Dietary Diversity Tools and Factors Affecting Dietary Patterns in Kolli Hills, India

by

Tian Huang

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Nutrition and Metabolism

Department of Agriculture, Food, and Nutritional Sciences
University of Alberta

Abstract

The first part of this study is a narrative literature review to provide an overview of the methods used to assess dietary diversity. The second part of this study is a case study to explore the factors affecting dietary diversity as well as the perceptions of a kitchen garden intervention in improving dietary diversity in Kolli Hills, India. An ethnographic approach was used for the case study. Data collection methods included participant observation, focus group discussions and individual interviews. Thematic analysis was conducted to identify key patterns in all three data sources. As suggested by the literature review, dietary diversity is a good proxy indicator for nutrient adequacy and various health outcomes. The case study of Kolli Hills suggests that there has been a decrease in dietary diversity from 25-30 years ago to today. The kitchen garden intervention has increased the access to a variety of vegetables.

Contents

List of Figures

List of Tables

Introduction

This thesis is part of a broader research initiative between the University of Alberta and M.S. Swaminathan Research Foundation (MSSRF) [1] funded by the International Development Research Centre (IDRC) [2]. The goal of the broader initiative is to alleviate poverty and malnutrition (APM) in three different agro-biodiversity hotspots in rural India. Increasing dietary diversity is a desirable outcome for these populations as a means to increase nutritional quality and prevent micronutrient deficiencies. Specific tools to assess dietary diversity in these populations are beneficial. Although an abundant amount of literature examines dietary diversity for different populations in both developed as well as developing nations, there has been a lack of uniformity in these tools in regards to the parameters used. These variations make the generalization of the association between dietary diversity and micronutrient deficiencies difficult. Furthermore, exploratory research studies could be used to explore opportunities and barriers related to increasing dietary diversity. Thus, the overall aim of the present study is to provide a narrative review of the literature of methods used to assess dietary diversity and to qualitatively explore the factors affecting dietary diversity in one project site of the APM project.

The first objective of this thesis is to provide a comprehensive review of the literature of different methods of assessing dietary diversity and to provide recommendations for assessing dietary diversity in developing nations, especially in rural India. Specific objectives are: 1) To provide an overview of the different parameters used to operationalize dietary diversity, with emphasis on strengths and weaknesses within each parameter; 2) To provide a qualitative overview of the strength of association

between dietary diversity and various health indicators; and 3) To critically examine the appropriateness of various methods in assessing dietary diversity in developing nations, with specific considerations for populations in developing countries. A previous systematic review examined tools to assess dietary diversity, and thus, the narrative review that is planned in this thesis builds on the work of a previous narrative review [3].

The second objective of this thesis is to explore factors affecting changes in dietary variety in Kolli Hills, India and the perceptions of the value of a kitchen garden initiative for improving dietary variety. An understanding of the factors affecting changes in dietary variety in Kolli Hills will serve to inform strategies and interventions to improve dietary variety in this population. Knowledge of participants' perceptions towards the kitchen garden intervention will assist in understanding the sustainability and feasibility of such interventions for this population. Kolli Hills, a mountainous region in the southern state of Tamil Nadu, is one of the agro-biodiversity hotspots that the broader project targets. This smaller research project under the broader APM project will assist in understanding the food situation of Kolli Hills and serve as an interim qualitative evaluation of the kitchen garden intervention. An ethnographic approach will be utilized to allow for the exploration of interrelated beliefs, values and behaviour underlying food choices within the context of a changing environment. The immersion of the ethnographer in local culture, as well as the use of multiple data collection methods will add breadth and depth to understand local food culture.

This literature review will focus on defining and assessing dietary diversity and food security in Indian populations, ethnography, and determinants of food choices. Here,

dietary diversity will be defined, and the tools used to assess dietary diversity will be described. To understand the importance of assessing dietary diversity, the association between dietary diversity and various health indicators will be examined. In order to provide background and context on the population of interest in this study, the food security situation of Indian populations will be described in this review. Lastly, this review will describe the methodology and framework that this study will utilize to explore the food situation and kitchen garden intervention in Kolli Hills.

References

[1] M.S. Swaminathan Research Foundation , "M.S.Swaminathan Research Foundation - Center for Research on Sustainable Agriculture and Rural Development," 17 November 2013. [Online]. Available: http://www.mssrf.org/. [Accessed 17 November 2013].

[2] International Development Research Centre , "International Development Research Centre," [Online]. Available: http://www.idrc.ca/EN/. [Accessed 13 November 2013].

[3] M. Ruel, "Operationalizing dietary diversity: a review of measurement issues and research priorities," *The Journal of Nutrition,* vol. 133, no. 2, pp. 3911S - 3926S, 2003.

Chapter 1: Literature review

1.1 Defining and assessing dietary diversity at the individual level

Assessment of dietary diversity is defined as the number of foods or food groups consumed over a reference period. In the literature, the term dietary diversity has been used interchangeably with dietary quality. With increases in the prevalence of chronic disease in many countries, it is important to emphasize that increasing dietary diversity, along with consideration for limiting selected nutrients such as fats, sugar, and salt, may improve overall dietary quality [1].

Some tools have been developed in North America to assess overall dietary quality. However, these tools have not been commonly used to evaluate dietary diversity in developing nations. Reasons for this may include the complexity of administering these tools and the questionable relevancy of some of the parameters measured for populations in developing nations. Two prominent tools used to describe dietary quality are described below.

1.1.1 Dietary quality indices

In 2005, the United States Department of Agriculture (USDA) released a Healthy Eating Index (HEI), a measure of individual diet quality that assesses conformance to Federal dietary guidance based on the recommendations of MyPyramid. It is a standardized tool with scoring criteria that takes into consideration the amount of food consumed from each food group based on MyPyramid recommendations [4]. It was constructed for

monitoring dietary intake and nutrition promotion activities for the US population. The newest revised version of HEI includes nine adequacy and three moderation components to measure compliance with dietary guidelines [4]. The higher the total score between 0 and 100, the higher the compliance to guidelines. This tool may be useful to assess the dietary quality of US populations, evaluate interventions, and provide information on dietary patterns [4]. It must be noted that this tool measures the adherence to a particular set of dietary guidelines; yet some studies have shown that HEI scores are not highly correlated with health outcomes [3]. Although this tool is suggested to be applicable for use in US populations to assess dietary quality, its applicability in other cultural settings is unknown, as this tool reflects the dietary patterns of US populations.

In contrast, the dietary quality index (DQI) was developed to assess dietary quality cross-culturally [4]. The DQI focuses on four main aspects including: variety, adequacy, moderation, and overall balance. Its measure of dietary variety takes into consideration participants' adherence to the recommended portion sizes within each of the five food groups, including: meat/poultry/fish/egg, dairy/beans, grains, fruits, and vegetables. It must be noted that these tools are a measure of overall dietary quality rather than simply dietary diversity, as it has considerations for limiting the intake of various nutrients such as salt, fat and sugar as well as having a diverse diet [4].

1.1.2 Food variety and dietary diversity scores

The two most common approaches to assessing dietary diversity in developing countries at the individual level are measuring Food Variety Scores (FVS) and Dietary Diversity Scores (DDS). This involves a totaling of the foods or food groups consumed. Single food

counts are referred to as food variety scores (FVS) while food group counts are referred to as dietary diversity scores (DDS) (Ruel, 2003). There are, however, huge discrepancies and variations between studies in terms of the reference period used, considerations for portion sizes, the classification of food groups, and the optimal number and types of food to be grouped together to calculate dietary diversity. These variations between dietary diversity and micronutrient deficiencies make the generalization of the association between the two difficult.

The utilization of different reference periods to measure FVS and DDS has been reported in the literature, ranging from 1 to 15 days [5]. In addition, there is currently no consensus on the level of aggregation of foods or number of food groups to sum when creating food group diversity indicators. For children aged 6-23 months, the World Health Organization has determined a food group diversity indicator that sums 7 food groups [6]. However, in the adult population, the number of different food groups varies [7].

Overall, the lack of uniformity reported in the literature regarding the parameters used to assess dietary diversity, including the reference period used, portion size considerations, and food group aggregation has led to challenges in comparing between studies.

1.1.3 DDS standardized questionnaire

The Food and Agriculture Organization (FAO) of the United Nations has developed a standardized questionnaire from which various dietary diversity scores can be calculated [7]. This data collection tool entails a simple dietary recall method for which

respondents are asked about their food consumption over the past 24 hours. This information is then recorded into one of 16 standardized food groups to calculate a dietary diversity score. This dietary diversity questionnaire can be used to collect information either at the household or the individual level [7]. However, as this tool is not culture, population, or location specific, it is imperative to consider local context prior to deployment in the field. In addition to appropriate language translations, it must be verified that the foods in the questionnaire reflects dietary patterns of local populations. The specific parameters used should be defined according to the specific research questions under investigation and the diet of the population that is of interest to assess. For instance, if the purpose of research is to investigate a typical diet of individuals in rural, agricultural-based communities, assessing dietary diversity at different points in the agricultural cycle may provide insight into seasonality of food security [7].

It is often time consuming and labour intensive to collect extensive dietary data at a population level to assess micronutrient adequacy, especially in developing nations where there are limited resources to support the collection of large scale data. Simple indicators to monitor dietary diversity at the individual level are important to characterize the micronutrient adequacy of the diet for certain populations in developing nations in order to monitor the effectiveness of various interventions programs in improving micronutrient deficiencies. Many questionnaires using DDS and FVS to assess dietary diversity are documented in the literature.

1.2 Association of dietary diversity with various indicators of health

Recommendations to encourage the consumption of a variety of foods have been incorporated into dietary guidelines of many different countries. Health professionals have also long been encouraging the general public to diversify their diets. For example, a key guideline in the set of Indian Dietary Guidelines published by the National Institute of Nutrition recommends that "a nutritionally adequate diet should be consumed through a wise choice from a variety of foods." [8].

Low micronutrient intakes in developing nations are a concern [9]. The consequences of low micronutrient intakes may be severe. Iodine, iron, and vitamin A deficiencies are of particular concern in the developing world [9], and these deficiencies represent a major threat to the health and well-being of low income populations of different countries.

Micronutrient deficiencies disproportionately affect women and children in many countries. India has the greatest number of vitamin-A-deficient children in the world, with 20 million children with some form of this deficiency and approximately 330000 deaths due to it each year [10]. Vitamin A deficiency also significantly affects many women in India, causing many clinical symptoms as well as increased maternal morbidity and mortality during pregnancy and lactation [10]. More than 12% of all mothers in India experience night blindness, a clinical sign of vitamin A deficiency, particularly in rural areas [10]. A strategy to address the issue of vitamin A deficiency in children is the administration of vitamin A supplementation which provides semi-annual doses of 200000 IU to children one to four years of age [10]. In the literature, the promotion of homestead gardens which grow vitamin A rich fruits and vegetables have

also been documented to have favourable effects on vitamin A status in women and children [10].

The consequences of iodine deficiency may be severe, potentially resulting in goiter, growth stunting and neurological impairments [10]. Children are especially affected by iodine deficiency. Each year, approximately 6.6 million children in India are born with mental impairment attributable to iodine deficiency in mothers [10]. Although salt iodization has been implemented in India to address iodine deficiency, households consuming iodized salt declined from 50% in 1999 to 37% in 2003 due to national critics questioning the health benefits of iodized salts [10]. There are many criticisms of the mandatory iodization of salt in India including, the assertion that iodization hurts small-scale salt producers in India [10].

The prevalence of iron deficiency anemia is high in India; it is estimated to affect nearly 58% of pregnant women, 50% of non-pregnant non-lactating women, 56% of adolescent girls and 80% of children under two years of age [11]. The consequences of iron deficiency anemia in these populations include: increased maternal mortality and adverse pregnancy outcomes, decreased resistance to infections, and altered cognitive function in children [11]. Policies and strategies to address the problem of iron deficiency anemia require approaches that take into consideration multiple causative factors including food based approaches such as dietary diversification and food fortification with iron, iron supplementation and improved health services and sanitation [11].

Many studies have suggested associations between dietary diversity and micronutrient adequacy in various populations in both developed and developing nations, including

among infants and young children [12] adolescents [13] and adults [14]. This makes dietary diversity scores a potential proxy indicator for micronutrient adequacy in these populations.

Despite the suggested association between dietary diversity and micronutrient adequacy in the literature, existing validation studies of the relationship between dietary diversity and nutrient adequacy vary among the indicators used, the validation methods, and the population studied. These variations between dietary diversity and micronutrient deficiencies make the generalization of the association difficult. However, despite the lack of uniformity in the use of indicators and methods, studies have consistently shown a positive association between dietary diversity and micronutrient adequacy. For instance, some validation studies of dietary diversity scores assessed the association between dietary diversity scores and calculated individual and average micronutrient intake as determined from 24-hour dietary recalls using Pearson's correlation coefficient [15]. Many studies have consistently shown a positive association between dietary diversity scores and micronutrient adequacy for multiple nutrients, suggesting that the relationship between the two factors is robust. [1].

Dietary diversity may be assessed at the individual or household level. Individual dietary diversity reflects the diversity in an individual's diet while household level dietary diversity reflects the diversity in a household's food basket [16]. While individual dietary diversity scores can be used as a proxy indicator of the nutritional quality of the individual, evaluating household level dietary diversity is used as a proxy measure of the socio-economic level of the household. Numerous studies have shown a statistically significant relationship between total household per capita income and dietary diversity

[17]. An analysis of 59 households in 47 developing countries in recent years showed that diets in higher-income households are more diverse, irrespective of the region [17]. As household income increases, the contribution of cereals, roots, and tubers to total per capita dietary energy supplies (DES) decreases and the relative contributions of animal-source foods and fruits and vegetables increase significantly [17].

1.3 Food security in Indian populations

Food security is an important public health and social issue in India, related to many political, economic, and social processes. Food security is defined as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain healthy and active life" [18]. Various indicators have suggested that a significant portion of the population of India is vulnerable to food insecurity. Food insecurity exists when food security is limited or uncertain [19]. Potential consequences of food insecurity include hunger, malnutrition and negative effects on health and quality of life [20] [19]. Indian poverty lines were constructed based on the definition of "an income level that is just sufficient to meet the defined calorie norm", in other words, an income level which would allow for a person to sustain a minimum level of calorie consumption [21]. Based on the minimum level of calorie requirements, and cost of the minimum food needs basket in the market can be calculated and the poverty line may be determined from the expenditure required for food [21]. India poverty lines were created in reference to calorie norms, with average per capita calorie consumption for rural households at 2400kcal per capita and 2100kcal per capita for urban households [22]. The calorie norms were determined based on the "Recommended Dietary Allowances for Indians"

established by the National Institute of Nutrition [23]. The difference in calorie norms between urban and rural households were based on suggested differences in energy expenditure between urban and rural lifestyles [23]. It must be noted, however, that these calorie norms have been prescribed for several decades and recent reviews by the Indian government have been conducted to investigate the need to revise calorie norms in calculating the poverty line as lifestyle and consumption patterns have changed in India in the past 35 years [23].

Data suggest many states have falling per capita dietary energy intakes [22] and in 2009, 79.8% and 63.9% of the population living in rural and urban households have per capital consumption of less than 2100kcal and 2400kcal, respectively. A significant percentage of the Indian population is estimated to be poor and malnourished. There are various estimates of poverty in India. Statistics from the FAO estimates that approximately 22% of India's population is undernourished, translating to approximately 250 million people [24]. Labourers, tribespeople, Dalits (formerly known as the low caste untouchables) and Muslims remain the poorest Indians. In 2008, UNICEF estimated that India was home to 42% of the developing world's underweight and 32% of the developing world's stunted [25]. The costs of malnutrition in India are high, with stunting and micronutrient deficiencies resulting in productivity losses equivalent to 2.95% of GDP annually [17].

1.3.1 Government food distribution and supplement programs

Several government programs and policies were implemented to address the issue of food security in India. The Public Distribution System (PDS) and the Integrated Child Development Services (ICDS) will be discussed here.

Public distribution system

The Public Distribution System (PDS) is one of the most important public safety nets to address food security in India. The PDS provides subsidized food grains as well as other essential commodities through a network of fair price shops nationwide [26].The PDS has undergone many changes since its implementation. Until 1992, access to food grains and other commodities has been universal for all Indians. Challenges related to corruption and high operational costs have eventually led to the Targeted Public Distribution (TPDS) in existence today. Under the TPDS, households are classified into two categories: Below Poverty Line (BPL) and Above Poverty Line (APL). Households with BPL status continue to receive subsidized food grains and other commodities [26]. Essential commodities such as rice, wheat, sugar, kerosene and palm oil are supplied to people utilizing the PDS at subsidized prices [26]. For individuals living in rural areas who struggle to pay the prevailing market prices, an effective PDS system has the potential to allow them access to a more affordable, diverse, and nutritious diet.

Distributing and selling of food grains through the PDS is the responsibility of both the government of India as well as state governments. Tamil Nadu's PDS has the highest percentage of usage in all of India, at 82.4% of all households [27]. Fair price shops are distributed across the state, and many exist in tribal areas. The network of Fair Price shops in Tamil Nadu is run by Cooperatives and women self-help groups. Encouraging members of the community such as women's self-help groups to run the operation of Fair Price Shops have shown to increase their efficacy [27]. As of 2004, there were 4673 fair price shops and 36 mobile fair price shops in Tamil Nadu [27]. There is a government guideline indicating that no family cardholder is to travel more than 2 km to reach a Fair

Price shop [27]. Mobile Fair Price shops have also been effective at reaching households in rural and hilly areas.

A number of studies have been done to evaluate various aspects of the PDS [27]. The PDS has been criticized for its inefficiency in distributing quality goods to households [27]. Nakkiran et al. (2004) conducted a qualitative study to evaluate various aspects of the PDS, including the availability of goods in Fair Price Shops, the quality of goods distributed, and the accessibility of fair price shops in several rural villages in Tamil Nadu. Many respondents opined that the location of FPS is often at central locations close to government centres and away from many remote villages in hilly areas. Further, the hours of Fair Price Shops may vary, with 6pm being a common closing time for many shops. Many workers who return to their homes after 6pm lack the opportunity to purchase goods [27]. Some respondents also reported that FPS did not always contain all the essential commodities at one time, requiring purchasing members to make several trips in the course of a week. Lastly, many respondents felt that goods distributed through FPS were inferior in quality compared with the same items available in the market. Overall, many factors have prevented the full potential of the PDS in providing a security net for rural populations in food security.

Integrated child development services

Integrated Child Development Services (ICDS) is the largest national program for the amelioration of maternal and child health [28].The beneficiaries of the program include children below 6 years of age, pregnant and lactating mothers, and other females aged 15 to 44 years. Services in this program include: supplementary nutrition program, immunization, health check-up, referral services, nutrition and health education and

pre-school education. These services are provided through villages centres called anganwadi centres (AWC) [28]. Utilizing a holistic approach, the ICDS provide an opportunity to improve the health and nutritional status of its beneficiaries. It is one of the programs serving the extreme underprivileged communities of the remote areas of the country [29]. AWC's are located in both urban as well as rural areas, with an estimated average of one AWC servicing 400-800 people in urban and rural areas. However, in tribal communities, the estimated ratio is one AWC per 300-800 people (WCD http://wcd.nic.in/icds.htm).

The supplementary feeding program is a large component of ICDS. A goal of this program is supplementing family meals. Feeding support is provided to beneficiaries for 300 days in a year [29]. The type of meals provided varies from state to state but usually consists of a hot meal to be picked up at the AWW containing a combination of pulses, cereals, and vegetables [29]. There are, however, some areas of weaknesses in the ICDS Scheme. Many studies have suggested that participants reported poor quality and lack of variety of the meals provided, leading to low usage of this program in especially remote areas [30]. Participants reported receiving food from AWW that was dry, over-seasoned or lacked variety [30]. Other studies have reported other issues with the ICDS program, including the inadequate training and support provided to AWW workers, lack of community support for ICDS initiatives, and lack of focus on the nutrition and health education component of the program [29]. Overall, the effectiveness of ICDS in many communities in India, especially rural areas, may be questionable in ameliorating food security.

1.4 Food consumption and dietary diversity in India

India has experienced significant economic and social changes in the past decades. The National Sample Survey Organization (NSSO) is an organization under the Ministry of Statistics of the Government of India responsible for the collection of socio-economic information in India. An India Human Development analysis based on three rounds of National Sample Survey (NSS) conducted in 1993-1994, 2004-2005, and 2009-1010 provided insight into the consumption and expenditure behaviour of households in India [31]. According to survey data, there was a sharp reduction in cereal consumption between 1993 and 2009 – 15% in rural areas and 12% in urban areas. The consumption of milk and milk products increased, more substantially for urban areas (10% between 1993 and 2009) [31]. Overall, intake of meat/fish/poultry increased slightly in both urban (5%) as well as rural areas (2%) between 1993 and 2009. Interesting vegetable intake increased in the first eight years for both rural and urban populations but decreased in equal amount in the second eight years between 1993 and 2009 [31].

It must be noted that despite these trends in consumption patterns over the years, the diets of Indians residing in rural areas have a higher proportion of cereals when compared with those residing in urban areas. Although there appears to have been a change in food consumption towards non-cereal items such as meat/fish and fruits and vegetables in both rural and urban areas, the consumption of meat/fish/eggs and fruits/vegetables remain lower in rural households compared with urban households [31].

A Food Diversity Index (FDI) based on the same NSS data [31] is calculated as the sum of squares of the shares of various food items in the food consumption basket ($\mathbf{FD_{lit} = \sum_{j=1}^{5} S^2_{jit}}$). It has suggested changes in dietary diversity at the household level of both urban and rural populations between the time period of 1993 and 2009. Five food groups were taken into consideration: 1) cereals and pulses, 2) milk, milk products, eggs and meats, 3) oil, 4) sugar, and 5) fruits and vegetables. FDI was generated for different income classes for both urban and rural areas. A lower index corresponds with a more diverse household food basket. This method of determining household level food diversity is based on a validated method [32] with some modifications. The poor in both rural and urban areas were found to have less diversified diets at all three periods (i.e., 1993, 2004, and 2009). From 1993 to 2009, the food basket increased in diversity for both rural and urban populations, for lower as well as higher income populations. It was shown that in rural areas, food diversity increased at a faster rate for the poor during 1993-2004, corresponding to a 15% decline in the index compared with 12% for the non-poor. These national level data are important in examining national trends in food consumption and dietary diversity. However, given the diversity of cultures in India, it is also of importance to examine the unique food situation of various geographic locales and assess the dietary diversity of specific populations.

Individual level DDS or FVS may serve as simple and useful indicators in specific populations to predict the nutritional adequacy of their diets and to monitor the effectiveness of food-based interventions to ameliorate micronutrient deficiencies. To date, only two studies assessing individual DDS have been conducted in Indian populations [33] [34].

One study examined the association between DDS and nutrient adequacy and the other assessed the association between dietary scores and growth references. Rani, Arends, & Brouwer (2010) validated the DDS as an indicator of nutrient adequacy of the diet of Indian children aged five to eight years in the Haryana state. To calculate DDS, a 13 food group dietary diversity indicator used by Arimond, et al., 2010 was used. A two-day 24-hour dietary recall method was used to measure the mean daily intake of multiple nutrients for individual subjects and in order to calculate the probabilities of adequacy for various nutrients. Pearson's correlation coefficient was used to determine the association between DDS and the probability of adequacy for each nutrient for each subject. In this particular population of children, vegetarian diets were predominant and no study subject consumed animal source products. The mean probability of adequate nutrient intake for all nutrients was low, at only 40%. DDS was found to be positively and significantly associated with nutrient adequacy in the study [33]. Cut-off points for DDS to classify subjects who are at greatest risk of inadequate micronutrient as well as ones who may be meeting mean probability of adequacy of nutrients (MPA) were determined. Based on the data, it was suggested that a DDS score of between 6 and 7 food groups would meet cut-off points for nutrient adequacy for this population.

Hooshmad and Udipi (2013) conducted a study to determine the association between DDS and underweight, stunted, and wasted school children ages 6-9 years in urban India and Iran. Dietary diversity scores were assessed based on frequency of consumption of individual food items categorized into 11 individual food groups. The reason for this classification of food groups was not reported. Based on the frequency of consumption of the foods in various food groups, a score was assigned to each food group and an overall dietary diversity score was calculated for each participant. Results suggest that

DDS were significantly higher for Indian children with normal weight or those who were overweight ($F=32.197$, $p=0.001$) and lowest for underweight children. Higher DDS was associated with improved better height for age status. An analysis of individual food group consumption suggested that weight was associated with greater consumption of every food group for Indian children [34].

The lack of dietary diversity is a concern for many Indian populations. Valid tools to assess dietary diversity, including DDS and FVS are important to assess the nutrient adequacy status of populations and serve as useful tools to assess progress for intervention studies to ameliorate dietary diversity of Indian populations. However, to date, only two studies have been conducted to assess the dietary diversity of children. Although children are a vulnerable group for which micronutrient deficiencies may have devastating effects, other vulnerable groups include women of childbearing age and pregnant and lactating women. A review of the literature was not able to identify any studies examining dietary diversity and nutrient adequacy in adult Indian subjects. Studies to validate DDS and FVS for use in adult populations are warranted and research to explore dietary diversity of different populations is important. In addition to studies utilizing DDS and FVS to assess the dietary diversity of Indian populations, in-depth studies to examine the unique food situation of various communities facing limited dietary diversity are also important. Understanding the food situation of different communities will serve to inform interventions studies to ameliorate dietary diversity in these populations.

1.5 Ethnography

Ethnography may be utilized as a methodology to understand the unique food situation and culture of various communities. It has been used in research to examine many aspects of behaviour, including food behaviour. Personal and household level decisions on food choices must be examined in context of environmental forces in order to achieve an in-depth understanding of the opportunities and barriers to increasing consumption patterns of nutrient rich foods. Using an ethnographic approach, data collection can be conducted in a natural setting where participants live and experience day to day decisions on food procurement practices.

The term 'ethnography' can be broadly defined as writing about any ethnically, culturally, or socially defined group of people [35]. Ethnography as a methodology seeks to understand groups of people by sharing of social or cultural space with participants [35]. The product of ethnography is therefore a reliable account about a group of people and their culture and behaviours [35].

Traditionally, ethnographers commit long periods of time living in communities of interest in order to holistically and reliably describe the socio-cultural life of that particular group of individuals [35]. Nowadays, many ethnographic studies are conducted over shorter periods of time with a more specific focus on a particular aspect of a community's culture or society [35]. Regardless of the specific methods used in the study or the time periods of study, ethnography seeks to build theories of culture and society as well as human attitudes and behaviours [35].

Historically, anthropologists have used ethnography to study cultures in remote settings [36]. Modern researchers apply ethnographic methods to study aspects of society and various social problems, for instance, poverty, globalization [36] and societal breakdown [36]. Historically, data gathering in ethnography is primarily participate observation and intensive fieldwork to be involved in the lives of participants [36]. Other data collection methods may include formal and informal interviews as well as examination of relevant secondary documents [37].

Focused ethnography constitutes much of contemporary ethnography and has gained increasing popularity in recent years. Compared with conventional ethnography, focused ethnography is usually characterized by shorter term spent in the field. It is used for researchers who aim to focus their study on only limited elements of society [38] and to focus on distinct community or organization or social phenomena [37]. Data collection methods share many similarities with conventional ethnography. However, focused ethnographies tend to have pre-selected topics of inquiry [37] and the interviews are usually focused and highly structured around specific topics or issues [37]. Although a specific focus is important in guiding each data collection method, different data collection methods contribute to breadth and depth of understanding of a particular issue or social phenomenon.

In regards to studies utilizing ethnography to examine food behaviour, the Canadian Council of Food and Nutrition conducted an ethnographic study to gain insight into Canadians' attitudes and behaviours toward food and nutrition [39] and have gained some insight into the factors influencing Canadians in making food choices. To date, only one qualitative study has been identified which examined localized dietary

transitions Kolli Hills, India [40]. This study utilized an ethnographic approach to gain qualitative understanding of local perceptions and interactions among food, environment, and agricultural change.

Focus groups, as a method of data collection, involve engaging small groups of people in an informal group discussion around a particular topic or set of issues [41]. Focus groups alone or in triangulation with other qualitative research methods such as participant observation and individual interviews are useful methods to explore opportunities and barriers to increasing dietary diversity in certain population groups. There are many advantages of using focus groups to explore household level decision making regarding food choices. The focus group presents a less threatening environment for participants to discuss perceptions, ideas and thoughts. For some relatively isolated tribal communities in India this may be an advantage. Furthermore, group interactions and conversation during focus groups have the advantage of bringing to surface topics that are either habit ridden or not thought out in detail by participants, thus adding to the depth of the information collected [42]. Decision making processes involving food may be habit ridden. The use of focus groups to explore this issue will add depth to the information collected.

In terms of the criticisms and limitations of ethnography, much of the criticism of qualitative research in general may also be applied to ethnography [37]. The criticism of the contested nature of ethnography is in regards to its credibility and consistency in findings as well as the fluidity of boundaries in studying various topics [37]. Although measures are often taken in ethnographic studies to increase the trustworthiness of findings as a means to ensuring rigor in research design, it is never claimed that

ethnographic studies have the ability to generate generalizations to other community, populations or similar social issues.

1.6 Determinants of food choices: a review of theories and models

Many factors affect an individual's decision making process in regards to making food choices. The environment may facilitate or inhibit the ability of people to act on their biological preferences to food. Many categories of influences on individual food choices exist, including factors related to food, to the individuals making the choices, as well as the broader social and physical environment. This review will focus on providing an overview of some of the theories and models to describe the multitude of determinants of food choices. There is currently minimal literature examining determinants of food choices for populations in developing countries. A review of theories and models used in conceptualizing determinants of food choices have been conducted to select the most appropriate model to understand the food situation of populations at risk of limited dietary diversity in India. A brief critical review of ecological models has been conducted, and its strengths and limitations described.

Furst et al. (1996) provided one of the earliest conceptual models of the processes involved in an individual's determination of food choices. In the conceptual model, factors influencing food choices were grouped into three components: 1) life course, 2) influences and 3) personal system. The life course component encompasses the life history of an individual in relation to the social, cultural, and physical environments to

which a person has been and is exposed [43]. The life course is essential and creates a set of influences for the individual which in turn shapes his/her personal systems [43].

The five major influences of food choices proposed include: individual ideals, personal factors including food preferences and physiological factors, resources including time and access to financial resources, social framework such as influences from the social environment, and food context related to the availability of food in various food systems [43]. Personal systems entail two major components: 1) value negotiations that involve weighing of different considerations in making food choices, and 2) individualized strategies for making food choices. This model contributes to an understanding of food practices and the complex interplay between individual food choices and the larger food environment [43] and attempts to conceptually portray the determinants of a single food choice event [43].

Devine et al (2005) discussed the use of a life course perspective for understanding food choice behaviours in a changing world. Three frameworks for understanding food choices were proposed, including temporal, social and historical (Devine , 2005). The temporal framework emphasizes an individual or group's food choices in context of changing time periods, and how food choice trajectories change and transition over time in a person's life (Devine, 2005). Devine et al. (1998) conducted a survey of adults of different ethnicities in low and middle income households to examine life course events associated with fruits and vegetable consumption. Examples of life course events associated with increased fruits and vegetables intake included development of food skills, making dietary changes for health, and eating from a garden from childhood [44].

The social framework focuses on the influences of social class, race, ethnicity, and gender and how these factors change in the course of the life span. Social and gender roles such as marriage and parenthood may affect motivations for making food choices. For instance, in many cultures, women have special relationships with food and may be primarily responsible for food provisioning in the household. However, in face of the changing nature of gender roles for men and women, food choices made by men and women in various cultures may also be changing (Devine, 2005).

Finally, the historical framework examines food choices in the context of changing economic and political environments. This framework emphasizes the importance of changing food trends on food intake. This includes changes in the supply of convenience foods resulting in increased intake of dietary fat, sodium, and calories of people (Devine, 2005).

1.6.1 A Review of ecological models of behaviour change

These various models and frameworks proposed to predict and understand food behaviour suggest the multitude of influences on food choices. The ecological model integrates these multiple levels of influence to depict the dynamic interrelations between individuals and environmental factors [47]. In the past two decades there has been a significant increase in the application of various ecological models in research and practice [45] to guide interventions in many health problems. Ecological models have evolved much over the years, many were meant to be applied broadly to behaviours while some were created for application to certain health promotion or health behaviours in certain contexts [45]. Categories or hierarchies or behavioural influences have been depicted in numerous ways depending on the behavioural model,

ranging from McLeroy's (1988) five sources of influence: intrapersonal, interpersonal, institutional, community, and policy to Bronfenbrenner's (1979) micro, meso, exo and macro environment approach. This diversity of models illustrates the adaptability and robustness of ecological models [45].

All ecological models focus on multiple levels of influence around a specific topic or phenomenon. However, the application of models may differ slightly. Some models, such as McLeroy's (1988) ecological model may be more suited to guide behavioural interventions while other ecological models, such as Bronfenbrenner's ecological model has been primarily used to understand behaviour [45]. For instance, McLeroy's ecological model has a focus on institutional and policy level influences which makes them easily translatable to institutional and policy level changes that may need to occur to influence positive changes on a certain behaviour. While Bronfenbrenner's ecological model (1979), with its emphasis on the interactions that occur on each level of influence, has been used widely in the literature to understand the dynamic influences affecting certain behaviour. Each level of influence in Bronfenbrenner's ecological model (1979) is a subsystem that is nested within another system. It is impossible for one to refer to one level of influence without referencing the others. This makes Bronfenbrenner's ecological model suited to describe complex interrelated influences on a specific behaviour.

There are strengths and weaknesses in using ecological models in understanding health related behaviours. An important strength of all ecological models is the consideration for multiple levels of influence, including environmental influences, on a particular behaviour. This broadens the options for effective interventions to promote a desirable

behaviour. A general weakness of using ecological models to describe influences on behaviour is the potential lack of specificity of the most important influences on a particular behaviour in order to inform strategies and interventions [45]. Multiple factors exert synergistic effects to influence a particular phenomenon. Despite the ability of ecological models to depict the multitude of effects on a particular issue, it is difficult to disentangle the effects of one effect from another simply based on ecological models.

1.6.2 Bronfenbrenner's ecological model

Bronfenbrenner's ecological model will be used to explore factors affecting changes in dietary choices in Kolli Hills India. The nature of this particular model makes it a preferable framework to understand this research objective. Food habits are an essential aspect of the culture of Kolli Hills, influenced by complex interactions between the social and political environment of Kolli Hills [40]. Bronfenbrenner's ecological model allows the description of the interconnectedness and the interactions between these layers of structure and influence. Bronfenbrenner's ecological model has been used in the literature as a framework to understand lone senior's women's' perceived realities regarding their ability to access to a nutritionally adequate diet and the various levels of influences affecting their perceived access to food [46]. The conceptualization of levels of the environment is conceived as a set of nested structures, suggesting that the system cannot be understood when broken down into single levels of influence [46]. Reciprocal exchanges and interdependencies exist between each level of influence. Overlapping influences exist and changes in one part of the system will stimulate changes in other parts [46].

From the inner to the outermost of Bronfenbrenner's ecological model, the levels of influence are of follows:

Microsystems describe the pattern of activities, social roles, and interpersonal relations experienced by the individual in a face-to-face setting. Examples include an individual's immediate settings such as home, neighborhood and informal social networks [46]. It is within this immediate environment that proximal processes operate to influence the individual [47]. The mesosystem consists of the interactions and linkages that take place between two or more microsystems [47]. Examples include the relations between the home and community facilities. The exosystem comprises of the interactions between two or more settings, one of which does not include the individual [47] but still functions to influence the individual. In other words, the exosystem consists of social structures which are removed from the individual yet influencing processes at the microsystem level [46]. This may include government policies, media influences, and formal and informal social networks [46]. Finally, the macrosystem consists of overarching meaning systems [46] encompassing belief systems and worldviews which ultimately shape one's experience at other levels of influence [46]. Chronosystems, an extension of Bronfenbrenner's ecological model, emphasizes the importance of the environment in historical time. An individual's behaviour may be examined in context of various changes that may occur, including changes in one's life course in family structure, employment, and socioeconomic status as examples [47]. This model is suited to serve as a framework to understand factors influencing food choices in communities by describing various levels of influences and their dynamic interactions.

1.7 Study rationale and research objectives

There are two parts to this study. The first part of the study begins with a narrative review of dietary diversity tools. This part of the study builds on a previous review that was published in 2003 [1]. Specific objectives include:

1. To provide an overview of the different parameters used to operationalize dietary diversity, with emphasis on the strengths and weaknesses within each parameter.

2. To provide a qualitative overview of the association between dietary diversity and various health indicators.

3. To critically examine the appropriateness of various methods in assessing dietary diversity in developing nations, with specific recommendations for populations in developing countries.

The second part of the study is a qualitative study under the umbrella of the collaboration between MSSRF and University of Alberta to ameliorate food and nutritional security in three rural sites in India. The objectives of the smaller qualitative research study are:

1. What are the factors affecting changes in food choices in Kolli Hills, India from the perspective of men and women of different age groups in Kolli Hills?

2. What are the perceived values of the kitchen garden initiative, with emphasis on its improvement on the consumption of a variety of vegetables?

1.7.1 Narrative review of dietary diversity tools

Individual dietary diversity scores (DDS) and food variety scores (FVS) are common indices to assess dietary diversity. These simple indicators to assess dietary diversity are important to assess the micronutrient adequacies in other developing nations where limited resources are available to collect detailed dietary data.

Although an abundant amount of literature examines dietary diversity for different populations in both developed as well as developing nations, there has been a lack of uniformity in these tools in regards to the parameters used. Assessing DDS is the most common approach to examine dietary diversity. The difference in parameters includes the classification of foods into appropriate food groups, the portion size considerations, and the reference periods used.

For children aged 6-23 months, the World Health Organization has determined a food group diversity indicator that sums 7 food groups [6]. However, in other populations, a range of different number of food groups has been used [7]. The Food and Agriculture Organization of the United Nations has recently developed a standardized questionnaire from which various dietary diversity scores can be calculated [7]. These guidelines for measuring household or individual dietary diversity provides specific recommendations on the aggregation of foods into food groups, considerations for minimum quantities of food consumed, and consideration for reference periods. The guidelines also briefly discussed various considerations in tool administration, including optimal time of the year to administer this tool. This paper will further discuss key considerations for each parameter, especially in adapting these parameters to populations in developing nations.

Narrative systematic reviews, or integrative reviews, are important to survey the current state of knowledge around a particular topic [48]. Rather than testing a hypothesis as a meta-analysis would do, narrative systematic reviews may serve to reveal problems, weaknesses, contradictions or inconsistencies around a particular phenomenon or topic [50]. The systematic nature of the review allows a narrow focus of literature with criterion based selection of relevant evidence [48]. Lastly, narrative reviews are an approach that allows for the inclusion of diverse methodologies [49]. The nature of this type of review is most suited to provide the most current state of evidence around tools to assess dietary diversity, with inclusion of studies with diverse methodologies and different outcome reporting methods.

The overall objective is to provide an overview of different methods of assessing dietary diversity and provide considerations for assessing dietary diversity in developing nations.

Specific objectives are:

1. To provide an overview of the different parameters used to operationalize dietary diversity, with emphasis on the strengths and weaknesses within each parameter.
2. To provide a qualitative overview of the association between dietary diversity and various health indicators.

3. To critically examine the appropriateness of various methods in assessing dietary diversity in developing nations, with specific recommendations for populations in developing countries.

Ruel [3] conducted a review of methods to assess dietary diversity, with discussions on the strengths and weaknesses of different parameters in DDS indexes. A number of important studies have been published since then to examine either the dietary diversity of populations in different countries or to validate the association between DDS indexes and micronutrient adequacy. A more current review of methods to assess dietary diversity will provide further insight into the utilization of such tools in the field for various purposes.

1.7.2 Qualitative exploration of food situation in Kolli Hills

Factors affecting changes in dietary choices

A chosen project site in the APM project is Kolli Hills, a mountainous region in the Namakkal district of the southern state of Tamil Nadu, India. Kolli Hills covers about 283km^2 and has a population of 42200 as per the 2011 census [50]. Today, most households in this area belong to small farmers, with marginal land holdings. Common crops grown by farmers are jackfruit, hill banana, coffee, pineapple, black pepper, and cassava [50]. A tribal population, the Malaiyali tribe, primarily resides in this area. It has also been suggested that low income populations in rural India are especially vulnerable to micronutrient inadequacy related to low dietary diversity [31].

Based on local accounts, this population currently experience some challenges related to food security, and there has been decreases in dietary diversity over the past 20

years. Finnis [42] conducted a study using ethnographic data collection methods to study changes in production and consumption patterns in Kolli Hills, India. This study focused on the agricultural shift which resulted in the abandonment of millet growing for consumption in favor of cash crop cassava cultivation. Two main reasons for this included environmental changes related to increasingly unpredictable rainfall and changes in the demand for material and social goods [40]. An unpredictable rainfall pattern makes the cultivation of cassava, a relatively drought resistant crop, more favourable when compared with other crops. Furthermore, the increasing demand villagers have for material and social goods have increased the need for money, further supporting their decision to grow cassava as a cash crop [40]. Given these agricultural shifts in the area, it is also of importance to examine if there are other changes in production and consumption patterns of foods in other food groups and the potential nutrient implications of these changes. An understanding of factors resulting in decreases in dietary diversity in this population will be imperative in informing strategies and interventions to ameliorate the lack of dietary diversity in this population by taking into consideration the goals, priorities, and voices of community members.

The Alleviating Poverty and Malnutrition in Agrobiodiversity Hotspots (APM) is a project jointly planned and implemented by the M.S. Swaminathan Research Foundation (MSSRF) and the Faculty of Agriculture, Life and Environmental Sciences at the University of Alberta. The project aims to alleviate severe poverty in three selected agro-biodiversity hotspots in rural India. The tribal populations living in these areas experience a lack of economic prosperity, high rates of illiteracy, and low human development indicators [50] despite the rich biodiversity of traditional crops in these areas, representing a paradoxical phenomenon. Some specific objectives of the project

are increasing farm productivity by promoting sustainable use of local crop and livestock diversity, enhancing food and nutrition security at the individual, household and community levels, and enhancing on and off farm livelihood diversification options [50].

Kitchen garden intervention

As an initiative of the APM project, a kitchen garden intervention was implemented in each of the project sites to increase availability and improve access to a variety of vegetables throughout the year in order to enhance food and nutrition security. Here, the term kitchen garden is used interchangeably with household garden, or home gardens. It refers to cultivation of a small portion of land which is around the household or in close proximity from the home [51].

The kitchen garden intervention was composed of three parts:

1. Administering a survey to determine household preferences for vegetables.
2. Distributing seeds and agricultural inputs to intervention households.
3. Providing educational sessions on ways to incorporate vegetables into recipes.

Prior to distributing seeds to households, a survey was administered by field staff to participating households to inquire about the types of crops they wish to grow in their kitchen garden. Results showed that households wanted to grow tomatoes, cauliflower, leafy greens and beets. High quality seeds of these plants were distributed, and educational sessions were provided by local staff on kitchen garden management and the incorporation of these vegetables into various local recipes. Participating households received ongoing support on the management of kitchen gardens. It is of

importance to understand if the implementation of kitchen gardens has influenced changes in food production, consumption, and consequently dietary diversity. The objective for this component of the study, under the umbrella of the broader collaborative project, is a qualitative study to explore factors affecting changes in food choices in Kolli Hills, India and the perceptions of the value of the kitchen garden initiative in improving dietary choices. The specific research questions for my component of the study are:

1. What are the factors affecting changes in changes in food choices in Kolli Hills, India from the perspective of men and women of different age groups in Kolli Hills?

2. What are the perceived values of the kitchen garden initiative, with emphasis on its improvement on the consumption of a variety of vegetables?

To explore factors affecting changes in dietary choices and the perceptions of the value of kitchen gardens, an ethnographic approach is used. This qualitative methodology allows for the exploration of interrelated beliefs, values, and behaviours underlying food choices within the context of a changing food environment [38].

References

[1] M. Ruel, "Operationalizing dietary diversity: a review of measurement issues and research priorities," *The Journal of Nutrition,* vol. 133, no. 2, pp. 3911S - 3926S, 2003.

[2] P. Guenther, k. Casaval, J. Reedy, S.Kirkpatrick, H. Hiza, K.Kucynski, L. Kahle, and S. Krebs-Smith. "Update of the Healthy Eating Index: HEI-2010," *Journal of the Academy of Nutrition and Dietetics,* vol. 113, pp. 569-580, 2013.

[3] G. Kourlaba and D. Panagiotakos, "Dietary quality indices and human health: A review," *Maturitas,* vol. 62, pp. 1-8, 2009.

[4] S. Kim, P. Haines, A. Siega-Riz and B. Popkin, "The Diet Quality Index- International (DQI-I) provides an effective tool for cross-nataional comparison of diet quality as illustrated by China and the United States," *The Journal of Nutrition,* vol. 133, no. 11, pp. 3476-84, 2003.

[5] A. Drewnowski, S. Ahlstrom Renderson, A. Driscoll and B. Rolls, "The Dietary Variety Score: Assessing Diet Quality in Healthy Young and Older Adults," *Journal of the American Dietetic Association,* vol. 97, no. 3, pp. 266-271, 1997.

[6] World Health Organization, "Indicators for assessing infant and young child feeding practices. Part 2 Measurement," WHO, Geneva, 2010.

[7] G. Kennedy, T. Ballard and M. Dop, "Guidelines for measuring household and individual dietary diversity," Food and Agriculture Organization, Rome , 2011.

[8] National Institute of Nutrition, "Dietary Guidelines for Indians," National Institute of Nutrition, Hyderabad, 2011.

[9] World Health Organization, "Micronutrient deficiencies," 2013. [Online]. [Accessed 1 August 2013].

[10] J. Chow, S. Darley and R. Laxminarayan, "Cost-effectiveness of disease interventions in India," Resources for the Future, Washington, 2007.

[11] Central Statistics Office, Ministry of Statistics and Program Implementation, "India Country Report: Mid-term Statistics Appraisal," Central Statistics Office, Ministry of Statistics and Program Implementation, New Delhi, 2010.

[12] N. Steyn, J. Nel, G. Nantel, G. Kennedy and D. Labadarios, "Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy," *Public Health Nutrition,* pp. 644 - 650, 2006.

[13] P. Mirmiran, L. Azadbakht, A. Esmaillzadeh and F. Azizi, "Dietary diversity score in adolescents - a good indicator of the nutritional adequacy of diets: Tehran lipid and glucose study," *Asia Pacific Journal of Clinical Nutrition,* vol. 13, no. 1, pp. 56-60, 2004.

[14] J. Foote, S. Murphy, L. Wilkens, P. Basiotis and A. Carlson, "Dietary variety increases the probability of nutrient adequacy among adults," *Journal of Nutrition,* vol. 134,

pp. 1779-1785, 2004.

[15] M. Arimond, D. Wiesman, E. Becquey, A. Carriquiry, M. Daniels, N. Fanou-Fogny, M. Joseph, G. Kennedy, Y. Martin-Prevel and L. Torheim, "Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings," *American Society for Nutrition,* vol. 140, no. 11, pp. 2059S-20695, 2010.

[16] A. Swindale and P. Bilinsky, "Household dietary diversity score (HDDS) for measurement of household food access: indicator guide," Food and Nutrition Technical Assistance Project, Academy for Educational Development , Washington, D.C , 2006.

[17] FAO, WFP, IFAD, "The State of Food Insecurity in the World 2012.Economic growth is necessary but not sufficient to accelerate reduction of hunger," FAO, Rome , 2012.

[18] World Health Organization, "Food Security," 2013. [Online]. Available: http://www.who.int/trade/glossary/story028/en/. [Accessed 3 August 2013].

[19] J. Stuff, P. Casey, K. Szeto, J. Gosset, J. Robbins, P. Simpson, C. Connell and M. Bogle, "Household food insecurity is associated with adult health status," *The American Society for Nutritional Sciences,* pp. 2330-2335, 2004.

[20] C. Campbell, "Food insecurity: A nutritional outcome or a predictor," *The Journal of Nutrition,* pp. 408-415, 1991.

[21] M. Sivakumar and A. Sarvalingam, "Poverty Underestimation in Rural India - A Critique," Munich Personal RePEc Archive, Tamil Nadu, 2010.

[22] A. Deaton and J. Dreze, "Food and nutrition in India: Facts and interpretations," *Economic and Political Weekly,* p. 2009, 14 Feb 2009.

[23] M. Pal and P. Bharati, "Executive summary of development of methodology towards measurement of poverty," Indian Statistical Institute, Kolkata, 2005.

[24] Food and Agriculture Organization, "Food security statistics," [Online]. Available: http://www.fao.org/economic/ess/ess-fs/fs-data/ess-fadata/en/. . [Accessed 7 Aug 2013].

[25] UNICEF, "State of the world's chidlren," UNICEF, New York, 2009.

[26] R. Khera, "India's public distribution system: utilisation and impact," *The Journal of*

Development Studies, vol. 47, no. 7, pp. 1038-1060, 2011.

[27] S. Nakkiran, "A study on the effectivenss of the public distribution system in rural Tamil Nadu," The Planning Commission of India, Porayar, 2004.

[28] U. Kapil and R. Pradhan, "Integrated Child Development Services scheme (ICDS) and its impact on nutritional status of children in India and recent initiatives," *Indian Journal of Public Health,* vol. 43, no. 1, pp. 21-25, 1999.

[29] Kapil, "The Integrated Child Development Services (ICDS) Scheme: A program for holistic development of children in India," *Indian Journal of Pediatrics,* vol. 69, pp. 597-601, 2002.

[30] M. Huff-Rousselle, S. Purushothaman, N. Tirupathaiah and J. Fiedler, "Assessment of decentralized food models in India's ICDS program," Food and Nutrition Technical Assistance Project (FANTA), Washington, DC, 2007.

[31] R. Gaiha, N. Kaicker, K. Imai, V. Kulkarni and G. Thapa, "Has dietary transition slowed down in India: An analysis based on 50th, 61st and 66th rounds of NSS," ASARC, 2012.

[32] J. Hoddinott and Y. Yohannes, "Dietary diversity as a food security indicator," FANTA, Washington DC, 2002.

[33] V. Rani, D. Arends and I. Brouwer, "Dietary diversity as an indicator of micronutrient adequacy of the diet of five to eight year old Indian rural children," *Nutrition and Food Science,* vol. 40, no. 5, pp. 466-476, 2010.

[34] S. Hooshmad and S. Udipi, "Dietary diversity and nutritional status of urban primary school children from Iran and India," *Journal of Nutritional Disorders and Therapy,* 2013.

[35] R. Madden, Being Ethnographic, India: SAGE, 2010.

[36] M. Patton, Qualitative Research and Evaluation Methods - 3, Thousand Oaks, California: SAGE Publications, 2010.

[37] E. Cruz and G. Higginbottom, "The use of focused ethnography in nursing research," *Nursing Research,* vol. 20, no. 4, pp. 36-43, 2013.

[38] H. Knoblauch, "Focused ethnography," *Forum: Social Qualitative Research,* vol. 6, no. 3, p. art 44, 2005.

[39] Canadian Council of Food and Nutrition , "Ethnographic study: a new perspective on Canadians' attitudes and beliefs towards food and nutrition," Canadian Council of Food and Nutrition , Missisauga, 2010.

[40] E. Finnis, "The political ecology of dietary transitions: Changing production and consumption patterns in the Kolli Hills, India," *Agriculture and Human Values,* vol. 24, no. 3, pp. 343-353, 2007.

[41] S. Wilkinson, "Focus groups: A feminist method," in *Feminist Perspectives on Socia Research*, New York, University Press , 2004, pp. 271-295.

[42] D. Morgan, Focus Groups as Qualitative Research Volume 16, London: SAGE Publications, 2008.

[43] T. Furst, M. Connors, B. CA, J. Sobal and L. Falk, "Food choice: A conceptual model of the process," *Appetite,* vol. 26, no. 3, pp. 247-65, 1996.

[44] C. Devine, M. Connors, C. Bisogni and J. Sobal, "Life course influences on fruit and vegetable consumption: Qualitative analysis of food choices," *Journal of Nutrition Education,* vol. 30, no. 6, pp. 361-370, 1998.

[45] K. Glanz, B. Rimer and K. Viswanath, Health Behaviour and Health Education 4th Ed., San Fransisco: John Wiley & Sons, 2008.

[46] R. Green-LaPierre, P. Williams, T. Glanville, D. Norris, H. Hunter and C. Watt, "Learning from "Knocks in life": Food insecurity among low-income lone senior women," *Journal of Aging Research,* 2012.

[47] U. Bronfenbrenner, "Ecological Models of Human Development," in *International Encyclopedia of Education* , Oxford: Elsevier, 1994, pp. Vol 3, 2nd ed.

[48] R. Baumeister and M. Leary, "Writing narrative literature reviews," *Review of General Psychology,* vol. 1, no. 3, pp. 311-320, 1997.

[49] R. Whittemore and K. Knafl, "The integrative review: updated methodology," *Methodological Issues in Nursing Issues,* pp. 546-553, 2005.

[50] M.S.Swaminathan Research Foundation; University of Alberta, "Alleviating poverty and malnutrition in agrobiodiversity hotspots: a baseline report," 2013.

[51] D. Galhena, R. Freed and K. Maredia, "Home gardens: A promising approach to enhance household food security and well-being," *Agriculture and Food Security,*

2013.

Chapter 2: Narrative review of dietary diversity tools

2.1 Introduction

Eating a variety of foods has been a message incorporated into the healthy eating guidelines of many nations [1] [2] in order to ensure the adequate intake of a variety of nutrients. Consuming a diverse diet along with reducing the intake of fat, sugar, and salt, has been shown in the literature to have protective effects from chronic diseases [3].

Dietary diversity is defined as the number of foods or food groups consumed over a reference period [4]. Low dietary diversity is especially a concern in many developing nations. Studies have shown that many populations in developing nations experience low dietary diversity, with diets consisting primarily of cereals or starches with low varieties of fruits and vegetables as well as animal products [5]. Low micronutrient intakes in developing nations are a concern [6]. The consequences of low micronutrient intakes may be severe. Iodine, iron, and vitamin A deficiencies are of particular concern in the developing world [6], and these deficiencies represent a major threat to the health and well-being of low income populations of different countries. Many developing nations also face challenges related to rising rates of obesity and chronic illnesses as a result of urbanization and changes in food distribution systems and dietary patterns [7].

It is often time consuming and labour intensive to collect extensive dietary data on a population level to assess micronutrient adequacy, especially in developing nations where there are limited resources to support the collection of large scale data. Simple indicators to monitor dietary diversity at the individual level are important to characterize the micronutrient adequacy of the diet for certain populations in developing nations in order to monitor the effectiveness of various intervention programs in improving micronutrient deficiencies.

There is currently a lack of uniformity in the literature in regards to the indices used to assess dietary diversity. Approaches to assessing dietary diversity involve a totaling of the foods or food groups consumed. Single food counts are referred to as food variety scores (FVS) while food group counts are referred to as dietary diversity scores (DDS).There are, however, huge discrepancies and variations between studies in terms of the reference period used, the classification of food groups, and the optimal number and types of food to be grouped together to calculate dietary diversity.

For children aged 6-23 months, the World Health Organization has validated a food group diversity indicator that sums 7 food groups [8]. This indicator has been consistently used in the literature to evaluate dietary diversity in children 6-23 months. However, in other population, a range of different number of food groups has been reported to be used [4].

The Food and Agricultural Organization (FAO) in 2011 released a set of guidelines on assessing dietary diversity on the individual as well as household level [9]. Information on dietary diversity may be collected on the individual level or the household level depending on the purpose of assessment. The evidence to support current guidelines

for assessing individual as well as household level dietary diversity is based on literature published in these areas.

Collecting dietary diversity information on the individual level may be important in assessing the dietary patterns or monitoring of nutritional programs or agricultural interventions to diversify the diet of a population [9]. It has been suggested that the dietary diversity status of a household as a unit is important in the assessment of a household's economic access to food [9]. These guidelines for measuring household or individual dietary diversity provide specific recommendations on the aggregation of foods into food groups, considerations for minimum quantities of food consumed, and consideration for reference periods. The food group aggregation suggested to be used in this tool for individuals is based on a large, multi-country study conducted by Arimond et al [17]. It is the largest study to compare several DDS with different food group aggregations in predicting micronutrient adequacy for adults. The recommendations for assessing household level dietary diversity are based on the food group aggregation proposed by Swindale and Bilinsky [18]. The guidelines also briefly discussed various considerations in tool administration, including optimal time of the year to administer this tool. However, as this tool is not culture, population, or location specific, it is imperative to consider local context prior to deployment in the field [9].

Previous FAO Guidelines for assessing individual and household level dietary diversity [10] have classified individual food items into 14 food groups for calculation of individual dietary diversity score and a 12 food group score for calculation of household level dietary diversity (HDDS). The 12 food groups used to calculate HDDS include: cereals, white roots and tubers, vegetables, fruits, meat, eggs, fish and other seafood, pulses

legumes and nuts, milk and milk products, oils and fats, sweets, spices, condiments and beverages [10].

The most recent version of FAO guidelines on assessing individual and household level dietary diversity [9] recommends classifying foods into 9 categories. Appendix 2 shows the changes in food group aggregation between the two versions. Both set of guidelines propose determining dietary diversity from the collection of dietary data from a 24-hour reference period. In terms of minimum quantities to be consumed in order to be considered towards the calculation of a dietary diversity score, previous guidelines recommended using a 10g of a food item minimum intake [10] whereas current guidelines recommended setting a 15g minimum [9].

To date, only one review study has been conducted [4] on indices to assess dietary diversity, with discussions on the strengths and weaknesses of different parameters in DDS indices. A number of important studies published since then have examined either the dietary diversity of populations in different countries or have validated the association between DDS indices and micronutrient adequacy. A more current review of indices to assess dietary diversity will provide further insight into the utilization of such indices in the field for various purposes.

The objective of this review was to provide an overview of the different indices used to assess dietary diversity and considerations for assessing dietary diversity in developing nations.

Specific objectives are:

1. To provide an overview of the different parameters within indices used to operationalize dietary diversity, with emphasis on the strengths and weaknesses within each parameter.

2. To provide a qualitative overview of the association between dietary diversity and various indicators of nutritional status as well as with household economic status/food security.

3. To critically examine the appropriateness of various methods in assessing dietary diversity in developing nations, with specific considerations for populations in developing nations.

2.2 Methods

2.2.1 Inclusion criteria

Only studies which focused on populations in developing countries were included. Studies which focused on children 6-23 months of age were excluded, as the World Health Organization has validated a tool which can be used across cultures to assess dietary diversity in this age group [8]. Included studies had to utilize a dietary diversity index in the study; dietary diversity indices may include DDS or FVS. As an objective of this review was to provide a qualitative overview of the associations between dietary diversity and various health outcomes, studies which assessed dietary diversity indices with health outcomes including anthropometric measurements, biochemical assessment or other health related indices were included. No language or publication

date restrictions were imposed. Only full text articles were included in this review. Non-human studies were excluded from this review.

2.2.2 Literature search

A literature search was conducted with the assistance of a librarian (L.D.). Databases that were searched included Medline, Embase, CINAHL, Global Health, Web of Science, Scopus up to August 2013. No date restrictions were placed as there have been little changes in indices to assess dietary diversity in the literature. Studies were limited to only those with human populations; and animal studies were eliminated. Index headings with names of certain developed countries were eliminated through the search strategy. As the population of interest is individuals in developing nations, no language restrictions were placed on searches. In order to search for grey literature, a Google search was performed using the same search terms. The search strategy is shown in the Appendix 1.

2.2.3 Screening

The first level of screening combined all of the studies identified from each database and further screening eliminated duplicates. Located articles were examined for relevance to the topic and potential fit by title. Studies in languages other than English were reviewed with the assistance of others. If the title was unclear, then the abstract was reviewed for relevance to topic. To locate all important articles, reference lists of relevant articles were also reviewed. For articles which the abstracts suggested relevance to the topic, the full text of the article was reviewed. Figure 3.1 shows a flow diagram of screening of the included and excluded articles for review. An initial

literature search strategy identified 2500 studies. After removal of all duplicates 1190 articles remained. After located articles were reviewed for fit by title, only 58 relevant articles remained from all databases combined.

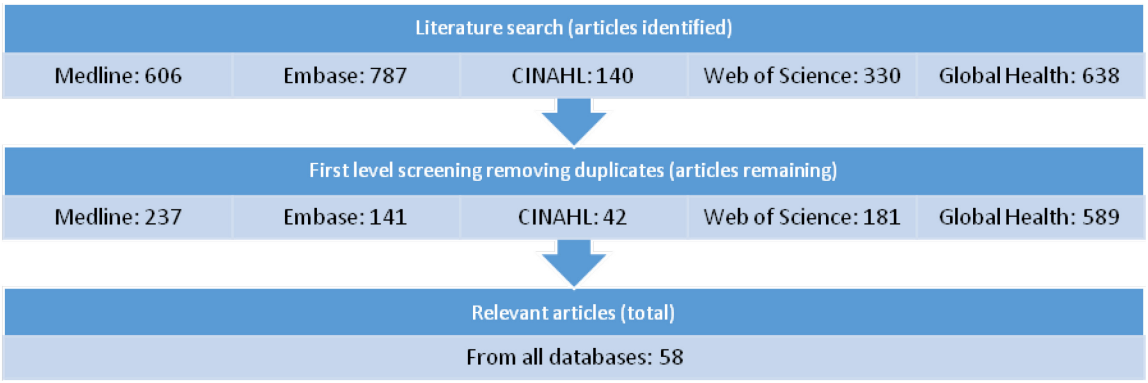

Figure 2.1: Flow Diagram of Study Screening Process

2.3 Results

2.3.1 Study screening

The literature search retrieved 606 references from Medline, 787 from Embase, 140 from CIHNAHL, 330 from Web of Science, and 628 from Global Health (1973 – present). A total of 1157 duplicate citations were removed. Of the remaining studies, 1190 abstracts were reviewed for fit with the inclusion criteria. In the final review of full articles, a total of 58 studies were included in the review. The search of the grey literature retrieved three relevant reports.

2.3.2 Description of indices

To assess dietary diversity, some methods used DDS while others used FVS. Single food counts are referred to as food variety scores (FVS) while food group counts are referred

to as dietary diversity scores (DDS). Forty-eight studies used DDS to assess variety in the diet and 4 studies used FVS. Methods of determining DDS differed in several main parameters: the food group aggregation used in calculating DDS, the reference period that the index is based on, and minimum portion considerations. Table 3.1 summarizes the different parameters of each index.

Table 2.1: Parameters of various dietary diversity indexes

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
Studies utilizing dietary diversity score without or in conjunction with food variety score (in ascending order of number of food groups in index)					
Azadbakht and Esmaillzeadeh (2012)	Isfahanian female university students	5 food group DDS	U.S. Food Guide Pyramid	Past year (information converted into daily intake)	½ serving of any subgroup in 1 day as per U.S. Food Guide Pyramid
Azadbakht, L., Mirmiran, P., Azizi, F. (2005)	Tehranian adult male ages 18-49	5 food group DDS	U.S. Food Guide Pyramid	2 days, non-consecutive	½ portion as per USDA Food Guide Pyramid
Azadbakht and Esmailzeadeh (2006)	Tehranian adults over 18 years of age	5 food group DDS	U.S. Food Guide Pyramid	Past year (information converted into daily intake)	½ portion as per USDA Food Guide Pyramid
Azadbakht and Esmailzeadeh (2011)	Iranian female ages 18-28	5 food group DDS	U.S. Food Guide Pyramid	Past year (information converted into daily intake)	½ portion as per USDA Food Guide Pyramid
Clausen et al (2005)	Older adults in Botswana	5 food group DDS	U.S. Healthy Eating Index	1 week	×

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
		and FVS			
Fitzgerald et al (1992)	Pregnant women in peri-urban Guatemala	5 food group DDS	^	9-14 days within 3 weeks	×
Mirmiran et al (2006)	Adult women in Tehran, Iran	5 food group DDS	U.S. Food Guide Pyramid	2 days, non-consecutive	½ portion as defined by US Food Guide Pyramid
Mirmiran et al (2004)	10-18 year old adolescents in Iran	5 food group DDS	U.S Food Guide Pyramid	2 days, non-consecutive	½ portion as defined by US Food Guide Pyramid
Gewa et al (2011)	School children in rural Kenya	6 food group DDS	^	3 days, non-consecutive	3 DDS: with minimum intake 1g, 15g and variable intakes
Badari et al (2012)	Malaysian households	6 food group DDS and FVS	Malaysian Food Pyramid	FVS: 1 week reference DDS: 1 day	×
Rathnayake, Madushani and Silva (2012)	Rural elderly people in Sri Lanka	6 food group DDS and FVS	As Krebs-Smiths et al (1987)	1 day	×
Maitland (2006)	Households in the Turks and Caicos Islands	7 food group DDS	^	1 week	×
Ihab et al (2012)	Non-lactating and non-pregnant women ages 18-55 years	8 food group DDS	^	1 week	×

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
	in rural Malaysia				
Nupo et al (2013)	Adult women in rural areas of Ogun State, Nigeria	8 food group DDS	FANTA/WHO(2006) and Azadbakht (2005)	1 day	½ serving as per USDA Food Guide Pyramid
Arsenault et al (2013)	Young children 24-48 months of age and their primary female caregiver in rural Bangladesh	9 food group DDS	As per Arimond et al (2010)	2 days, non-consecutive	Two different scores calculated: one with 1g minimum food consumption and a second with 10g consumption for children and 15g for adults
Steyn et al (2006)	South African children ages 1-8	9 food group DDS	As per Hatloy et al (1998)	1 day	×
Jin et al (2009)	Chinese adults aged 18-59 years of age	9 food group DDS based on	Chinese Food Guide Pyramid	3 days	×
Savy et al (2007)	Adult women in rural Burkina Faso	9 food group DDS	As per FAO (2004)	1 day, 2 days, or 3 days. All consecutive	×
Vakili et al (2013)	Girls aged 15-18 in Iran	9 food group DDS	As per FAO (2004)	1 day	15g
Faber et al (2009)	Households in Limpopo Province, South Africa	9 food group DDS	As per Steyn (2006)	1 day	×
Labadarios et	Adolescents	9 food	As per Steyn (2006)	1 day	×

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
al (2011)	and adults age 16 and older in South Africa	group DDS			
Steyn et al (2012)	Pregnant women aged 15 years and older in Kenya	9 food group DDS and FVS	As per Steyn (2006)	1 day	×
Oldewage Theron and Kruger (2009)	Elderly in Sharperville, South Africa	9 food group DDS and FVS	As per FAO (2004)	7 days	×
Oldewage Theron et al (2011)	Black adult women in South Africa	9 food group DDS	As per FAO (2010)	1 week	×
Torheim et al (2003)	Adults ages 15-59 in rural Mali, West Africa	10 food group DDS and FVS	As per Hatloy (1999)	2 days	0.1g
Torheim et al (2004)	Adults in Western Mali	10 food group DDS and FVS	As per Hatloy (1999)	7 days	×
Hatloy et al (1998)	Chidlren 13-58 months of age in Southeastern Mali	10 food groups DDS and FVS	As per Kant (1991)	3 days, consecutive or 2 days, consecutive	×
Fujita et al (2012)	Women ages 18-46 in Kenya	10 food group DDS	As per Kennedy et al (2007)	1 day	×
Hatloy et al (2000)	Rural and urban children ages	10 food group DDS	As per Hatloy et al (1998)	1 day	×

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
	6-59 months				
Cabalda et al (2011)	Children ages 2-5 in Philippines	10 food group DDS	As per Kennedy et al (2007)	1 day	10g
Ekesa et al (2011)	Preschool children from banana dependent households in DRC and Burundi	11 food group DDS	As per FANTA (2004)	1 day	×
Jayawardena et al (2013)	Sri Lankan adults	12 food group DDS	Based on Sri Lankan Food Pyramid	1 day	DDSP: 1 portion as per guidelines
		8 food group DDSP (Dietary diversity score with portions)			
Hoddinott and Yohannes (2002)	Draws on household level data from 10 countries: Bangladesh, Egypt, Ghana, India, Kenya, Malawi, Mali, and Mexico	12 food group DDS	^	1 day	×
Kennedy et al	Household members in	12 food group	HDDS: As per Swindale and	HDDS: 1 day	×

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
(2010)	Burkina Faso, Lao PDR, and northern Uganda	HDDS And 8 food group food FCS	Bilinsky (2006) FCS: Developed by World Food Program	FCS: 1 week	
Nnyepi et al (2008)	Female or male head of household in Okavango in Botswana	12 food group HDDS	As per Swindale and Bilinsky (2006)	1 day	×
Nyangweso et al (2007)	Households in Vihiga, Kenya	12 food group HDDS	As per Swindale and Bilinsky (2006)	1 day	×
Rani et al (2010)	Children ages 2-5 in rural India	13 food group DDS	As per Arimond et al (2010)	2 days	×
Li et al (2011)	Chinese children and adolescents aged 2-17	13 food group DDS	As per Stookey et al (2000)	3 days, non-consecutive	25g
Becquey et al (2010)	Urban households in Burkina Faso	14 food group DDS	As per FAO (2008)	2 days, non-consecutive	×
Savy et al (2005)	Adult mothers and their children under 5 years of age	14 food group DDS	Consideration for local foods consumed combined with FAO (2008) guidelines	1 day	×
Ajani (2010)	Women of child-bearing age and their children	14 food group DDS	As per FAO (2008)	1 day	×

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
	under 5 years of age in Nigeria				
Akrofti et al (2010)	HIV positive and HIV negative households in Eastern Region, Ghana	14 food group DDS	As per FAO (2007)	1 day	×
Keding et al (2012)	Women 15 to 45 years of age in Tanzania	14 food group DDS and FVS	As per FAO (2007)	1 day	×
Martin-Prevel et al (2012)	Households and female head of household in rural Burkina Faso	14 food group DDS	As per FAO (2008)	1 day	×
Chua et al (2012)	Children ages 1-6 from Orang Asli tribes in Malaysia	15 food group DDS	Adapted from FAO (2008)	7 days	×
Bezerra and Sichieri (2011)	Adults in Brazilian households	27 food group DDS	Based on Brazilian Food Guidelines	1 week	×
	Studies utilizing multiple DDS with different food group aggregations				
Arimond et al (2010)	Women of child-bearing age in Burkina Faso, Mali,	6, 9, 13, or 21 food group Dietary diversity	^	1 day	15g minimum

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
	Mozambique, Bangladesh, and Philippines	score (DDS)			
Martin Prevel et al (2010)	Adults in Burkina Faso	6, 9, 13, or 21 food group DDS	^	3 days, non-consecutive	15g
Olney et al (2009)	Households in rural Cambodia	6 food group DDS for the household level and 9 DDS food group DDS for individuals in the household	^	3 days or 1 week	×
Soto-Mendez et al (2011)	Adults women in rural and urban women in Guatemalan	3 indexes : 6 food group DDS 8 food group DDS 25 food group DDS	8 food group DDS developed based on WHO (2006)	2 days, non-consecutive	×
		Studies utilizing only FVS			
Nurfaizah et al (2009)	Non pregnant women of child bearing age children aged 2-9	FVS	^	3 days	×

Study	Population	Tool(s) used	Protocol used in index development (if applicable)	Reference period	Minimum portion size considerations
Ekesa et al (2008)	Preschool children 2-5 years in western Kenya	FVS	^	1 week	×
Ekesa et al (2009)	Preschool children 2-5 years	FVS	^	1 week	×
Ferguson et al (1993)	Children ages 3-6 from rural Malawi and Ghana	FVS	^	3 days, consecutive	×

Examples of ½ potion of U.S Food Guide Pyramid are half a slice of bread, half cup of raw leafy vegetables, half of a medium fruit, half a cup of milk or yogurt, and 1-1.5 ounces of cooked lean meat.

^ Information not specified

× Parameter not considered

Acronyms

DDS: Dietary diversity scores

HDDS: Household level dietary diversity scores

FVS: Food variety scores

MPA: Mean probability of adequacy of nutrients

MAR: Mean adequacy ratio of nutrients

FFQ: Food frequency questionnaire

FAO: Food and Agriculture Organization of the United Nations

FANTA: Food and Nutrition Technical Assistance

FCS: Food consumption score

Food group aggregations used in calculating DDS ranged from 5-27 food groups. Eight studies used indices based on five food groups [11] [12] [13] [14] [15] [16] [17] [18], three studies used indices based on six food groups [19] [20] [21], one study used indices based on seven food groups [22], two studies used indices based on eight food groups [23] [24] , 10 studies used indices based on nine food groups [25] [26] [27] [28] [29] [30] [31] [32] [33] [34], six studies used indices based on 10 food groups [35] [36] [37] [38] [39] [40], One study used an index based on 11 food groups [41], five studies used an index based on 12 food groups [42] [43] [44] [45] [46], two studies used indices based on 13 food groups [47] [48], six studies used indices based on 14 food groups [49] [50] [51] [52] [53] [54], one study used an index based on 15 food groups [55], and one study used an index based on 27 food groups [56]. Several studies used multiple indices in their studies consisting of different food group aggregation for comparison purposes [57] [58] [59].

Protocols used to develop indices varied greatly across studies. Most studies reported taking into consideration country specific dietary guidelines in food aggregation as well as recommendations from the FAO. FAO recommendations will be described in more detail in the subsequent section. Food group aggregations were often based on agricultural commodity categorization as well as a certain degree of similarity in nutrient profile. In more disaggregated food groupings, food groups rich in specific nutrition are further separated into subgroups. For instance, vitamin A rich fruits and vegetable are separated from other fruits and vegetables [49].

Reference periods used by indices to assess the diversity in the diet ranged from 24 hours to 14 days in the literature. Of the studies included in the review, 24 studies

utilized a 24 -hour reference period only, 15 studies used a reference period of two and/or three days (either consecutive or non-consecutive) to capture the variations that may exist in the diet, seven studies used a reference period of one to two weeks and the remaining studies used multiple reference periods for comparison purposes.

In regards to minimum portion size considerations, some studies required that a minimum portion of food be consumed before it was considered towards the DDS. Seven studies required that a minimum consumption amount of ½ serving of a U.S. Food Guide Pyramid serving per food item. Eight studies require a minimum portion consumption amount of between 0.1 and 25g of intake, and 37 studies did not take into consideration minimum consumption amount to calculate DDS.

2.3.3 Use of indices

Of the studies included in this review, 14 studies validated dietary diversity indices with nutrient adequacy, 15 studies examined the association between dietary diversity indices and various nutritional indicators, five studies studied the association between dietary diversity indexes and food security, and 18 studies used dietary diversity indexes to assess the effectiveness of interventions or simply to study the dietary pattern of various populations.

2.3.4 Strengths and weaknesses within each parameter to predict nutrient adequacy

Parameters of DDS may affect the tools' ability to predict nutrient adequacy. First, a comparison between DDS and FVS was made. Studies which examined the strengths and weaknesses within each parameter of DDS are described below. Parameters of DDS

include food group aggregation, reference period, and minimum portion recommendations.

Food Variety Scores and Dietary Diversity Scores

Both FVS and DDS have been used in the literature to assess dietary diversity. Some studies have been done to compare the use of FVS versus DDS in assessing variety in the diet to compare the relative effectiveness of these tools to assess nutrient adequacy [35]. Torheim et al (2003) assessed the validity of both FVS and DDS in predicting nutrient adequacy for adults in Mali, West Africa. Mean nutrient adequacy (MAR) was determined from both a validated food frequency questionnaire (FFQ) as well as a 2-day weighed food record (WR). The correlation between FVS and FFQ as well as FVS and WR were statistically significant at 0.5 and 0.4 respectively, with p value $<$ 0.05; the correlation between DDS and FFQ as well as DDS and WR were also statistically significant at 0.2 and 0.4, respectively, with p $<$ 0.05. These results suggest that both FVS and DDS are correlated with MAR calculated from WR as well as FFQ, and FVS was suggested to be a better predictor of nutrient adequacy.

Likewise, Hatloy et al (1998) examined whether a simple count of food items (from FVS) and food groups (from DDS) can predict the nutritional adequacy of children ages 13-58 months in South-eastern Mali. These scores were evaluated against the mean nutrient adequacy ratio (MAR) calculated from a three-day WR of children. Every food item consumed by participants was counted towards the FVS regardless of the quantity consumed. A positive correlation was found between both FVS and MAR as well as DDS and MAR of 0.3 and 0.39, respectively, p $<$ 0.001. Although both FVS and DDS were significantly correlated with MAR, results suggested that it was relatively easier to

achieve a satisfactory intake of all nutrients by consuming more food groups than simply increase the number of food items consumed [37]. This suggests that DDS is likely a better predictor of nutrient adequacy than FVS.

A more recent study by Rathanayake, Madushani, and Silva (2012) assessed the validity of both FVS and DDS as indicators of nutrient adequacy in elderly people of Sri Lanka. All indicators were significantly correlated with MAR, with Pearson's correlation coefficient for MAR and FVS and MAR and DDS being 0.45 and 0.48, respectively, with $p < 0.01$. However, a study by Rani, Arends and Brouver (2010) in rural Indian children suggested that FVS had a stronger positive correlation with MPA compared to DDS, with Pearson's correlation coefficient at 0.23 and 0.27 for DDS and FVS, respectively [48].

The correlation between DDS and MAR in the literature ranges from 0.12 to 0.76. For FVS, correlations with MPA range from 0.33 to 0.45. There is insufficient evidence to suggest what is considered high low or moderate association between FVS or DDS and nutrient adequacy. However, results suggest that there are inconsistent results regarding which indicator – FVS or DDS is a better predictor of nutrient adequacy. Despite this, studies appeared to suggest that both FVS and DDS indices were significantly and positively associated nutrient adequacy.

Food group aggregation

Dietary Diversity Scores are often calculated based on a totaling of food groups consumed. Foods must be aggregated into meaningful categories for relevant DDS to be calculated. Food group aggregation to calculate DDS ranged from 5 to 23 in the

literature. In the examination of the contribution of dietary diversity to overall nutrient adequacy, food should be aggregated based on specific nutrient content [4]. In determining household level dietary diversity, foods may be aggregated according to the economic value of food items in order to measure household economic access to food [4]. In regards to specific aggregations of food groups for dietary diversity scores, there is currently no uniformity across studies for specific groupings of foods into food groups

One study compared the validity of different levels of food group aggregation to predict micronutrient adequacy. The Women's Diet Diversity project examined the association between dietary diversity and nutrient adequacy in women in developing nations of child bearing age [57]. The study completed in rural Bangladesh compared eight dietary diversity indicators and their relative association with 11 micronutrients. These eight indicators varied in the degree of food aggregation, ranging from 6 to 21 major food groups. A minimum 15 grams of food must be consumed for the food item to count towards a food group. In the more disaggregated food diversity indicators, nutrient dense foods such as animal source foods, fruits and vegetables are more disaggregated than staple food groups. All of the eight dietary indicators were found to be significantly associated with the intake of all 11 micronutrients even after controlling for energy intake [57]. Correlations between DDS and MPA ranged between 0.19 and 0.52 (p values vary), depending on the country of interest. The 9 food group indicator was selected as the indicator of choice to be incorporated into FAO guidelines on measuring individual dietary diversity [9]. There is some evidence that increasing the disaggregation of food groups may result in better indicator performance; this relationship, however, is not conclusive [57].

FAO guidelines on food group aggregation

The FAO Guidelines on measuring household and individual dietary diversity specifies a 9 food group indicator to measure individual dietary diversity and a 12 food group indicator to measure household level dietary diversity [9]. The 9 food group indicator includes starchy staples, dark green leafy vegetables, vitamin A rich fruits and vegetables, other fruits and vegetables, organ meat, meat and fish, eggs, legumes and nuts and seeds, and milk and milk products. The food group aggregation to create a household level dietary diversity score (HDDS) is different. Additional groups includes oils and fats, sweets, spices, condiments and beverages as these food items may be important in assessing a household's economic ability. Further, all vegetables in this indicator were grouped into one food group whereas IDDS separated fruits and vegetables according to nutrient profile. These guidelines provide useful recommendations for the aggregation of foods into meaningful groups to determine individual and household level dietary diversity. However, as these food group aggregations are neither culture nor location specific, much adaptation may be required prior to its utilization in the field to ensure that these food groups reflect the dietary patterns of the local population with careful consideration for dietary restrictions related to culture or religion [9]. For instance, certain food groups may be eliminated from the tool if they are not an item that is appropriate to the culture. Dietary patterns may vary significantly across cultures, and groups of food for the evaluation of dietary diversity may only be defined locally.

Reference period

The recall time period to collect information regarding dietary diversity information from participants varied between studies. In this review, most studies used recall periods of one-day for simplicity (refer to Table 1). Some studies utilized multiple non-consecutive days including one weekday and one weekend day for the recall period. This was done in order to capture any potential variations in intake between different days of the week.

To date, no study in the developing nations has compared the validity of a one-day or multiple day dietary recall in predicting nutrient adequacy. However, Savy et al. (2007) conducted a study to compare dietary diversity scores measured over one-day and three-day periods by assessing their relationship with socio-economic characteristics and nutritional status of rural African women. Both scores were found to be significantly associated with the Body Mass Index (BMI) of the women; the mean BMI of the women increased with increasing tertile of the DDS [27]. Results suggested that diets in Burkina Faso, similar to many other developing nations, are monotonous and low in diversity and intra-individual variations in consumption from day to day is very low, and DDS calculated from one day is sufficient to predict the women's nutritional status [27].

The FAO Guidelines on measuring household and individual dietary diversity recommends a reference period of the previous 24-hours in assessing dietary diversity [9]. This was the timeframe chosen as it is less subject to recall error and less cumbersome for the respondent to recall. A single reference period of 24-hours does not provide an indication of an individual's habitual intake; however, it does allow for dietary assessment at the population level in order to monitor progress for nutritional interventions [9]. Repeated 24-hour recalls can be utilized as a method to assess a

typical diet at the individual level [60]. Depending on the objective of dietary diversity assessment, it may be necessary to adapt the tool and use other reference periods.

Consumption frequency

Food frequency questionnaires (FFQ) are designed to gather information on habitual intake by asking about the frequency with which some food items or specific food groups are consumed over a longer reference period. These reference periods may vary significantly from weeks to a year. Kennedy et al (2010) compared the performance of the household dietary diversity score (HDDS) and the food consumption score (FCS) in two common indicators used in food security surveillance. These indicators were compared based on populations from three developing nations – Burkina Faso, Lao PDR, and northern Uganda. Household level food group consumption over one-day and seven days were compared. It was suggested that the dietary diversity scores calculated from the seven day reference period may underestimate the kinds of foods consumed. The likely explanation is under-reporting during the longer recall period due to memory error. This impact of memory error must be taken into consideration when using reference periods longer than one day in indicators to assess dietary diversity. Furthermore, the FCS, which took into consideration the frequency of consumption of various food groups as well as the types of foods consumed were found to better correlated with household level energy intake than scores that took into consideration only the types of foods consumed [44]. In assessing DDS, additional components of the assessment tool which asks about the frequency of consumption have the potential to result in added accuracy in predicting micronutrient adequacy and energy intake.

However, the potential of added accuracy must be weighed against the additional time and effort required in data collection and analysis [44].

Portion size considerations

Considerations for a minimum quantity of consumption before a food is counted towards DDS varied across studies. Many studies have not required a minimum quantity of a food item to be consumed prior to its inclusion in the DDS while some studies have required that a minimum serving of food be consumed before it can be counted towards dietary diversity scores (refer to Table 1).

In assessing individual DDS, Arimond et al (2010) suggested that including a minimum consumption quantity of 15g appeared to have improved the association between dietary diversity scores and micronutrient adequacy for women 15-49 years of age. This is reasonable as the quantity of a food item consumed may not be sufficient to contribute a significant amount of certain micronutrients [4]. Understanding of dietary patterns of specific populations of interests will help in determining what normal portions of certain foods consumed are and to determine if setting a minimum consumption amount will influence the assessment of micronutrient adequacy.

In calculating HDDS, FAO Guidelines for assessing individual and household level dietary diversity recommends that there is no need to set minimum quantities below which foods are not considered as even small quantities of consumption for certain food items indicate that household has the economic ability to purchase that item [9].

2.3.5 Association of dietary diversity with nutrient adequacy, nutritional status and food security

Fourteen studies validated dietary diversity indexes with nutrient adequacy. Structural validity was evaluated, assessing the degree to which dietary diversity indices are an adequate reflection of nutrient adequacy in the diet [61]. Fifteen studies assessed the association of dietary diversity indexes with indicators of nutritional status and five studies assessed the association between dietary diversity and food security. Tables 3.2, 3.3 and 3.4 organize the studies identified according to the purpose of the study. An overview of the association between dietary diversity and various indicators of nutritional status as well as with household economic status/food security is provided in subsequent sections.

Table 2.2: Association of dietary diversity with nutrient adequacy

Study	Item of interest	Dietary diversity tool	Population	Outcome
Study participants – children and adolescents (n=6)				
Arsenault et al (2013)	To quantify micronutrient intakes	9 food group DDS	Young children 24-48 months of age and their primary female caregiver in rural Bangladesh (n = 480)	Correlation between DDS and MPA of 0.63, $p < 0.05$ for children
Gewa et al (2011)	To determine the ability of dietary diversity scores (DDS) to predict	6 food group DDS	School children in rural Kenya (n=520)	Correlation between DDS and MPA, ranging from 0.46 to 0.51, $p <$

	micronutrient intake			0.001
Hatloy et al (1998)	To assess whether a simple count of food items and food groups can predict the nutrient adequacy of the diet	FVS and 10 food groups DDS	Children 13-58 months of age in Southeastern Mali (n=77)	Correlation between FVS and MAR of 0.33, $p < 0.001$ and between DDS and MAR of 0.39, $p < 0.001$.
Mirmiran et al (2004)	To determine dietary diversity and its relation to dietary adequacy	5 food group DDS	10-18 year old adolescents in Iran (n=304)	Correlation between DDS and MAR of 0.42, $p < 0.001$.
Rani et al (2010)	To validate DDS as an indicator of nutrient adequacy of diet of Indian rural children	FVS and 13 food group DDS	5-8 year old Indian rural children (n=232)	Correlation between DDS and MPA of 0.21, $p < 0.01$
Steyn et al (2006)	To assess whether dietary diversity is good indicator of nutrient adequacy	9 food group DDS	South African children ages 1-8 (n=2200)	Correlation between DDS and MAR of 0.726, $p<0.0001$, and between FVS and MAR of 0.657, $p<0.0001$.
Study participants – adult women (n=4)				
Arimond et al	To assess the potential of DDS	6, 9, 13, or 21 food	Women of child-bearing	Correlations between DDS

(2010)	to serve as proxy indicators of micronutrient adequacy	group DDS	age in Burkina Faso, Mali, Mozambique, Bangladesh, and Philippines	and MPA of between 0.19 and 0.52, p values vary.
Arsenault et al (2013)	To quantify micronutrient intakes	9 food group DDS	Young children 24-48 months of age and their primary female caregiver in rural Bangladesh (n = 480)	Correlation between DDS and MPA of 0.63, $p < 0.05$ for women
Azadbakht and Esmaillzeadeh (2012)	To determine relationship between dietary energy density and dietary diversity	5 food group DDS	Isfahanian female university students (n=289)	Correlation between DDS and dietary energy density of -0.3, p=0.03
Mirmiran et al (2006)	To determine relationship between dietary diversity between and within food groups and nutrient adequacy	5 food group DDS	Adult women in Tehran, Iran (n=286)	Correlation between whole grain diversity score and protein and vitamin B of 0.35. Correlation between fruit diversity score and vitamin C of 0.44. Correlation between meat diversity score and protein of 0.34. Correlation between dairy

				diversity score and calcium of 0.54. P < 0.05 for all correlations.
Torheim et al (2004)	To determine relation between dietary diversity and nutrient adequacy	FVS and 10 food group DDS	Adults in Western Mali (n= 502)	Correlation between DDS and MAR of 0.30 and between FVS and MAR of 0.34. P<0.001.
Study participants – adult men (n=1)				
Azadbakht, L., Mirmiran, P., Azizi, F. (2005)	To examine relationship between variety scores of food and probability of nutrient adequacy	5 food group DDS	Tehranian adult male ages 18-49 (n=295)	Correlation between whole grain diversity score and protein of 0.3. Correlation between fruit diversity score and vitamin C of 0.4. Correlation between meat diversity score and protein intake of 0.3. Correlation between dairy diversity score and calcium of 0.4. P < 0.05 for all correlations.
Study participants – both adult men and women (n=6)				
Becquey et al (2010)	To assess the ability of dietary diversity index and to approximate	14 food group DDS	Urban households in Burkina Faso (n=1056)	Correlation between individual DDS and MAR of between 0.12

	dietary adequacy of households			and 0.19, p < 0.001.
Jin et al (2009)	To estimate the diet diversity of adults aged 18-59 and its association with nutrient adequacy	9 food group DDS	Chinese adults aged 18-59 years of age (n=42336)	Correlation between DDS and adequacy ratio of 0.30, 0.25, and 0.22 for meat, vegetables, and soy, respectively. P values vary.
Martin Prevel et al (2010)	To compare DDS calculated from FFQ data and 24 hr recalls	6, 9, 13, or 21 food group DDS	Adults in Burkina Faso (n=182)	DDS generated from FFQ have a weaker correlation with MPA than DDS generated from 24 hr recall methods.
Rathnayake, Madushani and Silva (2012)	To assess the validity of FVS, DDS, and DSS as indicators of nutrient adequacy in Sri Lanka.	6 food group DDS FVS	Rural elderly people in Sri Lanka (n=200)	Correlation between FVS and DDS and MAR was 0.45 and 0.48 respectively, p < 0.01.
Torheim et al (2003)	To assess the validity of two diet quality indexes, FVS and DDS	10 food group DDS FVS	Adults ages 15-59 in rural Mali, West Africa (n=145)	Correlation between FVS and MAR obtained from FFQ and WR of 0.5 and 0.4, respectively. Corresponding

				correlations for DDS were 0.2 and 0.4. $p < 0.05$.

Acronyms

DDS: Dietary diversity scores

FVS: Food variety scores

MPA: Mean probability of adequacy of nutrients

MAR: Mean adequacy ratio of nutrients

FFQ: Food frequency questionnaire

WR: weighed records

Table 2.3: Association of dietary diversity and nutritional indicators

Study	Item of interest	Dietary diversity tool	Population	Outcome
Study participants – children and adolescents (n=7)				
Chua et al (2012)	To determine the relationship between dietary diversity and nutritional status	15 food group DDS	Children ages 1-6 from Orang Asli tribes in Malaysia (n= 216)	DDS positively correlated to wt-for-age β = 0.203, $p < 0.001$ and ht-for-age β = 0.123, $p < 0.05$
Ekesa et al (2009)	To determine dietary diversity, nutrient intake, and nutritional	FVS and 8 food group DDS	Preschool children ages 2-5 (n=144)	About 7%, 3.6% and 8.1% of changes in underweight,

	status			stunting and wasting can be attributed to changes in dietary diversity.
Hatloy et al (2000)	To analyze the associations between FVS and DDS and nutritional status of children	10 food group DDS	Rural and urban children ages 6-59 months (n= 2315)	Children from urban households with low FVS or DDS had a doubled risk (OR > 2) of being stunted and overweight in urban areas.
Li et al (2009)	To examine the associations between dietary/food/nutrient intake and plasma lipid profiles related to stunting and overweight status	13 food group DDS based on 4 food groups	Chinese children and adolescents 2-17 years (n=13770)	Mean DDS for stunted and stunted overweight children were 4.18 for normal ht and wt children compared with mean DDS of 3.77 and 3.75 for stunted and stunted overweight children, respectively. P < 0.05.
Nurfaizah et al (2009)	To identify the presence of dual burden of malnutrition in the same household in Orang Asli in Malaysia	FVS	Non pregnant women of child bearing age and children aged 2-9	Dual burden households were associated with FVS of children (OR: 0.71, 95% CI: 0.51-0.95) and

			(n = 182 households)	FVS of women (OR: 1.92 95% CI: 1.02-1.89)
Vakili et al (2013)	To assess the DDS and its related factors among adolescents high school girls in Ahvaz-Iran	9 food group DDS as per FAO (2010)	Girls aged 15-18 in Iran (n=506)	In participants with DDS > 6, mean BMI, waist circumference, and waist to hip ratio were slightly greater.
Study participants – adult women (n=5)				
Azadbakht and Esmailzeadeh (2011)	To assess the relationship between DDS and obesity and abdominal obesity	5 food group DDS as per USDA Food Guide Pyramid	Iranian female aged 18-28 (n= 289)	The probability of obesity decreased with quartiles of DDS (OR: 1.00, 0.41, 0.31, and 0.21, p=0.03). This was the same for abdominal adiposity with OR among quartiles of 1.00, 0.55, 0.36, and 0.21, p=0.02)
Fujita et al (2012)	To assess how well DDS predicts serum vitamin A	10 food group DDS	Women ages 18-46 in Kenya (n=214)	DDS positive effect on serum retinol (β=0.05, p = 0.045).
Nurfaizah et al (2009)	To identify the presence of dual burden of malnutrition in the same household in	FVS	Non pregnant women of child bearing age and children aged	Dual burden households were associated with FVS of children (OR: 0.71, 95% CI:

	Orang Asli in Malaysia		2-9 (n=182)	0.51-0.95) and FVS of women (OR: 1.92 95% CI: 1.02-1.89)
Savy et al (2005)	To develop food variety and diversity scores in order to assess dietary quality as well as nutritional status of the women	14 food group DDS	Adult women in Burkina Faso (n=691)	Women in the lowest tertile of DDS had a 22.8% prevalence of underweight vs 9.8% in the higher tertile ($p < 0.0001$).
Savy et al (2007)	To compare the dietary diversity scores measured over 1-day vs 3-day period by assessing their association with socio-economic status and nutritional status of	9 food group DDS	African women Adult women in rural Burkina Faso (n=550)	17.7% of women in the lowest DDS tertile were underweight compared with 3.5% for those in the highest tertile (p=0.0003 and 0.0007 respectively).
Study participants – both adult men and women (n=4)				
Azadbakht and Esmailzeadeh (2006)	To assess the relationship between dietary diversity score and cardiovascular risk factors according to blood lipid profile	5 food group DDS	Tehranian adults over 18 years of age (n=581)	The probability of having obesity decreased with increasing quartiles of DDS (OR: 1.39, 1.06, 1.28, 1.11, and 1.00, p for trend = 0.03).
Bezerra and Sichieri (2011)	To assess the association between a	27 food group DDS	Adults in Brazilian	DDS was negatively

	healthy DDS and nutritional status		households (n = 35237 households)	associated with underweight (β=-0.38, p=0.04) and positively associated with excess wt (β = 0.98, p=0.05).
Clausen et al (2005)	To examine the association between dietary diversity and physical and cognitive functioning	FVS and 5 food group DDS	Older adults in Botswana (n=1085)	Self-reported ability to function increases with increasing FVS scores
Jayawardena et al (2013)	To explore associations between dietary diversity with obesity	12 food group DDS	Sri Lankan adults (n=600)	Adults in the highest BMI category of ≥ 25 kgm-2 had the highest DDS and FVS. Mean DDS was 6.67 in BMI category ≥ 25 kgm-2 compared with 5.69 in BMI category of ≤ 18.5 kgm-2

β to denote correlation coefficient

Acronyms

DDS: Dietary diversity scores

FVS: Food variety scores

MPA: Mean probability of adequacy of nutrients

MAR: Mean adequacy ratio of nutrients

FFQ: Food frequency questionnaire

OR: Odds ratio

Ht: Height

Wt: Weight

BMI: Body Mass Index

Table 2.4: Association between dietary diversity and household economic ability and/or food security

Study	Item of interest	Dietary diversity tool	Population	Outcome
Study participants – children and adolescents (n=1)				
Labadarios et al (2011)	To assess dietary diversity in South Africans aged 16 years and older and evaluate DDS as a proxy indicator of food security	9 food group DDS	Adolescents and adults age 16 and older in South Africa	There were significant differences in DDS by Living Standard Mean (LSM) analysis. The lowest LSM group had the lowest DDS.
Study participants – adult women (n=1)				
Ihab et al (2012)	To identify the association of food expenditure and dietary diversity with food insecurity status	8 food group DDS	Non-lactating and non-pregnant women ages 18-55 years in rural Malaysia	Total food expenditure and DDS were found to be associated with household food insecurity after controlling for potential confounder. Mothers from food insecure households had lower DDS on all

				food groups
Study participants – adult men and women (household) (n=3)				
Faber et al (2009)	To describe dietary diversity in relation to other food security indicators, including living standards measure, months of food shortages and household insecurity and access scale (HFIAS).	9 food group DDS	Households in Greater Sekhukhane, South Africa	Compared with households with a DDS of less than 4, households with a DDS of greater than 4 had fewer assets, experienced more food shortages and had a higher HFIAS. An inverse correlation was found between HFIAS and dietary diversity.
Hoddinott and Yohannes (2002)	To examine whether dietary diversity can be used to measure household level food access and to investigate the magnitude of association between dietary diversity and household food access	12 food group DDS	Draws on household level data from 10 countries: Bangladesh, Egypt, Ghana, India, Kenya, Malawi, Mali, and Mexico	A 1% increase in dietary diversity is associated with 1% increase in household per capita consumption, a 1% increase in household per capita calorie consumption, 0.5% increase in household per capita caloric availability from staples and a 1.4% increase in household per capita caloric availability from

				non-staples.
Kennedy et al (2010)	To provide an overview of HDDS and FCS in food security and dietary assessments	12 food group HDDS And 8 food group FCS	Household members in Burkina Faso, Lao PDR, and northern Uganda	Both scores (HDDS and FCS) showed moderate correlations with other proxy measures of food security.

Validation of individual level dietary diversity with nutrient adequacy

Variations in dietary diversity index used and the method of validation between dietary diversity and micronutrient deficiencies make the generalization of the association difficult. Despite these differences, studies have been able to consistently demonstrate the association between various dietary diversity indicators and nutrient adequacy.

Studies which validated various dietary diversity indexes with nutrient adequacy varied significantly in the population and age group of interest, dietary diversity indicator and the method of validation. Of the included studies, six studies focused on children and adolescents, four studies focused on adult women, one study focused only on men, and six studies focused on both men and women. Indices with different food group aggregations were used, ranging from five to 21 food groups. Indices used for children and adolescents ranged from five to 13 food groups, indices used for adult women ranged from five to 21 food groups, the index used for men was a five food group DDS, and indices for adult men and women ranged from six to 21 food group aggregations.

Outcomes include correlations between DDS and nutrient adequacy ratios (NAR) and between DDS and mean probability of adequacy (MPA) of various nutrients.

Nutrient Adequacy Ratio

In the validation of DDS with nutrient adequacy, some studies have utilized the nutrient adequacy ratio (NAR). This method was first developed by Madden and Yodder (1972) and has been utilized extensively in many studies [62]. NAR is the ratio of intake of a particular nutrient to its recommended dietary allowance (RDA) [62]. Participants' intake of various nutrients are calculated and compared with the RDA. The mean adequacy ratio (MAR) is the average of the NAR, computed by summing the NAR and dividing by total nutrients. NAR are usually truncated at 100% of the RDA to avoid high consumption levels of some nutrients compensating for low levels of others in the resulting mean adequacy ratio [62].

Probability of Adequacy

Most studies have used the probability of adequacy method in validating DDS. The probability of adequate nutrient intake method may be more physiologically meaningful than the ratios of intakes to the RDA [63]. The probability that a given nutrient intake is adequate for an individual can be calculated if the requirement distribution is known. If the distribution can be assumed to be approximately normal, then it may be defined by the estimated average requirement (EAR) and its standard deviation. The probability of subjects' consuming adequate amounts of a nutrient may be determined.

Mean adequacy ratio and mean probability of adequacy

Studies have consistently shown that FVS and DDS are significantly and positively associated with both mean adequacy ratio (MAR) and mean probability of adequacy (MPA). The correlation between DDS and MPA in the literature ranges from 0.19 to 0.63. The correlation between DDS and MAR in the literature ranges from 0.12 to 0.76. For FVS, correlations with MPA range from 0.33 to 0.45 in the literature. Due to the different dietary diversity indicators used and the variations in statistical analysis performed, the strength of association between dietary diversity and nutrient adequacy cannot be determined universally and may be highly context and population specific. Although it is difficult to comment on the strength of association between FVS or DDS with MAR or MPA, studies examining the association between various indices and nutrient adequacy are important for validating various indices for use in different populations.

Sensitivity and Specificity Analyses Sensitivity-specificity analyses are important in identifying the best cut-off points for predicting nutrient adequacy for dietary diversity scores. This analysis was performed by receiver's operator curve (ROC) to quantify the accuracy of DDS to correctly classify children with high and low MPA or MAR values and to determine the best DDS cut-off point that maximized sensitivity and specificity. This ROC is a plot of true positive (correctly classifying subjects as meeting adequacy of nutrients) and false positive rate for different cut-off points [48]. Sensitivity analysis determines the percentage of subjects who are not at risk of nutrient inadequacy and are correctly classified by high DDS. Specificity analysis is done to maximize the

percentage of subjects truly at risk of low nutrient adequacy and who are correctly classified by low DDS [48]. As this analysis is highly context specific, comparison across studies done in different populations is difficult. For DDS to serve as useful indicators of nutritional adequacy in a resource poor setting, a minimum DDS score corresponding to a nutritionally adequate diet is useful. Some studies have calculated DDS cut off scores for different populations and are described below.

Rani, Arend and Brouver (2010) aimed to validate DDS as an indicator of nutrient adequacy of the diet of Indian children aged five to eight years-old. Taking into consideration sensitivity and specificity, a DDS of between six and seven was determined to be sufficient to identify subjects with a nutritionally adequate diet with mean probability of intake of 75% [48]. This suggests that for a diet to meet 75% of average nutrient requirements, consumption of between six and seven out of the nine food group dietary diversity indicator is required. Although these findings are unique to different populations of interest and may be affected by the different methods of calculating dietary diversity, the cut off scores determined provide useful comparisons for similar studies to be done in these populations.

Oldewage-Theron et al (2009) focused on dietary adequacy in relation to nutritional status of elderly in Sharpeville, South Africa between ages 60 and 100. The NAR method described briefly above was used and DDS was correlated with dietary information collected from a two-day dietary recall for each subject. Results showed that as dietary diversity increased the MAR also increased. However, findings showed that the MAR was below one for all subjects, suggesting that no subject met the nutrient requirements for all of the nutrients. An optimal cut-off point for DDS was determined

to identify as many inadequate diets as possible without losing too much ability to identify those respondents with a nutritionally adequate diet. To reach a mean adequacy ratio of greater than 70%, DDS of six is required. This means that for subjects to meet over 70% of mean nutrient requirements, consumption of at least six out of a nine food group dietary diversity indicator is required.

FAO Guidelines on interpreting DDS

The FAO Guidelines for assessing individual and household level dietary diversity have suggested that there are not established cut-off points in terms of the number of food groups to indicate adequate or inadequate dietary diversity for HDDS or IDDS. The mean score or distribution of scores is important for analytical purposes and to determine the target score for programming purposes [9].

Energy Intake

It is of importance to note that literature suggests that dietary diversity may be significantly correlated with energy intake in the adult population. Increasing the total caloric intake may be associated with an increase in the intake of a variety of foods. Arimond et al (2010) examined micronutrient adequacy of women's diets in rural Bangladesh as a part of the Women's Dietary Diversity project. Each dietary diversity indicator, regardless of levels of food group aggregation, significantly correlated the mean probability of adequacy of nutrients. However, correlations were slightly attenuated when energy was controlled for, ranging from 0.39-0.52 before controlling for energy to 0.32-0.46 after controlling for energy, p-value varying between 0.001 and 0.05 [57]. This suggests that by increasing the quantity of food intake alone contributes

to improved dietary diversity. A study by Mirmiran et al (2006) has also demonstrated the weakening of the correlation between dietary diversity scores and the mean adequacy of nutrients after controlling for energy intake. As improved energy intake significantly correlates with mean nutrient adequacy of many essential nutrients, intervention programs that focus on improving food security and subsequently energy intake of participants may naturally lead to improved micronutrient intake of participants (Ruel, 2003). It is important for intervention programs with a focus on improving dietary diversity to disentangle the associations between dietary diversity, energy intake, and nutrient adequacy for the target population in order to understand whether a focus on improving dietary quantity and/or dietary quality is most important in improving the nutrient adequacy of the target population.

Azadbakht and Esmailzeadeh (2012) explored the relationship between dietary energy density and dietary diversity for a sample of Iranian female university students. A 5 food group dietary diversity based on the USDA Food Pyramid was utilized. It was suggested that students at the top tertile of DDS had the lowest mean dietary energy density [11]. Overall, an inverse significant association between dietary energy density and DDS was suggested. How dietary diversity is associated with dietary energy appears to depend on the population and their dietary patterns.

Dietary diversity and health and nutrition status

Many studies have examined the association between dietary diversity and various indicators of nutritional status. Outcome measures of nutritional status include anthropometric measures, clinical and biochemical indicators [64]. Anthropometric measurements are sensitive to less severe levels of malnutrition, whereas biochemical

and clinical indicators are usually used as outcome measures of more severe malnutrition [64]. Anthropometric measurements are objective and quantitative elements of nutritional status [65]. For children, the assessment and interpretation of anthropometric measurements such as height and weight are important in determining nutritional status [65]. For adults, assessing weight status is also important in evaluating nutritional status.

Populations of interest included children and adolescents as well as adults. Seven studies focused on children and adolescents [55] [66] [38] [47] [67] [28], five studies focused on adult women [11] [39] [67] [50] [27], and four studies focused on both adult men and women [13] [56] [15] [42]. Dietary diversity indicators ranged from 5 to 27 food groups. Outcome measures included anthropometric measurements for children and adults as well as serum retinol concentration in adult women. Specific outcome measures in children included anthropometric measurements, such as height and weight measurements, body mass index (BMI), mid-upper arm circumference (MUAC), waist circumference, and waist-to-hip ratio as well as risk of stunting, risk of overweight and obesity, Specific outcome measures in adult women included anthropometric measurements, such as BMI, body fat percentage, and MUAC as well as risk of obesity and abdominal obesity, and serum retinol concentration. Outcome measures for studies focusing on adult men and women included cardiovascular risk factor, weight measures, prevalence of obesity and physical and cognitive functions.

Anthropometric measurements

All studies which have assessed the association between dietary diversity and anthropometric measurements in children have suggested evidence of a positive

correlation between dietary diversity and various anthropometric measures. Chua et al (2012) aimed to determine the relationship between dietary diversity and nutritional status in children aged 1-6 in Malaysia; the results suggested that DDS was positively related to weight-for-age z-scores and height-for-age z-scores. Li et al (2011) examined dietary diversity in relation to stunting and overweight status in children aged 2-17 years of age in China. Results suggested that compared with children of normal height and weight, stunted children as well as stunted overweight children had lower dietary diversity [47]. A study done with adolescent girls in Iran showed that participants with higher dietary diversity scores (greater than 6) also had greater BMI, waist circumference and waist-hip ratio [28]. However, only the difference in waist-hip ratio was significant [28]. Likewise, in a study with 10-18 year-old adolescent girls, Mirmiran et al (2004) showed that participants with higher dietary diversity (i.e., greater than 6) had significantly higher BMI than participants with DDS of less than 6.

Inconsistent results were shown in the adult population related to dietary diversity and anthropometric measurements. Two studies [67] [42] have shown positive correlation between dietary diversity with anthropometric indices while five studies showed the opposite [14] [50] [27] [13] [56]. A study by Azadbakht and Esmaillzadeh (2010) in female adults aged 18 to 28 years of age in Iran suggested that the probability of obesity and abdominal obesity decreased with quartiles of DDS. Participants in the lowest quartile of DDS had the highest risk of being overweight [14]. Studies in other populations show contradicting results. A study by Jayawardena et al (2013) to explore associations between dietary diversity and obesity in Sri Lankan adults showed that as dietary diversity scores increased, the BMI level, waist circumference and energy consumption significantly increased . Similar results were shown in a study by Savy et al

(2005), which showed that the more varied/diversified the diet as reflected by FVS and DDS, the higher the anthropometric indices in a population of adult mothers in Burkina Faso.

Bezerra et al (2011) assessed the dietary diversity score at the household level and evaluated its association with consumption of unhealthy food items as well as risk of being overweight and underweight. A high household level DDS was positively associated with excess weight and negatively related to underweight. The relation between dietary diversity and nutritional status as indicated by anthropometric measurements vary depending on the population of interest. Depending on their the types and quality of food available and accessible to the population of interest, a higher dietary diversity may be related to higher energy consumption leading to higher BMI's for children as well as adult participants. Although this may be favourable for some populations, excess energy intake may lead to excess weight gain for other populations thus increasing their risk of chronic illnesses. Dietary diversity scores are not indicators of dietary quality; interventions and public messaging to promote increased dietary diversity must also promote the maintenance of appropriate energy intake balance.

Micronutrient status

The impact of dietary diversity on micronutrient status is an area that is under-studied. To date only one study has investigated the relationship between dietary diversity and serum micronutrient profile. Fujita et al (2012) examined the ability of DDS to predict micronutrient status in a population of adult women in rural Kenya, with focus on serum vitamin A levels. A logistic regression model was used to test DDS as a predictor of serum retinol as an indicator of vitamin A sufficiency. Results suggested that even after

controlling for wealth, age, acute phase reaction, hemoglobin, vitamin A intake and vitamin A supplementation, DDS is still a significantly and positively associated with vitamin A status (t = 2.01, p=0.045) [39]. It was suggested that even an addition of one food group to one's diet would reduce the odds of vitamin A insufficiency (OR = 0.64, p = 0.026) [39].

This study was important in providing some insight on the association between dietary diversity and the bioavailability of nutrients. As DDS was determined to be a significant predictor of serum retinol concentration after controlling for dietary vitamin A intake, this suggested that a diverse diet with a wide range of food intake may facilitate the bioavailability and absorption of ingested vitamin A. This is important, as precursors of retinol which originated from plant-based foods have lower bioavailability than from animal products. Consuming a diverse diet may enhance the bioavailability and bioconversion of vitamin A [39]. For populations with low dietary diversity, this may suggest the potential for micronutrient fortification of foods. Furthermore, biochemical measurements are often invasive and especially challenging to conduct in more remote populations in developing countries. There is potential for using DDS in to predict micronutrient status of these populations.

Dietary diversity and household food security

Some studies have assessed the association of dietary diversity with food security and/or household level socioeconomic status. Four studies focused on the household with children and adults as a unit [30] [29] [43] [44]and one study focused on adult women. Dietary diversity indices used food group aggregations of between eight and 12 food group aggregations. Outcome measures included: 1) household per capita

consumption 2) measures of household economic ability such as Living Standard Mean index, 3) household insecurity and access scale (HFIAS), and 4) individual reporting of food insecurity status.

As household level economic resources increase, it is possible that households may be equipped to better diversify their diets. The FAO Guidelines on assessing individual and household level dietary diversity has indicated that household level dietary diversity may be used to assess the household economic access to food [9]. Hoddinott and Yohannes (2002) conducted a multi-country analysis to examine the association between dietary diversity and household economic status. This is the main study that influenced the 12 food group aggregation recommended in the FAO guidelines for assessing household level dietary diversity. Household level dietary consumption was assessed by conducting 24-hour recalls over a 7-day period for participating households. Information on household energy consumption as well as household food expenditure was gathered. Results showed that increases in dietary diversity were associated with increased per capita consumption as well as per capita energy availability. As household income increased, there was more expenditure on fruits and vegetable varieties as well as animal products [43].

Other studies were done to examine the appropriateness of dietary diversity as a proxy measure of household level food security by examining DDS in relation to Living Standard Means (LSM) and Household Food Insecurity Access Scale (HFIAS). The LSM system is used to classify people according to their living standards by including criteria such as degree of urbanization and ownership of material goods such as cars and electronic appliances to classify people in high or low categories [30].

Labadarios et al (2011) suggested that there were significant differences in DDS by LSM analysis ($p < 0.05$) with the lowest LSM group also having the lowest mean DDS of 2.93 (CI: 2.81-3.05) in several South African provinces.

A study by Faber et al (2009) described dietary diversity in relation to the HFIAS in a South African population. The HFIAS is an approach that has been used to estimate the prevalence of food insecurity in different cultural settings [29]. The HFIAS is often used by food security programs to assess the impact of their programs by asking questions on the access component of food insecurity; a higher HFIAS score suggests increased experiences of food insecurity [29]. Faber et al (2009) compared households with DDS of greater than and less than 4. Households with DDS ≤ 4 had a higher HFIAS of 16 (95% CI: 15-17) compared with a DDS of 9.8% (95% CI: 8.8-10.9) for households with DDS $>$ 4. An inverse correlation existed between HFIAS and DDS ($r=-0.450$, $p < 0.01$) [29].

On the individual level, Ihab et al (2012) examined the association between dietary diversity and food insecurity status in non-breastfeeding and non-lactating mothers in rural Malaysia. A dietary diversity score was determined using data from a food frequency questionnaire and food security status was rated using the Radimer/Cornell scale. Compared with mothers from food secure households, mothers from food insecure households had significantly lower dietary diversity scores [23]. The mean dietary diversity score of respondents from food insecure households is 8.87 out of 30 compared with the score of 12.69 out of 30 from food secure households [23].

Overall, several studies have examined the relationship between dietary diversity and outcome measures related to the individual food security status as well as household economic status and food security status. Due to differences to outcomes reported, it is

difficult to compare the association between dietary diversity and food security across studies. However, studies have consistently shown a significant relationship between dietary diversity and outcome measures related to food security on the individual, as well as the household level. For studies in low income populations in developing countries, simple dietary diversity indicators may also serve as proxy to household level food insecurity.

2.4 Discussion

Dietary diversity indexes including FVS and DDS may serve as useful proxies in determining micronutrient adequacy as well as nutritional status in populations in developing countries where there are limited resources to collect extensive data. There is no international consensus on food group aggregation appropriate for different age/sex groups as well as other parameters of the index including optimal reference period to be used and minimum portion size considerations. Despite this, FAO Guidelines for assessing dietary diversity on the individual and household level provides recommendations for each of these dietary diversity index parameters and a set of questionnaires that may be adapted to local context prior to use in the field [9]. These guidelines by FAO have evolved over the years to be consistent with findings from new literature.

Studies have been done to compare the strengths and weaknesses of the variations for each dietary diversity parameter. In the literature, both FVS and DDS were found to be positively correlated with nutrient adequacy. It is reasonable to assume that increasing

the number of food groups consumed would better diversify the micronutrient intake in the diet, if foods were grouped according to similar nutrient content. However, some studies suggested that FVS is a better indicator for dietary diversity than DDS while others suggest the opposite. There is currently no universal guideline on the optimal number of types of food grouping in terms of food group aggregation for the DDS. Based on a study by Arimond et al (2010), a 9 food group indicator was selected as the recommended index to assess individual dietary diversity. The 12 food group HDDS based on the work of Yohannes and Hoddinott (2002) continues to be the indicator of choice to assess household level dietary diversity. This was selected due to the index's significant and positive correlation with nutrient adequacy in populations in a multi-country study [43].

Other considerations for choosing a food group aggregation for use in the field are the ease of data collection and analysis. Increasing the disaggregation of food groups in such a tool based on micronutrient profile may improve its ability to predict micronutrient adequacy. Depending on the purpose of the assessment, a more disaggregated food list may be beneficial as it is more sensitive in detecting differences in consumption of specific types of food over time. It must be taken into consideration, however, that more disaggregated food group indicators may be more difficult to operationalize as it will entail more precise decisions on correct food groups when designing data collection instruments [57]. This is a practical consideration especially for developing nations as there may already be time and resource limitations for data collection.

Studies examining the optimal reference period to use in measuring dietary diversity in a developing nation have suggested that DDS calculated from a 1-day dietary recall is

sufficient in predicting nutritional status in a sample of women in Burkina Faso [27]. For studies of populations in developed nations, dietary diversity recall periods ranged from 1 to 15 days [68] [69]. Studies have shown that the rate at which new foods were eaten increased as a function of time until reaching a plateau at about 15 days days [68] [69]. However, the number of new foods consumed increased most significantly from day 1 to day 3, suggesting that a recall period of less than 3 days may potentially underestimate dietary diversity. It must be noted, however, that these studies were done with participants residing in North America. The day to day variations in dietary patterns may vary significantly across cultures and it is possible that populations in developing nations have fewer variations in food intake from day to day, and a one day reference period may be sufficient to capture the dietary diversity of the population. The FAO suggests using a reference period of 1 day to minimize recall errors [9]. Depending on the population of interest, underestimating dietary diversity using a recall period of only one day may or may not a concern.

Finally, applying a minimum portion size consideration to the DDS index may be of benefit. Intuitively, applying a minimum portion consideration will prevent overestimating micronutrient intake as some foods may not be consumed in sufficient amounts to contribute significantly to nutrient intake. Arimond et al (2010) has shown that applying a minimum portion of 15g to included foods allow better prediction of nutrient adequacy. Based on this study, FAO recommendations have incorporated these recommendations into their guidelines [9].

Validation studies have consistently shown a positive association between dietary diversity and nutrient adequacy despite the lack of uniformity in the methods and

indexes used to measure dietary diversity. This relationship between dietary diversity and nutrient adequacy has also been suggested in children and adult populations in developed countries [70]. It must be noted that studies have suggested a weakening of the association between dietary diversity and energy intake [57]. Whether dietary diversity is associated with increased energy intake depends on intake patterns and food availability and accessibility situation of the population of interest. It is also possible that increasing dietary diversity is associated with increased energy intake, as a one's food consumption may increase when the diet is less monotonous and more palatable. Further, for programming purposes, it is essential to identify the mechanisms leading to improved overall micronutrient intake. For the specific target population, it is important to understand whether interventions with a primary focus on increasing food intake alone can lead to improved nutrient adequacy or if dietary diversification interventions are necessary to increase the probability of individuals meeting daily nutrient requirements [71].For populations which overweight and obesity may be a concern, there must be special consideration for maintaining appropriate energy intake along with dietary diversification. For instance, focus may be on increasing the intake of high quality, nutrient dense foods to ensure the intake of a variety of nutrients while limiting the consumption of items which are low in nutrients but high in energy.

Studies have consistently shown an association between dietary diversity and various indicators of nutritional status. There is some discrepancy in the literature regarding the association between dietary diversity and anthropometric measurements. Some studies have suggested that with increasing dietary diversity, the risk of overweight and obesity decreases [14] while other studies have shown contradicting results, increasing dietary diversity associated risk of overweight and obesity [42]. Dietary patterns may vary

significantly across cultures and population groups; it is impossible to generalize the implications of increasing dietary diversity on nutritional status in all populations. A study has shown that increasing DDS may be favorably associated with cardiovascular risk factors [13]. Dietary diversity may be favorably associated with maintaining healthy weight if increases in dietary diversity were attributed to increasing the consumption of healthy foods and low-energy-dense food groups such as whole grains, vegetables, and fruit. However, for many developing nations there have been considerable shifts in consumption patterns, increasing the prevalence of obesity and non-communicable diseases [7].

Urbanization in many developing countries proceeds at an alarming rate of approximately 5% per year in sub-Saharan Africa and Asia [7]. For many populations, urbanizations suggests a shift away from a diet of fresh fruits and vegetables, pulses, and other roots and tubers to a fast and convenience foods diet which is high in sugar, fat and salt [7]. The globalization of food distribution systems has allowed supermarkets to emerge in Latin America, East Asia, and South East Asia as major food distributors. Although access to major food retailers such as supermarkets may provide the opportunity to increase dietary diversity, they are often distribution channels for higher energy, low nutrient density foods and snacks [72]. For these populations, the increased access to a wide variety of foods or food groups may also be associated with the consumption of high energy, low nutrient density foods within these food groups. The nutrition transition experienced by many developing nations must be taken into consideration and dietary diversity must be promoted within the context of maintaining appropriate energy balance.

It must also be noted that although no study has examined this, some populations in developing nations may face challenges related to clean water and facilities for food preparation thereby affecting the absorption of nutrients from a wide variety of foods to improve nutritional status. If the goal of the assessment is to understand nutritional status of the population, these factors must be taken into consideration. One study [39] has suggested the association between dietary diversity and specifically serum retinol concentration. This suggests that interventions to promote a diverse diet may improve serum vitamin A status independent of vitamin A intake, it also suggest that DDS may serve as appropriate proxy indicators for micronutrient status. These findings are consistent with findings from studies in developed nations. In a study by Kant and Graubard (2005), DDS were found to be predictors of serum concentrations of vitamin C, vitamin E, folate, and carotenoids.

Lastly, household level dietary diversity may be used as an indicator for household food security [43]. More recent studies have also suggested similar relationship between dietary diversity and perceived food security status [23]. The FAO Guidelines for assessing dietary diversity suggests that HDDS reflects the economic ability of a household to access a variety of foods [9]. Caution must be taken if HDDS is used to assess individual nutritional status in a household. Using HDDS to assess nutritional status of individuals in a household may not take into consideration intra-household food distribution and any potential preferential food allocation patterns which may affect the nutritional status of certain individuals in a household thus weakening the association between household level dietary diversity and individual nutritional status.

2.4.1 Future research

Although this literature review showed that higher DDS are associated with improved nutrient adequacy for different populations, more research is needed in the area of using and interpreting DDS. DDS are calculated by summing the number of food groups consumed by the household or by the individual respondent over the specified recall period [9]. There are, however, no established cut-off scores in terms of the number of food groups to indicate adequate or inadequate dietary diversity for the FAO Guidelines [9]. For programmatic purposes, for example, to evaluate the change in dietary diversity before or after an intervention, the mean DDS of the population of interest may be compared before and after the intervention [9]. The FAO guidelines recommend taking into consideration the distribution of scores to set program goals [9].

International consensus on optimal cut-off scores for different populations were difficult to define and may be highly context specific to the dietary patterns of local population and the dietary needs of different demographic groups. Different cut-off scores have been suggested to indicate nutrient adequacy for different populations [48]. Due to the different methods used in assessing dietary diversity and the different populations of interest, it is difficult to generalize cut-off DDS for nutrient adequacy. Future research may consider using the FAO guidelines to calculate DDS and to determine cut-off scores for nutrient adequacy for different populations. These cut-off scores may serve as references for other studies that focus on the same or similar demographic groups.

2.4.2 Conclusion

In developing nations there are often constraints to collecting large scale dietary information for the assessment of nutritional adequacy and status. Evidence suggests that individual dietary scores may be a good reflection of micronutrient adequacy. On the household level, DDS may be useful for determining household economic ability to acquire food.

References

[1] World Health Organization, "Preparation and Use of Food-Based Dietary Guidelines , WHO Technical Report, Series 880," World Health Organization, Geneva, Switzerland , 1996.

[2] U.S. Department of Agriculture , "Food Guide Pyramid: A Guide to Daily Food Choices," U.S. Department of Agriculture Health and Human Resources, Washington, DC, 1992.

[3] M. McCollough, D. Feskanich, M. Stampfer and e. al., "Diet quality and major chronic disease risk in men and women: moving towrad improved dietary guidance," *European Journal of Clinical Nutrition,* vol. 57, pp. 930-939, 2002.

[4] M. Ruel, "Operationalizing dietary diversity: a review of measurement issues and research priorities," *The Journal of Nutrition,* pp. 3911S-3925S, 2003.

[5] FAO, WFP, IFAD, "The State of Food Insecurity in the World 2012.Economic growth is necessary but not sufficient to accelerate reduction of hunger," FAO, Rome , 2012.

[6] World Health Organization, "Micronutrient deficiencies," 2013. [Online]. [Accessed 1 August 2013].

[7] J. Schmidhuber and P. Shetty, "The nutrition transition to 2030. Why developing countries are likely to bear the major burden," *Food Economics - Acta Agriculturea Scandinavica, Section C,* pp. 150-166, 2007.

[8] World Health Organization, "Indicators for assessing infant and young child feeding practices," World Health Organization, 2010.

[9] Kennedy, G; Ballard, T; Dop, M, "Guidelines for measuring individual and household dietary diversity," Food and Agriculture Organization of the United Nations, Rome, 2011.

[10] Food and Agriculture Nutrition and Consumer Protection Division, "Guidelines for measuring household and individual dietary diversity," Food and Agriculture

Organization of the United Nations, Rome, 2008.

[11] L. Azadbakht and A. Esmaillizadeh, "Dietary energy density is favorably associated with dietary diversity score among female university students in Isfahan," *Nutrition,* pp. 991-995, 2012.

[12] L. Azadbakht, P. Mirmiran and F. Azizi, "Variety scores of food groups contribute to the specific nutrient adequacy in Tehranian men," *European Journal of Clinical Nutrition,* vol. 59, pp. 1233-1240, 2005.

[13] L. Azadbakht, P. Mirmiran, Esmaillzadeh and A. e. al., "Dietary diversity score and cardiovascular risk factors in Tehranian adults," *Public Health Nutrition,* vol. 9, pp. 728-736, 2006.

[14] L. Azadbakht and A. Esmaillzadeh, "Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth," *Public Health Nutrition,* pp. 62-69, 2010.

[15] T. Clausen, K. Charlton, K. Gobotswang and G. Ottesen, "Predictors of food variety and dietary diversity among older persons in Botswana," *Nutrition,* vol. 21, pp. 86-95, 2005.

[16] S. Fitzgerald, R. Gibson, L. Portocarrero, Q. D. Serrano, E. Vasquez, E. Zepeda, C. Lopez and N. Solomons, "Food consumption patterns and dietary diversity of pregnant women living in a peri-urban area of Guatemala City," *Ecology of Food and Nutrition,* vol. 27, pp. 1-15, 1992.

[17] P. Mirmiran, L. Azadbakht and A. Esmaillzadeh, "Dietary diversity score in adolescents - a good indicator of the nutritional adequacy of diets: Tehran lipid and glucose study," *Asia Pacific Journal of Clinical Nutrition,* vol. 13, no. 1, pp. 56-60, 2004.

[18] P. Mirmiram, L. Azadbakht and F. Azizi, "Dietary diversity within food groups: an indicator of specific nutrient adequacy in Tehranian women," *Journal of the American College of Nutrition ,* pp. 354-361, 2006.

[19] C. A. Gewa, S. P. Murphy and C. G. Neumann, "Dietary diversity scores predict dietary micronutrient adequacy among school children in rural Kenya," *Faseb Journal,,* p. 25, 2011.

[20] S. Badari, J. Arcot and S. Haron, "Food variety and dietary diversity scores to understand the food-intake pattern among selected Malaysian households,"

Ecology of Food and Nutrition, vol. 51, pp. 265-299, 2012.

[21] K. Rathnayake, P. Madushani and K. Silva, "Use of dietary diversity score as a proxy indicator of nutrient adequacy of rural elderly people in Sri Lanka," *Biomed Central Notes,* vol. 5, p. 469, 2012.

[22] T. Maitland, "Dietary habits, diversity and the indigenous diet of the Turks and Caicos Islands: implications for island-specific nutrition intervention," *West Indian Medical Journal ,* pp. 375-387, 2006.

[23] A. Ihab, A. Rohana, W. Wan Manan, W. Wan Suriati, M. Zalilah and A. Rusli, "Food expenditure and diet diversity score are predictors of household food insecurity among low income households in rural district of Kelantan Malaysia," *Pakistan Journal of Nutrition,* vol. 11, no. 10, pp. 967-973, 2012.

[24] S. Nupo, C. Oguntona, O. Onabanjo and E. Fakoya, "Dietary diversity scores and nutritional status of women in two seasons in rural areas of Ogun State, Nigeria," *Nutrition and Food Science,* vol. 43, pp. 60-67, 2013.

[25] N. Steyn, J. Nel, G. Nantel, G. Kennedy and D. Labadarios, "Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy," *Public Health Nutrition,* pp. 644 - 650, 2006.

[26] Y. Jin, Y.-P. Li, X.-q. Hu, Z.-h. Cui, Y.-n. He and G. Ma, "Association between dietary diversity and nutrients adequacy in Chinese adults," *Acta Nutrimenta Sinica,* pp. 21-25,29, 2009.

[27] M. Savy, Y. Martin-Prevel, P. Traissac and F. Delpeuch, "Measuring dietary diversity in rural Burkina Faso: comparison of a 1-day and a 3-day dietary recall," *Public Health Nutrition ,* pp. 71-78, 2007.

[28] M. Vakili, P. Abedi, M. Sharifi and Hosseini, "Dietary diversity and its related factors among adolescents: a survey in Ahvaz, Iran," *Global Journal of Health Science,* pp. 181-186, 2013.

[29] M. Faber, C. Schwabe and S. Drimie, "Dietary diversity in relation to other household food security indicators," *International Journal of Food Safety, Nutrition and Public Health,* vol. 21, pp. 1-14, 2009.

[30] D. Labadarios, N. Steyn and J. Nel, "How diverse is the diet of adult South Africans," *Nutrition Journal,* vol. 10, p. 33, 2011.

[31] N. Steyn, W. Parker, J. Nel, A. Rosemary and D. Mbithe, "The nutrition transition and adequacy of the diet of pregnant women in kenya," in *2012 International conference on nutrition and food sciences* , Singapore, 2012.

[32] Oldewage-Theron and R. Kruger, "Impact of food aid on food variety and dietary diversity of an elderly community in sharpeville, South Africa," *The Journal of Nutrition. Health and Agiing,* vol. 13, no. 4, pp. 300-308, 2009.

[33] W. Oldewage-Theron and R. Kruger, "Dietary diversity and adequacy or women caregivers in a peri-urban informal settlement in South Africa," *Nutrition,* vol. 27, pp. 420-427, 2011.

[34] J. Arsenault, E. Yakes, M. Islam, M. Hossain, T. Ahmed, C. Hotz, B. Lewis, A. Rahman, K. Jamil and K. Brown, "Very low adequacy of micronutrent intakes by young children and women in rural Bangladesh is primarily explained by low food intake and limited diversity," *The Journal of Nutrition,* pp. 197-203, 2012.

[35] L. Torheim, I. Barikmo, C. Parr, A. Hatloy, F. Ouattara and A. Oshaug, "Validation of food variety as an indicator of diet quality assessed with a food frequency questionnaire for Western Mali," *European Journal of Clinical Nutrition,* vol. 57, pp. 1287-1291, 2003.

[36] L. Torheim, I. Barikmo, C. Parr, A. Hatloy, F. Ouattara and A. Oshaug, "Validation of food variety as an indicator of diet quality assessed with a food frequency questionnaire for Western Mali," *European Journal of Clinical Nutrition,* vol. 57, pp. 1287-1291, 2005.

[37] A. Hatloy, L. Torheim and A. Oshaug, "Food variety - a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa," *European Journal of Clinical Nutrition,* vol. 52, pp. 891-898, 1998.

[38] A. Hatloy, J. Hallund and M. O. A. Diarra, "Food variety, socioeconomic status and nutritional status in urban and rural areas in Koutiala (Mali)," *Public Health Nutrition,* vol. 3, pp. 57-65, 2000.

[39] M. Fujita, Y. Lo and J. Baranski, "Dietary diversity score is a useful indicator of vitamin A status of adult women in Northern Kenya," *American Journal of Human Biology,* vol. 24, pp. 829-834, 2012.

[40] A. Cabalda, P. Rayco-Solon, J. Antonio and F. Solon, "Home gardening is associated with Filipino preschool children's dietary diversity," *Journal of the American Dietetic Association,* pp. 711-715, 2011.

[41] B. Ekesa, G. Blomme and H. Garming, "Dietary diversity and nutritional status of pre-school children from Musa-dependent households in," *African Journal of Food, Agriculture, Nutrition and Development,* vol. 11, no. 4, pp. 4896-4911, 2011.

[42] R. Jayawardena, N. Byrne, M. Soares, P. Katulanda, B. Yadav and A. Hills, "High dietary diversity is associated with obesity in Sri Lankan adults: an evaluaion of three dietary scores," *Biomed Central Public Health,* vol. 13, p. 314, 2013.

[43] J. Hoddinott and Y. Yohannes, "Dietary diversity as a food security indicator," FANTA, Washington DC, 2002.

[44] G. Kennedy, A. Berardo, C. Papavero, P. Horjus, T. Ballard, M. D. Dop, J. Delbaere and I. Brouwer, "Proxy measures of household food consumption for food security assessment and surveillance: comparison of the household dietary diversity and food consumption score," *Public Health Nutrition,* vol. 13, no. 12, pp. 2010-2018, 2010.

[45] M. Nnyepi, B. Ngwenya and R. Majelantle, "Assessment of food insecurity and dietary diversity in the Okavango Delta and the potential contribution of Indigenous foods," in *Managing Science and Technology for Sustainable Future: WASD Conference proceedings* , 2008.

[46] P. Nyangweso, M. Odhiambo, P. Odunga, M. Korir, M. Kipsa and A. Serem, "Household food security in Vihiga: determinants of dietary diversity," in *African Crop Science Conference Proceedings*, El-Minia , 2007.

[47] Y. Li, N. Wedick, J. Lai, Y. He, X. Hu, A. Liu, S. Du, J. Zhang, X. Yang, C. Chen, F. Hu and G. Ma, "Lack of dietary diversity and dyslipidemia among stunted overweight children: the 2002 China National Nutrition and Health Survey," *Public Health Nutrition,* vol. 14, no. 5, pp. 896-903, 2011.

[48] V. Rani, D. Arends and I. Brouwer, "Dietary diversity as an indicator of micronutrient adequacy of the diet of five to eight year old Indian rural children," *Nutrition and Food Science,* vol. 40, no. 5, pp. 466-476, 2010.

[49] E. Becquey, Y. Martin-Prevel, P. Traissac, B. Dembele and A. Bambara, "The household food insecurity acccess scale and an index-member dietary diversity scosre contribute valid and complementary information on household food insecurity in an urban west-african setting," *The Journal of Nutrition,* pp. 2233-2239, 2010.

[50] M. Savy, Y. Martin-Prevel, P. Sawadogo, Y. Kameli and F. Depheuch, "Use of variety/diversity scores for diet quality measurement: relation with nutritional

status of women in a rural area in Burkina Faso," *European Journal of Clinical Nutrition,* pp. 703-716, 2005.

[51] S. Ajani, "An assessment of dietary diversity in six Nigerian States," *African Journal Biomed Research,* vol. 13, pp. 161-167, 2010.

[52] S. Akrofi, I. Brouwer, L. Price and P. Struik, "Home gardens contribute significantly to dietary diversity in HIV/AIDS afflicted households in rural Ghana," *Journal of Human Ecology,* vol. 31, no. 2, pp. 125-134, 2010.

[53] G. Keding, J. Msuya, B. Maass and M. Krawinkey, "Relating dietary diversity and food variety scores to vegetable production and socio-economic status of women in rural Tanzania," *Food Security,* vol. 4, pp. 129-140, 2012.

[54] Y. Martin-Prevel, E. Becquey, S. Tapsoba, F. Castan, D. Coulibaly, S. Fortin, M. Zoungrana, M. Lange, F. Delpeuch and M. Savy, "The 2008 food price crisis negatively affected household food security and dietary diversity in Urban Burkina Faso," *The Journal of Nutrition,* pp. 1748-1755, 2012.

[55] E. Chua, M. Zalilah, Y. Chin and S. Norhasmah, "Dietary diversity is associated with nutritional status of Orang Asli Children in Krau Wildlife Reserve, Pahang," *Malaysian Journal of Nutrition ,* pp. 1-13, 2012.

[56] I. Bezerra and R. Sichieri, "Household food diversity and nutritional status among adults in Brazil," *International Journal of Behavioural Nutrition and Physical Activity,* vol. 8, p. 22, 2011.

[57] M. Arimond, D. Wiesman, E. Becquey, A. Carriquiry, M. Daniels, N. Fanou-Fogny, M. Joseph, G. Kennedy, Y. Martin-Prevel and L. Torheim, "Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings," *American Society for Nutrition,* vol. 140, no. 11, pp. 2059S-20695, 2010.

[58] M. Soto-Mendez, R. Campos, L. Hernandez, M. Orozco, M. Vossenaar and N. Solomons, "Food variety, dietary diversity, and food characteristics among convenience samples of Guatemalan women," *salud publica de mexico ,* pp. 288-298, 2011.

[59] D. Olney, A. Takudar, L. i. Iannott, M. Ruel and V. Quinn, "Assessing impact and impact pathways of a homestead food production program on household and child nutrition in Cambodia," *Food Nutrition Bulletin,* pp. 355-69, 2009.

[60] K. Jackson, N. Byrne, A. Magarey and A. Hills, "Minimizing random error in dietary intakes assessed by 24-hr recall, in overweight and obese adults," *European Journal of Clinical Nutrition,* vol. 62, pp. 537-543, 2008.

[61] D. Streiner and G. Norman, Health Measurement Scales: A practical guide to their development and use. 4th ed, Oxford, UK: Oxford University Press, 2008.

[62] J. Madden and M. Yodder, "Program evaluation: food stamps and commodity distribution in rural areas of central Pennsylvania," *Pennsylvania Agricultural Experiment Station Bulletin,* vol. 78, pp. 1-119, 1972.

[63] J. Foote, S. Murphy, L. Wilkens, P. Basiotis and A. Carlson, "Dietary variety increases the probability of nutrient adequacy among adults," *Journal of Nutrition,* vol. 134, pp. 1779-1785, 2004.

[64] R. Radhakrishna and V. Reddy, "Food security and nutrition: vision 2020," Planning Commmission of the Government of India, 2002.

[65] C. Hartman, R. Shamir, C. Hecht and B. Koletzko, "Malnutrition screening tools for hospitalized chidlren," *Current opinion in cliniical nutrition metabolic care,* vol. 15, pp. 303-309, 2012.

[66] B. Ekesa, M. Walingo and M. Abukutsa-Onyango, "Influence of agricultural biodiversity on dietary diversity of preschool children in Matunga division in Western Kenya," *African Journal of Food Agriculture Nutrition and Development,* pp. 390-404, 2008.

[67] S. Nurfaizah, M. S. Zalilah, G. Khor, K. Mirnalini, A. G. Nawalyah and R. Hejar Abdul, "Fod variety score is associated with dual burden of malnutrition in Orang Asli (Malaysian indigenous peoples) households: implications for health promotion.," *Asia Pacific Journal of Clinical Nutrition,* pp. 412-422, 2009.

[68] A. Drewnowski, S. Ahlstrom Renderson, A. Driscoll and B. Rolls, "The Dietary Variety Score: Assessing Diet Quality in Healthy Young and Older Adults," *Journal of the American Dietetic Association,* vol. 97, no. 3, pp. 266-271, 1997.

[69] C. Falciglia, A. Trover and S. Couch, "Dietary variety increases as a function of time and influences diet quality in children," *Journal of Nutrition Education and Behaviour,* vol. 36, no. 2, pp. 77-83, 2004.

[70] A. Kant, "Dietary patterns and health outcomes," *Journa of the American Dietetics Association,* vol. 104, pp. 615-635, 2004.

[71] M. Ruel, "Operationalizing dietary diversity: a review of measurement issues and research priorities," *The Journal of Nutrition,* vol. 133, no. 2, pp. 3911S - 3926S, 2003.

[72] T. Reardon and J. Berdegue, "The Rapid Rise of Supermarkets in Latin America: Challenges and Opportunities for Development," *Development Policy Review,* vol. 20, no. 4, pp. 371-388, 2002.

Chapter 3: Qualitative Exploration of Dietary Variety in Kolli Hills, India

3.1 Introduction

Malnutrition is of significant concern in India. It is estimated that India was home to 42% of the developing world's underweight population and 32% of the developing world's stunted population [1]. The National Family Health Survey conducted in 2005 suggested that approximately 36% of women and 34% of men aged 15-49 have a BMI below 18.5, indicating chronic nutritional deficiency [2]. In children, 48% of those under five years of age are stunted and 43% are underweight [2]. Wasting also affects 20% of children under five years of age in India [2]. The prevalence of malnutrition is higher in rural areas, among laborers, tribes people, and Dalits (formerly known as the low caste untouchables) having the highest prevalence of malnutrition. Scheduled tribes are a special designation provided by the Government of India for certain community groups across India based on consideration for their distinctive culture, and geographical isolation [3]. Children from Scheduled Tribes also have the poorest nutrition status, with 28% affected by wasting. In 2005, Scheduled Tribes constituted 8% of the population of India, making this a significant source of concern [2].

In addition to protein energy malnutrition, there is a high prevalence of micronutrient deficiency in many Indian populations. Iron deficiency anemia affects 55% of women, 24% of men and 40% of children aged 6-59 months [2]. Although the nationwide prevalence of clinical vitamin A deficiency is less than 1-2%, it is estimated that up to

60% of preschoolers and 12% of women have subclinical vitamin A deficiency [4] Lastly, one in four children was estimated to have goitre, a condition of severe iodine deficiency. Iodine deficiency in pregnant women in India was also estimated to have caused mental impairment of about 6.6 million children [4].

The National Sample Surveys of India, conducted at five year intervals, provides information on household level dietary intake and expenditure for representative sample of Indian populations from rural and urban India from all states. In the most recent round of survey in 2004-2005, results showed that on average in all of India, cereals constituted the largest component of the diet. Consumption of pulses, fruits and vegetables, milk products, and animal products was low. Consumption of a variety of foods from different food groups increases with increasing income in both urban and rural areas. Low income groups in rural experience the lowest variety in their diet [5].

The National Family Health Survey of India, based on nationally representative sample of men and women living in all states of India from ages 15-54, provides estimates of important indicators on family welfare, maternal and child health, and nutrition. This survey provides some information on the dietary patterns of individual members in a household. In the most recent survey in 2004-2005, results showed that in general women's food consumption was less diverse than that of men. Although over 90% of both men and women consumed leafy green vegetables at least once a week, only 55% of women compared with 67% of men, consumed milk products weekly. Similar differences were observed for consumption patterns in other food groups. Only 40% of women, compared with 47% of men consumed fruits weekly, 32% of women compared

with 41% of men consumed eggs weekly, and 35% of women compared with 41% of men consumed fish, chicken or meat weekly [2].

The Alleviating Poverty and Malnutrition in Agrobiodiversity Hotspots (APM) is a project jointly planned and implemented by the M.S. Swaminathan Research Foundation (MSSRF) and the Faculty of Agriculture, Life and Environmental Sciences at the University of Alberta. The project aims to alleviate severe poverty in three selected agro-biodiversity hotspots in rural India. The tribal populations living in these areas experience a lack of economic prosperity, high rates of illiteracy, and low human development indicators [6] despite the rich biodiversity of traditional crops in these areas, representing a paradoxical phenomenon. Some specific objectives of the project are: increasing farm productivity by promoting sustainable use of local crop and livestock diversity, enhancing food and nutrition security at the individual, household and community levels, and enhancing on and off farm livelihood diversification options [6].

A chosen project site of the APM project is Kolli Hills, located in the Namakkal District of the state of Tamil Nadu in the southern end of the Eastern Ghats range in South India. Kolli Hills covers about 283km^2 and has a population of 42 200 as per the 2011 census [6]. This area is mainly inhabited by the Malayalis, a Scheduled Tribe of India. Historically, this tribal group practiced a combination of subsistence agriculture, hunting, and gathering [7]. This tribal group does not historically practice any organized religion and does not traditionally have any dietary restrictions. Today, most households in this area are small farmers with marginal land holdings. Common crops grown by farmers are jackfruit, hill banana, coffee, pineapple, black pepper, and cassava [6].

Based on local accounts, this population currently experienced some challenges related to food security, and there have been decreases in the diversity of foods consumed over the past 20-25 years. To date, only one qualitative study has examined changes in production and consumption patterns of the Malayali Tribe in Kolli Hills with emphasis on millet cultivation and consumption [8]. According to Finnis [42], there have been agricultural shifts which resulted in the abandonment of millet growing for consumption in favour of cash crop cassava cultivation. Unpredictable rainfall patterns make the cultivation of cassava, a relatively drought resistant crop more favourable in comparison to other crops [8]. Given these agricultural shifts in the area, it is also of importance to examine if there are other changes in production and consumption patterns of foods in other food groups and the potential nutrient implications of these changes. An understanding of factors resulting in decreases in dietary diversity in this population will be imperative in informing strategies and interventions to ameliorate the lack of dietary diversity in this population by taking into consideration the goals, priorities, and voices of community members.

As an initiative of the APM project, a kitchen garden intervention was implemented in each of the project sites to increase availability and improve access to a variety of vegetables throughout the year in order to enhance food and nutrition security. The term kitchen garden is used interchangeably with household garden, or home gardens. It refers to cultivation of a small portion of land which is around the household or in close proximity from the home [9]. Prior to the implementation of the kitchen garden intervention in the area, kitchen gardens were limited in Kolli Hills. There is some evidence to suggest that home gardens, even without animal production strategies,

were associated with improved dietary diversity, greater consumption of vitamin A rich fruits and vegetables, other fruits and vegetables, as well as animal source foods [10].

The APM kitchen garden intervention was composed of three parts: 1) Administering needs assessment survey to households to determine household preferences for vegetables, 2) Distributing seeds and agricultural inputs to intervention households, and 3) Providing educational sessions on ways to incorporate vegetables into recipes for consumption. The needs assessment showed that a majority of households wanted to grow tomatoes, cauliflower, leafy greens and beets. High quality seeds of these plants in addition to others were distributed by MSSRF field staff. These included seeds of heritage varieties and hybrids, and vegetative propagated crops. The inclusion of local vegetables and greens promoted the sustainability of this initiative. Seeds produced by plants could also be used by participants to continue growing crops in kitchen gardens. Educational sessions were provided by local staff on kitchen garden management and the use of these vegetables in different recipes. A Registered Dietitian held monthly sessions with women in participating villages to provide hands on education on various recipes that can be prepared with kitchen garden crops. Attendance for these sessions ranged between 10-20 women. In regards to support for kitchen garden management, each household initially received poles and nets to set up the garden. At least one field staff was responsible for assisting each family in setting up the kitchen garden. Field staff also provided regular visits to households and ongoing support related to kitchen garden management, including pest control, irrigation, composting, and saving seeds for future use. Participants were encouraged to contact field staff at any point regarding any questions related to the management of kitchen gardens. Figure 1 shows an

example of a kitchen garden in Kolli Hills. Kitchen gardens vary in size depending on land availability of the household.

Figure 3.1: Kitchen Garden

It is of importance to understand if the implementation of kitchen gardens has influenced changes in food production, consumption, and consequently dietary diversity. This smaller research study under the broader APM project aims to qualitatively explore factors affecting changes in dietary variety in Kolli Hills and the perceptions of the value of the kitchen garden initiative in improving dietary patterns. The specific research questions are:

1. What are the factors affecting changes in dietary variety in Kolli Hills, India in the past 20-25 years, from the perspective of men and women of different age groups in Kolli Hills?

2. What are the perceptions of the kitchen garden intervention, with emphasis on its improvement on dietary diversity?

3.2 Methods

3.2.1 Study design

An ethnographic approach was chosen for this line of inquiry. An ethnographic approach will produce a reliable account of the food related practices of this population [11]. Specifically, an exploratory case study design helps to provide an in-depth understanding of the factors and processes involved in this phenomenon [12]. Further, a multiple case study design allows for two or more observations of a single phenomenon in order to confirm a particular construct in a phenomenon. This design allows for multiple cases to reveal different aspects of a single phenomenon [13]. This study design focused on the experiences of villagers in the Kolli Hills area from different demographics, specifically different ages and gender.

Male and female participants representing three age categories 20-40 years, 40-60 years and 60 years and above were included in the study. Data were collected separately for men and women in order to attend to potential power differentials that may have existed between genders and it allowed for comparisons across different demographic groups. When possible, men and women were chosen from the same household to allow for a comprehensive comparison of perspectives between men and women.

3.2.2 Sampling and recruitment

Purposive sampling was selected for this case study. Purposive sampling is the underlying principle for qualitative sampling in order to select information-rich cases [14]. Typical case sampling was used in this study to illustrate typical food and kitchen garden experiences of men and women participating in the APM project.

Two field visits to Kolli Hills took place between April 2012 and April 2013. The first field visit in May 2012 took place prior to the implementation of the kitchen garden intervention; and therefore, only factors affecting changes in dietary choices were explored. Participants were selected from households which demonstrated an interest in participating in kitchen gardens. The second field visit took place a year after the initial implementation of the kitchen garden; only participating households were selected to participate in this study. Several villages currently participate in the APM project and MSSRF field staffs have established working relationships with the people in these villages. Households were conveniently selected with the assistance of the MSSRF research team in Kolli Hills based on the information in the database.

During the first field visit, only factors affecting changes in dietary choices were explored. Two villages, Odaikaadu and Sellipatti were conveniently selected for data collection. During this field visit, only women of different age groups participated in two focus groups (n=16), with one focus group conducted with women ages 20-40 years (n=8) and one focus group with women ages 40-60 years (n=8).

In the second field visit, men and women from the villages of Soludaipatti, Oyangulai, Manjalpatti, and Paudipuduvalavu were invited to participate in the study. Five focus groups (n=32 participants) were conducted with men and women of different age groups. An equal number of men and women and men participated which included

women ages 20-40 years (n=6), 40-60 years (n=6), and 60+ years (n=4), as well as men ages 20-40 years (n=6), 40-60 years (n=6), and 60+ years (n=4). All participants from both field visits were invited to participate in the study by MSSRF field research staff. Oral consent to participate in this smaller research study under the APM project was provided by all participants.

Village description

Small clusters of houses form villages throughout the Kolli Hills. The villages of Soludaipatti, Oyangulai, Manjalpatti, and Paudipuduvalavu are villages of approximately 150 people. A school, a small restaurant, and one to two small shops are often available in each village, selling some homemade goods. Each village is located within a few kilometers of one another, and a main road connects the central hills with each village. Despite this, the distance required to travel to reach some important services on Kolli Hills such as government buildings, pharmacies and Fair Price Shops is approximately five to seven kilometers from each village. The distance to an open market which is available biweekly is approximately three to four kilometers from each village. Villagers travel these distances by foot or by motorcycle to purchase items from these locations. Figures 3.2, 3.3 and 3.4 show pictures of a typical village home and the market that the villagers have access to.

Figure 3.2: Village House

Figure 3.3: Villagers

Figure 3.4: Village Market

Bronfenbrenner's Ecological Model

Bronfenbrenner's Ecological Model is the framework that was used to understand and describe the factors affecting changes in dietary choices in Kolli Hills [15]. Bronfenbrenner's ecological model depicts multiple levels of influence on a phenomenon. From the inner to the outermost of Bronfenbrenner's ecological model, the levels of influence are microsystems, mesosystems, exosystems, and macrosystem [15].Microsystems describe the pattern of activities, social roles, and interpersonal relations experienced by the individual in a face-to-face setting [15]. The mesosystem consists of the interactions and linkages that take place between two or more microsystems a specific phenomenon [15]. The exosystem comprises of the interactions between two or more settings, one of which does not include the individual but still functions to influence the individual [15]. Finally, the macrosystem consists of overarching meaning systems encompassing belief systems and worldviews which ultimately shape one's experience at other levels of influence [15].

The nature of this particular model makes it a preferable framework to understand this research objective. Food habits are an essential aspect of the culture of Kolli Hills, influenced by complex interactions between the social and political environment of Kolli Hills [8]. Bronfenbrenner's ecological model allows the description of the interconnectedness and the interactions between these layers of structure and influence.

3.2.3 Data collection

The investigator accompanied field staff to visit each participating village and participants. Initially, the investigator served as mainly an observer to the environment and daily activities of participating households. The investigator assumed the role of a guest during visitations with each household. However, as more time was spent in the field, the investigator became more involved in the lives and activities of each participant and often visited each household with a translator and without MSSRF field staff. This included playing with the children in the villages, assisting the women with some household duties and the men with some gardening activities and observing their work in the fields. Gradually, the investigator became more immersed in the local culture and was able to provide accounts of everyday lives and activities of participants.

Data collection methods for this study included semi-structured focus group discussions, informal individual interviews, as well as participant observation. A total of 32 participants including 16 women and 16 men participated in focus group discussions. The men and women were selected from the same household when possible to allow for a comparison of perspectives. Five women of the age categories 20-40 years and 40-60 years who participated in focus group discussions also participated in informal individual interviews with the same questions. Participation in individual interviews was based on convenience sampling and the willingness of women to participate in private interviews. Four households with participants who participated in both the focus group discussions and individual interviews allowed the investigator to be present with them during family mealtimes and market purchases. The investigator assisted with simple meal preparation tasks and dined with the families. During mealtimes, the investigator

took note of interactions that occurred, themes of conversations related to food that occurred, and types of foods consumed. In order to allow participants to feel at ease during mealtime observations, multiple home visits took place over a period of time for each household. On average, each household was visited approximately three to four times and participants were able to behave more naturally for observation. During market purchases, the investigator accompanied the men or women to the market in their preferred mode of transportation and took note of any factors related to their food purchasing habits. Notes on observations were recorded immediately after the experience.

The use of multiple data collection methods is a data collection technique commonly used in ethnography, called methodological triangulation, which allows different methods to provide more comprehensive understandings and insights about the phenomenon of interest [16]. Information obtained from different sources – focus group discussions, individual interviews, and observations explored the changing variety of foods consumed in different research settings to allow for a more complete understanding of this phenomenon. Furthermore, different and contradicting information may emerge from focus group discussions and individual interviews despite using the same interview guide; the synergistic effect of focus group discussions may result in the surfacing of certain information while individual interviews may be more conducive for other conversations to take place. Likewise, what people say about their actions may contrast with their actual behaviour [16]. These inconsistencies are also important in understanding the phenomenon. Transcripts and notes obtained from all three sources were reviewed and themes related to the research question which appeared in different sources were noted as well as information which was revealed in

one or two sources. Noting the similarities and differences in patterns allows the identification of complementary or contradicting information related to research question.

3.2.4 Tool Development

A literature review was conducted to identify any tools which may be appropriate to collect retrospective data on past and current foods consumed. When no tools were identified, a simple semi-structured interview protocol was developed with the assistance of local researchers. The questions were developed based on the experiences of local researchers. This interview protocol simply asked questions about past food items that were consumed (e.g., 25-30 years ago) and current food habits. For each food item that participants had indicated that they consumed in the past but no longer consumed currently, the facilitator probed for the reasons for this change. The themes obtained from this interview tool contributed towards refining an interview tool that was used for data collected during the second field visit. The themes which emerged from these focus groups included changes in the foods production patterns, changes in food purchasing behaviour, and changes in food consumption patterns from 25-30 years ago to present day. The interview tool used during the second field visit included questions which asked about each of these aspects in the past (25-30 years ago) as well as the present.

For the second field visit, a new semi-structured interview guide was developed with the assistance of MSSRF research team in Kolli Hills that were familiar with the food environment of the people of Kolli Hills. Based on the information collected through the first field visit, more specific questions were drafted. These questions focused on

changes in food production, access to food, as well as utilization of foods. Questions related to the perceived impact of kitchen gardens on food production, access to foods and food utilization was also included. Questions were drafted and the wording of the questions was revised several times based on input from the MSSRF research team to improve ease of understanding.

3.2.5 Interview guide

The interview guide consisted of three main sections on different components of food security based on three periods: 1) Past food consumption, 2) Current food consumption, and 3) Food patterns after the implementation of the kitchen garden intervention (refer to Table 1). For each period, questions were asked regarding the different dimensions of food security that included: availability of foods, accessibility to foods, as well as utilization of foods. Availability of foods refers to sufficient quantities of foods available on a consistent basis [17]. These questions in the interview guide asked about the availability of the foods grown in the fields. Food accessibility refers to having sufficient resources to obtain appropriate foods for a nutritious diet (World Health Organization, 2013). Questions related to food accessibility in the interview guide asked about financial resources to obtain food from the market food system. Finally, the utilization dimension of food security refers to appropriate use of foods as well as adequate water and sanitation [17]. Questions related to food utilization in the interview guide included questions on food consumption as well as water sanitation. The final draft of the interview guide was reviewed by two agricultural professionals from MSSRF and a Registered Dietitian working in the area of Kolli Hills. A group meeting was held by the investigator to obtain feedback on the interview guide from

these professionals. No major changes were suggested for the interview guide. Some minor changes involving choices of words were suggested to improve the ease of understanding of questions.

Table 3.1: Interview guide components and corresponding questions

Time period	Dimension of food security	Question
25-30 years ago Think back to the time that there was more variety in your diet	Food availability	What did you grow in the fields for food? Where did you get your food?
	Food accessibility	Approximately how much was your household income?
	Food utilization	How much of your household income went towards food for the family? Tell me about your access to clean water to cook? Clean facilities to prepare and store food?
Think about the time period when there was less variety in your diet	Food availability	What did you grow in the fields for food? Where did you get your food?
	Food accessibility	Approximately how much was your household income?
	Food utilization	How much of your household income went towards food for the family? Tell me about your access to clean water to cook? Clean facilities to prepare and store food?
Kitchen garden implemented in your household	Food availability	What crops are grown in your home/kitchen garden?
	Food accessibility	Do you purchase vegetables/other food stuffs from the market? If so what? Where? How much? Since the establishment of

	Food utilization	your home/kitchen garden, how has your food purchasing habits at the market changed? How has your food gathering habits from the wild changed? How are kitchen garden crops used in a given month?

The interview guide was subsequently pilot tested on two female and one male villager for appropriateness in content and working of questions prior to its utilization in actual data collection. Two mock focus group discussions were conducted prior to the actual focus group discussions in order to familiarize the facilitators with the interview guide and follow up questions. For both sessions, the investigator conducted the mock focus group discussions with several individuals - the field staff which will be facilitating actual focus group discussions, a translator, a local Registered Dietitian, and the two agricultural professionals. A debriefing session took place after each session and discussions took place for the Registered Dietitian and the two agricultural professionals to provide feedback to the field staff on strategies to probe for more information during actual focus group discussions.

3.2.6 Focus groups

All focus group discussions were conducted in community centres located near the homes of participants for their comfort. Focus groups were conducted in the evening as this was identified to be the most convenient time for all participants. All focus groups were conducted in Tamil, the native language spoken in this area and facilitated by a field researcher employed by MSSRF.

During the first field visit, only focus group discussions were conducted. During each session, only the investigator and the facilitator were present to lead the discussions. All members present sat in a circle for ease of communication. The facilitator translated the overall content of what was said by participants as it emerged from the discussions to the investigator as they occurred. This allowed the investigator to instruct the facilitator on ways to lead the discussions to address the research questions. Each focus group lasted for about 50 minutes. Both focus groups were digitally recorded by a voice recorder. No other notes were taken during the discussions. However, a debriefing session took place after each focus group by the investigator and facilitator to discuss the main themes emerged during discussions as well as general progress of the discussions. As the facilitator could not translate much of the discussion to the investigator during focus group discussions, the facilitator used debriefing sessions to describe the content of discussions to the investigator. However, this method of conducting focus groups is not ideal as it does not allow the investigator to understand the content of the discussions as they occur in order to probe for more information on certain topics.

During the second field visit, focus groups were conducted with the involvement of a translator in addition to the facilitator and investigator. For each focus group discussion, aside from participants, members present included the investigator, a translator, and another field researcher to assist with the logistics of the sessions and take notes. All members present sat in a circle with participants for ease of communication. During focus group discussions, a separate translator translated the main themes discussed directly to the investigator, allowing the investigator to instruct the facilitator to probe for more information on a particular point or clarify any points raised. As the translator

was employed only for this research study and was not involved with MSSRF initiatives, this arm's length allowed for neutrality and provided some objectivity in translating the meaning of what was discussed during focus group discussions. During the second field visit, five focus groups were conducted in Kolli Hills with both men and women of different age groups with the assistance of a translator. This included women ages 20-40 (n=6), 40-60 (n=6), and 60+ (n=4) as well as men ages 20-40 (n=6), 40-60 (n=6), and 60+ (n=4). Each focus group discussions lasted approximately 40 minutes.

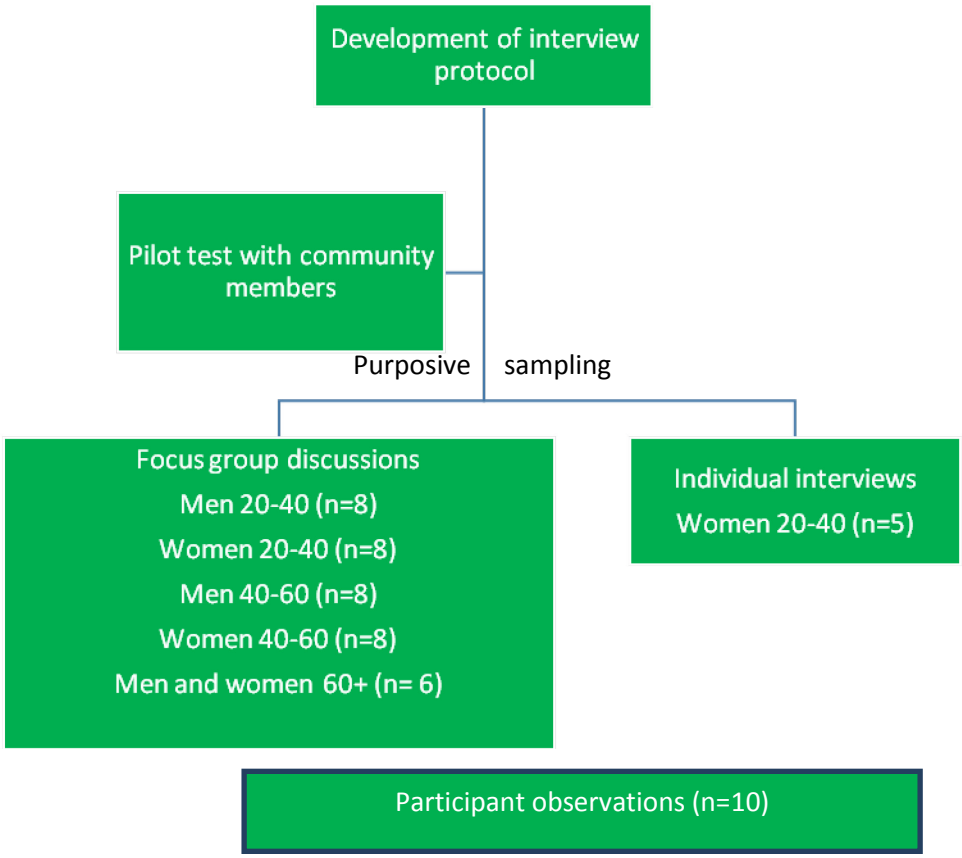

Figure 3.5: Flow diagram of data collection methods

3.2.7 Individual interviews

Informal individual interviews were also conducted with five women. Informal or conversational interviews allow ethnographers to elicit candid accounts from individuals

in a naturalistic manner [16]. As it was known that women may be the ones bearing the main responsibility of maintaining kitchen gardens, private conversations with individual women may provide some candid information on their perspectives on the kitchen gardens. It was possible that certain information related to kitchen gardens may be gender sensitive. Further, it was also for pragmatic reasons that only women participated in individual interviews; men were often away from the home for the majority of the day for consecutive days in pursuit of work in nearby estates. This often leaves women to be responsible for making daily food choices in the household.

3.2.8 Participant observation

Participant observation was also conducted with the participation of the translator along with the investigator. Participant observation, along with individual conversations and focus group discussion are important in methodological triangulation as what people report about their actions may contrast with their actual behaviour [16]. Immersion in the phenomenon of interest and the relationship that the investigator shares with participants are an integral aspect of ethnographic work, allowing the investigator to present ideas and describe experiences to readers [16]. Strategic locations related to food procurement and provisioning were selected to conduct participant observations; this included the household during mealtimes where food was normally consumed as well as the market where food was purchased. The investigator submersed herself in the observation environment by assisting with food preparation, dining with families during mealtimes, and accompanying members of the household to market to purchase goods. To learn about kitchen garden activities, the investigator participated in activities related to the maintenance of home gardens. This included

activities such as simple weeding and watering the crops. The investigator also communicated with many women during this time with the assistance of a translator. Written notes were made after the investigator and the translator left the site to avoid recording in front of families. The investigator would record notes independently and immediately after leaving each site. Subsequently, discussions would take place between the investigator and the translator to discuss their perspectives of the occurrences from each site. This adds a level of neutrality from the translator in interpreting what occurred during site observations. These families were mostly nuclear family structured, with a male and female head of household as well as several school aged children. This was the most typical family structure in the village.

3.3 Data Analysis

Inductive thematic analysis allows key themes to emerge and these concepts to be categorized from the data [16]. This method of analysis is commonly used in the analysis of ethnographic data as it allows for the analysis of themes, or patterns across data sets that are important in the description of a phenomenon [16]. This inductive process allows the investigators to generate tentative explanations from empirical work for the phenomenon of interest – factors affecting changes in dietary patterns. The themes that emerged from inductive thematic analysis were similar to the levels of influence described in Bronfenbrenner's Ecological Model while the final categorization of themes was created with consideration of the each level of influence in this model.

All the transcripts were analyzed and coded by the investigator to identify main recurring themes. NVivo software (version 10, QSR International) was used to organize and manage all the data from focus group discussions, individual interviews as well as

the field notes from participant observations. The first process is the analysis of convergence [14]. It entailed reviewing the data for recurring regularities, allowing patterns to emerge which can be sorted into categories, or codes [14]. The data were reviewed line by line by two independent researchers and sentences or paragraphs were categorized into codes. Some examples of initial codes included food preparation and utilization, food systems to obtain food, and income related food accessibility barriers. These codes are patterns of ideas related to the research question that have emerged from the data. Both researchers work between the data and the classification system to ensure the accuracy and meaningfulness of categorization.

Subsequently, the analysis of divergence takes place where both researchers reread all the data in order to search for statements that may fit into any of the established codes [14]. Some new codes were developed at this stage. The analysis of divergence also involves careful examination of data to identify any potential deviant statements that do not fit into the dominant recurring patterns [14]. NVivo 10, QSR International was used to organize the codes by grouping together similar statements into first order themes [11] and then grouping similar codes together into second order themes [11].

The independent researchers were able to agree on the meaning of the text as well as the categorization of content into themes with only minor disagreements. In the case of these minor disagreements, these discrepancies were discussed further until agreement was achieved. The interpretations of the content of these two researchers were then discussed with a researcher from Tamil Nadu for an additional validity check to contribute to the trustworthiness of interpretation [11].

Ethics approval for this smaller study under the APM project has been obtained from the Research Ethics board from the Department of Agricultural, Food and Nutritional Sciences (AFNS) at the University of Alberta.

3.3.2 Ensuring Rigour

Submersion of the investigator in the research setting with participants allowed the identification and verification of recurring themes and contributes to credibility of the patterns and themes identified [18]. Credibility of information collected was also enhanced by constant reflexivity practiced by the investigator in the field in which the investigator assessed the influence of one's own background and perceptions in the research process [18]. A strategy in reflexivity practiced by the investigator involved examining any preconceptions that exist on how the investigator thinks participants may answer each of the questions in the interview guide. Prior to actual focus group discussions, the investigator attempted to answer all the questions from the interview guide from the perspective of the participants. These answers were compared to actual answers provided by participants after each focus group discussion based on debriefing notes. This process allowed for the identification of preconceptions that the investigator may have related to these questions. A preconception that existed was the idea that financial means were limited for food purchasing in these communities. It was then ensured that this preconception did not influence the interpretation of information collected. Another strategy involved rereading previous days' field notes and reflecting upon them to make note of any subjective opinions held by the investigator. Reflexivity is also practiced in each stage of data analysis, including careful documentation of how codes are interpreted into themes to answer the research question.

A strategy that is central to ensuring credibility of information gathered is member checking to ensure that the participants' viewpoints are correctly translated into data [18]. After the initial transcription of data from focus group discussion and individual interviews, the investigator and the translator met with as many participants as possible to briefly review some main themes which emerged during the session with participants; this was to verify that the investigator's interpretation of the information was indeed what was intended to be communicated. Meetings were held with 12 participants, including five women who participated in both focus group discussions and individual interviews, and seven men who participated in focus group discussions. Focus group discussion and individual interviews from both field visits were digitally recorded and transcribed by the translator immediately post-interviews in order to capture the information as accurately as possible. These transcripts were also compared with any notes that were taken by a field researcher present during focus group discussions to capture any additional information or inconsistencies.

After each focus group discussion, a debriefing session took place with the investigator, the facilitator, the translator, and other field staff present during the discussions. This allowed for main themes which emerged during focus group discussions to be documented immediately. These main themes were then discussed with research participants to ensure that these ideas were reflective of their experiences.

Although it would be ideal to analyze the data in the original language that interviews and focus groups were conducted in to preserve cultural nuances of the information from the data sources, this was not possible as the investigator responsible for much of data analysis was not fluent in Tamil. Several strategies were used to ensure the

accuracy of the transcriptions and preserve the cultural meaning of the translated transcripts. Although the transcripts were not analyzed in the native language that focus group discussions and interviews were conducted, several measures were taken to ensure the credibility of the findings. First, measures were taken to reduce the possibility of translation resulting in loss of cultural specific meanings in transcripts. All transcripts were taken back to Canada and validated by an external researcher who was fluent in both English and Tamil. The external researcher was able to listen to digital recordings and verify the accuracy and quality of the content transcribed. Second, the transcripts were back translated from English to Tamil for comparison purposes to assess the accuracy of initial translations by the external researcher. The results of this process suggested that the initial translations were reasonably accurate in capturing all the main ideas emerged during discussions. The use of back-translation is common in cross-cultural research settings as it allows two original language versions which can be compared to highlight cultural nuances lost in translation [19]. This external researcher was at arm's length to the research project; her neutrality in transcribing the data helped to ensure credibility of the findings.

To contribute to the confirmability of findings, the external researcher also reviewed all transcripts and observation notes throughout the research process to see if similar themes and meanings from the data can be derived.

3.4 Results

The results of this study described below include data from several different sources. The age, employment status, and education level of participants were obtained after each focus group discussion. Information on income of participants was obtained from a

separate demographic survey administered to all study participants in 2011 as a part of the broader APM project. The demographic survey asked about annual income of each participating household. The names of each household member were also recorded and all information was organized on a spreadsheet. The names of participants in each focus group were gathered and based on this information, their annual household incomes were obtained.

A list of food items recalled to be consumed in the past as well as in the present was generated primarily from data collected through focus group discussions. Information on the factors related to changes in food variety was obtained from all data sources, including focus group discussions, individual interviews, and participant observations.

Table 3.2: Key characteristics of study participants in Kolli Hills, India

Characteristic	Number of participants (% of total participants)
Mean age for each participant group	
Women 20-40	28.2
Men 20-40	31.0
Women 40-60	40.9
Men 40-60	47.8
60+	68.2
Employment status (other than farming)	
Employed (women)	2 (12.5)
Employed (men)	9 (56)
Education level	
No Schooling	6 (18.8)
Primary (Grades 1-5)	9 (28.1)
Secondary (Grades 6?-10)	13 (40.6)
Higher secondary (11, 12)	5 (15.6)
Annual household income (Rs) *	
< 5000	3 (9.4)
5000-20000	6 (18.8)
20000-40000	4 (12.5)
> 40000	18 (52.6)

*Information on annual household income was obtained from a separate demographic survey administered to all study participants in 2011 as a part of the broader APM project. Income included both on farm and off farm incomes.

The age range of participants was between 28 and 69 years. All participants were from small farming households. Male participants often held jobs other than farming outside of the community as construction workers or on plantations in nearby estates. Most participants received some education; none reported completing education higher than higher secondary education. A wide range of annual household incomes were reported; most reported an annual household income of more than 40000 Rs.

The exchange rate of Indian Rupee to Canadian Dollar is 1 to 0.017. State specific poverty lines exist in India. In year 2011-2012, the poverty line in rural Tamil Nadu was a monthly income of 880 Rs per person [20]. Twelve percent of participants of this smaller research study would be considered to be below the poverty line.

3.4.1 Retrospective recall of food consumed and dietary variety

The number of foods identified as being consumed in the past and present were recorded from each focus group conducted. The average number of foods in each food group reported as being consumed during both time periods was recorded. Overall, there was an overall decrease in dietary diversity, with decreases in the number of foods consumed from grain products, fruits, vegetables and meat products. Results suggest that the most significant decreases in variety occurred in grain products, fruits, and meat products, with a decrease in the average number of different foods consumed from 7 to 3, 12 to 3, and 9 to 3 for grains products, fruits, and meat products from the

past (25-30 years) to present day (see Figure 4.2). For a more detailed list of foods consumed in the past and in the present see Table 4.3.

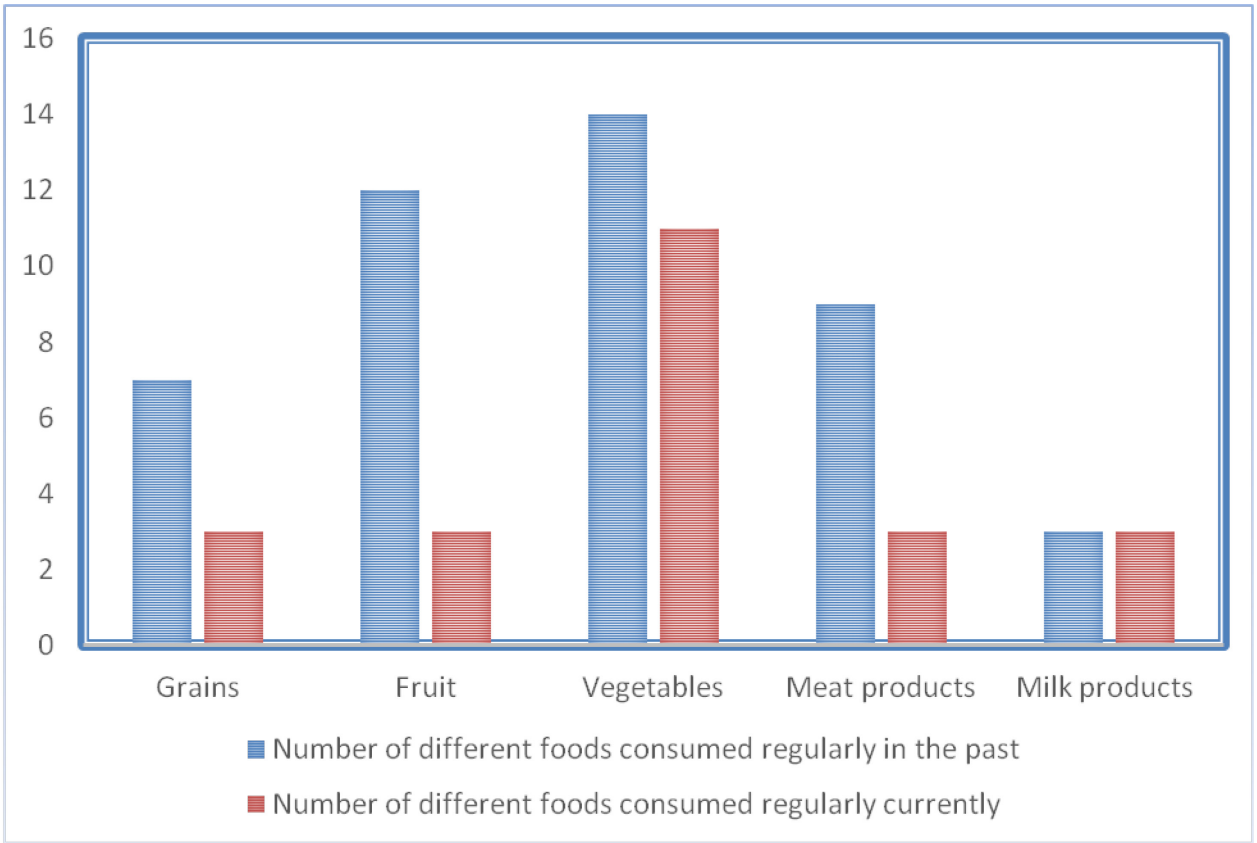

Figure 3.6: Number of foods in each food group consumed weekly or biweekly in the past (25-30 years ago) and currently

Table 3.3: List of foods consumed in the past and present

Food group consumption	Past	Present
Cereals and millets	From field (Millet varieties) – kari, varagu, thenai, hali, kenaru, ragi, samai From field (Rice varieties) – pulathi kal nellu (mettu nallu), samba nellu	From ration shop – rice, wheat Field - rice from ponni, IR 50 and IR8
Fats and oils	From livestock – butter, From market - palm oil (only some households)	Ration shop - palm oil
Condiments and spices	From market - cumin, garlic, pepper, masala	From market – cumin, garlic, pepper, masala
Fruits	From the wild - Banana, pomegranate, lemon, guava, citrus fruits, orange, pineapple, arasi medulai, plums, blackberry, thorati palam, mango , gooseberry, jackfruit	From market - mango, banana, oranges (less often), guava (less often), jackfruit
Green leafy vegetables	From the wild - Pannai keerai, kuppa keerai, kakana keerai, sengkeerai, ponna kanna keerai, vallarai, kunni keerai, pulchai keerai, velanganni keerai, aval yeri keerai, yeengi keerai, menna keerai, thagarai keerai mookuthi keerai, saembu keerai, pudina, poosani keera, coriander	From the wild – kuni keerai, pannai keerai, kulaichi keerai From Kitchen garden and market – fenugreek leaves, spinach, drumstick leaves, amaranth, colocasia leaves, cabbage
Roots and tubers	Wild - Malai kelangu, mullai kelangu, chakara valli, sembu kelangu, vetha la valli kelangu, kuchi kelangu, aatu kaal tubers or modavattu tubers, colocasia, mooradu	Field - Cassava (a bit) Market - and kitchen garden – carrots, radish, beet root, onions, potatoes, sweet potatoes
Other vegetables	Field - bittergourd, beans, drumstick, avarai beans, brinjal (eggplant) pumpkin , thovarai beans, mustard, Wild –drumstick	From kitchen garden and market - brinjal, green beans, drumstick, mullangi, tomato, lady fingers (okra), cauliflower, kothavarai, bittergourd, bottlegourd, sorakkai,
Meat products	Wild - Mongoose, squirrels, birds, wild pigs, wild goat, alungu (lizards), rabbits, pigeons, porcupine Livestock – cows (for milk), goats, hens	Livestock - Pig, hen, chicken (1-2 kg consumption per month per family)

Milk products	From livestock - Buttermilk, yogurt, milk	Market - Milk (less now), buttermilk (less now)

Grain products

All participants mentioned that white rice has replaced millet as the predominant staple grain product consumed by households currently as compared with 20-25 years ago. Rice is obtained either from the farmers' fields or through Fair Price Shops (FPS) through India's Public Distribution System (PDS). Many millet varieties such as Thenai, Samai, and Ragi consumed 25-30 years ago are no longer cultivated in their fields or consumed today. Although these millet varieties are still available for purchase in the markets, these products are not subsidized like rice through the PDS. In comparison with rice, the cost of millet is higher in the market, making it less accessible to community members.

Fruits and vegetables

As described by all participants, fruits and vegetables 20-25 years ago were plentiful. Many varieties of berries and citrus fruits which were reported to be consumed in the past were no longer consumed today. Participants also suggested that fruits such as guava and oranges were consumed less frequently compared with 20-25 years ago. In regards to vegetable consumption, participants reported consuming a wide variety of wild greens 20-25 years ago. These local greens were no longer reported to be consumed today.

Meat products

There has been a significant decrease in variety of meat products. A variety of meat from the wild such as mongoose, squirrels, rabbits, lizards, and pigeons which were

reported to be commonly consumed 20-25 years ago are not reported to be consumed today.

Milk products

Although the variety of milk products reported to be consumed 20-25 years ago including buttermilk, yogurt, and milk are also reported to be consumed today, participants expressed that the quantity of milk consumed in their diet has significantly decreased.

3.4.2 Factors affecting changes in dietary variety

Many factors affecting changes in dietary variety were identified by participants. The subsequent sections outline the different factors affecting changes in dietary variety within each level influence in Bronfenbrenner's Ecological Framework from macro to micro level factors. Factors affecting changes in dietary variety were identified to be 1) Societal value related to wealth generation; 2) reliance on market system; 3) environment factors; 4) changes in taste preferences and 5) drudgery related to farming and food preparation. Pseudonyms are used in all citations below.

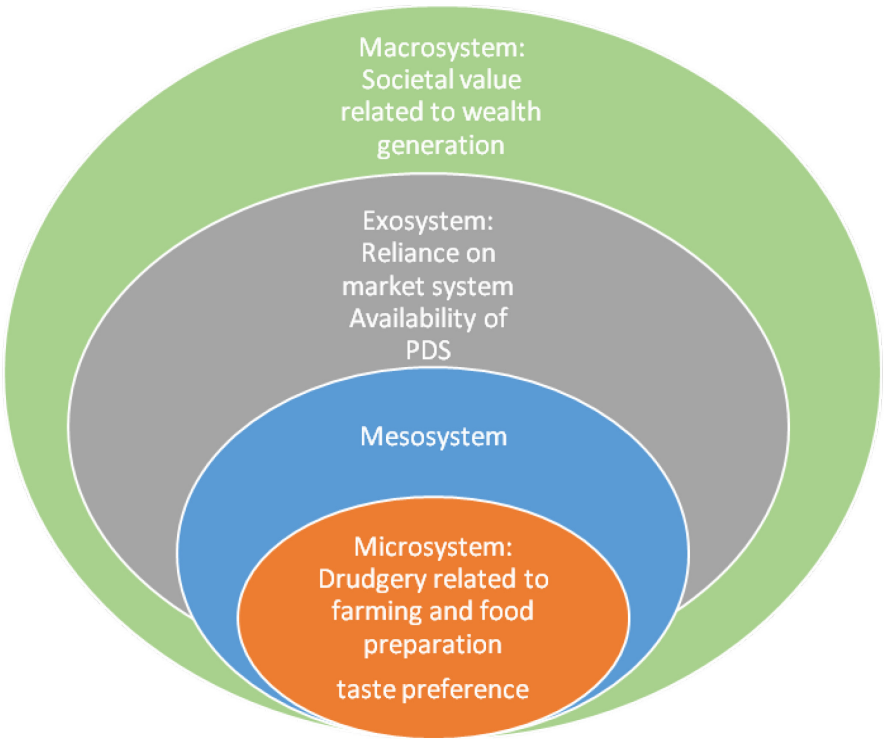

Figure 3.7: Different levels of influence explaining factors affecting changes in dietary variety according to Bronfenbrenner's Ecological Framework

Macrosystem

The macrosystem is defined as the overarching meaning systems conveyed symbolically through culture [15]. This encompasses the worldview held by men and women in the community.

Societal value related to wealth generation

There is a strong emphasis and value on wealth generation amongst participants, contributing to the transition from subsistence farming to cash crop cultivation. In the past, fruits, vegetables, and millet varieties were grown in the fields of farmers' for consumption. However, the lack of revenue generated from these crops has led to the decrease in cultivation of and complete abandonment of millet cultivation amongst these farmers in favour of growing cash crops. Today, a large percentage of farmland is

used for the cultivation of cassava, the main cash crop in Kolli Hills. Cassava is a very drought resistant crop that can withstand unpredictable rainfall patterns, and manual labour associated with its cultivation is relatively minimal in comparison to millet.

Pavorathy (age 54): *No money….we didn't get money from growing millets, we are not able to sell it, those days people had it only for food.*

Radhiga (age 34): *If we grow vegetables and millets today, then we have no money. Since we started growing cassava, we have to buy everything to eat.*

The trend towards cash crop farming has led to increased reliance on market systems to obtain food for consumption, making them vulnerable to fluctuating market prices for fruits, vegetables, and other commodities and subsequently affecting access to a variety of foods for consumption. There is, however, a perception amongst all participants that foods consumed in the past were natural and healthy as compared with the foods which are high in pesticides and other chemicals today.

As suggested by participants, there is a change in expectations for a good quality of life. Families associate a high standard of living with attainment of more education at better institutions for their children, leading to increase demand for money for tuition costs.

Maliga (age 32): *If we have 2-3 kids, then we have to pay fees for them, we spend money on all of this. If we put them in government school, then we don't pay anything…but if we want good private schools then we have to pay, that is an expense.*

Ajeetha (age 54): *To raise children in the past we only gather food for them from the wild. It was easy.* Some women also suggested that there is increased emphasis and desire for material goods compared with 20-25 years ago.

Radhiga (age 42): *When we wanted to eat in the past, we will get food from fields and hilly areas. We don't get money or clothes. The food we get is enough to just fill our stomach every day. There is nothing else.*

Ajeetha (age 54): *Before in childhood we don't have proper dress. Young people now have dress, nice jewelry.*

A higher standard of living was also associated with obtaining care from medical institutions for pregnancy and childbirth. Women reported frequent visits to the hospitals related to pregnancy and childbirth contributing to the already high expenditures faced by households.

Lakhshmi (53): *Before, for childbirth we do not go to hospitals. If the pain is for 4-5 days we stay at home. Now if anything happens we have to go to the hospital.*

Sindhu (24): *50000 rupees get spent for delivery, and they ask us for 10 checkups during the 10 months of pregnancy, that is 1000 rupees more.*

Overall, the increased aspiration for wealth generation towards a higher standard of living has contributed towards the transition from subsistence farming to cash crop cultivation. This resulted in the abandonment of cultivation and consumption of nutritious millet varieties and has also decreased the availability of a variety of fruits and vegetables grown by farmers for consumption.

Exosystem

Exosystem consists of the social structures, both formal and informal, removed from the individual, yet regulating and influencing their everyday lives within the microsystem [15].

Reliance on market system to obtain foods

The increased in reliance on markets to obtain fruits and vegetables from 20-25 years ago has changed consumption patterns. In the past, consumption of fruits was suggested to be heavily dependent on the season.

Sanjiv (age 45): *When it's guava season we eat that for fruit and when other fruits are in season we mainly just eat that. Before, according to seasons we ate what was in the trees, now we buy everything.*

For households with sufficient income to obtain a variety of fruits from the market, the transition to increase market reliance may be an enabler to allow households greater access to a variety of fruits. However, high food expenses were identified by many households as an important barrier to purchasing the desire food items for consumption.

Anand (age 43): *In the past if we earn 10 rupees, we could spend 2 rupees and bring back 8 rupees. Nowadays, even if we make 100000 rupees it will just go…just in kara valli's market.*

Santosh (25): *Now per kg, brinjal is 50 rupees, last time I go to market without buying brinjal (eggplant). For 300 rupees, the shopping bag is still empty.*

Overall, the increased dependence on markets to obtain fruits and vegetables and the high cost of fruits and vegetables has prevented households from accessing and consuming a wide variety of fruits and vegetables.

Environmental changes

Changes in rainfall patterns and soil fertility were identified to be a leading reason for the changes in production patterns in the area. Due to increasingly unpredictable rainfall patterns, millet cultivation has become more challenging. A pragmatic solution to address this was the change from millet, fruits and vegetables cultivation to growing the relatively drought resistant cassava.

Sindhu (age 32): *For paddies, we used to sow it and rain will come and it will grow, no river or well water needed. Only rain water. Now the season has changed, so now we cannot do that because as seasons changed there is less rain, it will not grow. Now we only cultivate cassava and some rice varieties.*

Climate changes also appeared to have changed the availability of fruit varieties from the wild.

Kumar (age 56): *Plums, guava, berries, and citrus fruits we use to get from the wild hilly areas. There used to be lots. Now we are also getting some but only very limited, and only some seasons, otherwise we will not get.*

Further, decreases in the availability of forest land for community hunts performed once a month by men in the community has decreased animal source protein in the diet of community members. Over the past 10-20 years, increased clearing of forest land and

trend of young men leaving the community for work has led to the erosion of the tradition of community hunts.

Sanjiv (age 56): *Men used to hunt before. They used to hunt, now no one goes for that now. It is very hard to get hunting meat from land.*

Overall, climate changes in this area was identified to be a significant factor preventing the cultivation of a wide variety of crops traditionally grown in this area 20-25 years ago. These changes have also significantly affected the types and quantity of fruits readily available from the wild to be gathered. These factors in combination with decreased availability of forest land for hunting has resulted in decreased availability of a variety of foods for consumption.

Microsystem

Microsystem refers to factors on the individual level and an individual's interactions with immediate settings such as home, neighbourhood, and informal social networks [15].

Changes in food preferences

Participants described foods consumed in the past as healthy. Millets were also perceived to be very nutritious and good for the body. Foods consumed today were perceived to be less nutritious, with high levels of disease inducing chemicals.

Sindhu (age 43): *Eating this rice, we are becoming weak.*

There appears to be different preferences for food in the children. Many women indicated that although many adults still remember consuming millet as the main staple and prefer it to rice, their children will not eat it.

Maliga (age 34): *So many of the kids these days won't eat thinai or samai cooked any way, like in porridge….only regular rice.*

This intergenerational change in the preference of traditional foods such as millets has contributed towards changing food habits in the household. The little exposure children have to millets as well as a lack of understanding of its nutritious benefits have led to millets to be the less preferred option compared to rice. As white rice is readily available through Fair Price Shops (FPS), this has become the predominant staple for families for many years.

Drudgery related to farming and food preparation

Women in the age group 20-40 described drudgery related to farming practices and time barriers related in food preparation as factors affecting the availability and utilization of various foods. Women reported spending long hours in the field on farming related activities with little time for food preparation for the family.

Lakshmi (age 32): *If we go to work at 7 o'clock in the morning, by the time we come home it's 5-5:30 in the evening. Then there is only time to bathe the kids and get the food ready.*

The unreliable supply of power in the village has made the use of power tools to grind millets challenging, leaving women the only option of hand pounding millets for

consumption. Obtaining rice from FPS relieves women of this drudgery, resulting in increased rice consumption and decreased millet consumption.

Radhiga (age 28): *To eat millet we have to grind. If we don't grind it we can't eat. We are not able to grind it in the machine and eat it. There is no power. So we have to use our hands to stone pound it .Rice we only need to boil and eat.*

There are changes in expectations related to time investment in food preparation between generations. In focus groups of women 40-60 years of age, the women described hand pounding millets for consumption to be the norm in her youth.

Pavarthi (age 58): *What do the ladies of this generation know? Tell these ladies to hand pound. They can't do it, they can't.*

In addition to the drudgery experienced by women related to food preparation in the household, families also experience drudgery related to raising livestock and in the fields related to millet cultivation

Radhiga (age 38): *In those days, each house would have 4-10 cows. Today, even raising one cow per household is very tough. We are not able to take care of one cow.*

As men in the community often left for work in nearby estates for higher wages, this poses a challenge for women in the community to be responsible for activities in the field as well as the home.

Maliga (26): *We can manage if the men go to Kerala or somewhere and earn and then come back. People feel that way and then they go.*

Overall, the drudgery the women experience related to food preparation at the household level favours the consumption of rice from FPS instead of millet or other grains requiring extensive preparation. As many men and women in the community also hold employment outside of the home in addition to farming, the ability of households to raise livestock also decreases. These factors have contributed to changes in dietary patterns and subsequently the decrease in consumption of millet varieties and milk products.

3.4.3 Perception of kitchen garden intervention

Crops grown in kitchen gardens

The kitchen garden intervention has been in place for participating households between 1-2 years. Households get yield from their kitchen garden twice a year, between the months of November and March. Common crops grown in the kitchen garden include tomatoes (Lycopersicon esculentum) , cabbage (Brassica oleracea capitata group), cauliflower (Brassica Oleracea), carrots (Daucas carota), beet root (Beta vulgaris crassa), bittergourd (Momordica charantia), bottlegourd (Lagenaria Siceraria), brinjal (Solanum melongena), radish (Rapnus sativus), lady fingers (okra) (Abelmoschus esculentus), and cluster beans (Phaseolus vulgaris). Due to a lack of rainfall and irrigation challenges, there is little yield in kitchen gardens between the months of April and October.

How kitchen garden has affected purchasing habits

Households reported visiting the market to purchase vegetables from the market once every five to ten days on average. For many households, due to the long distance required to travel to the market, men were often responsible for purchasing goods from

the market for the family. However, as more and more men migrate to nearby estates for work, this role has been increasingly assumed by women. All participants reported a significant decrease in money spent at the market during the months of November and March because of kitchen gardens. Participants reported an average decrease of 50-200 rupees weekly spent at the market, a significant reduction in expenses for each household.

Ajeetha (age 25): *Before kitchen garden we spend 200 rupees every time we go to the market. In a week markets are opened twice. We go to the market 4 times a month so in a month we spend about 800 rupees on food. After kitchen garden we spend less money, maybe 80 rupees less each time.*

Although variety of vegetables grown in kitchen gardens were also available for purchase at the market, the presence of kitchen gardens has improved households' access to a variety of vegetables during the months of November and March.

How kitchen garden has affected consumption patterns in the household

Vegetables from kitchen garden were mostly consumed by the household or shared with neighbours and other family members. Only a few households reported selling crops from kitchen gardens for additional income. All households reported increases in the frequency and amount of vegetables consumed as a result of kitchen gardens. However, participants did not report an increase in foods from other food groups after the implementation of the kitchen garden intervention as a result of money saved from purchases or from selling kitchen garden crops. Male participants reported that money

saved from growing own vegetables instead of purchasing vegetables from the market were used towards paying the debt that was owed.

Raja (34): We have lots of debt. The money we make or save all go to paying debt. We work very hard but we do not know how to plan for our spending and saving.

Perceptions of the overall value of kitchen garden

All participants expressed satisfaction in the implementation of the kitchen gardens for their improvement in access to a wide variety of vegetables between months of greatest yield from kitchen gardens.

Further, participants also valued the kitchen garden for allowing households improved abilities to share food with family and neighbours outside of the household. As sharing was repeatedly described by many participants as an important community value, kitchen gardens were important assets for the entire community.

Sindhu (age 35): *Sharing is very important. We share the tubers from the past and now we also share vegetables from the garden.*

Gender roles related to kitchen gardens

All participants described the management of kitchen gardens as a family activity usually involving all members of the family, although women and children were primarily responsible for the daily activities in the garden such as watering and weeding. Women reported increased self-efficacy related to kitchen garden management.

A theme that emerged exclusively from individual interviews is the increased control women have over foods consumed in the household as a result of kitchen gardens. Due to the long distance, men often bear the responsibility of traveling to the market. However, as women had expressed, the produce purchased from the market may not be reflective of what the household requires for meals for the week. With the implementation of kitchen garden vegetables, women had greater control over the types of foods prepared for the household for the week.

Maliga (age 26): *He [husband] buys what is cheap and he just buys 2 kg of all vegetables sometimes what is good price…so sometimes we don't have enough of some carrots or tomatoes but now we have from the garden and I can use what we need.*

3.5 Discussion

This ethnographic study used a retrospective recall method to explore the changes in dietary patterns from the perspective of men and women from different age groups in Kolli Hills. This study showed that there was an overall decrease in dietary variety. The variety of foods consumed in the food groups: grain products, fruits and vegetables, and meat products have decreased from 25-30 years ago to present day. This may have potential implications for nutrient adequacy in this population. Grain products (or cereals) are an important source of nutrients in the Indian diet, offering protein, calcium, iron, and B-complex vitamins [21]. The many millet varieties previously consumed 25-30 years ago were replaced by white rice obtained from the PDS today. The main millet varieties reported to be consumed by participants in the past, including

Thenai, Ragi and Cambu, are higher in calcium, protein, and iron than the rice consumed today. Although cereals are not overall very rich in minerals such as calcium and iron, they contribute significantly to the intake of these nutrients in the Indian diet due to the large quantities consumed [21].

Meat products are a source of good quality protein and provide B-vitamins [21]. The decrease in the consumption of wild animals from community hunts may decrease the protein intake in the diet of the Malayalis. Fruits and vegetables are good sources of a variety of nutrients. The reported decrease in consumption of gooseberry, citrus fruits and guava may lead to decreases in the intake of vitamin C, and the decrease in consumption of mango and citrus fruits may result in lower intake of beta-carotene, a precursor to vitamin A [21]. Lastly, although participants still reported consuming the same variety of milk products in the diet, they also emphasized the decrease in overall quantities consumed. Milk and milk products are considered to be important foods in the diet of Indians. Milk is commonly used to make ghee and fermented products such as buttermilk and curd are an important component of the diet of South Indians [21]. Despite this, the decrease in consumption of milk products in the diet of Malayalis today may suggest a potential decrease in the calcium and protein intake.

The trend towards decreasing dietary variety in this population differs from the dietary trend observed from documentations of changes in dietary variety on the national level, based on data collected from the National Survey Sample Organization of India between 1993 and 2004. Data from rural India shows that there was a reduction of cereal consumption of 10%. There was a slight increase in the intake of vegetables as well as meat/fish/poultry while the consumption of fruits rose sharply [22]. There is a lack of

information on changing dietary trends in the state of Tamil Nadu from late 1980s until today. However, a technical report by the National Nutrition Monitoring Bureau of India, based on data collected in rural households across India in 2001, suggests that the average consumption of all food groups were overall low for each age/gender/physiological groups from children to adults in rural Tamil Nadu [23]. The consumption of green leafy vegetables, fruits and milk products were especially low and resulted in insufficient intake of many nutrients according to the RDI [23].

The low dietary diversity described in our study is consistent with the findings of a similar study by Finnis [42], which examined changing production and consumption patterns in Kolli Hills, India. Finnis [42] suggested that in the diets of the Malayali people in present day, rice was consumed daily at each meal, accompanied by few vegetable varieties. No sources of animal protein, including eggs and milk were found to be present in the diet through any dietary recalls. The reported low dietary variety in their present day diet is consistent with the monotonous dietary patterns described in the study by Finnis [42].

A study by Anburaja and Nandogopalan [125] to examine the current agricultural activities of the Malayali Tribe in the Pachamalai Hills of Tamil Nadu, an area which is 146km from Kolli Hills, suggested that although animal husbandry is practiced by the Malayali Tribe, these animals contribute little to regular meat consumption. Goat, cattle, poultry, and pigs are often maintained by the Malayalis [7]. However, only a limited number of cattle and bullocks are maintained for ploughing, and the production of milk from cows is nil. Although piggery is a popular animal husbandry, indigenous pigs are usually only consumed during festivals and marriage ceremonies. Only some goats and

poultry are maintained for money and consumption [7]. These practices may be similar to the Malayali people of Kolli Hills.

Many factors were identified to be influential on decreasing dietary variety in our study. The main reason emphasized by all participants is the increased reliance on market systems to obtain food and a lack of financial resources to purchase a variety of foods for consumption. The increased reliance on market systems to obtain food were the results of two main factors: changing weather patterns and increased aspirations towards wealth generation. As climate changes lead to increasingly unpredictable rainfall patterns, millet and vegetable cultivation became increasingly challenging thus favoring the utilization of available of available agricultural land to cultivating a relatively drought resistant crop, cassava. Increased aspirations for cash generation demonstrates a desire for higher quality of living associated with the attainment of higher education, adequate medical care, and possession of material goods.

Environmental changes have also made it more difficult for men in the community to engage in community hunts. The lighter workload associated with cassava cultivation also allows men to migrate to take up additional work as labourers to increase household income level.

Women also work long hours in the field. The drudgery associated with preparing millets for consumption makes its consumption an even less favourable choice in comparison to rice purchased at subsidized prices through the PDS. There appears to be an intergenerational difference in expectations related to the amount of work required for food preparation. The extensive work required for hand pounding of millet in

addition to fieldwork and other household duties despite the lack of electric tools was simply accepted as a norm in the older generation.

Adults identified millets as a healthy food that is good for the body. Children, however, did not share the same perception of millets as adults and did not prefer millets as a staple food. This intergenerational change in taste preferences influences the types of foods consumed in the household, favouring the consumption of rice over the nutritious millet.

The findings of this study confirm the findings by Finnis et al [42] in her exploration of the reasons contributing to the transition from millet farming to cassava cultivation in Kolli Hills. In her study, Finnis [42] described the social and physical environment of the Malayalis leading to local dietary changes. Similar to the experiences and perceptions described by participants in our study, participants in her study described unpredictable and disappointing rainfall patterns leading to the change in crop cultivation [8]. Specifically, millets depend heavily on May-June rains, which have become increasingly erratic. On the contrary, cassava is planted later in the year, prior to the October-December season when rainfall has remained relatively consistent. Furthermore, the cultivation of cassava offers a relatively lighter workload in comparison to millet farming. As farmers grow increasingly accustomed to lighter workloads, the cassava growing culture continues.

Our finding of increased aspiration towards wealth generation is also consistent with the description of the social environment in Kolli Hills described in the study by Finnis [42]. Households perceived cassava to offer economic opportunities to allow the purchase of market goods such as jewelry, electricity, electronic goods and support

educational expenses for their children towards an overall more 'developed' life [8]. The study also alluded to the time requirements and arduous labour associated with manually removing the outer husks of millets. Rice obtained from the PDS, in comparison, is purchased pre-processed [8].

Although similar themes emerged from our study as the study by Finnis [42], our study also showed the intergenerational changes in expectations related to food preparation and the changes in food preferences across generations. These factors on the microsystem level are also important factors leading to changes in dietary patterns and dietary variety.

Kitchen gardens were valued overall as important assets for each household as well as for the community. All participants reported improvements in access to and consumption of a variety of vegetables between the months of November and March. In addition to the improvements in food accessibility as a result of this initiative, kitchen gardens encourage the enactment of traditional values such as sharing in the community. These benefits of kitchen gardens have been documented in many studies. A recent review study by Galhena, Freed, and Maredia [53] of home/kitchen gardens from various countries suggest that home gardens have important contributions to household food security by increasing availability, accessibility and utilization of food products [9]. Home/kitchen gardens have the potential to supplement staple-based diets with additional protein, vitamins and minerals, contributing to a balanced diet [9]. A study by Talukder et al [133] on a Bangladesh homestead gardening program suggests that through homestead gardening, households increase access to a diversity of plant

and animal food items which lead to an overall increase in dietary intake and boost the bioavailability and absorption of essential nutrients [24].

Home/kitchen gardens have also been documented for their contributions in building integrated societies [9]. Interactions in and around home gardens are important in creating and reinforcing social ties between the household and the community [9]. Participating households often exchange crops from gardens for social, cultural, or religious purposes, thus building social capital [25].

Furthermore, the kitchen garden initiative may have contributed towards changing gender roles in household level food choices. Although all participants report that all members of a household take part in the management of kitchen gardens, women and often children were mostly responsible for daily activities in the gardens. Men were often responsible for purchasing foods from the markets for the family. Individual interviews with women suggested that men were not always aware of the types of foods that the household needs. As women were predominantly responsible for the management of kitchen gardens, the kitchen garden initiative allows them to exert greater control over the types of foods consumed in the household.

Kitchen gardens have been suggested in the literature to play an important role in women's empowerment. In many cultures, women's contribution in home gardens is immense. A study by Aguilar et al [135] of women in the Andes suggested that plentiful home gardens assisted in elevating women's status by demonstrating her productivity and commitment to a family's well-being [26]. Other studies have suggested that for situations where women are the main decision makers regarding gardening practices and use of income earned by selling garden produce, there have been improvement in

household level nutrition [24] and especially the nutritional status of children as the income generated was for food for the family [24]. However, further research is required to explore the role of kitchen garden interventions in increasing women's autonomy and control over foods consumed in the household and the potential implications of this.

In regards to the sustainability of a kitchen garden intervention in the community, women reported increased confidence in the management of a kitchen garden and the desire to continue such practices beyond the support of MSSRF. The involvement of children in kitchen garden activities suggests an intergenerational transfer in knowledge and skills related to gardening practices, contributing to the sustainability of such practices in the community. A lack of irrigation was identified by all participants as the main challenge for crops to grow year round. Tap water is only supplied to households on limited days of the week. Most families rely heavily on well water for irrigating kitchen gardens. Hand watering increases labour demands to manage kitchen gardens. To improve and sustain kitchen gardens in the community, irrigation challenges must be addressed.

Strengths of this study is its inclusion of a wide range of perspectives from men and women of different age groups on changing dietary variety as well as the value of kitchen garden intervention in the community. The method of long term retrospective data gathering where participants are asked to recall information from several decades ago has been utilized in surveys such as the Malaysian Family Life Surveys [27]. To improve the accuracy of retrospective data, participants were asked to identify important holidays or other events in their life history if they were unable to give the

exact date of an event [27]. A similar strategy to reduce the possibility of recall error was utilized in our study, as participants were asked to identify an occurrence or event in the village which marked the time point at which there was a change in dietary patterns.

It is important to note that this study provided only a qualitative examination of food intake from the perspective of men and women of different age groups; data on quantity of foods consumed was assessed in another study for the APM project but this data is not available at this time. This makes the estimation of nutrient intake and adequacy impossible. However, the findings of our study may be used for triangulation purposes with quantitative studies to examine dietary intake in this population.

3.6 Conclusion

There has been a decrease in dietary variety for the people of Kolli Hills from 25-30 years ago to present day. Factors related to this decrease in dietary variety are complex and multilayered, from changes in preferences related to food preparation and consumption to changes in reliance on various food systems and societal values related to wealth generation. Findings of this present study suggest that a wide range of strategies on various levels may be employed to improve dietary variety in this population, from individual level education involving adults and children on the benefits of millet consumption to national and state level policies to improve the market demand for millets. To improve access to and consumption of a variety of vegetables, kitchen garden interventions may be considered in communities experiencing similar food security challenges. In areas with comparable climate conditions, addressing irrigation challenges would be essential to improve produce growth year round. Overall,

the findings of this study are important in informing future practice. Understanding the changes in dietary patterns from the perspective of community members will serve to inform future interventions to improve dietary diversity while taking into consideration the voices, knowledge, and priorities of community members. Furthermore, in depth understanding of the perceptions of the kitchen garden initiative lends insight into the feasibility and sustainability of such interventions in the community.

The findings of this study also invite future exploration of the potential effect of kitchen gardens on gender roles related to food provisioning in certain cultures. Further research is required to explore the role of kitchen garden interventions in increasing women's autonomy and control over foods consumed in the household and the potential implications.

References

[1] UNICEF, "State of the world's chidlren," UNICEF, New York, 2009.

[2] Ministry of Health and Family Welfare Government of India, "National Family Health Survey (NFHS-3)," International Institute for Population Sciences, Mumbai, 2005-2006.

[3] Ministry of Tribal Affairs, "Scheduled Tribes," 23 January 2014. [Online]. Available: http://www.tribal.nic.in/Content/DefinitionpRrofiles.aspx. [Accessed 26 January 2014].

[4] M. Gragnolati, M. Shekar and M. Das Gupta, "India undernourished children: A call for reform and action," The World Bank, 2005.

[5] The National Survey Sample Organization, "Nutritional intake in India 2004-2005 Report No. 513," Ministry of , New Delhi, 2007.

[6] M.S.Swaminathan Research Foundation; University of Alberta, "Alleviating poverty and malnutrition in agrobiodiversity hotspots: a baseline report," 2013.

[7] V. Anburaja and V. Nangdagopalan, "Agricultural activities of the Malayali Tribal for subsistence and economic needs in the mid elevation forest of the Pachamalai Hills of Eastern Ghats, Tamil Nadu," *International Journal of Agricultural Research, Innovational, and Technology,* vol. 2, no. 1, pp. 32-36, 2012.

[8] E. Finnis, "The political ecology of dietary transitions: Changing production and consumption patterns in the Kolli Hills, India," *Agriculture and Human Values,* vol. 24, no. 3, pp. 343-353, 2007.

[9] D. Galhena, R. Freed and K. Maredia, "Home gardens: A promising approach to enhance household food security and well-being," *Agriculture and Food Security,* 2013.

[10] A. Girald, J. Self, C. McAuliffe and O. Olude, "The effects of household food production strategies on the health and nutrition outcomes," *Pediatric and Perinatal Epidemiology,* vol. 26, pp. 205-222, 2013.

[11] R. Madden, Being Ethnographic, India: SAGE, 2010.

[12] C. Streb, "Exploratory case study," in *Encyclopedia of Case Study Research* , Thousand Oaks , Sage Publications , 2010, pp. 373-375.

[13] F. Santos and K. Eisenhardt, "Multiple Case Study," in *The Sage Encyclopedia of Social Science Research Methods*, Sage Publications , 2004, pp. 685-686.

[14] M. Patton, Qualitative Research and Evaluation Methods - 3, Thousand Oaks, California: SAGE Publications, 2010.

[15] U. Bronfenbrenner, "Ecological Models of Human Development," in *International Encyclopedia of Education* , Oxford: Elsevier, 1994, pp. Vol 3, 2nd ed.

[16] S. Reeves, A. Kuper and B. Hodges, "Qualitative research methodologies: ethnography," *BMJ,* vol. 337, pp. 512-514, 2008.

[17] World Health Organization, "Food Security," 2013. [Online]. Available: http://www.who.int/trade/glossary/story028/en/. [Accessed 3 August 2013].

[18] L. Krefting, "Rigor in qualitative research: the assessment of trustworthiness," *The American Journal of Occupational Therapy,* vol. 45, no. 3, pp. 214-222, 1991.

[19] K. Regmi, J. Naidoo and P. Pilkington, "Understanding the processes of translation and transliteration in qualitative research," *International Journal of Qualitative Methods,* vol. 9, no. 1, pp. 16-26, 2010.

[20] The Planning Commission of India , "Press Notes on Poverty Estimates, 2011-12," The Government of India , New Delhi, 2013.

[21] C. Gopalan, B. Rama Sastri and S. Balasubramanian, Nutritive Value of Indian Foods, Hyderabad: National Institute of Nutrition, 1971.

[22] N. Kaicker, V. Kulkarni and R. Gaiha, "Dietary transition in India: An analysis based on NSS data for 1993 and 2004," 2010. [Online]. Available: http://econpapers.repec.org/paper/pasasarcc/. [Accessed 2 November 2013].

[23] National Nutrition Monitoring Bureau of India, "Diet and nutritional status of rural population. Technical report No. 21," National Institute of Nutrition, Hyderabad, 2002.

[24] A. Talukder, L. Kiess, N. Huq, S. de Pee, I. Darnton-Hill and M. Bloem, "Increasing the production and consumption of vitamin A rich vegetables: lessons learned in

taking the Bangladesh homestead gardening programme to a national level," *Food and Nutrition Bulletin,* vol. 21, no. 2, pp. 165-172, 2000.

[25] I. Blanckaert, R. Swenne, M. Paredes Flores, R. Rosas López and S. Lira, "Floristic composition plant uses and management practices in home gardens of San Rafael Coxcatlán. Valle de Tehuacán-Cuicatlán, México," *Journal of Arid Environments,* vol. 57, pp. 39-62, 2004.

[26] M. Aguilar-Stoen, S. Moe and S. Camargo-Ricald, "Home gardens sustain crop diversity and improve farm resilience in Candelaria Loxicha, Oaxaca,," *Human Ecology,* vol. 37, pp. 55-77, 2009.

[27] M. Beckett, J. Da Vanzo, N. Sastry, C. Panis and C. Peterson, "The quality of retrospective data: An examination of long-term recall in a developing country," *The Journal of Human Resources,* 2002.

Chapter 4: Discussion and Conclusion

4.1 Summary and importance of studies

The thesis consisted of two parts. The first part of the thesis focused on a narrative review of dietary diversity tools, building on a previous review published in 2003 [1]. Specific objectives of this study were:

1) To provide an overview of dietary diversity with emphasis on the parameters used to operationalize the tools.
2) To provide a qualitative overview of the association between dietary diversity and various health outcomes, including anthropometric, biochemical and other health-related indices.
3) To critically examine the appropriateness of various dietary diversity methods for assessment in developing nations

This narrative review was important in building upon the review that was published in 2003 [1]. The review suggested that individual dietary scores may be a good reflection of micronutrient adequacy. At the household level, DDS may be useful for determining household economic ability to acquire food. Since its publication, the concept of dietary diversity and its potential as a proxy indicator for nutrient adequacy and household economic ability have received much public attention. Since 2003, a number of studies have been published on this topic. The Food and Agriculture Organization (FAO) recently updated a set of guidelines for assessing individual and household level dietary diversity [2] that may be adapted to a local context prior to use. Thus, a more recent review was

important to provide an overview of the state of current knowledge on dietary diversity tools.

Dietary diversity indices including Food Variety Score (FVS) and Dietary Diversity Score (DDS) may serve as useful proxies in determining micronutrient adequacy as well as nutritional status of populations in developing countries where there are limited resources for collecting extensive dietary data. There is currently no international consensus on food group aggregation for different age/sex groups as well as other parameters including an optimal reference period and minimum portion size considerations. This narrative review has provided considerations for these parameters of dietary diversity indices.

The second part of the thesis was a qualitative study conducted under the umbrella of the collaborative project between M.S. Swaminathan Research Foundation (MSSRF) and the University of Alberta to ameliorate food and nutritional security in three rural sites in India [3]. This smaller research study focused on a tribal community in Kolli Hills in the Southern tip of India. The objectives of this smaller research study were:

1) To explore factors affecting changes in dietary variety in Kolli Hills from the perspective of men and women of different age groups.
2) To explore the perceived value of the kitchen garden initiative, with an emphasis on improving the consumption of a variety of vegetables.

Understanding the changes in dietary patterns from the perspective of community members will serve to inform future interventions to improve dietary diversity while taking into consideration their voices, knowledge, and priorities. Furthermore, an in-depth understanding of the perceptions of the kitchen garden initiative will lend insight

into the feasibility and sustainability of such community-based interventions. Also, an understanding of the community's perceived challenges related to kitchen gardens serves to improve this community-based initiative. Lessons learned from this community may also apply to other communities in the world experiencing similar food security challenges.

4.2 Main findings of thesis

4.2.1 Narrative review of dietary diversity tools

This narrative review of dietary diversity tools suggested that most of the dietary diversity indices used to assess nutrient adequacy at the individual level entailed the use of dietary diversity scores (DDS) or food variety scores (FVS), and a totaling of food groups and food items consumed over a period of time, respectively. Although both DDS and FVS were found in the literature to be positively correlated with nutrient adequacy, the DDS was suggested to have a stronger association with nutrient adequacy [4]. Indeed, it seems intuitive that increasing the number of food groups consumed would enhance the diversity of the diet's micronutrient content. The parameters of the DDS include: the different food group aggregation, the reference period used, and the portion size considerations of the foods used calculating the DDS. In regards to the method of food group aggregation, there are currently no universal guidelines on the optimal number of food groupings. However, a recent study by Arimond et al (2010) suggested that the 9-food group indicator performed the best in predicting nutrient adequacy when compared with the 6, 13, and 21 food group aggregations which were based on nutrient content; although all of the indicators were associated with nutrient

adequacy. In more disaggregated food groupings, food groups rich in specific nutrients are further separated into subgroups. For instance, vitamin A rich fruits and vegetable are separated from other fruits and vegetables [2].

The 9-food group indicator included starchy staples, dark green leafy vegetables, vitamin A rich fruits and vegetables, other fruits and vegetables, organ meat, meat and fish, eggs, legumes and nuts and seeds, and milk and milk products. The 9-food group aggregation was the one adopted for use in the FAO guidelines [2].

For simplicity, most of the studies used a recall period of one-day; however, there is continued dispute over the optimal recall period to collect information on dietary diversity. There is no study in the developing nations that has compared the validity of one-day or multiple-day dietary recalls in predicting nutrient adequacy. However, a study by Savy et al. [102] has suggested that since diets in developing nations are low in diversity, a DDS calculated from one-day is sufficient to capture dietary diversity. For simplicity, the FAO guidelines recommend using a 24-hour recall period for reducing the potential effects of recall error [2].

In regards to portion size considerations, a study by Arimond et al [17] suggested that a consumption of 15 grams as a minimum appeared to improve the association between dietary diversity scores and micronutrient adequacy for women aged 15-49 years. This is reasonable as the smallest quantity of a food item consumed may not be sufficient to contribute a significant amount of certain micronutrients [1]. An understanding of the dietary patterns of specific populations of interests will help to determine the usual portion size of certain foods and whether setting a minimum consumption amount will influence the assessment of micronutrient adequacy. Validation studies have

consistently shown a positive association between dietary diversity and nutrient adequacy despite the lack of uniformity in the methods and indices used to measure dietary diversity. It must be noted that some studies have suggested a weakening of the correlation between dietary diversity scores and mean adequacy of nutrients after controlling for energy intake [5] [6]. As improved energy intake significantly correlates with mean nutrient adequacy of many essential nutrients, intervention programs that focus on improving food security, and subsequently energy intake of participants may naturally lead to improved micronutrient intake of participants [1].

Furthermore, studies have consistently shown an association between dietary diversity and various indicators of nutritional status. There is, however, some discrepancy in the literature regarding the association between dietary diversity and anthropometric measurements. Some studies have suggested that with increasing dietary diversity, the risk of overweight and obesity decreased [7] while other studies have contradictory results, in that, increasing dietary diversity was associated with a higher risk of being overweight and obesity [8]. Dietary patterns may vary significantly across cultures and population groups; thus, it is impossible to generalize regarding the implications of increasing dietary diversity on nutritional status in all populations.

One study suggested there was an association between dietary diversity, and specifically, serum retinol concentration [9]. This study suggested that interventions to promote a diverse diet may improve serum vitamin A status independent of vitamin A intake, and it also suggested that DDS may serve as an appropriate proxy indicator for micronutrient status.

Lastly, household level dietary diversity may be used as an indicator for household economic ability [10]. More recent studies have also suggested a similar relationship between dietary diversity and perceived food security status [11]. The FAO Guidelines for assessing dietary diversity suggested that Household Dietary Diversity Scores reflects the economic ability of a household to access a variety of foods [2]. Overall, in conclusion, in developing nations where often there are constraints to collecting large scale dietary information for the assessment of nutritional adequacy and status. Evidence suggested that individual dietary scores may be a good reflection of micronutrient adequacy. On the household level, DDS may be useful for determining household economic ability to acquire food.

4.2.2 Qualitative exploration of the food situation in Kolli Hills

The ethnographic study conducted as part of this thesis project suggested that there was an overall decrease in dietary variety in the diet of the people of Kolli Hills from 25-30 years ago to present day. The variety of foods consumed in the food groups: grain products, fruits and vegetables, and meat products have decreased from 25-30 years ago to present day. It is difficult to conclude if the caloric intake of the people of Kolli Hills has increased or decreased. It is possible that the caloric intake has remained constant despite the decreases in dietary variety. The perceived reduction in both dietary variety and access to a wider range of foods from the food groups may have potential negative implications for nutrient adequacy that may include decreased intake of calcium, protein, iron, vitamin C, vitamin A, and protein in this population.

Many factors were identified in this study as being potentially influential on decreasing dietary variety. Such factors affecting changes in dietary variety were identified to be: 1) societal value related to wealth generation; 2) reliance on the market system; 3) environmental factors; 4) changes in taste preferences of children and 5) drudgery related to farming and food preparation.

The community members of Kolli Hills have shifted their values from a position of subsistence farming to one of wealth generation. Increased aspirations for cash generation demonstrated a desire for higher quality of living associated with the attainment of higher education, adequate medical care, and possession of material goods. This has led to the choice of cultivating a cash crop, cassava, as a means of generating income instead of practicing traditional subsistence farming. Increased reliance on market systems to obtain food coupled with limited financial resources has reduced the community's access to a variety of foods.

Over the years, Kolli Hills has experienced some environmental changes. Such climate changes has led to increasingly unpredictable rainfall patterns challenging the cultivation of millet and vegetables, in favour of utilizing available agricultural land to grow cassava, a relatively drought resistant crop. Also, the lighter workload associated with cassava cultivation has also allowed men to migrate to other communities to take up additional labourer work to increase their household income level. Other changes in land policies related to access to forest land for hunting have also made it more difficult for men in the community to engage in community hunts. Community hunts served as way to increase access to a source of good quality protein and to supplement the diet in way that otherwise would be unaffordable or unavailable.

The taste preferences of children were important in influencing the dietary choices at the household level. The adults in Kolli Hills identified millets as a healthy food that is good for the body whereas the children did not share this perception of millets and did not prefer millets as a staple food. This evolution of intergenerational changes in taste preferences has influenced the types of foods consumed in the household leading the community to favor the consumption of rice over the nutritious millet.

Lastly, women have the burden of dual roles, that is, they work long hours both in the field and in the home leaving them with less time to prepare foods, including millet. Millet is a grain that is higher in protein than rice which makes it a superior choice over rice, but it requires more preparation than rice. The drudgery associated with preparing millet makes its consumption an even less favorable choice in comparison to rice that is purchased at subsidized prices through the PDS. As well, there appears to be an intergenerational difference in expectations related to the amount of work required for food preparation. The younger generation appeared to be less inclined to engage in laborious food related activities. The extensive work required for hand pounding of millet, in addition to fieldwork and other household duties, despite the lack of electric tools, was simply accepted as a norm by the older generation.

Kitchen gardens were valued overall as important assets for each household as well as for the community. All participants reported improvements in access to and consumption of a variety of vegetables between the months of November and March. In addition to the improvements in food accessibility as a result of this initiative, kitchen gardens encouraged the enactment of traditional values such as sharing food in the community.

Furthermore, the kitchen garden initiative may have contributed towards changing gender roles in household level food choices. Although all participants reported that all members of a household take part in the management of kitchen gardens, women, and often, children were mostly responsible for daily activities in the gardens. Men were often responsible for purchasing foods for the family from the markets. Individual interviews with women suggested that men were not always aware of the types of foods that the household needs. As women were predominantly responsible for the management of kitchen gardens, the kitchen garden initiative allowed them to exert greater control over the types of foods consumed in the household. Increased autonomy and independence in food procurement decisions may be important in fostering women's empowerment.

There were many challenges to maintaining and sustaining the kitchen garden intervention in the community. In regards to the sustainability of kitchen garden intervention women reported having increased confidence in the management of the kitchen garden and the desire to continue such practices beyond the support of MSSRF. The involvement of children in kitchen garden activities suggested there was an intergenerational transfer in knowledge and skills related to gardening practices that contributed to the sustainability of such practices in the community. A lack of irrigation was identified by all participants as the main challenge for growing crops year round. Tap water is only supplied to households on limited days of the week. Most families relied heavily on well water for irrigating kitchen gardens. Hand watering increased the labour demands for managing the kitchen gardens. Addressing the future irrigation challenges is imperative for improving and sustaining kitchen gardens in the community.

4.3 Strengths and limitations of studies

4.3.1 Narrative review of dietary diversity tools

The narrative review of the dietary diversity tools provided an update of the current state of knowledge around parameters used in dietary diversity tools and the association of dietary diversity tools with various health outcomes. One of the strengths of this review was the utilization of a systematic method for searching the literature to identify both peer-reviewed as well as grey literature to allow for a comprehensive overview of the topic.

The nature of a narrative systematic review is the inclusion of studies with diverse methodologies [12]. This allows for comprehensive understandings of certain topic areas. As an example, methods to validate various dietary diversity indicators against nutrient adequacy vary in the literature. In validating DDS with nutrient adequacy, some studies have utilized the nutrient adequacy ratio (NAR) [13] while others have used the probability of adequacy method (PA) [14]. The NAR method involves comparing participants' intake of various nutrients with their recommended dietary allowance (RDA). The PA method is more commonly used in recent studies [14]. The probability that a given nutrient intake is adequate for an individual can be calculated if the requirement distribution is known. If the distribution can be assumed to be approximately normal, then it may be defined by the estimated average requirement (EAR) and its standard deviation. The probability of subjects' consuming adequate amounts of a nutrient may be determined. The inclusion of studies with different

methods to evaluate the association of DDS with nutrient adequacy allowed for a more comprehensive understanding of the state of knowledge in this area.

A limitation of this type of review is its inability to disentangle and understand the reasons for inconsistencies that may exist between some of the factors. As an example, there was inconsistent evidence regarding the association of dietary diversity with anthropometric measurements. In the adult population, some studies have suggested that probability of obesity and abdominal obesity decreased with increasing DDS [7] while others have suggested as dietary diversity scores increased, the BMI, waist circumference as well as the probability of overweight also increased [8]. This review has revealed inconsistencies in the relationship between dietary diversity and anthropometric measurements in different populations. However, it was difficult to generate any conclusions about the potential reasons for this inconsistency. Overall, both the heterogeneity in the study designs and the reporting methods of each study has made it difficult to make comparisons between studies in this review.

4.3.2 Qualitative exploration of food situation in Kolli Hills

An ethnographic approach was suitable to explore the research questions as it entailed the immersion of the ethnographer in local culture to provide rich descriptions of the food situation of Kolli Hills and of the kitchen garden intervention from the perspective of participants. The immersion of the ethnographer in the local culture resulted in the sharing of very personal perspectives from local women on their perceived benefits of the kitchen garden intervention in their area. The results of the study also confirmed the findings of an earlier ethnographic study that examined the changing food production and consumption patterns of millets in Kolli Hills [15].

One strength of this study was the inclusion of a wide range of perspectives from men and women of different age groups. When possible, male and female participants were recruited from the same household to allow for better comparison of perspectives. This ethnographic study took place over the period of one year with the inclusion of two field visits. Qualitative research has a flexible nature with an iterative approach [16]. The research design is often flexible and the data gathering procedures are adjusted based on new insights gathered from incoming data [16]. Lessons learned from the first field visit to Kolli Hills on focus groups discussions improved the data gathering methods used in the second field visit. Naturally, themes which emerged from the two focus groups conducted during the first field visit were also used to develop the interview protocol for the second field visit.

The changes that were made to the way data were collected in the first field visit compared to second enhanced the quality of the data. During the first field visit, only the ethnographer and field researcher were involved in conducting focus groups. The field researcher was primarily responsible for facilitating the focus group discussions. During the discussions, the facilitator attempted to translate into English the main themes which emerged as they occurred for the ethnographer's benefit. Although the ethnographer was able to broadly understand the main ideas emerging from the discussions, she was not able to effectively instruct the facilitator to lead discussions in way allowing for a more in-depth understanding of various ideas. During the second field visit, focus groups were conducted with the involvement of a translator in addition to the facilitator and the ethnographer. During these focus the group discussions, a dedicated translator translated directly to the ethnographer the main discussion themes into English, allowing the ethnographer to instruct the facilitator to probe for more

information on a particular point or clarify any points raised. As the translator was employed only for this research study and was not involved with MSSRF initiatives, keeping an arm's length to the project added neutrality and provided some objectivity in translating the meaning of what was discussed during focus group discussions.

Expansion of the themes addressed in the interview protocol used in the second round of focus groups and interviews improved data collection. The semi-structured interview protocols used in the first field visit were rather simplistic, with only a few questions asking about past food items consumed (25-30 years ago) and current food habits. For each food item that participants had indicated that they consumed in the past but no longer consumed currently, the facilitator probed for the reasons for this change. The themes which emerged from the first focus groups conducted during the first field visit contributed towards the development of a more comprehensive semi-structured interview questionnaire which guided participants to elaborate on various dimensions of food security and various factors that they have perceived to result in changes in dietary variety.

A limitation of this ethnographic study may be the exclusive reliance on retrospective data recall where participants were asked to recall dietary habits from several decades ago. Recall errors may be associated with this method [17]. Strategies were employed in the present study to improve the accuracy of the reported time frame which marked changes in dietary variety. Participants were asked to identify an occurrence or event in the village which marked the time point at which there was a change in dietary patterns. In this study, participants identified the construction of a new road or the increase in Fair Price Shops in the village as events which coincided with a decrease in dietary

variety. Documents in the village confirmed the approximate time of these events to be 25-30 years ago. This allowed us to confirm the accuracy of the reported time frame of dietary change by participants. Similar strategies have been used in the retrospective surveys to improve the accuracy of time frames reported by participants [17]. For instance, interviewers may cross reference events in a participant's life to more accurately gather information of a particular occurrence of interest during a survey [17].

It was not within the scope of this study to assess the nutrient adequacy of the population. This study provided a qualitative examination of food intake; we did not assess the quantity of usual portions of foods as well as frequency of consumption of each food item either in the past 5-30 years or today. This made it difficult to generate conclusions on the nutrient adequacy of the diet. However, the findings of our study may be used for triangulation purposes with future quantitative studies that examine dietary intake in this population.

The National Sample Survey Organization under the Government of India has collected food consumption behaviour of Indians at the national level. Between 1993 and 2009, households in both urban and rural areas increased their intake of milk products, meat products, and fruits and vegetables [18]. These national level data are important in examining national trends in food consumption and dietary diversity. However, given the cultural diversity in India, it is also of importance to examine the dietary intake of various geographic locales and assess the dietary diversity of specific populations.

4.4 Implications for policy and/or future research

4.4.2 Narrative review of dietary diversity tools

This literature review provided a critical analysis of current literature on dietary diversity indices and considerations for the use of different indices for populations in developing nations. This literature review suggested that current individual level dietary diversity indices documented in the literature were useful proxy indicators for nutritional adequacy and status and household level dietary indices were useful for determining the household economic ability to acquire food. The FAO guidelines on assessing individual and household level dietary diversity also provided practical recommendations on adapting indices to local culture and dietary patterns prior to use in the field [2].

Although this literature review showed that higher DDS were associated with improved nutrient adequacy for different populations, more research is needed in the area of using and interpreting DDS. DDS were calculated by summing the number of food groups consumed by the household or by the individual respondent over the specified recall period [2]. There are, however, no established cut-off scores in terms of the number of food groups to indicate adequate or inadequate dietary diversity for the FAO Guidelines [2]. For programmatic purposes, i.e., to evaluate the change in dietary diversity before or after an intervention, the mean DDS of the population of interest may be compared before and after the intervention [2]. The FAO guidelines recommend taking into consideration the distribution of scores to set program goals [2].

International consensus on optimal cut-off scores for different populations were difficult to define and may be highly context specific to the dietary patterns of local population and the dietary needs of different demographic groups. Different cut-off scores have been suggested to indicate nutrient adequacy for different populations [19]. Due to the

different methods used in assessing dietary diversity and the different populations of interest, it is difficult to generalize cut-off DDS for nutrient adequacy. Future research may consider using the FAO guidelines to calculate DDS and to determine cut-off scores for nutrient adequacy for different populations. These cut-off scores may serve as references for other studies that focus on the same or similar demographic groups.

4.4.3 Qualitative exploration of food situation in Kolli Hills

Findings of this present study suggested that a wide range of strategies at various levels may be employed to improve dietary variety in this population, from individual level education involving adults and children on the benefits of millet consumption to national and state level policies to improve the market demand for millets. To improve and access to and consumption of a variety of vegetables, kitchen garden interventions may be considered in communities experiencing similar food security challenges. In areas with comparable climate conditions, addressing irrigation challenges would be essential to improve produce growth year round.

Further research is required to explore the role of kitchen garden interventions in increasing women's autonomy and control over foods consumed in the household and the potential implications. The kitchen garden initiative may have contributed towards changing gender roles in household level food choices. Although all participants reported that all members of a household take part in the management of kitchen gardens, women and often children were mostly responsible for daily activities in the gardens. Men were often responsible for purchasing foods from the markets for the family. Individual interviews with women suggested that men were not always aware of the types of foods that the household needs. As women were predominantly

responsible for the management of kitchen gardens, the kitchen garden initiative allowed them to exert greater control over the types of foods consumed in the household. Increased autonomy and independence in food procurement decisions may be important in fostering women's empowerment.

Lastly, studies to gather quantitative information on the current dietary intake patterns of this population will be important to collect. It is a method of cross-validation when quantitative and qualitative studies yield comparative results [16]. The qualitative information on perceptions of dietary variety may be triangulated with quantitative data of dietary intake as a means of validating the data collected. Dietary information obtained from a one day 24-hr recall, for instance, will provide information on group mean intakes of certain nutrients, and food frequency questionnaires may help to provide insight into the habitual intake of this population [20]. This information may be compared with the food items reported to be consumed today as obtained through our study to better understand the variety in the diet of the Malaiyali people.

References

[1] M. Ruel, "Operationalizing dietary diversity: a review of measurement issues and research priorities," *The Journal of Nutrition,* pp. 3911S-3925S, 2003.

[2] Kennedy, G; Ballard, T; Dop, M, "Guidelines for measuring individual and household dietary diversity," Food and Agriculture Organization of the United Nations, Rome, 2011.

[3] M.S.Swaminathan Research Foundation; University of Alberta, "Alleviating poverty and malnutrition in agrobiodiversity hotspots: a baseline report," 2013.

[4] L. Torheim, I. Barikmo, C. Parr, A. Hatloy, F. Ouattara and A. Oshaug, "Validation of food variety as an indicator of diet quality assessed with a food frequency questionnaire for Western Mali," *European Journal of Clinical Nutrition,* vol. 57, pp.

1287-1291, 2003.

[5] M. Arimond, D. Wiesman, E. Becquey, A. Carriquiry, M. Daniels, N. Fanou-Fogny, M. Joseph, G. Kennedy, Y. Martin-Prevel and L. Torheim, "Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings," *American Society for Nutrition,* vol. 140, no. 11, pp. 2059S-20695, 2010.

[6] P. Mirmiram, L. Azadbakht and F. Azizi, "Dietary diversity within food groups: an indicator of specific nutrient adequacy in Tehranian women," *Journal of the American College of Nutrition ,* pp. 354-361, 2006.

[7] L. Azadbakht and A. Esmaillzadeh, "Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth," *Public Health Nutrition,* pp. 62-69, 2010.

[8] R. Jayawardena, N. Byrne, M. Soares, P. Katulanda, B. Yadav and A. Hills, "High dietary diversity is associated with obesity in Sri Lankan adults: an evaluaion of three dietary scores," *Biomed Central Public Health,* vol. 13, p. 314, 2013.

[9] M. Fujita, Y. Lo and J. Baranski, "Dietary diversity score is a useful indicator of vitamin A status of adult women in Northern Kenya," *American Journal of Human Biology,* vol. 24, pp. 829-834, 2012.

[10] J. Hoddinott and Y. Yohannes, "Dietary diversity as a food security indicator," FANTA, Washington DC, 2002.

[11] A. Ihab, A. Rohana, W. Wan Manan, W. Wan Suriati, M. Zalilah and A. Rusli, "Food expenditure and diet diversity score are predictors of household food insecurity among low income households in rural district of Kelantan Malaysia," *Pakistan Journal of Nutrition,* vol. 11, no. 10, pp. 967-973, 2012.

[12] R. Baumeister and M. Leary, "Writing narrative literature reviews," *Review of General Psychology,* vol. 1, no. 3, pp. 311-320, 1997.

[13] K. Rathnayake, P. Madushani and K. Silva, "Use of dietary diversity score as a proxy indicator of nutrient adequacy of rural elderly people in Sri Lanka," *Biomed Central Notes,* vol. 5, p. 469, 2012.

[14] J. Foote, S. Murphy, L. Wilkens, P. Basiotis and A. Carlson, "Dietary variety increases the probability of nutrient adequacy among adults," *Journal of Nutrition,* vol. 134, pp. 1779-1785, 2004.

[15] E. Finnis, "The political ecology of dietary transitions: Changing production and consumption patterns in the Kolli Hills, India," *Agriculture and Human Values,* vol. 24, no. 3, pp. 343-353, 2007.

[16] B. Dicicco-Bloom and B. Crabtree, "Making sense of qualitative research: the qualitative research interview," *Medical Education,* pp. 314-321, 2006.

[17] M. Beckett, J. Da Vanzo, N. Sastry, C. Panis and C. Peterson, "The quality of retrospective data: An examination of long-term recall in a developing country," *The Journal of Human Resources,* 2002.

[18] R. Gaiha, N. Kaicker, K. Imai, V. Kulkarni and G. Thapa, "Has dietary transition slowed down in India: An analysis based on 50th, 61st and 66th rounds of NSS," ASARC, 2012.

[19] V. Rani, D. Arends and I. Brouwer, "Dietary diversity as an indicator of micronutrient adequacy of the diet of five to eight year old Indian rural children," *Nutrition and Food Science,* vol. 40, no. 5, pp. 466-476, 2010.

[20] Medical Research Council, "Dietary Assessment - Food Frequency Questionnaire," [Online]. Available: www.dapa-toolkit.mrc.ac.uk/dietary-assessment/methods/food-frequency-questionnaire. [Accessed 2 Oct 2013].

Appendices

Appendix 1

Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present
1. ((diet* or food) adj4 (diverse or diversity or diversification or variety)).mp.
2. (questionnaire* or instrument or scale or survey or score or scores or index or recall or recalls or diary or diaries or "24 hour" or 24-h or tool or direct observation* or dietary record).mp.
3. exp Questionnaires/
4. 1 and (2 or 3)
5. limit 4 to animals
6. 4 not 5
7. exp canada/ or exp united states/ or exp japan/ or korea/ or "republic of korea"/ or exp australia/ or baltimore/ or berlin/ or boston/ or chicago/ or "district of columbia"/

or london/ or los angeles/ or moscow/ or new orleans/ or new york city/ or paris/ or philadelphia/ or rome/ or san francisco/ or tokyo/ or austria/ or belgium/ or finland/ or exp france/ or exp germany/ or exp great britain/ or exp iceland/ or exp ireland/ or exp italy/ or liechtenstein/ or luxembourg/ or monaco/ or netherlands/ or exp scandinavia/ or switzerland/
8. 6 not 7

Embase 1974 to 2013 September 05
1. ((diet* or food) adj4 (diverse or diversity or diversification or variety)).mp.
2. (questionnaire* or instrument or scale or survey or score or scores or index or recall or recalls or diary or diaries or "24 hour" or 24-h or tool or direct observation* or dietary record).mp.
3. exp questionnaire/
4. 1 and (2 or 3)
5. exp animals/ or exp invertebrate/ or animal experiment/ or animal model/ or animal tissue/ or animal cell/ or nonhuman/
6. human/ or normal human/ or human experiment/
7. (rat or rats or pig or pigs or porcine or mouse or mice or hamster or hamsters or animal or animals or bovine or sheep or murine or primate* or zebra* or drosphil*).ti.
8. 4 not ((5 or 7) not 6)
9. exp canada/ or exp united states/ or exp japan/ or korea/ or "republic of korea"/ or exp australia/ or baltimore/ or berlin/ or boston/ or chicago/ or "district of columbia"/ or london/ or los angeles/ or moscow/ or new orleans/ or new york city/ or paris/ or philadelphia/ or rome/ or san francisco/ or tokyo/ or austria/ or belgium/ or finland/ or exp france/ or exp germany/ or exp great britain/ or exp iceland/ or exp ireland/ or exp italy/ or liechtenstein/ or luxembourg/ or monaco/ or netherlands/ or exp scandinavia/ or switzerland/
10. 8 not 9

CINAHL
S1 ((diet* or food) n4 (diverse or diversity or diversification or variety))
S2 questionnaire* or instrument or scale or survey or score or scores or index or recall or recalls or diary or diaries or "24 hour" or 24-h or tool or direct observation* or dietary record
S3 (MH "Questionnaires+")
S4 S1 and (S2 or S3)
S5 (MH "Canada+") OR (MH "United States+") OR (MH "Europe+") OR (MH "Austria") OR (MH "Belgium") OR (MH "France") OR (MH "Germany+") OR (MH "United Kingdom+") OR (MH "Iceland") OR (MH "Ireland") OR (MH "Italy") OR (MH "Liechtenstein") OR (MH "Luxembourg") OR (MH "Netherlands") OR (MH "Scandinavia+") OR (MH "Switzerland") OR (MH "Spain") OR (MH "Japan") OR (MH "South Korea") OR (MH "Australia+")
S6 S4 NOT S5

Web of science-

TS=("dietary diversity" OR "food variety") AND TS=(questionnaire* or instrument or scale or survey or score or scores or index or recall or recalls or diary or diaries or "24 hour" or 24-h or tool or direct observation* or dietary record)

Global health (1973 - Present)
1. ((diet* or food) adj4 (diverse or diversity or diversification or variety)).mp.
2. (questionnaire* or instrument or scale or survey or score or scores or index or recall or recalls or diary or diaries or "24 hour" or 24-h or tool or direct observation* or dietary record).mp.
3. questionnaires/
4. 1 and (2 or 3)
5. (rat or rats or pig or pigs or porcine or mouse or mice or hamster or hamsters or animal or animals or bovine or sheep or murine or primate* or zebra* or drosphil*).ti.
6. 4 not 5
7. exp developed countries/
8. 6 not 7

Appendix 2: Comparison of food group aggregation between IDDS (2008) and IDDS (2010)

IDDS (2008)	IDDS (2010)
Cereals	Starchy staples (including all cereals, white roots and tubers)
White tubers	
Vitamin A rich vegetables and tubers	Vitamin A rich fruits and vegetables
Vitamin A rich fruits	
Other vegetables	Other fruits and vegetables
Other fruits	
Dark green leafy vegetables	Dark leafy green vegetables
Organ meat (iron rich)	Organ meat
Flesh meat	Meat and fish
Fish	
Eggs	Eggs
Legumes, nuts and seeds	Legumes, nuts and seeds
Milk and milk products	Milk and milk products
Oils and fats	N/A