterns in a suburban community of Nepal and to investigate associations with the prevalence of overweight and obesity measured by BMI among adults participating in the Dhulikhel Heart Study.

## METHODS AND MATERIALS

### Study design and participants

This cross-sectional study utilized data from the first wave of the baseline survey of the Dhulikhel Heart Study (DHS). The DHS is a population-based observational cohort study designed to investigate cardiovascular diseases (CVD) and its conventional risk factors in a suburban Nepalese population. The study was designed to collect data on all residents aged 18 years and older residing in Dhulikhel (complete ascertainment). All of the households of the city were enumerated (n=2225) and about a third of the households (n=735) were randomly selected stratified by ward (nine administrative divisions) to represent the first wave of the study. Eligible adult residents living in the sample households were enumerated and contacted during household visits. Inclusion criteria were: being a permanent resident of Dhulikhel; having lived in Dhulikhel for at least six months; non-pregnant at the time of data collection; and able to communicate in Nepali or Newari language. A total of 1,372 eligible participants were enumerated in the first wave of the DHS, out of which the data collectors were able to contact 1,103 (80%) participants. Eligible subjects who provided informed consent (n=1,073, 78%) were recruited in the study. Thirteen participants, who had implausible BMI, were excluded in the present analyses. All subjects provided written informed consent for their participation in the study, and the institutional review boards of the University of Washington and the Nepal Health Research Council approved the study.

**Dietary assessment:**

We used a Food Frequency Questionnaire (FFQ) for assessing the usual dietary intake. The FFQ contains questions on the average consumption frequency during the past year for 115 commonly consumed food items. Subjects indicated their answers in times per day, per week, per month or per year, or as never. The questionnaire was supplemented with color photographs of 4 differently sized portions of foods developed by a professional photographer under controlled conditions including distance, angles, light and presentation. The food items that do not have natural units or applicable household measures were photographed. Different sizes of glasses or bowls were presented to estimate the amount of liquids. Subjects chose one of the amounts presented in the photographs. Other items were asked as a number of specified units (slice, number, spoon, etc.).

## Food Component Derivation

We used principal components analysis (PCA) to obtain food patterns reflecting the specific food items consumed.[20] Strong correlations should exist between variables (food groups) for this methodology strictly to be applicable. The correlation matrix of the food groups showed that several correlation coefficients exceeded 0.4, providing confidence that PCA was an appropriate method for assessing food patterns in this study (data not shown). From the database, 23 foods and food groups were created according to macro nutrient composition. The food groups and related foods are presented in appendix 1. The frequency of food group consumption was entered as number of servings per week. The PCA was performed using STATA with orthogonal rotation with varimax option to derive optimal non-correlated components (food patterns). A scree plot of eigenvalues derived from the correlation matrix of the standardized variables was examined to decide number of components to retain.[21]

## Assessment of obesity and overweight

BMI was calculated as weight in kilograms divided by height in meters squared. Overweight was defined as BMI of 25 $kg/m^2$ or higher and obesity was defined as BMI of 30$kg/m^2$ or higher based on international cut points.[22] Weight was measured without shoes and while wearing minimum clothing using an Omron Model HBF-400 scale and recorded to the nearest 0.1 pounds. Height was measured without shoes using a standard tape measure with participants standing against a wall for measurement and recorded to the nearest 0.1cm.

## Assessment of other variables

Data on physical activity was obtained using a global physical activity questionnaire[23] included in the participant baseline interview and expressed as metabolic equivalent of task (MET) minutes per week. A weekly MET equivalent of 600 would be 30 minutes brisk walking for 5 times per week or 15 minutes running for 5 times per week. Additional covariate information including age (years), sex (male/female), ethnicity (newar / brahmin, chhetri / other), religion (Hindu/ non Hindu), marital status (married/ not married), annual income (converted to US dollars), education (number of formal years of education), alcohol consumption (number of drinks per week), and smoking (pack-years) were self-reported in interviews conducted using standardized questionnaires. Three measurements of systolic and diastolic blood pressure were taken using Microlife automatic blood pressure measuring device. The mean of the three measurements was used in the analysis (mmHg). Hypertension was defined as systolic blood pressure 140 mm Hg or greater; or diastolic blood pressure 90 mm Hg or greater; or taking antihypertensive medication.[24] Diabetes mellitus was defined as glycated hemoglobin A1C 6.5% or greater.[25]

The confounding variables were chosen based on literature review. The variables are defined as confounding when they are associated with both the exposure (dietary intake) and the outcomes (overweight and obesity) and are not in the causal pathway.[26]

## Statistical Methods

Sample characteristics were described for males and females using means and standard deviations for continuous variables and percentages for categorical variables. Our main models utilized the generalized estimating equation (GEE) with multivariate logistic regression, exchangeable working correlation and robust variance. In Nepal, households generally consume food together and eating norms are shared by all of its members. We thus expected that the outcomes among individuals in the same household would be correlated. GEE corrects for correlation of responses for participants from common household (clustered within household), and robust variance estimators are used for valid inference under possibly misspecified correlation structure.[27] The food patterns derived using PCA are un-correlated and were analyzed separately in the statistical model with obesity (BMI ≥ 30 $kg/m^2$) and overweight (BMI ≥ 25 $kg/m^2$) as main outcomes. The odds ratio are reported with 95% confidence interval in the following three hierarchical models for each food pattern: (1) crude odds ratio; (2) odds ratio adjusted for demographic variables (age, sex, ethnicity, religion, marital status, income and education; and (3) odds ratio adjusted for demographic and lifestyle variables (alcohol consumption, smoking, physical activity, systolic blood pressure). We conducted sensitivity analysis by using the servings per week of food groups in each food pattern instead of factor score as an exposure. We explored the interaction of the derived food patterns with age and gender.

**RESULTS**

The demographic characteristics of the 446 men and 637 women in the study sample are shown in Table 3-1. The subjects were of mean age 40 years and about half of them were of Newar ethnicity. More males were educated and had higher annual income compared to females.

**Table 3-1. Demographic characteristics of 1,073 community based Nepalese adults participating in the Dhulikhel Heart Study**

| Characteristics | Male (n=446) | Female (627) | Total (1,073) |
|---|---|---|---|
| **Age, mean(SD) (years)** | 40.77(16.5) | 40.03(16.3) | 40.3 (16.4) |
| **Ethnicity (n,%)** | | | |
| Brahmin/ Chhetri | 135 (30.3) | 163 (26.6) | 298 (27.8) |
| Newar | 214 (48.0) | 313 (49.9) | 527 (49.1) |
| Other | 97 (21.7) | 151 (24.0) | 248 (23.1) |
| **Education (%, n)** | | | |
| No formal education | 77 (17.3) | 263 (42.0) | 340 (31.7) |
| Less than high school | 240 (53.8) | 238 (37.9) | 478 (44.6) |
| High school or more | 129 (28.9) | 126 (20.1) | 255 (23.8) |
| Mean years of education (SD) | 8.2 (5.1) | 5.4 (5.6) | 6.6 (5.5) |
| **Annual income, (mean, SD)** | 1348.3 (3606.6) | 474.4 (2608.2) | 873.7 (3091.6) |
| **Marital Status** | | | |
| Married | 339 (76.0) | 445 (71.0) | 784 (73.1) |
| Non married | 107 (24.0) | 182 (29.0) | 289 (26.9) |
| **Religion (n,%)** | | | |
| Hindu | 379 (84.9) | 531 (84.7) | 910 (84.8) |
| Non-Hindu | 67 (15.02) | 96 (15.3) | 163 (15.2) |

The prevalence of traditional risk factors for cardiovascular disease is presented in Table 3-2. More males were smokers, drinkers, and were less physically active compared to females. The prevalence of obesity was higher in females whereas hypertension and diabetes were more prevalent among males.

**Table 3-2. Traditional risk factors for cardiovascular disease in 1,073 community based Nepalese adults participating in the Dhulikhel Heart Study**

| Traditional risk factors | Male<br>n = 446 | Female<br>n=627 | Number<br>(n = 1,073) |
|---|---|---|---|
| **Smoking, n (%)** | | | |
| Never | 231 (51.8) | 495 (78.9) | 726 (67.7) |
| Former | 56 (12.6) | 43 (6.9) | 99 (9.2) |
| Current | 159 (35.6) | 89 (14.2) | 248 (23.1) |
| Pack years, mean (SD) | 8.4 (17.4) | 3.9 (11.6) | 5.8 (14.5) |
| **Alcohol, n (%)** | | | |
| Never drinkers | 229 (51.4) | 506 (80.7) | 735 (68.5) |
| Low (<1 glass per week) | 46 (10.3) | 52 (8.3) | 98 (9.1) |
| Moderate (1-3 glass per week) | 39 (8.7) | 20 (3.2) | 59 (5.5) |
| High (3 or more glass per week) | 132 (29.6) | 49 (7.8) | 181(16.8) |
| Drinks per week, mean (SD) | 12.8 (37.3) | 1.4 (6.5) | 6.2 (25.2) |
| **Physical activity, n (%)** | | | |
| < 600 MET minutes per week | 164 (36.8) | 259 (39.4) | 423 (39.4) |
| ≥ 600 MET minutes per week | 282 (63.2) | 368 (58.7) | 650 (60.6) |
| MET minutes per week, mean (SD) | 3107.1 (4934.9) | 4044.7 (6070.6) | 3496.9 (5452.7) |
| **BMI, n (%)** | | | |
| Underweight (<18.5 kg/m$^2$) | 28 (6.3) | 36 (5.7) | 64 (56.0) |
| Normal (18.5 - 24.9 kg/m$^2$) | 265 (35.4) | 354 (55.2) | 611 (56.9) |
| Overweight (25.0-29.9 kg/m$^2$) | 129 (28.9) | 186 (29.7) | 315 (29.4) |
| Obese (30.0 or more kg/m$^2$) | 24 (5.4) | 59 (9.4) | 83 (7.7) |
| BMI kg/m$^2$, mean (SD) | 23.6 (3.7) | 24.3 (4.3) | 23.9 (4.0) |
| **Hypertension, n (%)** | 176 (39.5) | 145 (23.3) | 321 (29.9) |

Based on the eigenvalues, scree plots, and interpretability of the patterns, the principal component analysis revealed four major dietary patterns: the factor loadings of each pattern after orthogonal rotation are shown in Table 3-3. The four factors explained 40% of the variation in the total food intake. The four patterns were labeled based on the food items that loaded highly as follows:

(i) Pattern 1: Mixed pattern (lentils, fruits and vegetables, fatty foods, noodles, tea and coffee)

(ii) Pattern 2: Fast food pattern (fast foods, sweets, soda)

(iii) Pattern 3: Refined grains-meat-alcohol pattern (refined grains, meat, fish, alcohol)

(iv) Pattern 4: Solid fats and dairy pattern (solid fats and dairy)

These patterns accounted for 17.3 %, 8.5%, 7.7%, and 6.5% of the variation in the food intake, respectively.

**Table 3-3. Score coefficients derived from principal component analysis of foods or food groups consumed by community based adults participating in the Dhulikhel Heart Study**

| | Components | | | |
|---|---|---|---|---|
| Food groups | 1 | 2 | 3 | 4 |
| Whole grains | 0.314 | -0.002 | 0.013 | 0.040 |
| Refined grains | 0.171 | -0.032 | **0.421** | -0.034 |
| Lentils | **0.753** | 0.052 | -0.024 | -0.004 |
| Vegetable oils | 0.242 | -0.019 | -0.093 | 0.021 |
| Solid fats | 0.011 | 0.229 | -0.033 | **0.556** |
| Fatty foods | **0.652** | 0.298 | 0.001 | -0.095 |
| Vegetables | **0.860** | -0.045 | 0.020 | 0.027 |
| Fruits | **0.788** | 0.215 | 0.084 | 0.116 |
| Potatoes | **0.469** | 0.175 | 0.101 | -0.006 |
| Nuts | 0.348 | 0.139 | 0.123 | 0.229 |
| Poultry | 0.333 | 0.302 | **0.434** | 0.000 |
| Red meat | 0.116 | 0.150 | **0.664** | -0.088 |
| Fish | -0.032 | 0.229 | **0.628** | 0.147 |
| Milk | -0.070 | -0.138 | -0.039 | **0.659** |
| Milk products | 0.125 | 0.101 | 0.026 | **0.709** |
| Fast food | 0.275 | **0.665** | 0.241 | 0.099 |
| Processed cereal | 0.355 | 0.021 | 0.115 | 0.259 |
| Noodles | **0.510** | 0.437 | 0.203 | -0.041 |
| Salty snacks | 0.436 | 0.091 | 0.008 | -0.079 |
| Soda drinks | 0.286 | **0.499** | 0.193 | 0.121 |
| Tea/Coffee | **0.459** | -0.036 | 0.063 | 0.198 |
| Sweets | -0.004 | **0.738** | -0.092 | -0.007 |
| Alcohol | -0.081 | -0.289 | **0.594** | -0.055 |

Extraction method: Principal Component Analysis; Rotation method: Varimax with Kaiser Normalization

Score coefficients > 0.4 are bold

Table 3-4 shows the associations of food patterns with prevalence of overweight and obesity. The refined grain-rice-alcohol pattern was positively associated with overweight. The odds of overweight were 19% higher for those who had a unit higher factor score (OR: 1.19, 95% CI: 1.03 -1.39; p=0,02) after adjusting for demographic and traditional CVD risk factors. There was no significant association between overweight and other food patterns (mixed, fast food, solid fats and dairy). Obesity was not significantly associated with any of the food patterns. The results were similar when we used number of servings of food groups in each food patterns as exposure instead of the factor score.

There was significant interaction between age and fast food pattern in association with obesity (p=0.01) and overweight (p=0.01). The association of other food patterns with obesity and overweight were not modified significantly by age and sex (Table 3-5). The association of overweight and obesity with the fast food stratified by age group is shown in Table 3-6. The odds of obesity was 64% higher for one unit higher fast food pattern score among 40 years or above age group after adjusting for demographic and traditional risk factors (aOR: 1.69, 95% CI: 1.19 - 2.39; p-value=0.003). Similarly, the odds of overweight was higher among those who consumed more fast food pattern in the older age group (40 years or more) in the adjusted model, but was not statistically significant. The results were similar when we additionally adjusted for other food patterns (not shown).

**Table 3-4. Association of overweight and obesity with the derived food patterns among 1,060 participants of the Dhulikhel Heart Study**

| | Model – 1<br>Univariate analysis<br>n=1,060 | | | Model – 2<br>Adjusted for demographic variables *<br>n=1,060 | | | Model – 3<br>Additionally adjusted for traditional risk factors **<br>n=1,060 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Odds Ratio | 95% CI | P-value | Odds Ratio | 95 % CI | P-value | Odds Ratio | 95% CI | P-value |
| **Overweight (BMI ≥ 25 kg/m²)** | | | | | | | | | |
| Mixed | 1.03 | (0.91 , 1.17) | 0.62 | 1.02 | (0.89 , 1.17) | 0.75 | 0.98 | (0.85 , 1.12) | 0.75 |
| Fast food | 0.90 | (0.80 , 1.03) | 0.12 | 1.04 | (0.89 , 1.21) | 0.63 | 1.04 | (0.89 , 1.22) | 0.61 |
| Refined grain-meat-alcohol | 1.15 | (1.02 , 1.30) | **0.03** | 1.17 | (1.02 , 1.35) | **0.03** | 1.19 | (1.03 , 1.39) | **0.02** |
| Milk and milk products | 1.12 | (0.99 , 1.27) | 0.07 | 1.12 | (0.98 , 1.28) | 0.10 | 1.14 | (0.99 , 1.31) | 0.07 |
| **Obesity (BMI ≥ 30 kg/m²)** | | | | | | | | | |
| Mixed | 0.93 | (0.73 , 1.17) | 0.53 | 0.92 | (0.71 , 1.19) | 0.53 | 0.87 | (0.67 , 1.14) | 0.32 |
| Fast food | 0.88 | (0.69 , 1.12) | 0.30 | 1.02 | (0.78 , 1.35) | 0.87 | 1.05 | (0.80 , 1.38) | 0.73 |
| Refined grain-meat-alcohol | 1.04 | (0.84 , 1.29) | 0.71 | 1.11 | (0.88 , 1.39) | 0.39 | 1.10 | (0.87 , 1.40) | 0.43 |
| Solid fats and dairy | 1.06 | (0.87 , 1.29) | 0.58 | 1.04 | (0.83 , 1.32) | 0.73 | 1.05 | (0.83 , 1.33) | 0.71 |

* Adjusted for age, gender, marital status, religion, ethnicity, education, annual income
** Adjusted for age, gender, marital status, religion, ethnicity, education, annual income, smoking, physical activity, systolic blood pressure

**Table 3-5. Effect modification by age and sex in the association of derived food patterns with obesity and overweight among the community-based adults participating in the Dhulikhel Heart Study**

| | Coefficient of Interaction | 95% CI | | P-value |
|---|---|---|---|---|
| **Overweight** | | | | |
| By age | | | | |
| Mixed | 1.01 | (1.00 , | 1.01) | 0.09 |
| Fast food | 1.01 | (1.00 , | 1.02) | 0.01 |
| Refined grain-meat-alcohol | 1.00 | (0.99, , | 1.01) | 0.80 |
| Solid fats and dairy | 1.00 | (0.99, , | 1.00) | 0.40 |
| By sex | | | | |
| Mixed | 0.91 | (0.71 , | 1.18) | 0.49 |
| Fast food | 0.71 | (0.54 , | 1.03) | 0.10 |
| Refined grain-meat-alcohol | 0.97 | (0.73 , | 1.29) | 0.84 |
| Solid fats and dairy | 1.13 | (0.87 , | 1.45) | 0.37 |
| **Obesity** | | | | |
| By age | | | | |
| Mixed | 1.00 | (0.99 , | 1.01) | 0.62 |
| Fast food | 1.02 | (1.00 , | 1.04) | 0.01 |
| Refined grain-meat-alcohol | 1.00 | (0.98 , | 1.01) | 0.91 |
| Solid fats and dairy | 1.00 | (0.99 , | 1.01) | 0.94 |
| By sex | | | | |
| Mixed | 0.73 | (0.52 , | 1.03) | 0.07 |
| Fast food | 1.50 | (0.82 , | 2.75) | 0.19 |
| Refined grain-meat-alcohol | 0.68 | (0.42 , | 1.11) | 0.13 |
| Solid fats and dairy | 1.01 | (0.68 , | 1.50) | 0.96 |

**Table 3-6. Association of overweight and obesity with the fast food pattern stratified by age among 1,060 participants of the Dhulikhel Heart Study**

| | Model – 1 Univariate analysis n=1,060 | | | Model – 2 Adjusted for demographic variables * n=1,060 | | | Model – 3 Additionally adjusted for traditional risk factors ** n=1,060 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Odds Ratio | 95% CI | P-value | Odds Ratio | 95% CI | P-value | Odds Ratio | 95% CI | P-value |
| **Overweight** | | | | | | | | | |
| Less than 40 years | 0.93 | (0.78 , 1.12) | 0.48 | 1.00 | (0.83 , 1.21) | 0.99 | 1.01 | (0.85 , 1.20) | 0.85 |
| 40 years or more | 1.18 | (0.92 , 1.51) | 0.08 | 1.10 | (0.86 , 1.41) | 0.54 | 1.24 | (0.96 , 1.62) | 0.11 |
| **Obese** | | | | | | | | | |
| Less than 40 years | 0.59 | (0.29 , 1.18) | 0.14 | 0.53 | (0.28 , 1.03) | 0.06 | 0.60 | (0.34 , 1.06) | 0.08 |
| 40 years or more | 1.60 | (1.10 , 2.33) | 0.01 | 1.43 | (1.01 , 2.16) | 0.04 | 1.69 | (1.19 , 2.39) | 0.003 |

* Adjusted for gender, marital status, religion, ethnicity, education, annual income

** Adjusted for gender, marital status, religion, ethnicity, education, annual income, smoking, alcohol intake, physical activity, systolic blood pressure

## DISCUSSION

In this study, we sought to identify dietary patterns associated with overweight and obesity in a population-based sample of suburban Nepal. Our findings revealed four major food patterns that characterized the dietary habits of the suburban Nepalese community: mixed pattern, fast food pattern, refined grains-meat-alcohol pattern, and solid fats and dairy pattern. Individuals characterized as consuming higher amount of refined-meat-alcohol food pattern were more likely to be overweight. Individuals 40 years or older were also more likely to be obese based on higher consumption of fast foods, soda, and sweets.

Not surprisingly, our study did not derive the same dietary patterns as other studies, as the diet of the Nepalese differs markedly from that of other populations. The differences in the food intake pattern and the study designs make it difficult to compare results across studies, especially between populations with dietary differences.[15] However, distinct dietary patterns reflecting different dietary behaviors have been related to disease rates in other countries.[28] Although the refined grains-meat-alcohol pattern was not derived in other studies, the food patterns highly correlated with these food groups have been shown to be associated with obesity in other populations. The refined grain in Nepali diet is predominantly white rice. In a study of Hispanic older adults, a dietary pattern based on rice was positively associated with risk of overall and central obesity.[29] Similarly, a traditional Japanese pattern, characterized by high intakes of rice, miso soup, and soy products, was reported to be significantly associated with a 1.8 fold increased risk of overweight (BMI $\geq 25$ kg/m$^2$) among Japanese women.[30] A rice based dietary pattern was also positively associated with overweight (BMI $\geq 25$ kg/m$^2$) in Korean adults.[31]

Several studies have shown that a meat based dietary pattern was independently associated with obesity. A pattern characterized by high intakes of meat, egg, fat, and oil was related to a higher risk of overweight (BMI ≥ 25kg/$m^2$) among Japanese women[30]. Maskarinec and colleagues also identified that a meat pattern characterized by high intakes of processed and red meats, fish, poultry, eggs, fats and oils, and condiments was positively associated with BMI among Hawaiian women[32]. An alcohol pattern was significantly associated with higher BMI in Swedish women.[33] Alcohol may be associated with overweight because of its contribution to energy intake.[34] In our study, the servings per week of red meat and alcohol were independently associated with overweight (data not shown).

Other studies have derived 'healthy patterns' comprising of fruits, vegetables, lentils, and whole cereals, which is associated with lower BMI.[35-37] The healthy foods[38] such as fruits and vegetables correlated with unhealthy foods like fatty foods[39] in our study. The fruits, vegetables and fatty foods are always seasoned with salt in the Nepalese diet and salt intake has been positively associated with obesity.[40] The beneficial effect of fruits and vegetables may have been counterbalanced by detrimental effect of fatty foods and salt, resulting in the null association between the mixed pattern and overweight/obesity in our study.

Consumption of fast food and soft drinks in large portion sizes has been found to contribute to the high energy densities and has been attributed to the escalating the rates of overweight and obesity in the United States.[41-44] In our population, the association between fast food and obesity and overweight was modified by age. There was a positive association of the fast food pattern with obesity and overweight in the older age group (40 years or older), but the association was null in the younger participants. The null association among the younger participants may be because of the residual confounding due to physical activity and age. It might also be possible that the traditional diet was replaced by fast food among young adults without major change in total energy consumption, whereas older adults consumed the fast food in addition to the traditional diet.

In our study, while we found a positive association between the refined grains-meat-alcohol pattern and overweight (BMI ≥ 25 $kg/m^2$), the association was not significant when we only looked at obesity as an outcome (BMI ≥ 30 $kg/m^2$). We may not have enough power to detect the significant association given the sample size and prevalence of obesity (7.7%).[45] The association was significant at lower BMI cut off (≥ 25 $kg/m^2$). Different BMI cut offs points have been used to identify people with high risk of undesirable health outcomes, especially for Asian population.[22] Studies suggest that Asians have a proportionally higher percentage of total body fat and abdominal fat than whites with the same BMI and therefore, obesity-related complications occur at lower BMI.[46]

One strength of our study is the use of data-driven food pattern analysis. This approach has emerged as a complementary approach to examine diet-disease relationship and is more predictive of disease risk than individual food or nutrients.[47] Furthermore, we used advance multivariate analysis to control for different socio-economic (age, gender, ethnicity, education, marital status, religion, income), and CVD risk factors (smoking, drinking, physical activity, systolic blood pressure.

The current study provides useful information elucidating the association between dietary patterns and the prevalence of overweight in Nepalese adults. However, several limitations should be considered when interpreting our results. Firstly, our study is a cross-sectional study, and it is not possible to determine the temporality of variables in this setting. Secondly, it is very possible that the obese people tend to under-report their energy consumption and overestimate healthy foods such as fruits and vegetables,[48-50] thus systematically biasing food intake assessment. Thirdly, the principal component analysis method itself also has limitations that arise from several subjective choices made in deciding the variable scale, number of variables, number of factors, and interpretation.[47] This may contribute to the inconsistency and substantially limit the ability to generalize the results. Fourth, we cannot generalize our findings to the entire Nepalese population because Nepal is a multiethnic country with vast diversity in the food habit and culture.[51] Finally, we were unable to adjust for the role of genetics in our models, which may modify the relation between diet and overweight.[2,52,53]

**Conclusions**

Our results suggest that higher intake of refined grains-meat-alcohol dietary pattern is associated with increased odds of overweight in suburban Nepalese adults. The fast food intake was associated with higher prevalence of obesity in the 40 years or older adults. This study adds to the existing literature by identifying relationships between dietary patterns and overweight / obesity in an understudied population residing in a low-resource setting. Identifying food-based dietary patterns may be useful in dietary counseling and public health efforts at decreasing obesity.

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# Chapter 4

# Food Patterns Measured by Principal Component Analysis and Diabetes in the Nepalese Adult


## ABSTRACT

**Background**: Type 2 Diabetes Mellitus (T2DM) has become an epidemic worldwide. Remarkably little data exist on relationships between food consumption or nutrition patterns and T2DM in Nepal despite evidence that the prevalence of diabetes is increasing dramatically.

**Objective:** The objective of this study was to assess the associations between type 2 diabetes and major dietary patterns derived using principal component analysis in suburban Nepal.

**Methods:** This cross-sectional study was conducted among 479 adult participants (18 years or above) of the Dhulikhel Heart Study, who provided blood samples in the baseline survey. Dietary intake information was collected through a validated semi-quantitative food frequency questionnaire (FFQ). Principal component analysis identified four major dietary patterns (mixed, fast food, refined grains-meat-alcohol, solid fats-dairy). Type-2 diabetes was defined as glycated hemoglobin (HbA1c) of 6.5 % or higher. We used generalized estimating equations (GEE) with multivariate logistic regression (with household as cluster), exchangeable correlations and robust variance to assess the association between the derived dietary patterns and type-2 diabetes adjusting age, sex, ethnicity, religion, marital status, income and education, alcohol consumption, smoking, physical activity, blood pressure, total cholesterol, triglyceride, and high density lipoprotein.

**Results:** Type-2 diabetes was positively associated with the refined grains-meat-alcohol pattern (aOR 1.18, 95% CI: 0.93 -1.49), and fat and dairy pattern (aOR 1.17, 95% CI:

0.89 -1.54). However, the associations were not statistically significant (p>0.05). There was no significant effect modification by age, sex, and body mass index in the association between the food patterns and type-2 diabetes (p>0.05).

**Conclusions:** Our findings were inconclusive regarding the association between the derived dietary patterns and type 2 diabetes. The hypothesis should be tested in a larger sample.

## BACKGROUND

Type 2 Diabetes Mellitus (T2DM) has become an epidemic worldwide.[1] By the time of diagnosis, many individuals have developed complications such as cardiovascular disease, renal dysfunction, and retinopathy.[2] Diabetes is a complex disease resulting from the interaction of genetic susceptibility factors, modifiable environmental and nutritional factors.[3] Hence, reducing diabetes through nutritional modification holds great promise as a strategy to help prevent cardiovascular diseases. Remarkably little data exist on food consumption or nutrition patterns despite evidence that the prevalence of diabetes is increasing dramatically in Nepal.[4-6]

Studies of the individual-level relationship between diet and type 2 diabetes mellitus have largely focused on macronutrients and fiber.[7-11] However, these dietary nutrients explain only a part of the total effect of diet on glucose metabolism. Moreover, daily food intake seldom consists of a single nutrient, and their combinations undoubtedly have interactive and synergistic effects. In addition, food additives, bioavailability, and physical properties of foods may affect glucose metabolism. The overall dietary pattern may be a more relevant risk factor for diabetes than individual foods and nutrients. Hence, the analysis of patterns of dietary intake by using principal component analysis has emerged as a useful tool for elucidating the relation of diet with diabetes and other diseases.[12-14]

Dietary patterns reflect the way foods are consumed in reality, which may provide insight into possibilities for dietary changes and may facilitate the translation of research to public health recommendations. Recent dietary intervention studies have indicated that interventions focused on dietary patterns can decrease blood pressure[15] and reduce cardiovascular complications.[16] American and European studies have suggested that desired dietary patterns to prevent diabetes include increased intake of vegetables, fruits and fish.[17-19] However, because dietary patterns in Nepal differ from those of other countries, the effects could be different. Nevertheless, little is known about the role of diets typically consumed by Nepalese. In addition, the effect of dietary patterns on diabetes independent of other lifestyle factors has not been assessed in the Nepalese population. The present study aims to identify dietary patterns in a suburban Nepalese community and to assess the association of the derived dietary patterns with diabetes prevalence.

## METHODS AND MATERIALS

**Study sample:** This study was based on data from the first wave of the baseline survey of the Dhulikhel Heart Study (DHS). The DHS is a population-based cohort designed to investigate cardiovascular diseases (CVD) and its conventional risk factors in a suburban community of Nepal. In the first wave, about one-third of the households (n=735) in the town of Dhulikhel were randomly selected from 9 strata based on administrative divisions. All eligible residents (n=1,372) of the sample households were invited to participate in the study. The eligibility criteria were: being a permanent resident of Dhulikhel; living in Dhulikhel for at least six months; non-pregnant; and able to communicate in *Nepali* or *Newari* language. Among 1,073 eligible subjects who participated in the study, those who had provided blood samples (n=474) were included in the current analysis. A written informed consent was obtained from all the participants, and the institutional review boards of the University of Washington and the Nepal Health Research Council approved the study.

**Dietary assessment**

Dietary intake information was collected through a semi-quantitative food frequency questionnaire (FFQ). The participants reported how often they had consumed 115 common foods in the past year in terms of times per day, per week, per month, per year, or never. The questionnaire was supplemented with color photographs of four different portion sizes for those food items that do not have natural units or applicable household measures such as slice, number, spoon etc. A professional photographer developed the photographs under controlled conditions including distance, angles, light, and presentation. Different sizes of glasses or bowls were presented to estimate the amount of liquids.

To identify dietary patterns collected in the FFQ, we applied principal component analysis to the data obtained from the 1,073 participants of the DHS. The detail of the process is explained elsewhere.[20] In brief, we grouped the food items on the questionnaire into 23 predefined food groups based on macronutrient. We applied principal components analysis using STATA software and varimax rotation to the food intake expressed as number of servings per week. The obtained factors (food patterns) are linear combinations of the included variables and explain the variation in the original variables as much as possible.[13,21] We retained four factors based on the eigenvalues, scree plot, and interpretability of the derived factors. For each participant we calculated the food pattern scores by summing the standardized intake of the foods, weighted by the factor loadings of the food.

Principal component analysis revealed four major dietary patterns. Factor 1 was dominated by intake of lentils, fruits, vegetable, fatty foods, noodles, tea and coffee (mixed pattern). Factor 2 included intake of fast foods, soda drinks and sweets (fast food pattern); Factor 3 included intakes of refined grains, meat, fish, alcohol (refined grain-meat- alcohol pattern); and Factor 4 consisted of milk, dairy products, and solid fats (solid fats and dairy pattern). Factors 1, 2, 3 and 4 accounted for 17.3 %, 8.5%, 7.7%, and 6.5% of the variation in the food intake, respectively.[20]

**Ascertainment of type 2 diabetes**

Type 2 diabetes was defined as glycated hemoglobin (HbA1c) of 6.5 % or higher.[22] Following a household interview, the participants were invited to a mobile blood collection center near their residence (20 minutes walking distance) within three months of the initial interview. Qualified personnel drew venous blood after 8-12 hours of overnight fast at the mobile blood collection centers. A total of 11.0 mL of blood was collected and transported on wet ice (HOPKINS BAG) without allowing samples to freeze or be exposed to an ambient temperature of greater than 25°C. HbA1c was estimated using the Nycocard analysis system (Axis shield Co., Norway) certified by the National Glycohemoglobin Standardization Program (NGSP) at the Department of Clinical Biochemistry, Dhulikhel Hospital-Kathmandu University Hospital, Nepal. All of the assays were routinely monitored through external quality-control programs using assayed chemistry & mission controls (Bio-Rad Laboratories and Diamond diagnostics, USA).

**Measurements of other variables:**

Information on socio-demographic variables such as age (years), sex (male/female), ethnicity (newar / brahmin, chhetri / other), religion (Hindu/ non Hindu), marital status (married/ not married), annual income (converted to US$), education (number of formal years of education), and smoking (pack-years) were obtained through a standardized health interview collected during home visits. We used the global physical activity questionnaire and expressed the measure as metabolic equivalent (MET) minutes per week.[23] One MET is defined as 1 kcal/kg/hour and is roughly equivalent to the energy cost of sitting quietly. The data for triglycerides (mg/dL), total cholesterol (mg/DL) and high-density lipoprotein (mg/dL) were from laboratory tests completed from the blood collection at mobile centers collected after the home visit. Three measurements of systolic and diastolic blood pressure were taken using Microlife automatic blood pressure measuring device. The mean of the three measurements was used in the analysis (mmHg). Hypertension was defined as a systolic blood pressure 140 mm Hg or greater; or diastolic blood pressure 90 mm Hg or greater; or taking antihypertensive.[24]

**Statistical Analysis**

We described the sample characteristics for the study participants using means and standard deviations for continuous variables, and percentages for categorical variables. We used generalized estimating equations (GEE) with multivariate logistic regression and exchangeable correlations to assess the association between the derived dietary patterns and type-2 diabetes measured as a binary outcome. GEE corrects for correlation and lack of independence for participants from common household and robust variance estimators are used for valid inference under possibly misspecified correlation structure.[25] The derived food patterns were analyzed separately in the statistical model with type 2 diabetes as the main outcome. The odds ratios are reported with 95% confidence interval in the following four hierarchical models for each food pattern: (1) crude odds ratio; (2) odds ratio adjusted for demographic variables (age, sex, ethnicity, religion, marital status, income and education; (3) odds ratio adjusted for demographic and lifestyle variables (alcohol consumption, smoking, physical activity, systolic blood pressure); (4) odds ratio adjusted for demographic, lifestyle and other cardiovascular risk factors (total cholesterol, triglyceride, and high density lipoprotein). We conducted sensitivity analysis by using the servings per week of food groups in each food pattern as an exposure instead of factor score. We explored the interaction of the derived food patterns with age, gender, and body mass index.

**RESULTS**

The characteristics of the 479 participants with the blood sample and 594 participants without the blood sample in the study sample are shown in Table 4-1. On average, those with the blood sample were slightly older and less educated than those without. There were more Newars with the blood sample. The average income was higher for those whose blood sample was not collected. There was no difference in the marital status and religion between the two groups.

**Table 4-1. Demographic characteristics of the community-based participants of the Dhulikhel Heart Study with and without blood sample**

| Characteristics | Participants with blood sample (n=479) | Participants without blood sample (n=594) |
|---|---|---|
| **Age, mean (SD) (years)** | 41.1 (16.4) | 39.7 (16.3) |
| **Ethnicity (n,%)** | | |
| Newar | 196 (40.9) | 331 (55.7) |
| Brahmin/Chhetri | 156 (32.6) | 142 (23.9) |
| Other | 127 (26.5) | 127 (20.4) |
| **Education (n,%)** | | |
| No formal education | 162 (33.8) | 178 (29.9) |
| Less than high school | 223 (46.6) | 255 (42.9) |
| High school or more | 94 (19.6) | 161 (27.1) |
| Mean years of education (SD) | 6.2 (5.4) | 6.9 (5.6) |
| **Annual income, mean (SD) (USD)** | 793.3 (3136.8) | 873 (3056) |
| **Marital Status** | | |
| Married | 360 (75.3) | 424 (71.4) |
| Non married | 119 (24.8) | 170 (28.6) |
| **Religion (n,%)** | | |
| Hindu | 406 (84.8) | 504 (84.8) |
| Non-Hindu | 73 (15.2) | 90 (15.2) |

The prevalence of cardiovascular disease traditional risk factors of participant of DHS with and without blood sample is presented in Table 4-2. The prevalence of non-smokers and non-drinkers was similar between both groups. On an average, participants with blood sample were slightly more likely to be hypertensive and physically active. The distribution of body mass index was similar between the two groups. The prevalence of type 2 diabetes was 31% among those with the blood sample, and could not be estimated for those without the sample.

Table 4-3 shows the associations of food patterns with prevalence of type 2 diabetes. None of the derived dietary patterns were significantly associated with type 2 diabetes among the adult participants of Dhulikhel heart study. In terms of the direction of the associations, refined grains-meat-alcohol pattern, and fat and dairy pattern were positively associated with diabetes. However, the associations were not statistically significant. Similar results were obtained when number of servings of food groups in each food pattern was used as the main exposure instead of food pattern score.

There was no significant effect modification by age, sex, and body mass index in the association between the food patterns and diabetes. (Table 4-4)

**Table 4-2. Traditional risk factors for cardiovascular disease in the community - based Nepalese adults participants of Dhulikhel Heart Study with and without blood sample**

| Traditional risk factors | Participants with blood sample (n=479) | Participants without blood sample (n=594) |
|---|---|---|
| **Smoking, n(%)** | | |
| Never | 329 (68.7) | 397 (66.8) |
| Former | 51 (10.7) | 48 (8.1) |
| Current | 99 (20.7) | 149 (25.1) |
| Pack years, mean (SD) | 6.2 (16.01) | 5.4 (13.2) |
| **Alcohol, n (%)** | | |
| Never drinkers | 331 (69.1) | 404 (68.0) |
| Low (<1 glass per week) | 37 (7.7) | 61 (10.3) |
| Moderate (1-3 glass per week) | 33 (6.9) | 26 (4.4) |
| High (3 or more glass per week) | 78 (16.3) | 103 (17.4) |
| Drinks per week, mean (SD) | 6.4 (23.7) | 5.9 (26.3) |
| **Physical activity, n (%)** | | |
| < 600 MET minutes per week* | 182 (38.0) | 241 (40.6) |
| 600 MET minutes per week | 297 (62.0) | 353 (59.4) |
| MET minutes per week, mean (SD) | 3689 (5423.1) | 3341 (5476) |
| **Body Mass Index** | | |
| Underweight (<18.5) | 31 (6.5) | 33 (5.6) |
| Normal (18.5 - 24.9) | 258 (53.9) | 353 (59.4) |
| Overweight (25.0-29.9) | 152 (31.7) | 163 (27.4) |
| Obese (30.0 or more) | 38 (7.9) | 45 (7.9) |
| BMI, mean (SD) (kg/m$^2$) | 24.0 (4.1) | 23.9 (3.9) |
| **Hypertension, n (%)** | 149 (31.1) | 172 (28.9) |
| **Diabetes, n (%)*** | 153 (31.9) | NA |
| **Triglycerides, n (%)*** | | |
| High (>200 mg/dl) | 367 (76.6) | NA |
| Borderline high (150–199 mg/dL) | 64 (13.4) | NA |
| Normal (< 150 mg/dL) | 48 (10.0) | NA |
| **HDL, n (%)*** | | |
| Low (<35 mg/dL) | 361 (75.4) | NA |
| Normal (>= 35 mg/dL) | 118 (24.6) | NA |
| **Total cholesterol, n (%)*** | | |
| High (>=200 mg/dl) | 26 (5.4) | NA |
| Borderline ( 200 – 239 mg/dL) | 73 (15.2) | NA |
| Normal (< 200 mg/dL) | 380 (79.3) | NA |

*

**Table 4-3. Association of the food patterns with type 2 diabetes in the 479 community-based adults participating in the Dhulikhel Heart Study**

| | Model – 1 Univariate analysis n=474 | | | Model – 2 Adjusted for demographic variables * n=474 | | | Model – 3 Additionally adjusted for traditional risk factors ** n=474 | | | Model – 4 Additionally adjusted for cholesterols *** n=474 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Odds Ratio | 95% CI | P-value | Odds Ratio | 95 % CI | P-value | Odds Ratio | 95% CI | P-value | Odds Ratio | 95% CI | P-value |
| **Food patterns#** | | | | | | | | | | | | |
| Mixed | 0.91 | (0.77, 1.07) | 0.25 | 0.98 | (0.81, 1.18) | 0.81 | 0.97 | (0.80, 1.17) | 0.73 | 0.92 | (0.74, 1.15) | 0.48 |
| Fast food | 0.77 | (0.58, 1.02) | 0.07 | 1.05 | (0.77, 1.44) | 0.74 | 0.97 | (0.69, 1.37) | 0.86 | 0.96 | (0.70, 1.31) | 0.79 |
| Refined grain-meat-alcohol | 1.02 | (0.81, 1.29) | 0.85 | 1.09 | (0.81, 1.46) | 0.58 | 1.11 | (0.81, 1.52) | 0.54 | 1.18 | (0.93, 1.49) | 0.18 |
| Fats and Dairy | 1.18 | (0.93, 1.49) | 0.18 | 1.20 | (0.93, 1.55) | 0.15 | 1.21 | (0.93, 1.57) | 0.16 | 1.17 | (0.89, 1.54) | 0.26 |

# Factor scores were used as continuous variable in the model
* Adjusted for gender, marital status, religion, ethnicity, education, annual income
** Adjusted for gender, marital status, religion, ethnicity, education, annual income, smoking, alcohol intake, physical activity, systolic blood pressure
*** Adjusted for gender, marital status, religion, ethnicity, education, annual income, smoking, alcohol intake, physical activity, systolic blood pressure, total cholesterol, HDL, triglyceride

**Table 4-4. Effect modification by age and sex in the association of food patterns with diabetes among the 479 community based adults participating in the Dhulikhel Heart Study**

| | Coefficient of Interaction | 95% CI | | P-value |
|---|---|---|---|---|
| **By age** | | | | |
| Mixed | 1.00 | (0.99 , | 1.21) | 0.50 |
| Fast food | 1.01 | (0.99 , | 1.02) | 0.45 |
| Refined grain-meat-alcohol | 0.99 | (0.98, , | 1.01) | 0.80 |
| Solid fats and dairy | 1.00 | (0.99, , | 1.01) | 0.80 |
| **By sex** | | | | |
| Mixed | 0.88 | (0.59 , | 1.32) | 0.54 |
| Fast food | 0.94 | (0.52 , | 1.71) | 0.86 |
| Refined grain-meat-alcohol | 1.13 | (0.74 , | 1.73) | 0.57 |
| Solid fats and dairy | 1.26 | (0.79 , | 2.02) | 0.34 |
| **By body mass index** | | | | |
| Mixed | 0.96 | (0.92 , | 1.00) | 0.06 |
| Fast food | 1.02 | (0.96 , | 1.07) | 0.51 |
| Refined grain-meat-alcohol | 0.98 | (0.93 , | 1.03) | 0.47 |
| Solid fats and dairy | 0.99 | (0.93 , | 1.06) | 0.92 |

## DISCUSSION

The study tested the association of diabetes with the four dietary patterns that characterized the dietary habits of this suburban Nepalese community: mixed pattern, fast food pattern, refined grains-meat-alcohol pattern, and fats and dairy pattern. None of the derived food patterns were significantly associated with type 2 diabetes in this study.

The derived dietary patterns are different from other studies as the Nepali diet is evidently different from that of other populations. It is difficult to compare the results across studies because of differences in dietary intake between populations[26] and factor scores are specific to the population under study. Despite dietary pattern variation between populations, some common characteristics between the patterns derived in different studies have been related to type 2 diabetes as described below.[27]

A dietary pattern characterized by high consumption of fruits and vegetables was found to be associated with reduced risk of type 2 diabetes in the Health Professionals Follow-up Study and the Finnish Mobile Clinic Health Examination study.[18,19] The inverse association between type 2 diabetes and dietary patterns containing fruits, vegetables and soy products was also shown in Chinese[28] and Japanese populations.[17] A cross-sectional study of Seventh-Day Adventists in California reported a lower risk of diabetes among vegetarians, who consumed more legumes, fruits, and nuts.[29] The plant-based diet is characterized by low energy intake, low glycemic load, high fiber content and has phytochemicals and antioxidants that improve insulin metabolism.[30,31] In our study, fruits and vegetables were consumed together with other unhealthy foods such as fatty foods represented in the mixed pattern. The mixed pattern was inversely associated with type 2 diabetes prevalence, however the association was not statistically significant. The lack of statistically significant results may be due to inadequate sample size or due to the counterbalance of potential insulin resistance attributable to high fat foods.[32]

We observed positive associations, although not significant, between the refined grains-meat-alcohol pattern and type 2 diabetes. Intake of several meat products was associated with the risk of type 2 diabetes mellitus in Japanese women.[33] Chinese adults with higher consumption of meats, fried foods, and sweetened foods experienced a significantly increased risk of type 2 diabetes.[28]The Western pattern highly loaded with processed and red meat was correlated with fasting insulin levels in US population[34] and Swedish population.[35] The adverse effects of meat, dairy products and refined grains have been attributed to their higher saturated fat and carbohydrate content, which may lead to hyperglycaemia and hyperinsulinaemia, and therefore higher risk of diabetes.[7,36]

We had blood samples from 479 out of 1,073 participants of the first wave of the DHS participants. The smaller sample size of this study might have lead to insufficient power to detect an association.[37] The total energy and nutrient intake determined from the food frequency questionnaire were not calculated and validated, as these estimations might be biased.[38] Persons with a high score for a dietary pattern probably consumed more energy than those with a low score. The high energy intake usually increases the risk of type 2 diabetes[39], and the lack of adjustment for energy intake might cause a superfluous positive association and may have spuriously decrease the strength of inverse association.

The DHS data collectors made home visit to the participants to interview and invited the participants to the mobile clinic for subsequent collection of the blood sample. All participants who were invited did not show up at the clinic. We do not know the diabetic status of the people in the population who did not provide the blood sample. However, there was no major difference in the dietary scores, demographic characteristics, and traditional risk factors among those who provided the blood sample and those who did not. So, it is not likely that the participants of the study are unrepresentative of the entire sample. Diabetes was not diagnosed from the findings of oral glucose tolerance tests and levels of blood glucose. However, we measured HbA1c, which is a standard clinical method of assessing diabetes.[22] The HbA1C has several advantages to the oral glucose tolerance test and blood glucose levels, including greater convenience (fasting not required), possibly greater pre-analytical stability, and less day-to-day perturbations during stress and illness.[22]

Strengths of the current study include the geographic residency of participants from a non-Western country, which uniquely contributes to the literature. Another particular strength was the use of a FFQ that was specifically developed and validated in this population. The FFQ was administered by trained data collectors that result in consistent interpretations, higher response and better completion rates, especially among the population with a lower literacy rate.[40] The data-driven food pattern analysis has emerged as a complementary approach to examining the relationship between diet and chronic disease as the effects of overall diet rather than individual nutrients.[41] Furthermore, we have used advanced multivariate analysis to adjust for different socio-economic, lifestyle, and traditional CVD risk.

Limitations to consider in the interpretation of study include the subjective nature of some decisions used in factor analysis. These included choosing the method of rotation of the initial factors, determining the number of factors to retain, and labeling dietary patterns based on their factor loadings. Additionally, the results do not always correspond with the established dietary recommendations and comparisons across studies can be difficult because the outcomes are dependent on the specific population.[41] Inevitably, diet was measured with some error, although this would most likely result in non-differential misclassification with respect to disease, as most of the participants did not know about their disease status. The self-report of the other lifestyle related data might also have resulted in some misclassification and residual confounding in our models. Because this is a cross-sectional study, temporality cannot be established. Thirteen percent of the total diabetes cases were diagnosed before the study was conducted (data not shown). There is possibility that some dietary behavior modification may have occurred in previously diagnosed diabetes cases, leading to an estimated association towards the null. However, the results were not different when we excluded the previously known cases of diabetes in the analysis (data not shown). Finally, the results are only applicable to the populations with similar dietary behaviors especially in suburban Nepal.

**Conclusions**

Our findings were inconclusive regarding the association between the derived dietary patterns and type 2 diabetes. Although statistically insignificant, the refined grains-meat-alcohol pattern and solid fat and dairy pattern were positively associated with type 2 diabetes. Further work with larger sample size is needed to examine this relationship.

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# Chapter 5
# Conclusion and Implications for Future Research

In this dissertation, we tested the relative validity and reproducibility of a food frequency questionnaire administered to measure usual dietary intake of the participants of the Dhulikhel Heart study (DHS). Next, we identified the major dietary patterns representing food habits of the suburban Nepalese and investigated the relationship of the identified dietary patterns with overweight, obesity, and type 2 diabetes in a suburban community of central Nepal.

The FFQ was designed to measure the usual intake of major foods among adult (≥18 years) population of Dhulikhel town, a suburban community in the central Nepal. The servings per week of the foods in food groups, estimated by the FFQ, fairly represented the servings per week measured by an average of six 24-hour dietary recall implying acceptable validity. The reproducibility of the FFQ was established by the good correlation between the servings of food groups intake measured by two FFQs three months apart. Hence, the 115-item FFQ supplemented with the photographs of portion size is suitable to measure the habitual Nepalese diet. The present tool is useful to capture the habitual diet as a risk factor for the epidemiological studies of cardiovascular and other chronic diseases in central Nepal.

We used the food data from the validated FFQ to derive major dietary patterns in community-based participants of the DHS. Four dietary patterns were discovered: (1) mixed pattern characterized by healthy foods like fruits, vegetables, lentils, potatoes and unhealthy foods like fatty foods and moderately sweetened beverages (tea/coffee); (2) fast food pattern characterized by typical fast food items of developed countries such as burgers, sausages, pizzas, soda drinks, and sweets; (3) refined grains-meat-alcohol pattern characterized by refined grains, red meat, poultry, fish, and alcohol; and (4) solid fats and dairy pattern characterized by solid fats, milk, and dairy products. The food patterns represent typical Nepali diet and witness introduction of western fast food diet in the population.

The refined grain-meat-alcohol food pattern was positively associated with the prevalence of overweight (BMI ≥ 25kg/m$^2$). The odds of overweight were 19% higher for a unit increase in the score of the refined grain-meat-alcohol pattern (higher the score, more the intake of food groups). Age significantly modified the effect of the fast food pattern on overweight and obesity. Individuals older than 40 years, but not the younger, were more likely to be obese for higher consumption of fast foods. The mixed pattern, and solid fats and dairy pattern were not significantly associated with obesity and overweight.

Further, we tested the association of type 2 diabetes with the four dietary patterns. The findings were inconclusive. The refined grains-meat-alcohol pattern and fat-dairy pattern were positively associated with type 2 diabetes. However, the association was not statistically significant. The mixed pattern and fast food pattern had null associations with type 2 diabetes. We tested interactions between the dietary patterns and age, sex and body mass index, none of which were significant.

The current study is the first to test relative validity and reproducibility of a FFQ designed to measure Nepalese diet. We assessed diet throughout a year capturing the seasonal variation. The random errors from intra-person variations were removed by calculating the deattenuated correlation coefficients. The study measured food group intake rather than nutrient intake. This allowed dietary analysis to facilitate the recommendations aimed towards healthy eating. Although the validation study was conducted in a much smaller population, the sample had similar socio-demographic characteristics as the main cohort. Thus, the results of the validation study are generalizable to the DHS cohort.

The FFQ was administered in-person resulting in consistent interpretations and higher response rates in this population with high illiteracy. The data driven approach to derive dietary pattern is an emerging complementary approach to examine diet-disease relationship, and enables the translation of results into recommendable actions. We were able to collect and adjust for a wide range of socio-demographic, lifestyle and traditional CVD risk factors eliminating the possible alternative explanations of the current results.

The findings of the study should be interpreted in light of its limitations. First, we should be cautious to interpret validity of less frequently consumed food groups as six days of dietary recall may not be sufficient to represent their usual intake. Second, the observed correlation coefficients to measure validity and reproducibility may be higher because of greater between-person variation. Third, the factor analysis used for derivation of food patterns require subjective decision-making in choosing the variable scale, number of variables, number of factors to retain, and interpretations; substantially limiting the ability to generalize the results. Fourth, we did not consider genetic factors, which may modify the association of diet with overweight, obesity, and diabetes. Fifth, temporality cannot be established because of the cross sectional nature of the study. And finally, the results cannot be generalized in larger population, as Nepal is a multiethnic country with diverse food habit and culture.

The fact that the study was conducted in non-western setting makes it a unique contribution to the CVD literature. This study is one of the few attempts to characterize the Nepali diet and investigate its association with obesity and type 2 diabetes. Our results indicated that intake of refined grains, meat and alcohol increases the odds of being overweight, and individuals over the age of 40 are more likely to be obese due to fast food consumption in Nepalese adults. Greater efforts to disseminate information on the adverse health effects of fast food and refined grains, meat, and alcohol consumption should be made to increase awareness of the risks and help reduce CVD risk factors in Nepal.

These findings need to be replicated in longitudinal studies and using the alternate measures of adiposity such as waist circumference, hip-to-waist ratio, and percent of body fats. The confirmatory analysis of the dietary pattern derivation on other participants of the DHS can strengthen the findings of the study. A larger sample is necessary to test the association of the dietary patterns and type 2 diabetes. Other strategies for follow-up of these results may be to segregate the foods in the mixed dietary pattern into 'healthy' and 'non-healthy' foods and analyze them separately to understand the functioning of this pattern better. Since there is a wide body of evidence documenting the adverse effect of 'unhealthy' diets on overweight and obesity, future studies should also focus on specific food items within the dietary patterns that are responsible for these associations. Studying the nature of interactions between healthy and non-healthy foods, as well as food preparation processes, can be helpful to understand the mechanism of increasing prevalence of obesity and type 2 diabetes in the population. The methodology of this project could be used to investigate the association of dietary patterns with other cardiovascular diseases such as hypertension, high cholesterol, and metabolic syndrome. Understanding the relationship of dietary patterns with each of the CVD risk factors will facilitate to develop integrated intervention program in the community.

We plan to disseminate these study results at all levels from the policy makers to the health program implementers in Nepal. The authors will co-ordinate with the Ministry of Health and Population (MoHP) to present the findings at the annual health review meetings in the MoHP and Department of Health (DoH). We will prepare a brochure with highlights of the current study, in addition to other findings from the DHS and disseminate to the District Health Office at Dhulikhel. The health workers and health volunteers will also receive orientation and have access to the study findings via Internet.

There are scarce data on CVD and its risk factors in Nepal. The draft national policy on non-communicable disease focuses mainly on tobacco and alcohol control.[1] The national nutrition policy and strategy-2004 (updated in 2008) focuses on reduction of under-nutrition and promotion of ‘good dietary habits’ to increase body mass index of underweight women. The ‘good dietary habit’ has not been explained and the policy does not address the problem of over-nutrition at all.[2] The present research confirms the emergence of a fast food diet in suburban Nepal and implies its adverse health effect, at least on older adults. Similarly, the research suggests that traditional *Newari* diet of alcohol, refined grains, and meat can contribute to increasing the prevalence of obesity. Our study highlights the problem of over-nutrition and the role of the Nepalese diet in development of this problem. These results will enable policy makers to visualize the magnitude of the problem; and help facilitate development of an integrated approach for prevention and control of overweight and other non-communicable diseases in Nepal. Furthermore, this information may for preliminary basis for the policy makers to regulate fast food restaurants and their advertisements in Nepal.

At the regional level (Dhulikhel), this study builds evidence for the pressing need to build nutritional and CVD risk factor surveillance within the health information management system, which currently collects data on under-nutrition, infectious diseases and reproductive health.[3] Presently, the health workers and health volunteers are trained in delivery of services on communicable and reproductive health problems.[3] The results of this study seriously indicates that It is essential to train health workers and allocate resources in health system network to tackle the emerging problem of obesity, type 2 diabetes, and other non-communicable diseases.

Nepal has largely neglected the problem of non-communicable diseases such as diabetes, obesity and other CVDs risk factors. Low-income settings like Nepal face the challenge of redirecting already scarce health resources toward NCD prevention while competing with infectious diseases and reproductive health problems. The burden of CVDs and its risk factor will continue to rise unless proper surveillance system, adaptable interventions, and appropriate policies are on place. The present study emphasizes the critical need to address obesity and diabetes burden; design and implement nutritional and other interventions; and conduct further research to prevent these diseases in Nepal.

## REFERENCE FOR CHAPTER 5:


1. Nepal MoHaP. The integrated non-communicable diseases prevention and control policy of Nepal, 2003
2. Nepal MoHaP. National Nutrition Policy and Strategy. Kathmandu: Nutrition Section, Child Health Division, Department of Health Services, 2004.
3. Nepal MoHP. Department of Health Services. http://dohs.gov.np Accessed July 21, 2014.

Appendix 1: Food groups in the Food Frequency Questionnaire

(1) Cereals and lentils
    a. Whole cereals: wheat, millet, buckwheat, pearl millet, maize
    b. Washed cereals: roti (pan bread), sooji, beaten rice, white rice
    c. Whole Lentils: soyabean, whole pulse, sprout, check peas, dry peas, dry beans,
    d. Washed lentils: washed pulse
(2) Fats
    a. Oils: soybean oil, sunflower oil, mustard oil
    b. Milk fat: butter, ghee, tar (milk fat)
    c. Fatty foods: swaari, doughnut, pakauda, malpa, selroti
(3) Fruits and vegetables,
    a. Fruits: papaya, watermelon, pomegranate, mango, banana, lemon, grapes, lychee, plum, persimmon, guava, apple, pear, peach, pine apple, pomelo, grapefruit, orange, cucumber, carrot
    b. Vegetables: pointed gourd, green leafy vegetables, pumpkin, cabbage, broccoli, cauliflower, lady's finger, chayote, bottle gourd, tomato, egg plant, bitter melon, green bean, mushroom, bamboo shoots, jackfruit, sponge guard, gundruk (dried greens),
    c. Vegetable roots: sweet potato, potato, yam, radish, turnips, potato, garlic, onion
    d. Nuts/seeds: dried fruits, pistachio, walnut, almonds, cashew, peanut
(4) Meat and dairy,
    a. Poultry: egg, chicken with skin, chicken without skin, chicken momo,
    b. Buff: Buff slice, buff momo
    c. Pork: pork slice, pork momo
    d. Mutton: mutton slice, mutton momo
    e. Fish: non fried fish, fried fish
    f. Milk drinks: Milk, Milk tea, Milk coffee
    g. Milk products: cheese, paneer, yogurt
(5) Western foods
    a. Deep fried: Potato chips, French fries
    b. Sausage: chicken sausage, buff sausage, pork sausage
    c. Burgers: Chicken burger, veg burger
    d. Pizza, pasta, spaghetti

(6) Packaged food

a. Processed cereals: biscuit, cake, white bread, brown bread
b. Noodles: noodles, chowmein,
c. Salty snacks: pickles, dalmot/ bhujiya, canned food

(7) High sugar food

a. High sugar beverages: canned juice, fruit juice, Fanta, Sprite, Coke, Pepsi
b. Mildly sweetened beverages: Black coffee, Black tea
c. High sugar food: Ice cream, sweets, chocolate, sugar, jaggary, jam

Appendix– 2 Seasonal variations of fruits and vegetables

Fruits

1. Carrot: Jul – Mar (9 months)
2. Cucumber: Apr - Dec (9 months)
3. Pine apple: May-Sep (5 months)
4. Peach: Apr – Sep (6 months)
5. Guava: Sep-Jan (5 months)
6. Plum: May – Jul (3 months)
7. Lychee: May – Jul (3 months)
8. Papaya: Dec – Apr (5 months)
9. Grapes: Dec-Apr (5 months)
10. Banana: Jan- Dec (12 months)
11. Mango: Jun-Sep (4 months)
12. Pomegranate: Jan- Dec (12 months)
13. Watermelon: Apr – Jun (3 months)
14. Orange: Oct- Mar (6 months)
15. Pomelo: Nov- Dec (2 months)
16. Lemon: Sep – Feb (6 months)
17. Apple: Jan – Dec (12 months)
18. Pear: Jul- Oct (4 months)

Vegetables:

1. Cauliflower: Jul – March (9 months)
2. Cabbage: Jul – March (9 months)
3. Pumpkin: Jan – Dec (12 months)
4. Green bean: Dec – Mar (4 months)
5. Pointed gourd (parwar): Apr – Oct ( 7 months)
6. Bitter melon: Apr- Nov (8 months)
7. Egg plant: Jan – Dec (12 months)
8. Bottle groud (lauka): Arp – Oct (7 months)
9. Chayote (schoos): Aug – Mar (8 months)
10. Lady’s finger: Apr- Oct (7 months)

11. Sponge guard (ghiraula): Apr – Oct (7 months)
12. Jackfruit: Apr –Aug (5 months)
13. Mushroom: Jan – Dec (12 months)
14. Green leafy vegetables: Dec-Apr (5 months)
15. Broccoli: Sep- Jan (5 months)
16. Tomato: Jan – Dec (12 months)
17. Bamboo shoots: Jun-Nov (6 months)
18. Gundruk (dried greens): Jan – Dec (12 months)
19. Yam: Jan – Mar (3 months)
20. Sweet potato: Jan – Mar (3 months)
21. Potato: Jan – Dec (12 months)
22. Radish: Jul – Feb (10 months)
23. Turnips: Nov – Dec (2 months)
24. Potato: jan – Dec (12 months)
25. Garlic: Jan – Dec (12 months)
26. Onion: Jan – Dec (12 months)

Appendix – 3 Questionnaires (Sections relevant to the current study)

## DHULIKHEL HEART STUDY

**Personal questionnaire**

Interviewer code : __ __

### A. ELIGIBILITY CRITERIA

1. Are you resident of Dhulikhel ? (a) Yes ___ (b) No ___
2. Have you been living in Dhulikhel for past 6 months? (a) Yes ___ (b) No ___
3. Are you 18 years or above (a) Yes ___ (b) No ___
4. (If female), are you currently pregnant? (a) Yes ___ (b) No ___
5. Does participant appear to be cognitively able to conduct the interview?
6. (Enumerator will observe the condition of the respondent) (a) Yes ___ (Specify) ________________(b) No ___

### CONSENT

(a) Agree ___ (b) Disagree ___ → Interview ends

Interview start time………………….. Date of interview (DD/MM/YYYY)……………………………

### B. PARTICIPANT'S INTERVIEW

1. Ward number: __ __ 2. Tole Name ___________________ 3. Household number __ __ __ __ __ __
4. Family number: __ __ 5. Serial Number of the person from form1 __ __
6. Identification Number: __ __ __ __ __ __ __ __ __ *(DH-ward no.-household no.-family no.-personal serial no in the family.)*

### C. DEMOGRAPHIC CHARACTERISTICS

1. What is your full name ? ________________ _________________
2. Sex (Observe): (a) Male __(b) Female __ (c) Third gender __
3. What is your mobile number? __ __ __ __ __ __ __ __ __ __
4. What is your email address? (If not available write NA) ___________@ ______. com
5. What is your age? (Completed years) __ __ years
6. What is your birth date ? __ __ / __ __ / __ __ __ __
7. What is your citizenship number? __ __ __ __ __ __ __ __
8. What is your ethnic group?
   (a) Brahmin __ (b) Chettri/Thakuri/Sanyasi __ (c) Newar __
   (d) Magar/Tamang/Rai/Limbu __ (e) Sherpa/Bhote ___ (f) Kami/Damai/Sarki/Gaaine/Baadi __
9. What is your mother tongue? (a) Nepai __ (b) Newari __
10. What is your marital status?
    (a) Never married __ (b) Currently married __ (c) Separated __
    (d) Widowed __ (e) Cohabiting__ (f) Refused__
11. What was your age when you got married? __ __ years
12. What was age of your spouse when you got married? __ __ years
13. What is your religion?
    (a) Hindu __ (b) Buddhist __ (c) Muslim __ (d) Kirat __ (e) Christian
14. What is the highest grade or year of school you have ever completed, including college? ___ __ years
15. For How long did you have Vocational Training? __ __ months
16. Which one best describes the kind of work you have done most of your life?
    (a) Professional ___ (b) Clerical __ (c) Sales and services __ (d) Skilled manual __
    (e) Unskilled manual __(f) Agriculture __(g) Student __ (h) Housewife __ (i) Military / Police __
17. Which of the following describes your main status over the past 12 months?
    (a) Government employee __ (b) Non-government employee __ (c) Self-employed __
    (d) Non-paid __ (e) Home maker __ (f) Unemployed __ (g) Student __

18. Talking about the past year, what was your average earning? ____________ (per day / per month / per year)
19. Give me the name and contact number of three people with who you expect to be in close contact in future

## E. SMOKING

*Now I will ask you some smoking related questions, okay?*

20. Have you ever used tobacco such as cigarettes, bidi, pipe, cigars, khaini, surti, jarda paan, hukka, chilim, tamakhu? (a) Yes __ (b) No __ →
21. At what age did you start tobacco use? __ __ years
22. Have you used tobacco in the last month? (a) Yes __ (b) No __
23. At what age did you stop tobacco use? ____ years
24. Have you ever smoked cigarettes? (a) Yes __ (b) No __
25. How many days do you smoke in a typical month? __ __ days
26. The day when you smoke, on an average how many cigarettes do you smoke?................( number of cigarettes smoked per day)
27. Do you usually smoke filter cigarettes or non-filter cigarettes? ((Show Card; Picture Number) filter cigarettes have filter i.e. a small sponge at the end of the cigarettes)
    (a) Filter cigarettes __ (b) Non-filter cigarettes __ (c) Don't know __
28. Have you ever smoked bidi? (Asking about only bidi) (a) Yes __ (b) No __
29. How many days do you smoke in a typical month? ______days
30. The day when you smoke, on an average how many cigarettes do you smoke? ___
31. Have you ever smoked pipe or cigar? (a) Yes __ (b) No __
32. How many days do you smoke in a typical month? __ __ days
33. The day when you smoke, on an average how many cigarettes do you smoke? ___

## F. ALCOHOL DRINKING

34. Do you ever drunk any alcoholic drink such as beer, wine, jaad, chhyang, tongba, ningaar, raksi, soltyang, whiskey, brandy, rum, vodka, sherry, champagne? (a) Yes __ (b) No __ (c) Refused __
35. At what age did you start drinking alcoholic drink? ___ years
36. Do you ever drink beer? (Currently or in the past, ask only of beer) (a) Yes __ (b) No __ →
37. How many days do you drink beer in a typical month? __ __(Week/ Month)
38. The days when you drink, how many bottles (650 ml) of beer do you normally drink in one day? ______ml
39. What is the maximum number of drinks in one occasion you had in the past month? ______
40. Do you ever drink jaad, chhyang, tongba or nigaar? (a) Yes __ (b) No __ (9) Refused
41. How many days do you drink jaad, chhyang, tongba or nigaar in a typical month? ________ (Week/ Month)
42. The days when you drink, how many glassess of jaad, chhyang, tongba or ningaar do you normally drink in one day? (Show picture of glasses and write in ml from the booklet) _______ml
43. What is the maximum number of drinks in one occassion you had in the past month? (Show picture of glasses and write in ml from the booklet) ______ml
44. Do you ever drink wine, sheery or champagne? (a) Yes (b) No__(c) Refused
45. How many days do you drink wine in a typical month? …………… (Week/ Month)
46. The days when you drink, how many glasses of or champagne do you normally drink in one day? (Show picture of glasses -picture number 28) _______ml
47. What is the maximum number of drinks in one occasion you had in the past month? (Show picture of glasses -picture number 28) _______ml
48. Do you ever drink raksi, aila or soltyang (hard liquor)? (a) Yes __ (b) No __ (c) Refused__
49. How many days do you drink raksi, aila or soltyang in a typical month? ___(Week/ Month)
50. The days when you drink, how many glasses of rakshi, aila or soltyang do you normally drink in one day? ? (Show picture of glasses -picture number 28______ml
51. What is the maximum number of drinks in one occasion you had in the past month? Show picture of glasses -picture number 28) _____ml
52. Do you ever drink whisky, scotch, brandy, rum or vodka? (a) Yes __ (b) No __ (c) Refused

53. How many days do you drink whisky, scotch, brandy, rum or vodka in a typical month? ____(Week/ Month)
54. The days when you drink, how many glasses of whisky, scotch, brandy, rum or vodka do you normally drink in one day? ___ml
55. What is the maximum number of drinks in one occasion you had in the past month? ____ ml
56. In the past five years, has your alcohol intake increased, decreased or remained the same?
    (a) No__ (b) Increased intake __ (c) Decreased intake __
57. If you do not drink alcohol now, did you ever drink alcohol regularly? (for former drinker)(a) Yes __ (b) No __
58. At what age did you start drinking? ____ years
59. At what age did you stop drinking alcohol regularly? ___years
60. How many drinks per week did you usually drink? ____
61. What is the maximum number of drinks that you ever had on one occasion? ____

**FOOD FREQUENCY**

87. How many times do you usually eat in a day? (Times of eating) __
88. Do you regularly take any vitamin supplementation? (Vitamin supplement) (a) Yes __ (b) No __
89. If yes, which vitamins do you take? ______________
90. How many months ago did you start taking vitamin supplementation? _____ Months
91. Do you take calcium supplementation? (a) Yes __ (b) No __
92. How many months ago did you start taking calcium supplementation? _____ Months
93. Do you take iron supplementation? (a) Yes __ (b) No __
94. How many months ago did you start taking iron supplementation? ____ Months
95. Do you take fish oil or omega-3 supplementation? (a) Yes __ (b) No __
96. How many month ago did you start taking fish oil or omega-3 supplementation? ____ Months
97. Do you usually add table salt to food or fruit before eating? (Add table salt) (a) Yes __ (b) No __
98. Do you usually add sugar to your tea or coffee? (Add sugar) (a) Yes __ (b) No __
99. Do you use artificial sugar instead of sugar? (Artificial sweetener) (a) Yes __ (b) No __
100. Have you changed your eating pattern/food due to any disease? (a) Yes __ (b) No __
101. If yes, Name the disease ______________ _____________ _______________
102. How many times in a week do you eat out of home? (in a restaurant or hotel? ____
103. Do you usually eat animal fats with meat? (eat boso) (a) Yes __ (b) No __

104. Last year, what did you eat and how often (Show portion size picture)

| | Unit | | | | | Portion size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Frequency of eatin | **Never** | **Day** | **Week** | **Month** | **Year** | **A** | **B** | **C** | **D** | **None** |
| Rice | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Beaten rice | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Wheat | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Choumin | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| pasta macaroni spaghetti | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Sooji | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| atta roti | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| bhuteko maize | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| white bread | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| brown bread | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| kodo fapar bajra | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| whole pulse | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Washed pulse | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Sprout | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Cheakpeas dry peas beans | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Soyabean | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Broccoli Cauliflower | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| cabbage kohlrabi | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Pumpkin | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Potato | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Greenveg | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Radish Turnip | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Parwal | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Green Beans Peas | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Karela | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Egg Plant | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Tomato | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Lauka | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Schoos | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| lady's finger | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Ghiraula | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Rukhkatahar | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| YAM | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Sweet Potato | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Taamaa | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Gundruk | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Mushroom | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Garlic | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| onion_shallot | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Carrot | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Cucumber | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Orange | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| grape_fruti | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| pine_apple_freq | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| jujube_aaru | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| apple_pear | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Guava | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Alubakhada | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Lychee | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Grapes | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Lemon | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Banana | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Mango | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Pomegranate | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Watermelon | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Papaya | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Mutton | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| chicken_with_skin | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| chicken_without_skin | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| chicken_mo_mo | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Sausage | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Buff | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| buff_mo_mo | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| buff_sausage | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Pork | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| pork_mo_mo | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| fried_fish | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| nonfried_fish | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Egg | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| whole_milk | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| low_fat_milk | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Yogurt | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| milk_tea | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| black_tea | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| milk_coffee | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| black_coffee | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| coke_pepsi_mountain_dew | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| fanta_sprite | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| fruit_juice | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| canned_juice | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Paneer | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Pizza | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Cheese | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Biscuit | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Noodles | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| canned_food | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Peanut | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Cashew | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Almonds | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Walnut | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Pistachio | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Dried fruit | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Bhujiya | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| veg_burger | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| chicken_burger | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Potato chips | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Donought | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| ice_cream | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Chocolate | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Sweets | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Malpa | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Swaari | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Pakauda | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| french_fries | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| mustard_oil | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| sunflower_oil | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| soyabean_oil | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Butter | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Ghee | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Sugar | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Jaggary | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Jam | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |
| Pickels | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 0 |

## PHYSICAL ACTIVITY

***(****In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.****)***

### Activity at work

105. Does your work involve vigorous-intensity activity that causes large increase in breathing or heart rate like carrying or lifting heavy loads, digging or construction work, etc.. for at least 10 minutes continuously?

(a) Yes _ (b) No

106. If Yes, In a typical week, on how many days do you do vigorous- intensity activities as part of your work? (no.of days) _____ (days/ month/year)

107. How much time do you spend doing vigorous-intensity activities at work on a typical day?_____ (minutes/ hour)

108. In a typical year, how many months are you involved in this activity? ______ months

109. Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking [or carrying light loads] for at least 10 minutes continuously? (a) Yes __ (b) No __

110. In a typical week, on how many days do you do moderate- intensity activities as part of your work?
___ (days/month/year)

111. How much time do you spend doing moderate-intensity activities at work on a typical day? ___ (mins/ hour)

112. In a typical year, how many months are you involved in this activity? ______

**Travel to and from places** *(The next questions exclude the physical activities at work that you have already mentioned. Now I would like to ask you about the usual way you travel to and from places. For example to work, for shopping, to market, to place of worship)*

113. Do you walk or use a bicycle (pedal cycle) for at least 10 minutes continuously to get to and from places?
(a) Yes __ (b) No __

114. If yes, 10. In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places? _____ (days/ month/year)

115. How much time do you spend walking or bicycling for travel on a typical day? ___ (minutes/ hour)

**Recreational activities**

116. Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like [running or football,] for at least 10 minutes continuously?
(a) Yes __ (b) No __

117. If yes,13. In a typical week, on how many days do you do vigorous-intensity sports, fitness or recreational (leisure) activities? (number of days) _____ (days/ month/year)

118. How much time do you spend during vigorous-intensity sports, fitness or recreational activities on a typical day? ___ (minutes/ hour)

119. In a typical year, how many months do you do vigorous-intensity sports, fitness or recreational activities?
____ months

120. Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that causes a small increase in breathing or heart rate such as brisk walking,(cycling, swimming, volleyball)for at least 10 minutes continuously? (a) Yes __ (b) No __

121. If yes, 17 In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities? (Number of days) _____ (days/ month/year)

122. 18 How much time do you spend doing moderate-intensity sports, fitness or recreational (leisure) activities on a typical day? ___ (minutes/ hour)

123. In a typical year, how many months do you do moderate-intensity sports, fitness or recreational activities?
____ months

**Sedentary behavior**

124. 20 How much time do you usually spend sitting or reclining on a typical day? ___ (minutes/ hour)

## MEASUREMENT

*Now we are going to take some measurements*

214. Blood Pressure (three measurements)

Systolic blood pressure (1st ) __ Systolic blood pressure (2nd) __ Systolic blood pressure (3rd) __

Diastolic blood pressure (1st) __ Diastolic blood pressure (2nd) __ Diastolic blood pressure (3rd) __

Pulse (1st) Pulse (2nd) ___ Pulse (3rd) ___

215. Anthropometry

(a) Height :____ cm (b) Weight :___ pounds (c)Waist :___ cm (d) Hip: ___ cm

(e) Neck to middle finger: ___ cm