MASTER THESIS RESEARCH

Description of dietary patterns and food diversity in a selected sample of Maya women: a pilot field study in the Lake Atlitlán area, Guatemala

Chloë Carpi

Centre for International Health
Department of Global Public Health and Primary Care
Faculty of Medicine
University of Bergen

Main supervisor:

Cecilie Svanes

Professor, MD PhD

Department of Global Public Health and Primary care
Centre for International Health
University of Bergen

Co-supervisor:

Juan Pablo López Cervantes

PhD candidate, MD

Department of Global Public Health and Primary Care
Centre for International Health
University of Bergen

Academic year 2023

ABSTRACT

Background

Indigenous communities in Guatemala predominantly live in rural and difficult-to-reach areas. These communities have been historically discriminated, leading to a deficient social and political representation, and to poor understanding of the determinants of their health. A cross-sectional pilot study performed in 2021 among communities of indigenous Maya weavers living around the Lake Atitlán, Guatemala, collected anthropometric data that showed very high prevalence of short stature and overweight/obesity in women aged 14-77 years. Among the factors that may influence the anthropometric status of this population, diet composition and food diversity represent the most important, however, knowledge on these factors in indigenous communities is scarce.

Aim

The present study aims to describe the dietary patterns and diversity of a selected sample of Maya women who previously participated in the Lake Atitlán Respiratory Health Pilot Study, using the Minimum Dietary Diversity for Women (MDD-W), a standardized tool developed by the Food and Agriculture Organization of the United Nations (FAO).

Methods

The list-based MDD-W tool method was applied to develop a locally adapted tool assisted with pictures. This locally adapted MDD-W tool was then used in a two-weeks fieldwork during the dry season, to collect data for a pilot study of the dietary patterns and food diversity of a selected sample of Maya women living in the village of San Pablo la Laguna, close by the Lake Atitlán, Guatemala. The pilot study also collected socio-economic data and anthropometric measurements. One-hundred-and-forty-seven women who previously participated in the Lake Atitlán Respiratory Health Pilot Study, aged between 18 to 49 years and responsible for the nutrition in their household, were attempted to be invited using a community-led approach.

Results

A total of 86 participants were included in this study. Anthropometric measurements revealed that 78% of the women had an excess of weight and 84% had a waist-for-height ratio over the threshold of 0.5, known to be related to increased risk of cardio-metabolic and other diseases. Participants had a plant-based diet: 97% of the participants reported consuming grains, 90% pulses, 88% vegetables, 79% fruits and 78% dark green leafy vegetables, all during the last 24 hours. Regarding the animal-proteins intake, eggs were consumed by 94% of the participants, fish by 53%, poultry by 30%, and red meat by only 20%. The consumption of sugar-sweetened beverages was common: sweetened coffee was consumed by 85% of the participants and other sweetened beverages by 50%. Among the ten healthy food groups defined by the tool, the participants consumed on average 7.6 different groups, and close to 92% of them achieved the *minimum dietary diversity* as defined by the tool.

Conclusion

This pilot study using the list-based MDD-W tool method, locally adapted and assisted with pictures, enabled to describe the diet composition on a group level, showing a dietary pattern with mainly plant-based foods including grains, pulses, fruits and vegetables with small quantities of animal proteins except for eggs and fish. Thus, the local adaptation of the tool seemed to fit the participants' diet during the investigated dry season in terms of dietary pattern. However, the group diversity score that was calculated from the values of the MDD-W tool indicated a surprisingly high dietary diversity, which appeared to be overestimated for this population. Further studies are recommended to also assess foods quantities in order to describe and understand the dietary habits of Maya women living by the Lake Atitlán.

Keywords: Diet composition, food diversity, Lake Atitlán, Tz'utujil women, waist-for-height ratio

ACKNOWLEDGMENTS

First of all, I would like to thank and show all my gratitude to my supervisor Cecilie Svanes who always actively supported me, putting trust in me, and granting autonomy and responsibilities during these two years of work together. Thank you for this challenging master's thesis that we developed together, and which was the perfect completion of the Global Health master's programme. I am more than grateful to have had this unique opportunity to complete this study from its development to the final defence and publication, and including the fieldwork in Guatemala. I also want to thank you for your valued advice and feedback, for sharing your precious experience in the health research field, for putting trust in me and giving me the opportunity to present my work during the RHINESSA seminars. These two years taught me determination, patience, adaptation, and perseverance to never deviate from my goals. I grew up from a food-processing engineer to a global health master's researcher. You are the best supervisor I could have imagine to work with, and wish that our collaboration will continue in the next years.

I want to warmly thank my co-supervisor, Juan-Pablo Lopez Cervantes for your support at all times, for your accurate advice and suggestions for improvement throughout this study. Thank you for your kind words, for putting trust in me, for supporting my projects both professionally and personally, for understanding my worries related to the fieldwork, and for always making me feel relevant in my work. Thank you for these few days in Guatemala, where your help and supporting words before the start of the fieldwork were essential in this stressful moment. You are an amazing supervisor and I wish you all the best during your PhD, which I am sure you will manage brilliantly.

My thanks go to my fieldwork colleagues, Fernando Jerez and Rafael Duran who I shared these intense two weeks in San Pablo la Laguna, Guatemala with. Thank you for this unforgettable experience, to have shared your experience about Guatemala and Latin America that I love so much, to have enabled me to improve my Spanish, and for always making me feel safe and being there for me. I wish you all the best in your master's thesis for the coming year.

I would like to deeply say *Maltiox* (thank you in Tz'utujil) to Paulina Colum for her previous support during all the field study in her village of San Pablo la Laguna and also to all the participants, for their time, for hosting us in their houses, and for their trust. Thanks to all the children that I have met in this village who filled my heart of joy and love.

I wish to thank the Centre for Internal Health and the University of Bergen, for the quality of the lectures and the richness of this master's programme in Global Health. Thank you to all the professors and administrative staff for their precious support, and for making the world accessible to us in those two challenging years. Thank you for financially supporting your students during their master thesis and helping them to achieve the professional ambitions. Special thanks to Ana Lorena Ruano.

Finally, I would like to deeply thank my parents, my friends Carla, Selina and Venla, and my loved one, Grégoire, for all their love and support at all times, and for never stopping to believe in me. Very special thanks to my parents who always encouraged and supported me through all their love in my adventures around the world, to always make me feel confident in my choices, and to showing endless love regardless the distance. I am extremely grateful and proud to having all of you in my life. *Je vous aime tant, merci infiniment*.

SCIENTIFIC ENVIRONMENT

This master thesis is a sub-study of the Lake Atitlán Respiratory Health, first initiated by a research team from the Respiratory Health In Northern Europe, Spain and Australia (RHINESSA) research network and the Centre for International Health (CIH) in Bergen, Norway. Contact with the Institute of Nutrition of Central America and Panama (INCAP) has been established during the preparation of the thesis. The field experience will feed a larger upcoming research study, planned in 2024 in the same source population, Maya communities living by the Lake Atitlán, Guatemala.

.

CONTENT

TABLE OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

- **BMI:** Body Mass Index
- **CEGSS:** Centre for the Study of Equity and Governance in Health Systems (Guatemala)
- **DALYs:** Disability-Adjusted Life Years
- **ECRHS:** European Community Respiratory Health Survey
- **ENCOVI:** Encuestas Condiciones de Vida
- **FAO:** Food and Agriculture Organization of the United Nation
- **HFIAS:** Household Food Insecurity Access Scale for Measurement of Food Access
- **INCAP:** Institute of Nutrition of Central America and Panama
- **LMICs:** Low and Middle Income Countries
- **MDD-W:** Minimum Dietary Diversity for Women
- **NCDs:** Non-Communicable Diseases
- **PAHO:** Pan American Health Organization
- **RHINE:** Respiratory Health in Northern Europe
- **RHINESSA:** Respiratory Health In Northern Europe, Spain and Australia
- **SDGs:** Sustainable Development Goals
- **SOPs:** Standard Operating Procedure (SOP)

GLOSSARY

Basic Food Basket: The Instituto Nacional Estadisticas Guatemala (INE) defines the Basic Food Basket as a combination of 34 foods that contributes to covering the minimum energy (2 262kcal) and protein intakes, required for each member of one household (one household is defined as 4.77 persons). In January 2023, the daily cost of one basic food basket in Guatemala was 109.63Q (15.66$) [1].

BMI: A measure for indicating nutritional status in adults. It is defined as a person's weight in kilograms divided by the square of the person's height in metres (kg/m²) (WHO)

Central America: The sub-region of Americas that consists of the countries Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama (INCAP).

DALYS: Disability-Adjusted Life Years. One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent cases of the disease or health condition in a population (WHO).

Dietary patterns: Quantity, variety, or combination of different foods and beverages in a diet and, the frequency with which they are habitually consumed [2]

Double Burden of Malnutrition: The double burden of malnutrition is characterised by the coexistence of undernutrition along with overweight and obesity, or diet-related non-communicable diseases, within individuals, households and populations, and across the life course (WHO).

Energy: Calorie is one of the units to measure energy. It represents the quantity of energy required to increase by one degree Celsius the temperature of water under atmospheric pressure. Kilocalories (1 000 calories= 1 kilocalorie), or kcal is used in biological science to measure physiological activities of organisms. In human nutrition, food provides energy to the body to ensure its maintenance, functions and optimal growth. Under or overconsumption of energy can lead to severe outcomes regarding health.

Fertility rate: The average number of children a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. Unit: number of children per woman (WHO).

Guatemalan indigenous groups: Native people of Guatemala before the Spanish colonization. These groups include Maya people, Xinka people and Guarifunas people.

IDH: The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living (UN Development Reports).

Ladino people: People originated from historical interbreeding between the native indigenous people in Guatemala and European which colonized and occupied the country for three centuries. In Guatemala, they represent 53% of the population and speak Spanish as first language.

Maya people: People decedent from the Maya civilization and they represent the largest indigenous ethic group. The Maya are divided into 22 subgroups according to their language: Achi', Akateko, Awakateko, Chuj, Ch'orti', Itza', Ixil, Kaqchikel, K'iche', Mam, Mopán, Popti (Jakalteko), Poqomam, Poqomchi', Q'anjob'al, Q'eqchi', Sakapulteko, Sipakapense, Tektiteko, Tz'utujil, Uspanteko). Most of the Maya people are located in the western highlands in southern Guatemala [3].

Nutrient: Any substance normally consumed as a constituent of food: which provides energy; or which is needed for growth and development and maintenance of healthy life; or a deficit of which will cause characteristic biochemical or physiological changes to occur (FAO). Nutrients includes:

- Macronutrient: A necessary nutrient required in relatively large amounts (in grams) by the body, such as carbohydrates, fats and proteins.
- Micronutrient: Vitamins, minerals and certain other substances that are required in small amounts (milligrams or micrograms) for normal physiological function.

Nutrient adequacy: Sufficient intake of essential nutrients, needed to fulfil nutritional requirements for optimal health [4]. Micronutrient adequacy refers to intake of 11 essentials elements, including vitamin A, B1, B2, B3, B6, B12, C, folate, calcium, iron and, zinc [5]

Poverty: The proportion of the population living below the international poverty line, which is the percentage living on less than US$ 1.90 a day at 2011 international prices (WHO).

Proxy indicator: Indicator which assesses indirect sign/measure that can be representative or can approximate a phenomenon of interest without the presence of a direct sign/measure.

Response rate: The number of persons who completed the questionnaire divided by the number of eligible persons who have been invited to respond to the questionnaire, given in percentage.

Short stature: Height is below two standard deviations (SD) from the population's mean height for age and gender (WHO)

Stunting: Stunting is the impaired growth and development that children experience from poor nutrition, repeated infection, and inadequate psychosocial stimulation. Children are defined as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median. Impaired growth has adverse functional consequences on the child. Some of those consequences include poor cognition and educational performance, low adult wages, lost productivity and, when accompanied by excessive weight gain later in childhood, an increased risk of nutrition-related chronic diseases in adult life (WHO).

INTRODUCTION

1. Importance of nutrition

Nutrition is fundamental to achieve the highest standard of health, and greatly contributes to optimal development of each individual. Nutrition is multidimensional and it is reflected at the biological, sociocultural, economical, food security and sustainability level. Adequate nutrition prevents maternal and infant mortality, helps strengthen the immune system, reduces the risk of non-communicable diseases (NCDs), and improves productivity and longevity. Nutrition is defined as an equilibrium between optimal nutrients intake, and the correct assimilation of these nutrients, to ensure the body's maintenance, functions and growth. Diet should provide the required intake of macro and micronutrients, with each element in a sufficient amount to fulfil physiological needs.

Despite the very small amounts of micronutrients that are needed, micronutrient deficiency has severe impacts and long-term consequences on maternal and infant mortality, blindness, vulnerability to infections and intellectual capacities. Micronutrient deficiency is a form of malnutrition, and it is preventable by promoting food diversity to secure nutrient adequacy and, more generally, optimal health status. All countries are concerned about micronutrient deficiency in the population, particularly the Low- and- Middle-Income Countries (LMICs), which are greatly affected by this type of malnutrition [6].

Besides micronutrient deficiency, malnutrition also embraces undernutrition and overnutrition. Undernutrition refers to a low energy and/or nutrient intake and reflects a poor diet in terms of quantity and quality. Undernutrition takes three sub-forms: wasting (low weight-for-height), stunting (low height-for-age), and underweight (low weight-for-age). Overnutrition refers to an excess of energy and/or nutrient intake due to a poor-quality diet. Overnutrition takes various sub-forms as well: obesity and, overweight (high weight-for-height), as well as diet-related NCDs (e.g. heart disease, stroke, diabetes and some types of cancer) [7].

Malnutrition is one of the major global health challenges and is included under the second Sustainable Development Goals (SDGs) "Zero Hunger", which aims to end hunger, achieve food security, improved nutrition and promote sustainable agriculture [8]. By 2030, the United Nations (UN) targets to end malnutrition in all its forms and guarantee access to healthy food for everyone.

1.1 The Triple Burden of Malnutrition

Worldwide, most countries are experiencing the *Triple Burden of Malnutrition*, a concept defined as the coexistence of undernutrition, overnutrition and micronutrient deficiency at all levels within a population. LMICs are at a higher risk of the triple burden of malnutrition because they are still facing a high prevalence of under-nutrition-related conditions, such as stunting in children (**Figure 1**), while also experiencing a fast increase in prevalence of overweight and obesity [9;10].

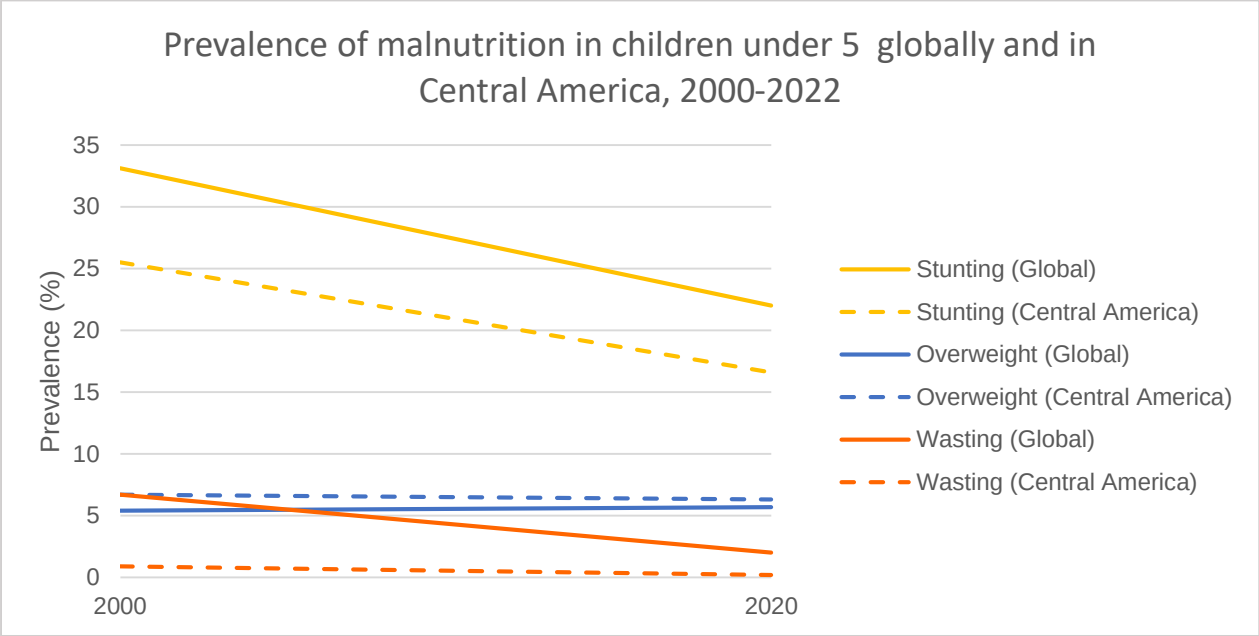


Figure 1: Prevalence of stunting, overweight and wasting in children under 5 globally and in Central America between 2000 and 2020
Source: UNICEF, 2021 [11]

Malnutrition remains one of the largest global health challenges. It is related to an increase in the cost of health care, it affects productivity at all levels, and decelerates economic growth globally. Malnutrition was in 2019 responsible for 5.2% of deaths in all age group, and the leading cause of Disability-Adjusted Life Years (DALYs) with 11.34% [12]. In 2020, the WHO estimated that 149 million children under 5 years were stunted, 45 million were wasted and 38.9 million were overweight or obese. In addition, the WHO estimates that 45% of children's mortality is related to undernutrition, with most of these deaths occurring in LMICs. Worldwide, the World Health Organization (WHO) reported that 1.9 billion adults are overweight or obese, while 462 million are underweight [7].

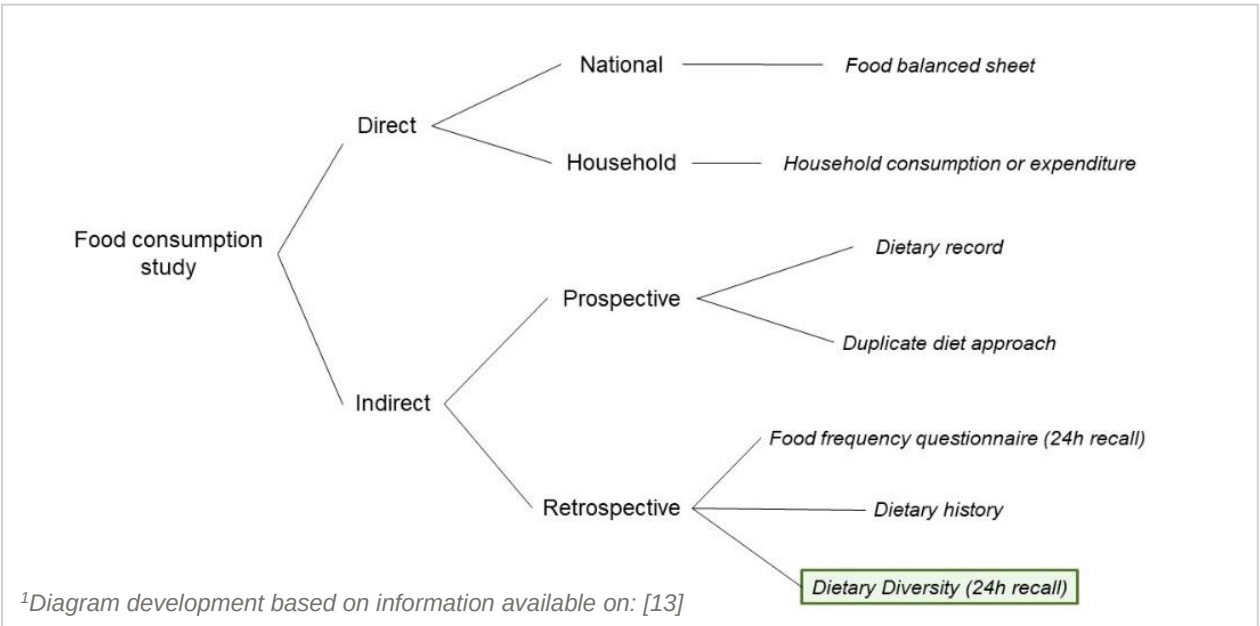
LMICs are importantly affected by the increasing incidence of obesity, which is the result of several factors. Changes in habits, a deep and fast transformation of the food systems and a general reduction of physical activities are among for the most important causes. Malnutrition is closely related to the food systems which are responsible for producing, processing, distributing, setting prices, and selling food items. Food systems shape the food market by influencing availability, accessibility, and diversity of the food supply. During the last decades, the opening of the global food trade has allowed multinational food companies to gain more power and penetrate the food markets of the LMICs with industrialized food. As a result, ultra-processed foods and beverages have become broadly available and cheaper. The lack of legislations on the quality of the products and the aggressive advertising campaigns focusing on children, contribute to make these products increasingly attractive to the population. Moreover, migration from rural to urban areas, the general increment of the income, the improvement of infrastructures and the increase of the number of working women (reducing the time dedicated to cooking) contribute to this deep nutritional change [9].

The groups at the highest risk of malnutrition-related conditions are generally women (included those in reproductive age), infants, children and adolescents. During key developmental age windows adequate nutrition is essential, even urgent. Malnutrition is complex and influenced by several risk factors, of which poverty is the leading one. For instance, the prevalence of obesity is higher among people that belong to the lowest quartile with respect to purchasing power compared to other quartiles [9].

1.2 Measuring malnutrition-related-conditions

Stunting, overweight or micronutrient deficiency are malnutrition-related conditions unequally affecting the population worldwide. To assess the nutritional status, a combination of anthropometric measurements and an overview of dietary patterns are often used [13], and are described below:

- Anthropometric measurements including weight, height, waist and hip circumferences allow to calculate key indicators such as Body Mass Index (BMI), height-for-age, or waist-for-height ratio (WtHR). These indicators provide information about the body shape and size, but also on the potential excess of adiposity, mainly in the abdominal region, which may result from a poor-quality diet.
- Measuring food consumption is complicated and several tools and approaches are available to estimate directly or indirectly the consumption at national, household and individual levels (**Figure 2**). These tools are useful for different purposes depending on the objectives of the assessment such as the total amount of food available for consumption (household consumption), usual food intake (food frequency questionnaire), or actual food intake (dietary diversity with 24-hour recall) [14]. These tools are commonly questionnaire-based where participants are interviewed on the different aspects of their food consumption. However, participants' characteristics such as sex, age, location, or ethnicity may have an impact on food consumption. Therefore, it is then fundamental for nutritional studies to consider the local socio-economic and cultural conditions.



[1]*Diagram development based on information available on: [13]*

Figure 2: Methodological approaches to study food consumption

1.2.1 Challenges of dietary studies in LMICs settings:

Dietary studies are important to estimate food habits, assess nutrient excess and/or deficiency, and to track dietary changes in a population. Quantitative dietary methods such as food frequency questionnaires, weight food records, or dietary history provide precise data on dietary patterns and nutrient adequacy. These methods require, highly experienced fieldworkers, important time for preparation and collection, and represent an important cost, which makes them more difficult to conduct in LMICs. However, dietary studies are particularly relevant in LMICs deeply affected by the triple burden of malnutrition, because they are tools to develop efficient evidence-based policies and programmes to improve food quality and diversity.

For this reason, The Food and Agriculture Organization (FAO) has developed different standardized tools to indirectly estimate diet composition and food diversity and overcome the limitations of quantitative methods in LMICs. These tools are low-cost, easy to use, and do not require extensive training for field workers; they serve health purposes to collect valuable data, evaluate nutritional outcomes and provide scientific evidence for research institutions and policy makers.

1.2.2 Minimum Dietary Diversity for Women (MDD-W)

Among these tools, the FAO has developed the *Minimum Dietary Diversity for Women* (MDD-W) in reproductive age (between 15 and 49 years of age), a simple proxy-indicator used to estimate dietary diversity of women on a group-level scale [5]. Food is classified into ten healthy food groups according to their nutritional profile as shown in **Table 1** and detailed in **Appendix 1**. MDD-W is a dichotomous[1] indicator, and based on the food classification, it measures whether a group of women has consumed or not, food from at least five of the ten food groups during the previous 24 hours. The main outcome of MDD-W is the proportion of women reaching this cut-off or the *group diversity score* (**Figure 3**). MDD-W is also appropriate to describe the proportion of women consuming each food group, from which dietary patterns can be drawn. These proxy-indicators of dietary diversity and patterns can support public health programmes to promote food diversity and reach micronutrient adequacy. Moreover, MDD-W takes into account unhealthy food, such as deep fried-food, salty snacks, or sweetened-beverages, which do not count into the ten food groups, but are recommended to be included in data collection. Assessing unhealthy food consumption is important to estimate its proportion in a regular diet. If over-consumption of this group is detected, it is important to communicate about negative health effects to limit its consumption and to possibly regulate food systems [5].

$$\text{Proportion of participants consuming} \geq 5/10 \text{ food-groups the last 24h} = \frac{\text{Number of participants consuming} \geq 5/10 \text{ food-group the last 24h}}{\text{Total number of participants}} \times 100$$

Figure 3: Formula for the group diversity score
Source: MDD-W guidelines, 2021 [5]

[1] Dichotomous refers to yes/no results. ***Yes***, the group of women that has consumed five or more items from the ten food groups in the previous 24 hours; or ***No***, if they have consumed four or less items from the ten food groups.

The MDD-W consists of a questionnaire in which participants are asked about the food consumed the previous day. MMD-W aims to estimate the real food consumption during the previous day, and thus, does not necessarily reflect the usual diet. It is recommended to collect data during weekdays to avoid unusual diet, such as that consumed during feasts; it is also recommended to consider seasonality. Data collection is based on two methods, list-based and open recall. In the open-recall method, participants are openly asked about what they have eaten the previous day; while in the list-based method, a short and limited list of food is enumerated to the participants who respond as to whether they have eaten or not each food.

Table 1: MDD-W's food classification
Source: MMD-W guidelines, 2021 [5]

MDD-W 10 food groups			
NB	Food group	Row	Food group sub-division
1	Grains, white roots and tubers, and plantains	A	Food made from grains
		B	White roots and tubers or plantains
2	Pulses	C	
3	Nuts and seeds	D	
4	Dairy	E	Milk
		F	Dairy products
5	Meat, poultry and fish	G	Organ meat
		H	Red flesh meat from mammals
		I	Processed meat
		J	Poultry and other white meats
		K	Fish and seafood
6	Eggs	L	
7	Dark green leafy vegetables	M	
8	Vitamin A-rich fruits and vegetables*	N	Vitamin A-rich vegetables or roots
		O	Vitamin A-rich fruit
9	Other vegetables	P	
10	Other fruits	Q	
Unhealthy food			
	Fried and salty food	R	Packaged salty snacks
		S	Deep fried foods
		T	Instant noodles
		U	Fast food restaurant foods, street food
	Sweet food	V	
	Sweet beverages	X	Sugar-sweetened beverages
		Z	Sweetened infusions

What are the advantages of using MDD-W?

The use of MDD-W to assess food diversity and thus the quality of a diet offers several advantages. It is a standardized method that follows a structured protocol and has been used for several years in different settings, this provides robustness. Further, this tool is not based on quantities and therefore, enables the collection of dietary data without facing the challenge related to quantitative studies. The MDD-W is a simple tool, easy to use and interpret, low cost and does not require specific resources such as extensive training, equipment, or data management skills. Finally, it reduces the burden on participants and investigators.

Overall, based on experience from different study groups and language adaptations, MDD-W is appropriate to describe micronutrient adequacy at a population level, describe the proportion of each food group consumed (dietary patterns), track diet change over time, compare dietary diversity among different populations, and evaluate the impact of policies. On the other hand, this tool is not appropriate for the development of individual dietary interventions, communicating behaviour changes, extrapolating the results to other population such as men and other groups of age, and assessing diet quality as a whole [5].

Why MDD-W is specific for women?

Women are identified as a vulnerable population in terms of nutrition. Women are nutritionally vulnerable especially during pregnancy and lactation periods, when the nutrient's demand is even higher than in adult men. Moreover, the women's nutritional status before and during pregnancy and lactation is an important determinant for both mother's and infant's health. Further, women are more exposed to a monotonous diet due to their social position and the priority given to them in many societies, where adult men and children are often privileged in the food queue. Finally, targeting women is strategic because culturally women are responsible for the food security of the household by selecting, buying and preparing food, and they are in charge for child feeding. Therefore, if a woman has a diverse and healthy diet, the rest of the household is more likely to have a similarly healthy diet [5].

Why choose the list-based method?

First, this method relies on short and simple questions that can be assisted with pictures to facilitate comprehension as suggested by MDD-W's guidelines (e.g., a question-related to the group 1: starchy food, will be: *Yesterday during the day and night, did you eat tortilla, bread, rice or pasta?*). This point is particularly relevant to avoid the language barrier when participants and investigators do not speak the same language. Other advantages of this method are fewer requirements for investigators' expertise, a shorter training time required for the investigators, and easier data processing and cleaning.

However, when choosing the list-based method, it is important to consider that it requires a longer time of preparation to locally adapt the questionnaire. Indeed, it relies on a limited list of foods, and it is crucial that this fits the local diet. If no pre-existing list is available for the target study population, investigators need to create a new one following the methodology defined by the tool's guidelines. Moreover, participants need to consider the ingredients of mixed dishes when responding to each food items is enumerated.

2. Dietary challenges in Guatemala

Guatemala is one of the largest countries of Central America with a total area of 108 890km². It shares its northern border with Mexico, the southern with both Honduras and El Salvador, and a contested one with Belize to the east. Guatemala is the most populated country of Central America with 17.92 million inhabitants in 2020. The country is characterized by a young population where 54% is under 24 years old and where the fertility rate is 2.67, which remains the highest in Central America [15]. **Table 2** shows key indicators of Guatemala related to income, development, health and inequalities in 2019. Guatemala is ranked among the least developed counties in the American continent according to the Human Development Index (HDI). This underdevelopment is especially associated with a high poverty rate and large inequalities within the population. Guatemala offers a unique ethnic diversity which is the result of its colonization processes, that continues to shape the economic, social, and cultural life of the country. In comparison to other Central American countries, Guatemala possesses a high proportion of indigenous people (44%), essentially Maya who represent 42% of the national population [16]. Spanish is the official language, spoken by most of the population as either first or second language. Moreover, 24 other languages are actively spoken in Guatemala and recognized by the government, including 22 different Mayan languages, as well as the Xinka and Garifuna languages as shown on the map on **Figure 4**.

Table 2: Income, development, health and inequality indicators of Guatemala, 2019
Source: [17]

Income		Development		Health		Inequality	
GNI	8,494 PPP$.	HDI	0,663 Rank: 127	Maternal mortality ratio (per 100,000 live birth)	95	GINI index	48,3
Population in multidimensional poverty	28,9%	Life expectancy (years)	74,3	Under 5 mortality ratio (per 1,000 live bith)	26,2	Inequality in education	30,8%
Population living under the national poverty line	60%	Expected years of schooling (years)	10,8	Child (<5) malnutrition stunting (moderate/sever)	46,7%	Gender inequality index (GII)	0,479
Unemployment rate (total labour force)	2,5%	Literacy rate (<15 years)	81,3%	Obesity in adult (WHO, 2016)	18,8%		

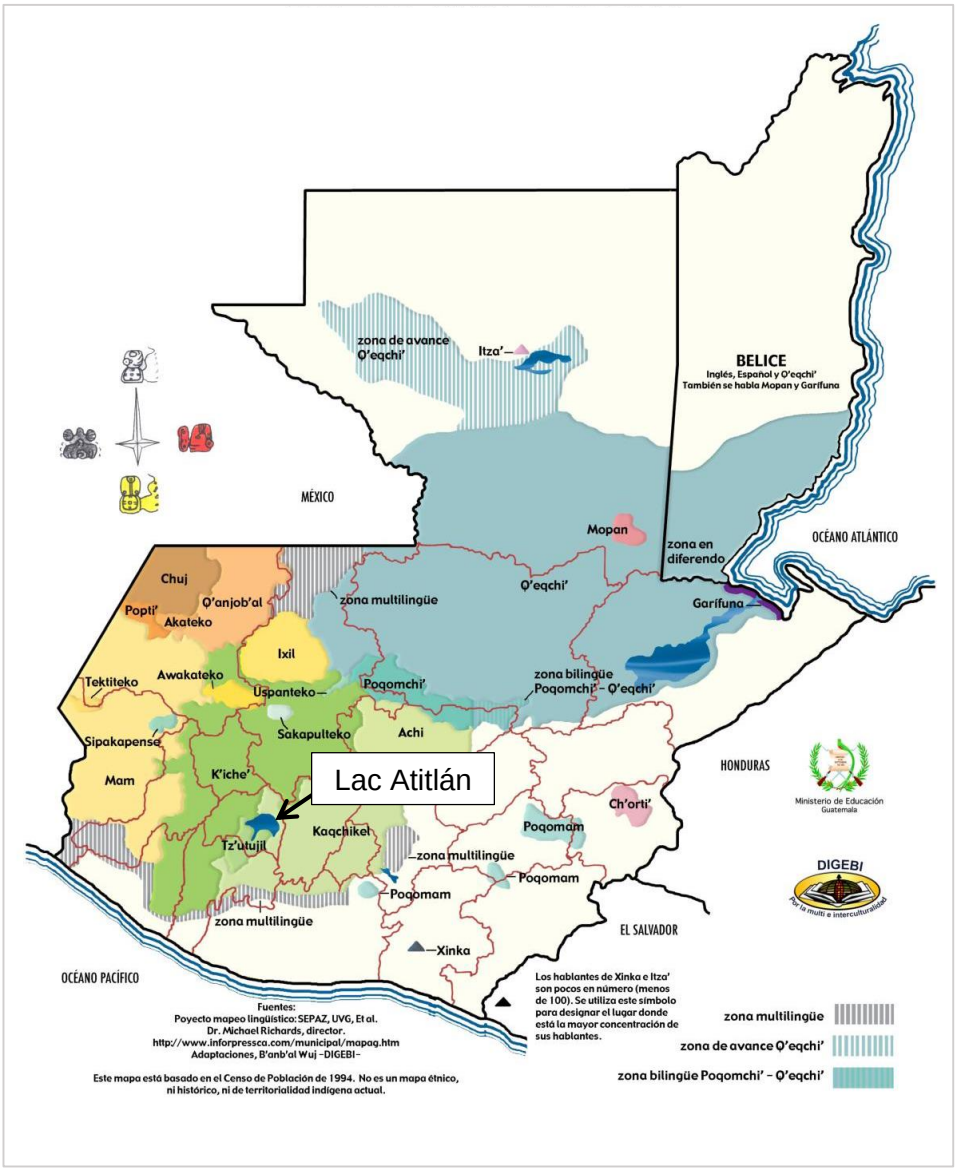


Figure 4: Linguistic map of Guatemala, Mayan, Xinca and Garifuna languages
Source: Ministry of Education of Guatemala [46]

The Lake Atitlán is located in the department of Sololá, where 38% of its inhabitants are living in rural areas, and where the Maya communities represents 96% of the local population [16]. The census from 2018 indicated that the three main Mayan languages spoken in this area were the K'iche', the Kaqchikel, and the Tz'utujil as presented in **Table 3**. Communities that speak Tz'utujil community represented only 1.7% of the national Maya population and 16% of the Maya people living around the Lake Atitlán [18].

Table 3: Distribution of K'iche', Kaqchikel and the Tz'utujil speakers in the country and in the department of Sololá in 2018
Source: Instituto Nacional de Estatisticas Guatemala, 2018 [16]

	National	Sololá
K'iche'	27.1%	44%
Kaqchikel	17.2%	39%
Tz'utujil	**1.7%**	**16%**

2.1 Inequity of indigenous communities

Indigenous people suffer from continuously steadily racism and discrimination, which are reflected in inequalities at all levels [19]. They experience higher poverty levels than the rest of the population. The Pan-American Health Organization (PAHO) report of 2012 states that more than three quarters of the indigenous population lives in poverty and that the average income for rural indigenous workers was 34% lower than among non-indigenous workers [20]. Access to education is not equal in the population, with a literacy rate in indigenous women of 58% in 2017 compared to 74% for women in the nation as a whole. These differences within the population have a strong impact on the health and well-being of indigenous people who are often left behind. For instance, departments with a high proportion of indigenous and rural communities have a higher maternal mortality rate compared to other departments, mainly due to a limited access to health services. Moreover, health-care services use Spanish as official language, not including other local languages, representing one of the biggest challenges for the Guatemalan Health System [21].

2.1.1 The Triple Burden of Malnutrition

The Triple Burden of Malnutrition is one of the major concerns in Guatemala where the prevalence of chronic malnutrition is the highest in the Americas [22]; indeed, the prevalence of stunting in children remains among the highest in the world.

The nutritional transition that modifies diet and physical activity patterns is worsening this situation. Malnutrition presents different profiles and outcomes according to ethnicity. In 2020, WHO reported that 43% of Guatemalan children under 5 years were stunted. The stunting rate in indigenous children reached 58%, 67% in children with mothers with no education, and 53% in rural areas [21]. Stunting is translated into short stature during adulthood, and indigenous women were on average 3.2cm shorter than non-indigenous women, according to evidence from 1995 [23]. Regarding adult overweight and obesity, the prevalence in men and women was respectively 48% and 58% in 2014 (PAHO 2017b). Overweight and obesity were more prevalent in non-indigenous women compared to indigenous (62% vs 49%) over the year 2014-2015, but the incidence is increasing faster in indigenous women [6-7]. Finally, in 2013 the prevalence of anaemia, which commonly result from iron inadequacy, was higher among indigenous women than non-indigenous and anaemia were exacerbate during pregnancy (15.8% vs 3.2%) [24].

2.1.2 Dietary patterns

Investigating malnutrition requires a good comprehension of local diets and food habits to understand how and why dietary patterns are shaped, and how they are evolving. The typical Guatemalan diet can be defined based on the last national survey *Encuestas de Condiciones de Vida* (ENCOVI). This study asked 11 536 households to report the diversity of food used over 15 days in 2014 and describe "the Guatemalan food basket" including the foods reported by over 50% of the study participants. The following list ranks by descending order (in %), the food most commonly consumed by the households: tortillas (98.7%), tomatoes (95.5%), beans (94%), refined sugar (93.1%), *pan dulce* (bread with sugar on top) (90.4%), eggs (90%), onions (89.9), potatoes and roots (87.8%), poultry (87.5%), rice (86.8%), salt (81.4%), vegetable oil (80.6%), other beverages (includes water) (80.4%), pasta (76.1%), bananas and plantains (75.2%), broth (73.2%), citrus (70.3%), hierbas (local dark green leafy vegetables) (68.7%), bread (65.2%), salad (64.3%), dehydrated soup (60.7%), güisquil and gücoy (58.2%), beef (54.8%), carrots (54%), sweetened- breakfast cereals (52.2%), soft drinks (52.1%), and cheese (50.4%) [25]. This study thus provides an overview of the foods that compose the "Guatemalan food basket", but it does not inform about dietary patterns. According to the recent literature, two main patterns can be identified in Guatemala, the traditional diet opposed to the western diet.

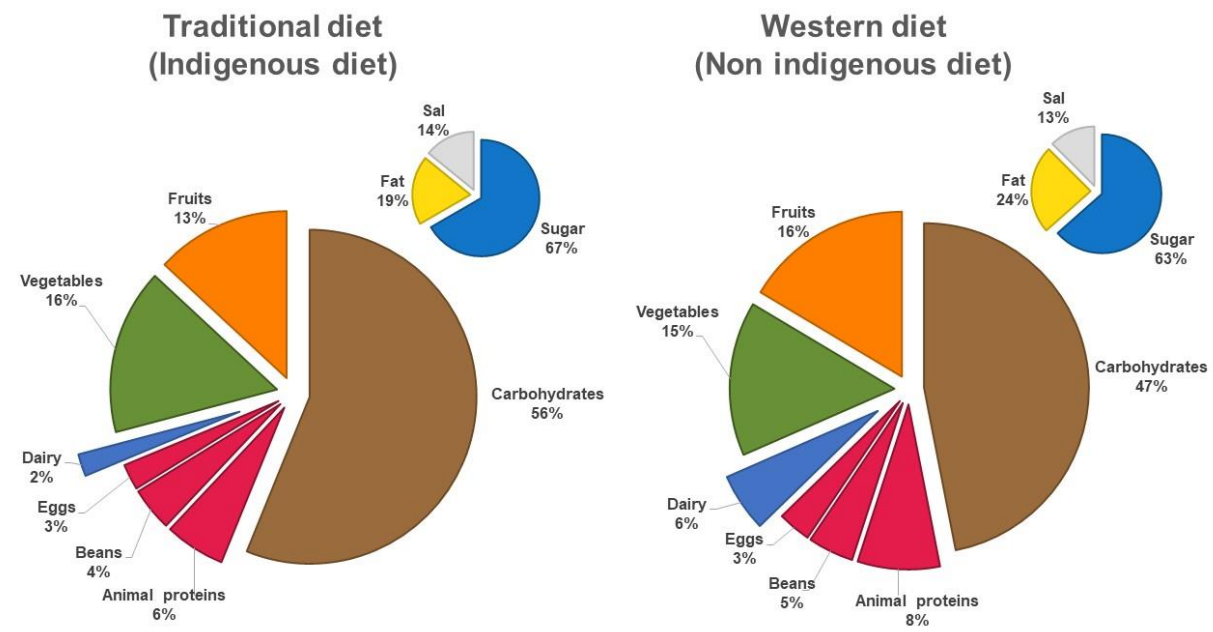
Traditional diet *versus* Western diet

The traditional diet is based on plant-origin food, characterized by high consumption of traditional foods such as tortilla, beans, and coffee, and very low consumption of animal-origin foods except for eggs. However, processed foods are increasingly incorporated into a traditional diet [26]. In 2016, a cross-sectional study assessed the association between socioeconomic factors as predictors of and dietary patterns. Results showed that a traditional diet is more common in rural and poor areas, and among indigenous households and individuals, particularly women. High adherence to the traditional diet was negatively associated with urbanity and schooling in both sexes and with economic status (annual expenditure) in men only. Low annual expenditures were associated with the "coffee and sugar" pattern in women (considered as a traditional beverage) [27].

Western diet, on the other side, is related to the nutritional transition associated with an increase in incomes and urbanity, and access to processed food in supermarkets, cheap prices, marketing's regulation, and thereby alterations in food habits and preferences. Diet is characterised by higher food diversity compared to the traditional diet, higher consumption of animal-origin products (red meat and dairy products), and large consumption of processed foods and sweetened beverages. A western diet is more common in urban areas and among richer households. The same cross-sectional study reported that high adherence to a western diet was positively associated with higher annual expenditure in both sexes, and with urbanity and a higher level of schooling in women. Results showed a linear association between annual expenditure and western diet, and high schooling was associated with low adherence to the traditional diet [27].

For comparison, **Figure 5** shows the comparison of the traditional (indigenous) and western (non-indigenous) diets in terms of contribution of the main nutrients to the energy intake (calculated with quantities consumed per day and transposed in Equivalent Male Adults[2]) [25].

[2] Units to compare food intakes and nutrient inadequacy between household from different size and compositions, based on nutritional requirement for one adult.



Represent the quantities consumed in a day for an Adult Male Equivalent
Illustration based on data available on *Tendencias de la situación alimentaria en Guatemala, 2022, INCAP [25]*

Figure 5: Comparison of indigenous and western diet and the contribution of food and macronutrient to energy intake

Main nutrients in the Guatemalan diet

Carbohydrates are fundamental in the Guatemalan diet but the sources and their contribution to energy intake differ between the traditional and the western diet. For indigenous people, 71% of the energy comes from carbohydrates, largely from tortillas, against 66% for the non-indigenous group. The traditional food monotony can be thus explained by the high consumption of carbohydrates (tortilla), largely common in households with higher level of poverty [28].

Animal products are considered expensive, and their consumption is correlated with the economical level. Thus, affordability is one of the main reasons to explain low animal product consumption, particularly in the traditional diet. For example, animal protein consumption is higher in urban areas [25]. The proportion of red meat in the energy intake was 6.4±4.5% for urban participants, against 2.5±2.4% for rural participants in 2006 [29]. Animal product consumption in the poorest households is influenced by income and food price fluctuations [30]. Finally, access to fresh products such as meat is limited in rural areas and indigenous communities, due to poor road infrastructures and preservation challenges [26].

Processed foods are common in both traditional and western diets, and important in the nutritional transition occurring in Guatemala. Increasing processed food consumption is a public health issue because it significantly increases energy intake which contributes to the expansion of weight-related diseases, without providing any beneficial nutrients. Processed food consumption is higher in urban areas and among the richest households [26]. Moreover, consuming processed food, especially soft drinks may be associated with social status distinction in a society where coffee is part of traditions, and where overweight and obesity are perceived as a characteristic of people belonging to a higher socio-economic status [31]. Additionally, the consumption of snacks, sweet food, and soft drinks are becoming more and more common in rural Guatemala [26]. For example, Tz'utujil Maya women consumed around two times a week Coca-Cola© and/or other soft drinks [32].

3. The Lake Atitlán Respiratory Health Pilot Study

In 2021, a pilot study on respiratory health was performed in rural Guatemala, "The Lake Atitlán Respiratory Health Pilot Study". The study was developed by a team of researchers from the University of Bergen in collaboration with the Centre for the Study of Equity and Governance in Health Systems (CEGSS) in Guatemala which focuses on the health of a specific group of indigenous communities known for their traditional textile works. Further, the collaboration with local associations: "Red de Defensores Comunitarios por el Derecho a la Salud (REDC Salud)", "Red de Mujeres Estrella Tzutujil", "Asociación de Mujeres Ixoq Ajqne" and "Fundación Tradiciones Mayas" which have experience working with indigenous communities in this area, helped to reach indigenous participants, historically sceptic to outsiders, concerned to be exploiting. The aim of this pilot study was to characterize different aspects of general and respiratory health in Maya families living in the region of Sololá around the Lake Atitlán, and assess potential associations of respiratory diseases with traditional weaving activities. The study provided knowledge on a difficult-to-reach and understudied population, generated a valuable biobank, and gave valuable insights into the feasibility to conduct a research study in this population [33]. Moreover, the exploratory nature of this study offers several possibilities to investigate this particular population, also with regard to other health-related conditions.

The pilot study was performed in the department of Sololá, in a village around the Lake Atitlán. The target population was indigenous weavers and their household members, including husbands, children, siblings, and parents. A total of 95 households with 291 persons were included in the study.

The team uniquely approached the population through collaboration with local associations, community leaders contributed to invite and gather study participants, and to perform the field work. **Figure 6** depicts the study protocol followed for the pilot project, which included paper-based interviews (translated onsite to the local languages Tzutujil or Kaqchikel), anthropometric measurements (i.e., weight, height and hip, and waist circumference), spirometry and collection of biological samples (i.e., urine and blood).

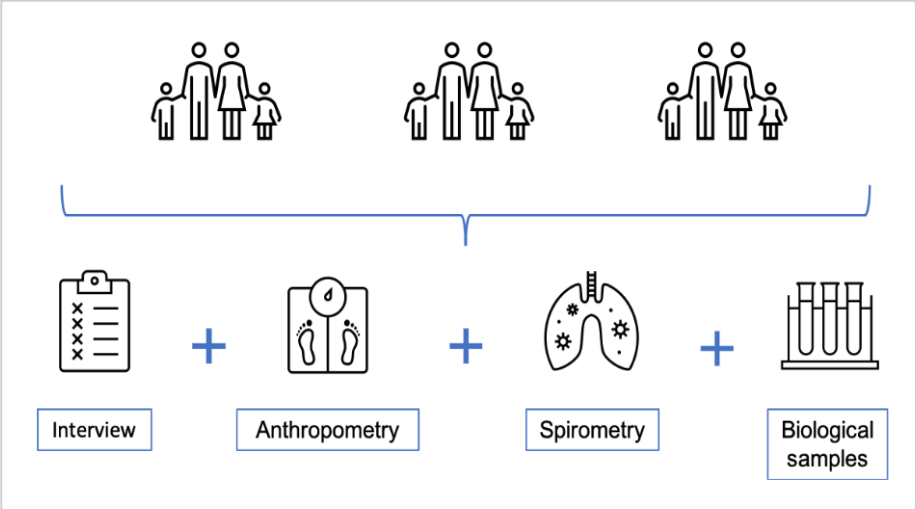


Figure 6: Lake Atitlán Respiratory Health Study, study protocol, 2021
Source: Lake Atitlán Respiratory Health Study (reproduced with permission of the authors) [33]

The protocol was harmonised with international studies (Respiratory Health In Nothern Europe - RHINE, European Community Respiratory Health Survey – ECRHS, and RHINESSA) and following adapted Standard Operating Procedures (SOPs). The Lake Atitlán Respiratory Health Pilot Study has received ethical approval from the Regional Committees for Medical and Health Research Ethics (REK Nord with reference 203917) in Norway and from the Ministry of Ethics in Health in Guatemala (Reference 29-2020).

From the results obtained by this pilot study, 82% of the participants were women with a median age of 34.2 years ranging from 14 to 77 years of age. Ninety-five percent of the female weavers answered that they belong to a Maya group, among those asked about their ethnicity. This population was characterized by low educational level, where 37% had incomplete primary school, 25% had incomplete secondary school and 25% reported no education. Moreover, the anthropometric measurements showed that the population is short in stature, where the mean height in female weavers was 146cm, in comparison to 159cm in men.

The mean weight in female weavers was 64.6 kg, as compared to 64.8 kg in men. The calculation of the BMI showed that the female population was largely overweight or obese, with a mean BMI of 30.1 kg/m² in female weavers, as compared to and 25.6 kg/m² in men. **Table 4** sums up the characteristics of the study population by occupation.

Table 3: Main characteristics of participants in the Lake Atitlán Respiratory Health Study, 2021
Source: Lake Atitlán Respiratory Health Pilot Study (reproduced with permission of the authors) [33]

	All participants (n=291)	Weavers (n=130)	Female non-weavers (n=95)	Male non-weavers (n=47)
Mean age, years (SD)	34.2 (13.4)	34.3 (12.2)	34.5 (13.9)	31.9 (13.2)
Ethnic group, n (%)	n=134	n=79	n=45	n=8
Maya	127 (94.8)	75 (94.9)	43 (95.6)	8 (100)
Sex, n (%)				
Female	239 (82.1)	126 (96.9)	95 (100)	0
Males	52 (17.9)	4 (3.1)	0 (0.0)	47 (100)
Education level, n(%)	n=68	n=51	n=15	n=2
None	17 (25)	11 (21.6)	5 (33.3)	1 (50)
Primary incomplete	25 (36.7)	19 (37.3)	5 (33.3)	1 (50)
Secondary incomplete	17 (25)	14 (27.5)	3 (20)	0 (0.0)
Height, cm (SD)	147.9 (6.8)	146.4 (5.1)	145.3 (4.8)	158.5 (5.8)
Weight, kg (SD)	63.7 (12.3)	64.6 (12.1)	62.8 (12.9)	64.8 (12.1)
BMI, mean (SD)	29.1 (5.7)	30.1 (5.6)	29.7 (5.9)	25.6 (4.3)

The pilot study thus managed to reach participants, overcome the language barrier and perform a study on this particular population in remote areas by use of a community led approach. These results serve as a basis for further work and demonstrate the need for studies focusing on nutrition.

4. Statement of problem and rationale

Indigenous communities in Guatemala predominantly live in rural and difficult-to-reach areas. These communities have been historically discriminated, leading to a deficient social and political representation, and to an increasing poor understanding of health determinants, including the nutritional status and dietary habits. Used to being exploited, the population may be sceptical to participate in initiatives by people from outside the communities. Previous evidence has shown that the triple burden of malnutrition is a serious problem in Guatemala, however, there is scarce research describing the factors that constitute and influence the nutritional habits of the specific indigenous communities. Given the findings of the Lake Atitlán Respiratory Health Pilot Study showing that indigenous women weavers and their household members living in the Lake Atitlán area were overweight and short, it is important to address the underlying nutritional patterns [33]. For these reasons, further studies with focus on nutrition among indigenous communities in Guatemala are needed to improve the knowledge on this topic, in order to contribute to a basis for locally adapted dietary advice.

The present study investigated the households that participated in the Lake Atitlán Respiratory Health Pilot Study, using the list-based method of the MDD-W tool, in order to describe the dietary patterns and diversity of indigenous women living around the Lake Atitlán, Guatemala. This study developed and piloted a local adaptation of the tool in this specific population, which will feed into a larger study and will contribute, at a greater scale, to increase knowledge on the understudied topic of nutrition in these communities.

5. Research question

This study aims to answer the following research question:

What are the dietary patterns in Maya women in an indigenous village by the Lake Atiltan area, Guatemala ?

6. Aims

This study aims to describe the dietary patterns and diversity of indigenous women part of the Tz'utujil community living by the Lake Atitlán, Guatemala, as assessed by the standardized tool MDD-W. The specific objectives are as follows:

1. Describe the following dietary indicators: diet composition, the dietary patterns through the distribution of the number of food groups, the proportion of unhealthy food, the food budget and food assistance.
2. Calculate the *group diversity score* as proxy-indicator of micronutrient adequacy.
3. Pilot the MDD-W tool using the list-based method assisted with pictures and locally adapted to this specific population.

The overarching short-term objective is to provide a better understanding of nutrition in this local community. Findings are planned to be shared with local nutritionists from the Institute of Nutrition of Central America and Panama (INCAP), to give feedback to community leaders aimed at opening a discussion on dietary habits. The long-term objective is to gain field experience on this difficult-to-reach population and serve as a basis for a larger and more detailed study that can drive policies and programmes to improve nutrition and health in these communities.

MATERIALS AND METHODS

This master's thesis on dietary diversity is part of a field study that took place in February 2023 in the Lake Atitlán in Guatemala. This field study covered data collection for two other master's theses from the master's programme in Global Health from the University of Bergen, with partially related topics. The three master theses included in the field study are considered as sub-studies of the Lake Atitlán Respiratory Health Pilot Study performed in 2021. Thus, data collection took place in the same village of San Pablo la Laguna, and participants were recruited from the 95 households previously assessed. The field study was then divided into two sections:

1. Nutrition section: developed by two investigators who sampled the same participants (Maya women in charge of the food in their households in reproductive age, between 18 to 49 years of age) using a shared questionnaire that included:
    a. Baseline questionnaire with questions about general information on the participants such as household size, source of income, or education level (**Appendix 2**).
    b. Food insecurity questionnaire using the *Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access*. Intended to collect data for another master's thesis.
    c. Dietary diversity using the *Minimum Dietary Diversity for Women* (MDD-W) using the list-based method and assisted with pictures. Intended to collect data for the present master's thesis.
    d. Anthropometric measurements (weight, height, and waist circumference)
2. Chemicals exposure section: developed by one investigator with a questionnaire on chemicals exposure aiming to collect data on exposures at home and at work. These data will be used for another master's thesis.

The present thesis is focuses on the data obtained from 1c: dietary diversity assessment, and 1d: anthropometric results, supplemented with information from 1a: bassline questionnaire.

1. Study design

This study was designed as a descriptive pilot field study based on two-weeks fieldwork, using the list-based questionnaire of the MDD-W tool to assess and describe dietary patterns and food diversity dietary of Maya women living around the Lake Atitlán. Additional data were collected with a baseline questionnaire to document local social conditions and by performing body measurements to describe anthropometric status. Piloting the MDD-W tool was needed in order to test its local adaptation, the correct understanding and the willingness of the participants to provide information concerning the language barrier, the relevance of using pictures as aid, the validity of the results obtained, and finally, to verify the usefulness of this tool in this population. This pilot study would then test the feasibility of conducting nutrition-related research in this difficult-to-reach population, report the strengths and the limitation of the methodology used, and thereby serve as a basis for nutrition-related part of a larger-scale study planned for 2024.

1.1 Study area

This field study was located in South Occidental region of the country, in the department of Sololá, around the Lake Atitlán (**Figure 7**). The Lake is surrounded by several indigenous villages, and among them, San Pablo la Laguna has been chosen for the study. San Pablo la Laguna had a population of 7 299 inhabitants in 2018, and 99.68% were identified as indigenous belonging to the Tz'utujil Maya community [16]. Inhabitants of San Pablo la Laguna speak Tz'utujil as their first language, and a considerable proportion of them do not speak Spanish at a high level, or even not at all. Most of the economic activities are developed around agriculture or weaving activities, including *crochet* and embroidery of traditional clothes (e.g., *huipil*). The Lake area is a tourist zone, and many activities are oriented to experience the culture in those indigenous villages. However, San Pablo la Laguna remains difficult to access due to its location, situated higher in the hills without direct access to the Lake which challenges the attraction of tourists.

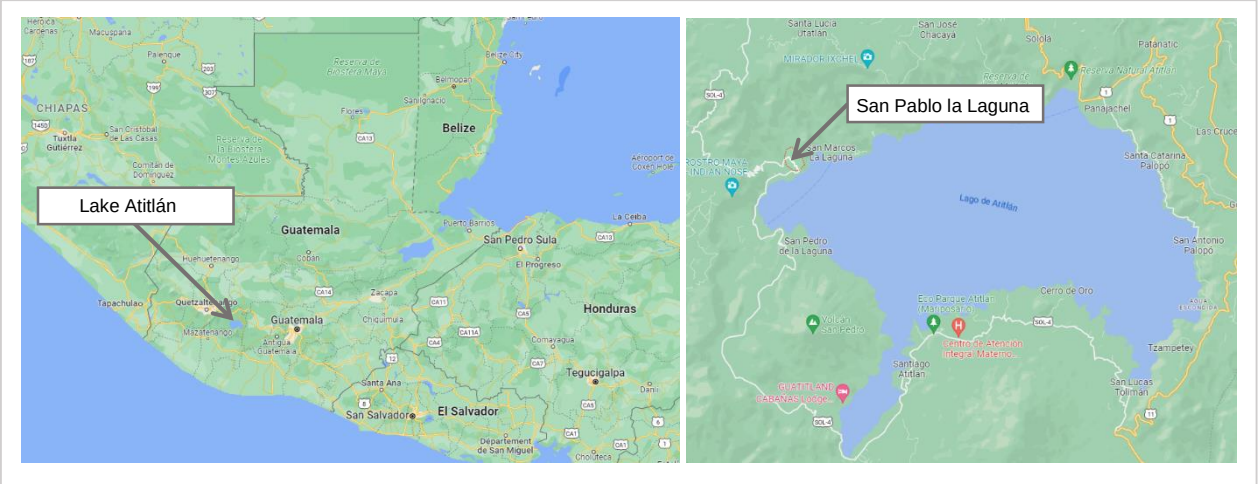


Figure 7: Map of Guatemala and localisation of the Lake Atitlán and San Pablo la Laguna
Source: Google Maps

1.2 Study population

1.2.1 Target population

The previous pilot study on respiratory health defined its source population as Maya people living around the Lake Atitlán, and targeted weavers (women) and their household members. The participants were initially approached by reaching weavers' organizations in the Sololá region that already collaborated with the CEGSS and explored their interest in participating in the respiratory health study. This community-led approach to the participants was important to avoid scepticism to participate in a study that involved foreign institutions. Once the interest was identified, a community leader and weaver belonging to one of the organizations (*Red de Defensores Comunitarios por el Derecho a la Salud – REDC Salud)* was selected and hired to perform the recruitment of participants belonging to those organizations, and living in San Pablo la Laguna, place where she lived and worked (convenience sampling method). The last step of the recruitment was done following a snowball sampling method since few women weavers were identified and invited by the community leader (seed persons) who were asked to extend the invitation to their household members. In total, 95 households (each represented by one woman weaver) were included, with 291 participants in the final sample.

1.2.2 Sampling

For the current research study on food diversity, the sampling frame was defined as the 95 households included in the previous pilot study on respiratory health. From the 291 participants (aged between 14 to 77), 147 women aged 18 to 49 years were identified. Given the communication already established between the community leader and the weavers that participated in the previous pilot study, the leader was asked to extend the invitation to the 147 women weavers. After application of exclusion criteria, a total of 86 participants were included in the final sample, representing a response rate of 58%.

Inclusion and exclusion criteria

Included participants were Guatemalan female weavers living in San Pablo la Laguna in reproductive age (15 to 49 years old) as defined by MDD-W guidelines. To avoid the inclusion of minors, this study included only women above 18 years of age. Women who were in their 49th year at the time of the study are included in the sample. Only women responsible for the food in their household were included, defined as the person in charge of selecting, buying, and preparing the food, and who knows the daily budget allocated for food.

Participants were excluded if they were pregnant or suffering from a health-related conditions that required a specific diet, such as diabetes. Indeed, pregnancy and some conditions have specific nutritional needs that should be covered by an adapted diet. These conditions constitute exclusion criteria defined by MDD-W guidelines. **Figure 8** depicts the sampling process.

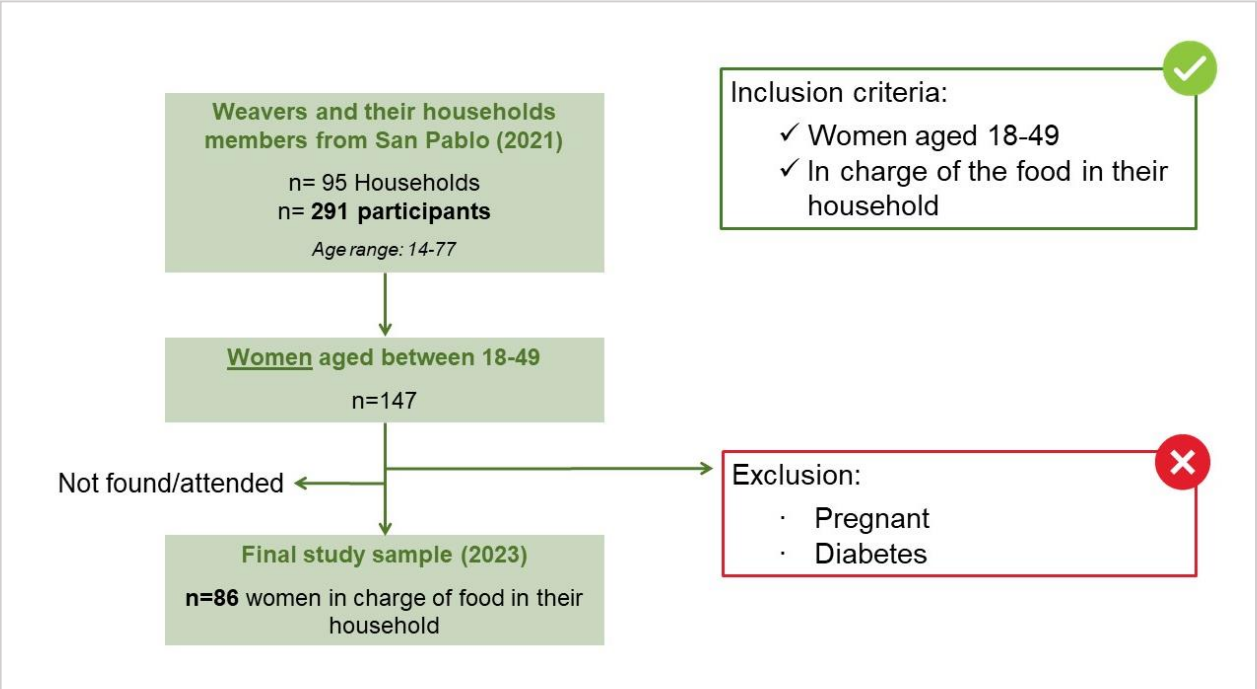


Figure 8: Flow diagram illustrating the sampling process

Recruitment of participants

Based on lists with the 147 potential participants, the community leader performed home visits to extend the invitation to the sub-study, with the instruction to meet at the municipal hall the next day in the morning.

2. Materials

2.1 MDD-W tool - List-based questionnaire

The MDD-W surveys using the list-based method require the following materials to correctly perform the data collection and reflect the local dietary patterns:

- Extensive food list which includes the most frequently consumed food locally (**Appendix 3**).
- Introductory text for the questionnaire (**Appendix 4**).
- Instructions and guidance sheets for the interviewers.
- The adapted questionnaire with a specific food list that considers local food and cultural norms (**Appendix 5**).

Local adaptation of the MDD-W list-based questionnaire

Figure 9 shows the list-based method for data collection, from the questionnaire's preparation to the recording of responses. A preliminary screening of the literature did not find any pre-existing or available questionnaire based on a food list specific to this study's source population (i.e., Tz'utujil Maya communities living around the Lake Atitlán). The investigators needed to first define this food list that fitted the local diet, which served as the basis to develop the questionnaire. The method to formulate a new questionnaire is detailed in the MDD-W guidelines [5].

First, the guidelines state to define an extensive food list of foods available in the study area. This list was made based on a preliminary scoping review on the *dietary patterns, nutrient adequacy and anthropometric outcomes of indigenous and non-indigenous population in Guatemala: a comparative study using scoping review*[3], which including a report from the INCAP on the Guatemalan food situation analysis [34]. Data used in this report were extracted from the last national survey ENCOVI (2014) which reported the most frequently food used by Guatemalan households, providing thus, a precise overview of the national food basket. Foods mentioned in the report have been classified into the food groups defined by MDD-W tool to design the extensive food list (**Appendix 3**).

Second, each food group and sub-group were limited to the seven foods most frequently consumed to shorten the questionnaire, reduce the burden for participants and investigators during interviews, and avoid recall errors. The MDD-W tool considers that seven foods per category are sufficiently representative of the most frequently consumed foods. The final questionnaire was developed based on this limited list, where each group and sub-group was converted into a question such as "*Yesterday during the day or at night, did you eat tortilla, bread, rice or pasta?*".

Figure 9: List based method for data collection, from the questionnaire's preparation to the recording of responses
Source: MMD-W, FAO, 2021 [5]

[3] Not included in this master thesis but planned to be published

Previous to the data collection, the questionnaire was presented to the community leader for a final revision, to remove the least common foods for this population or not seasonally available items during data collection.

Guidance for the interviews

Interviews were performed using the final questionnaire including 24 closed (yes/no) questions, with a section dedicated to unhealthy food and fortified food. The questionnaire was organized also to avoid double-counting. Each question was clearly enumerated, and, because questions do not rely on chronological order (e.g., from breakfast to dinner), participants were expected to take a moment to mentally recall the food consumed. The administration of the questionnaire lasted approximately 10 minutes, including a short introduction to explain the interview's procedures with particular emphasis on the 24-hours' recall period. As for the pictures to assist the questionnaire, for each question, a page showing pictures associated only with the foods enumerated at that time, was presented to the participants to facilitate comprehension. The final questionnaire is available in **Appendix 5** and the pictures in **Appendix 6**.

2.2 Anthropometric measurements

Anthropometric measurements consisted in recording weight, height, and waist circumference. The weight was recorded with a digital flat scale (Model Seca 813®) placed on a flat surface. Height was recorded using a portable stadiometer, and waist circumference using a tape calibrated in millimeters, with all measurements taken to the nearest millimeter. Given privacy reasons (i.e., taking off clothes), the anthropometric measurements were done partially following Standard Operating Procedures (SOPs) for anthropometric measurements. Adjustment were necessary.

2.2.1 Adjustments of measurements

Participants were willing to participate in anthropometric measurements if they were allowed to keep their clothes on (consisting of a blouse, a skirt, and a belt shown in **Figure 10**), mostly regarding the waist circumference that involved close body contact. Measurements were thus performed with the traditional clothes on, and weight and waist circumferences values needed to be adjusted. An example of the traditional clothes that indigenous women would normally wear were provided to the investigators to estimate their weight and the thickness of all the layers around the waist zone. The waist circumference of one investigator has been measured with and without the clothes to assess the thickness. The average clothes' weight was 1.62 kg which needed to be subtracted from weight values. Similarly, clothes increased the waist circumference by 12.2cm in average, to be subtracted to adjust the waist measurements (**Table 5**).

Figure 10: Example of women traditional clothes
Source: Chloë Carpi

Table 4: Adjustment of weight and waist circumferences values

	Mean	SD	IC 95
Clothes' weight	1.62 kg	0.12	[1.59;1.64]
Clothes' thickness at the waist	12.2 cm	0.28	[12.14;12.26]

2.2.2 Anthropometric indicators

Body Mass Index (BMI)

BMI is a common weight indicator to estimate the relation of the weight regarding the height of a person. BMI is calculated as detailed below (**Figure 11**).

$$BMI\ (kg/m^2) = \frac{Weight\ (kg)}{Height\ (m)^2}$$

Figure 11: Formula for BMI

This calculation provides a score that can be classified into four categories of body weight: underweight, normal weight, overweight, and obesity as shown in **Table 6** (for adults) [35]. However, BMI assesses only excess of weight and thus, makes no distinction between excess body fat and high muscle proportion. It is well known that excess of body weight associated with body fat increases the risk of NCDs such as cardiovascular diseases, high-blood pressure, diabetes, or some types of cancer. As the BMI-score increases, the risk of developing these conditions increases as well [35].

Table 5: Adult BMI adult's cut-offs values and definitions of weight status according to WHO [35]

BMI scores	Nutritional status
<18.5	Underweight
[18.5;24.9]	Normal weight
[25.0;29.9]	Overweight
≥30	Obesity

Waist circumference

The waist circumference is a simple indicator to capture the body fat distribution located in the abdominal region. Excess of abdominal adiposity is associated with an increase in premature death, stroke, or myocardial infarction. Waist circumference is a common indicator in anthropometric studies to estimate the risk of NCDs related to body fat in a population. SOPs for waist circumference measurements state that the measure should be collected using a measuring tape placed at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest (**Figure 12**). Participants are asked to breathe normally during the measurements. WHO defines cut-off values which vary from sex, age, and ethnicity. For the region of South America, studies recommended that waist circumference should not exceed 88-90cm in men and 83-84cm in women [36]. For this study, the midpoint of 83.5cm was arbitrary chosen as the cut-off for indigenous women living in Guatemala. However, the measure of waist circumference is not enough to estimate the body fat distribution as it does not consider height, which influences the risk of cardio metabolic diseases. For example, some studies showed that the risk of mortality from ischemic heart disease was lower in a taller population. As similar waist circumferences, the shorter populations have a higher risk of metabolic heart disease than the taller populations [36].

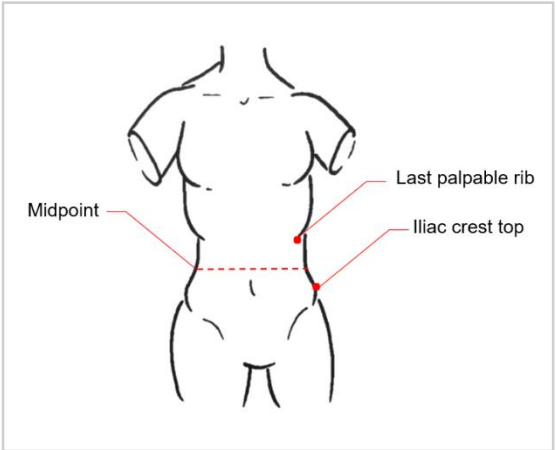


Figure 12: Placement of the tape for waist circumference measurement
Source: Chloë Carpi

Waist-for-height ratio (WtHR)

The waist-for-height ratio estimate the waist circumference regarding the height of a person to estimate the risk for metabolic heart diseases. Waist-for-height ratio is calculated as detailed below (**Figure 13**). Regardless of sex, age, or ethnicity, the WtHR cutoff is set to 0.5, and over this value, the risk to develop metabolic heart disease is increased [36].

$$WtHR = \frac{Waist\ circumference\ (cm)}{Height\ (cm)}$$

Figure 13: Formula for WtHR

3. Data collection

Data collection took place from February 14th to 28th, 2023 in San Pablo la Laguna, in Guatemala. The field worker team was composed of three master's students from the University of Bergen, two dedicated to nutritional studies and one to the study of chemicals exposure. Interviews were assisted by the local community leader for translation when it was necessary. For the nutritional studies, either field worker performed the interviews and the anthropometric measurements.

3.1 Interview's procedures

Participants were invited to attend the next day to the municipal hall of San Pablo la Laguna, which was rented for the occasion to perform the interviews. Meeting the inclusion criteria of the nutritional studies were allocated first to the nutritional station to perform questionnaires (baseline, HFIAS, and MDD-W) and provide anthropometric measurements. Thereafter, they were directed to the chemicals exposure station, together with the men and women younger than 18 and over 49 years of age. The community leader contributed to the translations from Spanish to Tz'utujil, the local language when it was necessary.

3.1.1 Nutritional interview's procedures

First, investigators made sure that participants met all the inclusion criteria by directly asking about food responsibility in the household, possible pregnancy, and eventual conditions requiring a specific diet. Then, participants were asked to answer the baseline questionnaire, followed by the HFIAS and MDD-W questionnaires. Finally, anthropometric measurements (weight, height, and waist circumferences) were collected following the SOPs.

3.2 Daily attendance and adaptation of the strategy

During the first phase of the data collection, irregular flows of attendance (**Figure 14**) steered investigators to adapt the strategy to meet the maximum number of participants during the limited time frame. From day 8, the strategy for recruitment was switched from invitations to the municipal hall to performing home visits. This strategy was chosen to accelerate the initial invitation process of home by home which was slow given the time frame, and limit the number of participants reached but who did not show up at the municipal hall. The same interview procedure detailed in part 3.1.1 was applied during the home visits. This change of strategy allowed to meet the final sample of 86 participants.

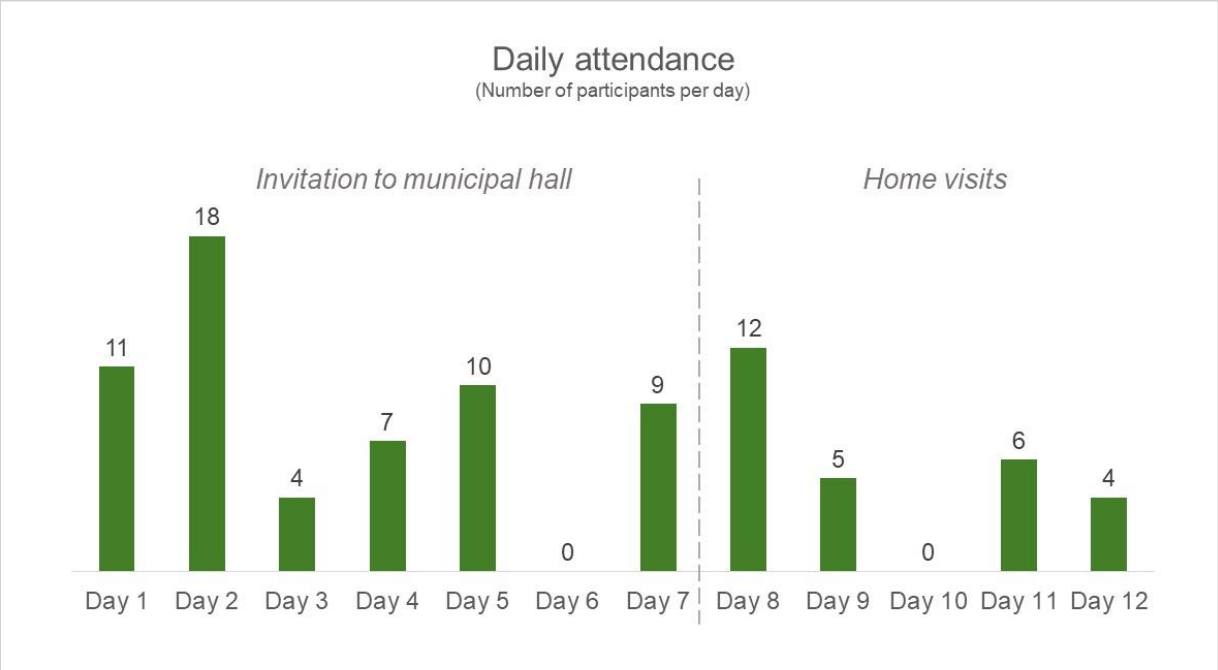


Figure 14: Daily flow of participants attendance

4. Data management and statistical analysis

The population baseline questionnaire, the HFIAS and the MDD-W were digital-based questionnaires and data were collected using the *Kobotoolbox*© software [37] using portable equipment, which enabled investigators to digitally design questionnaires and collect data from any devices (smartphones, tablets, or laptops) in offline mode. Descriptive analyses using Microsoft Excel were performed to present the general characteristics anthropometric status, food diversity and dietary patterns in the study population the sample.

5. Ethical approvals

The Lake Atitlán Respiratory Health Study had received ethical approval from the Regional Committees for Medical and Health Research Ethics (REK nord with reference 203917) in Norway and from the Ministry of Ethics in Health in Guatemala (Reference 29-2020). The protocol of the sub-study was sent as an addition to the Lake Atitlán Respiratory Health Study for approval to the Norwegian (**Appendix 7**) and Guatemalan (**Appendix 8**) committees, and was approved by both committees.

5.1 Risks and benefits for the participants

This study was considered a low-risk activity for the participant, justified by the reasons below:

- Data are collected through a non-invasive process. Two short questionnaires are included, and participants are expected to provide simple answers. Only the waist and hip circumference measurements involved close body contact, and was performed with their clothes on.
- Participant's daily routine was not disturbed by the study. The participation did not require modifying the diet habits. The protocol took approximately one hour to be completed.
- Respect to the participant's privacy and confidentiality.

The benefits from the participation consists in better understanding of the dietary habits and increased nutritional knowledge of this local community. The gained knowledge will be communicated to the community, and give a basis to improve the diet of participants, their family and the community. The gained knowledge will also contribute to further studies and increased knowledge of diet in the Maya communities of Guatemala.

5.2 Informed consent

Before answering the questionnaires, participants received the informed consent (**Appendix 9**). A specific time was allocated for reading and providing oral description of the protocol and the tools planned to be used, as well as clear information on the rights of the participants during the study, and the risks and benefits of their participation. Further clarifications were provided by investigators in case the participants had doubts. The community leader assisted with translation into the local language when it was necessary.

Two paper-based consent forms were printed; one was given to the participants while the signed copy was kept by the research team. Consent forms were stored safely on-site in a locked place. Participants were assigned a unique identification number to ensure anonymity. At the end of the field study, data were transferred to a password-protected computer and stored in a safe server of the University of Bergen (SAFE). Consent forms were shipped to Bergen and stored in a locker belonging to RHINESSA. Access to data is only granted by the principal investigator of the team in Norway and Guatemala.

RESULTS

1. Characteristics of the study sample

Table 7 shows the characteristics of the study sample based on the baseline questionnaire. The mean age of the participants was 34 years ranging from 19.8 to 49.9 years. Participants were living in households with an average of 4.5 other members and in charge of 1.6 children younger than 13 years of age. Most of them were married or in official relationships (*juntados* and *unidos,* in Spanish) and almost one-quarter were single including single mothers. Regarding education, half of the participants had not been to school, 14% had completed primary school, less than 10% had completed secondary school, and 16% had completed high school.

The main source of income varied between households. For almost one-quarter of the households, the income came from the weaving activities only (in women), one-quarter was dedicated to other activities only such as tuk-tuk driving (local taxi services) and construction for the husband, and laundry, cleaning and selling activities for the women, and one-quarter came from combined activities such as weaving for the women and agriculture for her husband. The majority (69%) of the participants reported working as weavers full-time. Weaving activities in San Pablo include traditional weaving, making *pelotitas* (small juggling balls) in crochet, and embroidery of traditional blouses (**Figure 15**).

Figure 15: Traditional embroidery and pelotitas
Source: Chloë Carpi

Regarding economic indicators, the average weekly income of the sample was 280 quetzales (Q) corresponding to approximately $40.1 US dollars, ranging from Q28 ($4) for the lowest value Q1000 ($142.9) for the highest. The standard deviation in weekly income was Q214.6 ($30.7).

2. Anthropometric status

Anthropometric indicators of the sample are detailed in **Table 8**. The mean height of participants was 144.8cm (range 133.5cm to 153.2cm), and almost 30% were considered to have short stature with a height under 145cm, as defined by WHO. The mean weight was 63.2kg (range from 42.2kg to 88.7kg), and the mean BMI was 30.1. According to the BMI classification, 78% of the participants had an excess of weight, 29% of them were overweight and 49% were overweight. The mean waist circumference was 81.7cm and 42% of the participants were above the cut-off of 83.5cm for South American women. Finally, the mean Waist-For-Height Ratio was 0.56, and 84% of participants were over the cut-off of 0.5.

Table 6: Characteristics of the 86 women of indigenous Tz'utujil aged 19 to 49 years, in charge of household's nutrition, and living by the Lake Atitlán, Guatemala

	All participants (n=86)	
Age		
Mean age, years (SD[1])	34 (7.9)	
Household size, mean (SD)		
Number of members	4.5 (2.5)	
Number of children < 13 years	1.6 (1.3)	
Number of adults in Reproductive Age	2.5 (2.1)	
Civil status, n (%)		
Single	23 (26.7)	
Married	51 (59.3)	
Separated/divorced	8 (9.3)	
Widow	4 (4.7)	
Education, n (%)		
No completed education	43 (50)	
Primary school complete	12 (14)	
Secondary school incomplete	8 (9.3)	
Secondary school complete	8 (9.3)	
High school incomplete	0 (0)	
High school complete	14 (16.3)	
University	1 (1.2)	
Main source of income of the household, n (%)		
Weaving only	21 (24.4)	
Agriculture only (husband)	13 (15.1)	
Other only	20 (23.3)	
Weaving and agriculture	19 (22.1)	
Weaving and other	13 (15.1)	
Weaving as woman's main income activity, n (%)		
Yes	69 (80.2)	
Economic indicators	Quetzal (Q)	US dollar ($)[2]
Weekly income, mean (SD)[3]	280 (214.6)	40.1(30.7)
Weekly income, median (min;max)[3]	250 (28;1000)	35.7 (4;142.9)
Daily food budget, mean (SD)	58 (38.6)	8.2 (5.5)
Daily food budget, median (min;max)	49 (17;200)	7 (2.4;28.6)
Participants under the poverty line[3], n (%)[4]	35 (40.7%)	
Participants spending less than cost of the daily Basic Food Basket, n (%)	81 (94.2)	
Food assistance, n(%)		
Participants having received food assistance in the last 6 months	12 (14%)	

[1]Standard Deviation (SD);
[2]Economic indicators are first calculated on the local currency the Quetzal (Q) and then converted in American dollars ($) based on the exchange rate in February 2023 (1$≈7Q);
[3]Weelky income was answered by 71 participants
[4]Poverty line define by the survey ENCOVI in 2014 as people earning less than 10 218Q per year which corresponds or approximately 213Q per week. In this study population.

Table 7: Anthropometric measurements in 86 women of indigenous Tz'utujil aged 19 to 49 years, in charge of household's nutrition, and living by the Lake Atitlán, Guatemala

	All participants (n=86)
Height (cm)	
Mean (SD)	144.8 (5.0)
Median (min;max)	143.7 (133.5;153.2)
Participants <145cm, n (%)	25 (29.1)
Weight (kg)	
Mean (SD)	63.2 (10.1)
Median (min;max)	62.3 (42.2;88.7)
BMI (kg/m²)	
Mean (SD)	30.1 (4.7)
Underweight, n (%)	0 (0)
Normal weight, n (%)	18 (20.9)
Overweight, n (%)	25 (29.1)
Obesity, n (%)	42 (48.8)
Waist circumference (cm)	
Mean (SD)	81.7 (7.4)
Participants >83.5cm, n (%)	36 (41.9)
Waist-for-Height ratio	
Mean (SD)	0.56 (0.06)
Participants >0.5, n (%)	72 (83.7)

3. Dietary indicators

3.1 Diet composition

Table 9 details the proportion, in percentage, of participants consuming each of the 10 food groups (and sub-groups 1, 5, and 8) the previous day. Food groups can be classified into foods that are "very common" (defined as consumed by more than 75% of the participants), "common" (consumed between 75% to 50%) and "less common" (consumed by less than 50% of the respondents). In the study population, very common foods were: starchy food (98%), eggs (94%), pulses (90%), other vegetables (88%), other fruits (79%), and dark green leafy vegetables (78%); common food items were: meat (74%), and vitamin A-rich food (71%); and less common foods were: dairy products (49%) and nuts and seeds (48%).

Table 8: Distribution of participants having consumed each food groups the last 24h, %

n=86	% (n)
1. Starchy food	98 (84)
1.1 Grains	97 (83)
1.2 Roots and tubers	37 (32)
2. Pulses	90 (77)
3. Nuts and seeds	48 (41)
4. Dairy	49 (42)
5. Meat	74 (64)
5.1 Red meat	20 (17)
5.2 Poultry	30 (26)
5.3 Processed meat	6 (5)
5.4 Fish	53 (46)
6. Egg	94 (81)
7. Dark leafy veg.	78 (67)
8. Vitamin A rich food	71 (61)
8.1 Vegetables	53 (46)
8.2 Fruits	62 (53)
9. Other vegetables	88 (76)
10. Other fruits	79 (68)

For the starchy group, grains (tortilla, bread, and pasta) were largely consumed by the participants (97%), compared to tubers and roots (37%), in the last 24 hours. Regarding the meat group, fish was the most frequently consumed (53%), followed by poultry (30%), red meat (20%), and processed meat (6%). The consumption of vitamin A-rich food was slightly more important in fruits (62%), such as mangoes, as compared to vegetables (53%), as shown in **Figure 16**.

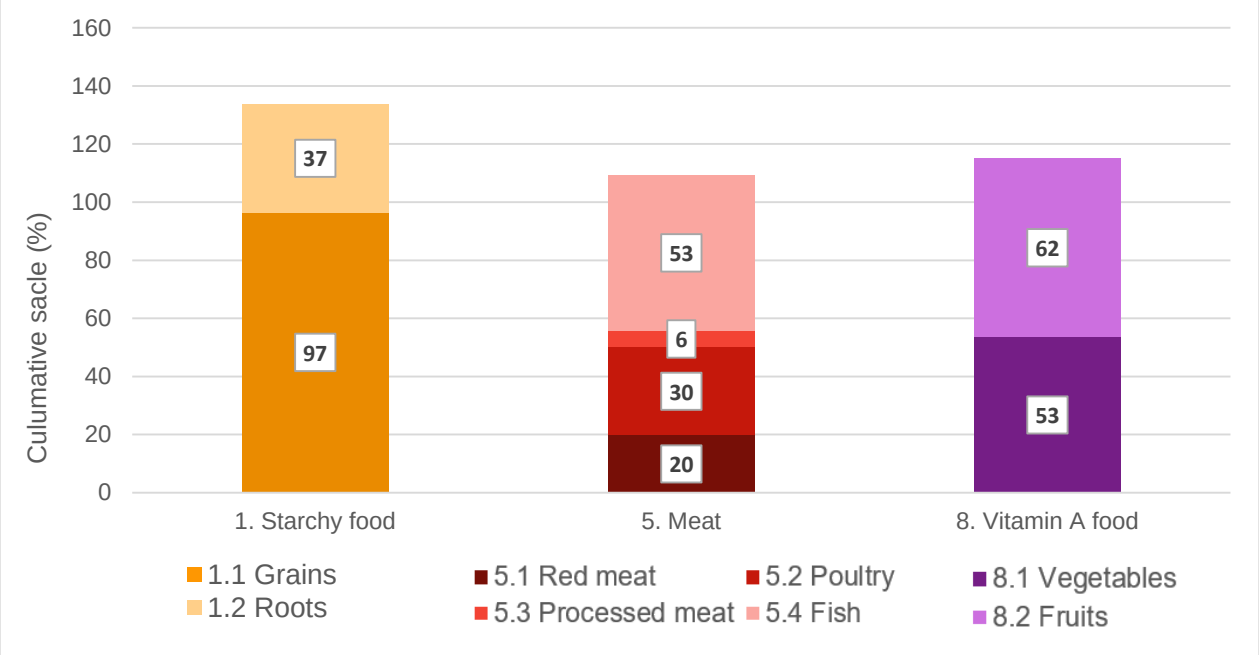


Figure 16: Percent of consumption of specific foods groups 1, 5 and 8

Finally, **Figure 17** depicts the percent of consumption in decreasing order of food groups.

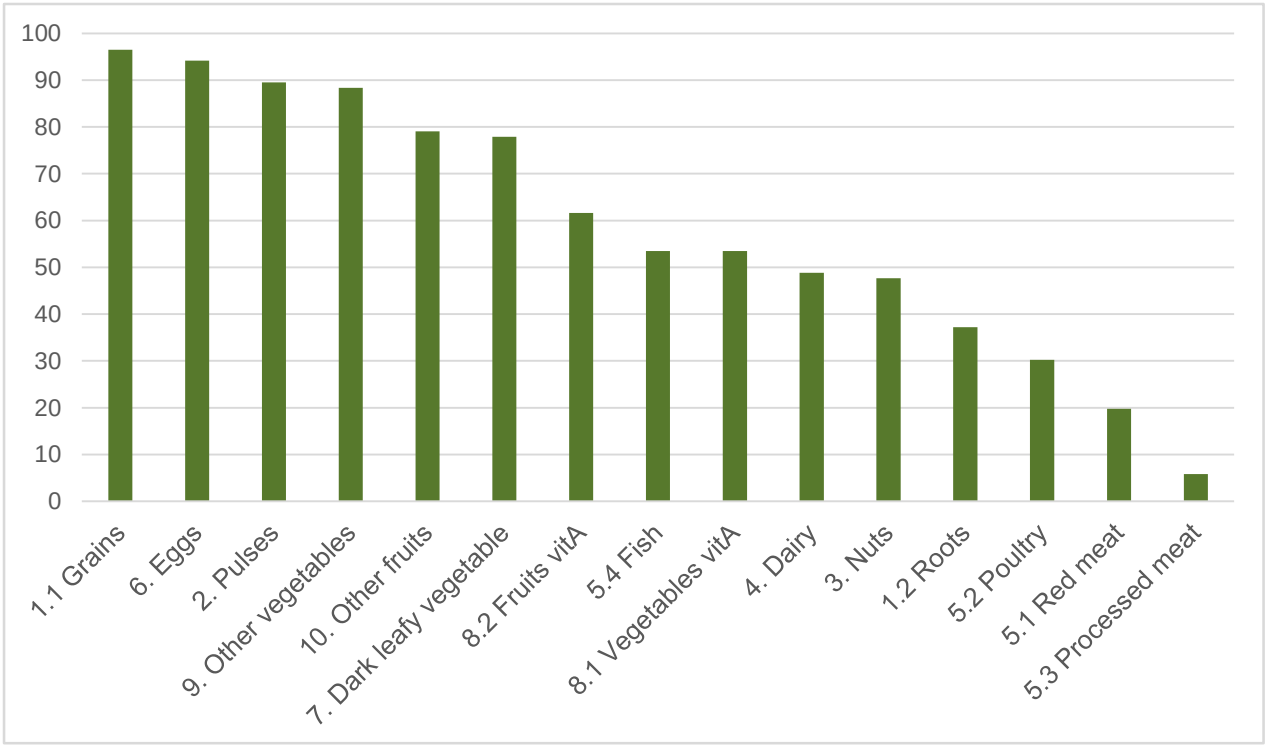


Figure 17: Percent of consumption of food groups by participants, during the previous day

Figure 18 enables to visualize the proportion of participants consuming each food group, and details sub-groups for group 1: starchy food, group 5: meat, and group 8: vitamin A-rich food. The thicker grey line represents the 50%, in other words, food groups under this line are consumed by less than 50% of the participants. Groups dairy products, nuts and seeds, roots, chicken, red meat and processed meat were under this limit.

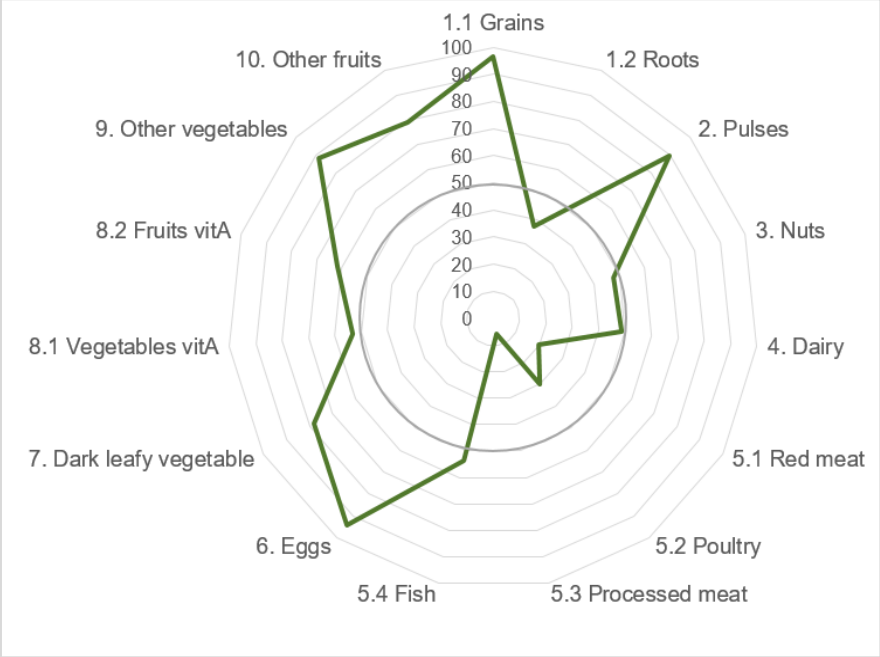


Figure 18: Distribution of food groups consumed the last 24h, group level, %

3.2 Dietary patterns by diversity score

Figure 20 represents the dietary patterns according to the numbers of food groups consumed by the participants on a cumulative scale (%), and results are detailed in **Table 10.**

Almost 8% of the participants (n=7) did not reach the minimum dietary diversity, consuming less than five out the ten food groups. For these participants the diet was plant-based which includes starchy food and pulses. When diversity was increased, dark green leafy vegetables (hierba mora **Figure 19**) and eggs were the first food included in the diet. Only for participants who had consumed three food groups the previous day, two out of three reported having eaten meat (beef). Among participants who consumed four food groups, two out of three reported including other vegetables, where tomatoes and onions were the most common.

Figure 19: Example of hierba mora
Source: Chloë Carpi

About 79% of the participants reported having consumed at least five out of the ten food groups during the last 24 hours, achieving the minimum dietary diversity. When diversity was increased (from 5 to 10 food groups), the first new groups added to the diet were other fruits (57%), and vitamin A-rich food (29%). Overall, this **Figure 20** shows that starchy food and pulses constitute staple food in the participants regardless of the level of diversity. In persons reporting higher diversity in terms of number of food groups, the report of meat became more frequent from 14% in those with five food groups to 88% for those with nine food groups, and the report of fruits and vegetables was also more important as food groups were increased. However, dairy products, nuts and seeds were the least reported groups even in high diversity categories (except in ten food groups).

Table 10: Distribution of each food group in the diet according to the number of food groups consumed the previous day (%)

	1FG	2FG	3FG	4FG	5FG	6FG	7FG	8FG	9FG	10FG
n	0	1	3	3	7	8	11	18	16	19
	Do not meet miminum dietary diveristy % (n)				*Meet miminum dietary diveristy % (n)*					
Starchy food	0	100 (1)	67 (2)	100 (3)	71 (5)	75 (6)	91 (10)	83 (15)	100 (16)	19 (100)
Pulses	0	100 (1)	67 (2)	100 (3)	71 (5)	75 (6)	91 (10)	83 (15)	100 (16)	19 (100)
Nuts	0	0	0	0	14 (1)	13 (1)	27 (3)	33 (6)	69 (11)	19 (100)
Diary	0	0	0	0	0	13 (1)	9 (1)	56 (10)	69 (11)	19 (100)
Meat	0	0	67 (2)	0	14 (1)	75 (6)	64 (7)	83 (15)	88 (14)	19 (100)
Egg	0	0	33 (1)	100 (3)	100 (7)	75 (6)	100 (11)	100 (18)	100 (16)	19 (100)
Dark leafy v.	0	0	33 (1)	33 (1)	71 (5)	25 (2)	82 (9)	83 (15)	94 (15)	19 (100)
Vitamin A	0	0	0	0	29 (2)	50 (4)	73 (8)	67 (12)	100 (16)	19 (100)
Other veg.	0	0	0	67 (2)	43 (3)	88 (7)	100 (11)	100 (18)	100 (16)	19 (100)
Other fruits	0	0	0	0	57 (4)	88 (7)	64 (7)	94 (17)	88 (14)	19 (100)

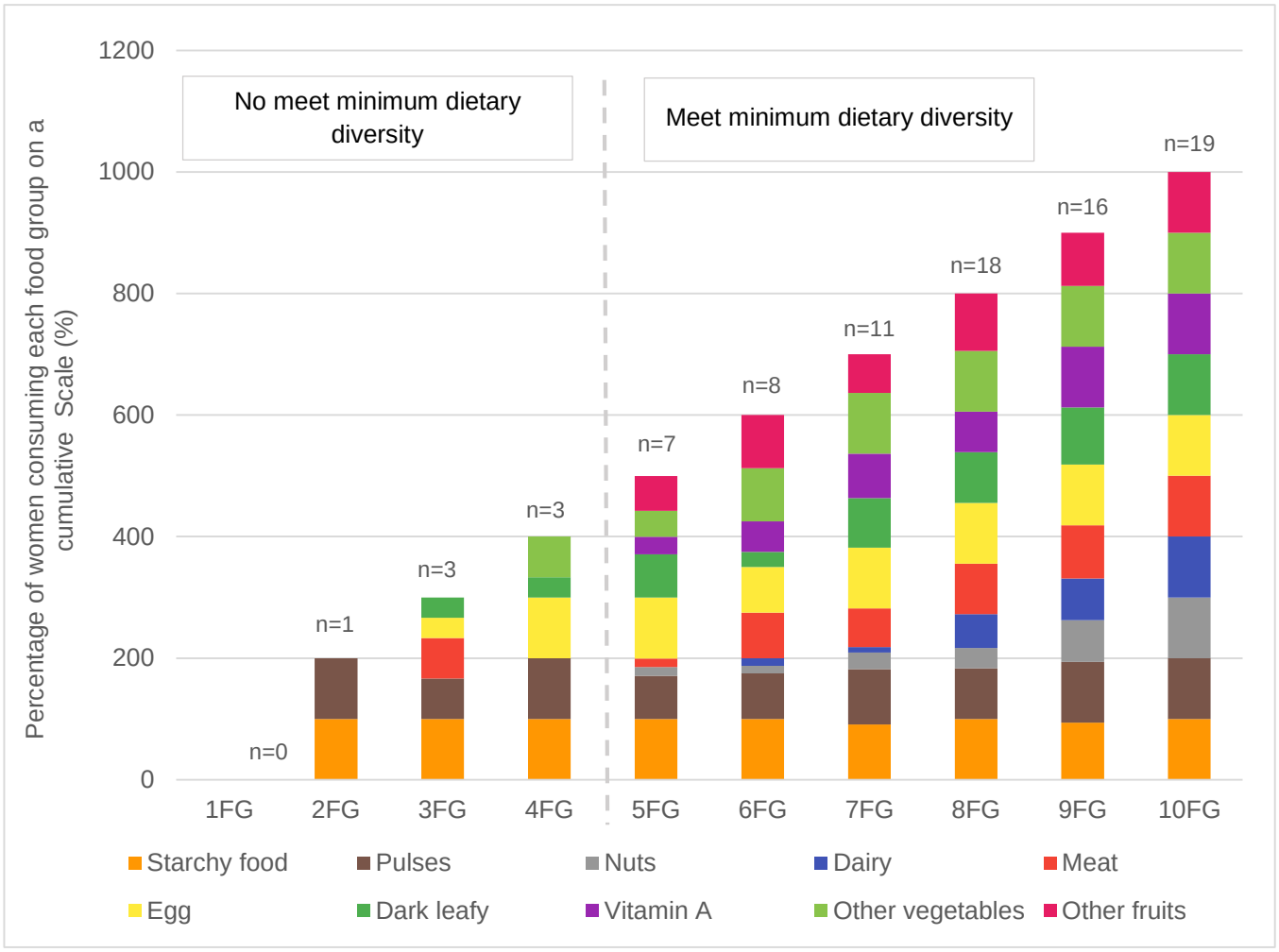


Figure 20: Distribution of each food group in the diet according to the number of food groups consumed the previous day, on a cumulative scale

3.3 Unhealthy habits

Figure 21 shows the distribution of participants who reported consumption of unhealthy foods the previous day, in decreasing order. Sweetened coffee was the most frequent unhealthy food, reported by 85% of the participants. Unhealthy foods reported by 50% to 75% of the participants included street food (69%), sweet food (66%), fat (54%), and sweet beverages (50%). Food consumed by less than 50% of the participants were fried food (29), snacks (19%), and dried soup (11%). The group *street food* included *tamales, paches,* and *chucitos*; these are traditional foods made with corn or potato dough and a small amount of chicken or beef in a sauce, wrapped in banana or corn leaves, and steam cooked. (**Figure 22**). The group *fat* includes vegetable oil, margarine and butter.

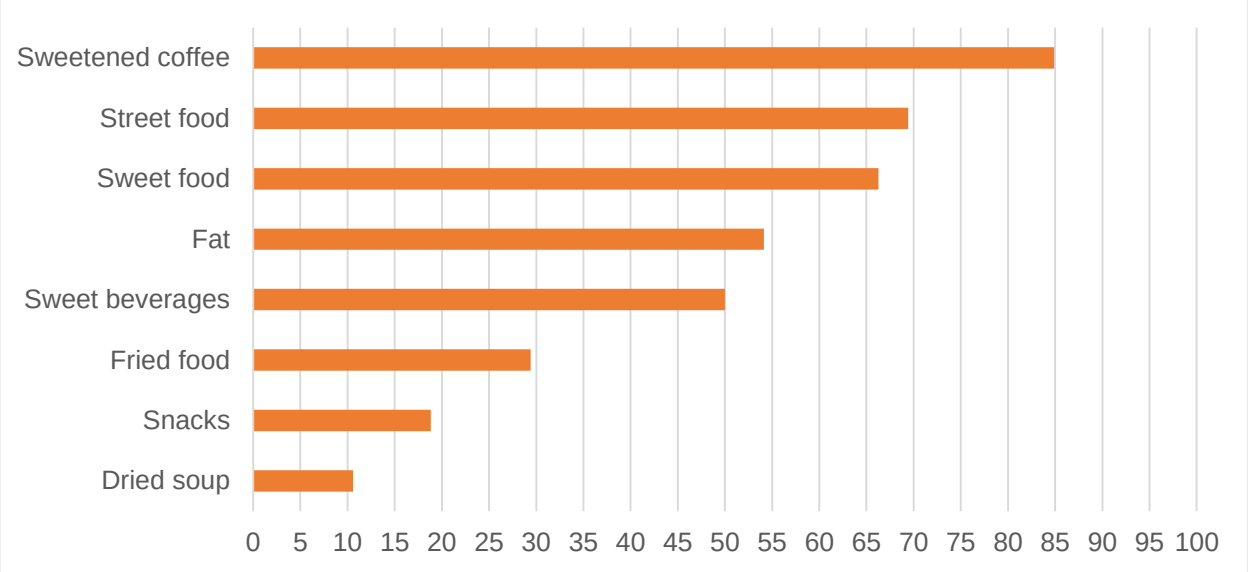


Figure 21: Percentage of consumption of unhealthy food by participants, during the previous day

Figure 22: Example of traditional street food; a. tamales, b. chuchitos, and c. pache
Source: [38]

3.4 Food budget

The daily budget allocated to food was shown in **Table 7**, and was in average Q58 ($8.2) ranging from Q17 ($2.4) to Q200 ($28.6). The gap between the lowest and highest value reflected inequalities related to food purchasing power in the study population. Almost 41% of the participants spend less than the daily cost of the Basic Food Basket[4].

[4] Combination of 34 foods which contribute to cover the minimum energy (2 262kcal) and protein needs nutritional needs, required for one household including 4.77 members [1].

3.5 Food assistance

Close to 14% of the participants had received food assistance in the last six months (**Table 7**). The most frequent food assistance reported was the Food School Programme (*Alimentación escolar*) corresponding to a food package which includes 500g of vitamin-A fortified sugar, 500g of pasta, five plantains and 500g of *Incaparina*© for each child over 3 years of age enrolled in school (Details of the package provided by one participant).

Almost half of the participants (48%) reported having consumed *Incaparina*©, a fortified food, the previous day (**Table 7**). *Incaparina* was developed by the Institute of Nutrition of Central America and Panama (INCAP) to prevent malnutrition for children and adults, including pregnant and lactating women. *Incaparina* is a mix of fortified flours (corn and soy) which high energetic density and which contains vitamins and minerals (vitamins A, B_2, and D, zinc, and calcium) and proteins with high bioavailability [38].

5. The group diversity score

Table 11 shows dietary diversity indicators that are calculated based on the criteria of the MDD-W tool. The mean *group diversity score* was 91.9% (n=79), according to the guidelines meaning that almost "*92% of participants achieved minimum dietary diversity, and they are more likely to have higher (more adequate) micronutrient intakes than the 8% (n=7) of participants who did not*". The mean number of food groups consumed by the sample was 7.6.

Table 10: Dietary diversity indicators

	n=86
Participants consuming ≥5 FG	79
Group diversity score, %	91.9%
Number of FG consumed, mean (SD)	7.6 (2.0)
Number of FG consumed, median (min;max)	8 (2;10)

6. Piloting the MDD-W

This field study enabled the team to pilot the MDD-W tool using the list-based method assisted with pictures on a sample of 86 indigenous women living in San Pablo la Laguna, in the Lake Atitlán area, Guatemala. The data collection allowed to test the local adaptation of the tool, measure the importance and impact of the language barrier, and estimate the usefulness of the pictures as an aid. From the data collected, the research team could draw conclusions regarding the dietary patterns. Food selected for the local adaption seemed to fit the diet for the season (dry season). Indeed, participants showed excellent cooperation attitudes and did not manifest uncertainty as food and picture were enumerated, except for the processed meat (chorizo) which was rarely consumed in the study population. Regarding the language barriers, the team reported that a significant part of the participants did not speak sufficient Spanish or did not feel comfortable enough to answer the questionnaire in Spanish and asked for support in translation to Tz'utujil. Finally, using the pictures during interviews was found to be very useful to support visually each enumerated questions, facilitating the comprehension of the questionnaire.

DISCUSSION

This thesis presents a pilot field study aiming to describe dietary patterns and food diversity in Maya women who previously participated in the Lake Atitlán Respiratory Health Study. Based on the MDD-W standardized tool from the FAO using the list-based method assisted with pictures, this study generates valuable data to describe dietary patterns, and provides other diet-related data to gain a better understanding of the perception of foods and nutrition in the study population. Moreover, to the extent of knowledge, this study is the first conducted among Tz'utujil Maya women living around the Lake Atitlán, a difficult-to-reach population, using this standardized tool. Finally, the methodology and the field experience generated during this pilot study will feed the development of a larger study, part of the Lake Atitlán Respiratory Health Study planned for 2024.

From a sample frame of 95 households included in the previous pilot study on respiratory health, 147 women aged 18 to 49 years were identified, and 86 of them were included as participants in the current study. Participants were on average 34 years of age, living in a household including on average 4.5 members, and in charge of 1.6 children under 13 years of age. Half of the participants were married, one-third were single or single mothers, and 50% of them had no education. Almost 80% of them reported weaving as their main income-generating activity, and almost one quarter mentioned that weaving was the main source of income of the household. The mean weekly income was Q280 ($40.1), ranging from Q28 ($4) to Q1000 ($142.9), and almost 40% of them are living under the national poverty line. Anthropometric measurements revealed that the mean height was 144cm and almost 30% were considered short in stature according to WHO's definition. The mean BMI of the sample was 30, and nearly 78% of the participants were either overweight or obese. Close to 42% of the participants had a waist circumference over the cut-off of 83.5cm and 84% of them had a waist-for-height ratio over 0.5.

Dietary patterns were characterized by a traditional plant-based diet with a rare intake of meat, and an important consumption of unhealthy food such as sweetened beverages and foods. Diet composition was described according to how common the food was consumed: very common (reported by more than 75% of the participants), common (reported by 75% to 50% of the participants), and less common (reported by less than 50% of the participants). In the study population, practically all the participants reported consuming starchy food during the last 24 hours, more specifically 97% had consumed grains, and 90% pulses. Vegetables (88%), including dark green leafy vegetables (78%), and fruits (79%) counted as very common foods. Regarding animal-origin products, eggs (94%) and fish (53%) were the most consumed in the last 24 hours. Other animal-products such as red meat (20%), poultry (30%) and processed meat (6%) were less common, as well as dairy products (49%) and nuts and seeds (48%). Regarding unhealthy food habits, sweetened coffee (85%) was very common, and street food (69%), sweet food (66%) and other sweet beverages (50%) were common in the study population. Almost 92% of the participants spend less than the cost of a Basic Food Basket, and the daily mean food budget was almost twice as lower as the cost of the basket. Noteworthy, around 50% of the participants had reported consumption of fortified food (Incaparina). Finally, the main outcome of MDD-W tool is the group diversity score which was surprisingly high regarding the socio-economic conditions, where 92% of the participants achieved the minimum dietary diversity.

Piloting the local adaptation of the MDD-W tool using the list-based method provided valuable data on dietary patterns and food diversity among this particular population. The research team reported that using pictures' assistance was useful given the language barrier.

1. Comments on the results

1.1 Characteristics of the participants

1.1.1 Estimating weekly income

The weekly income of the participant's household might be biased by imprecision of the questions leading to possible underestimation. To assess the economic status of the household of each participant, the research team asked the following question: *How much do you earn in a week or month approximately?* (*¿Cuánto dinero gana en total al semana o al mes aproximadamente?*) This was followed by the question asking whether weaving was the main occupation of the participant, giving space for confusion about the income generated by weaving only or by the household including income earned by the participants and her husband. This confusion was identified by the field workers during the first days of data collection and quickly corrected by specifying household's weekly income (*How much do you earn in a week or month approximately in your household? - ¿Cuánto dinero gana en total al semana o al mes aproximadamente en su hogar?*). Despite the early correction, it is possible that a part of the participants reported only their own income missing the part earned by their husbands, in this case they had one. However, results showed almost 60% of the participants were married, the husband's contribution to the household's income was then important.

1.1.2 The burden of poverty and inequalities

From the last survey ENCOVI in 2014, the national poverty line was established to Q10 218 per year, which represents approximately Q213 per week (30.4$) [39]. In the sample, the mean weekly income was Q280 corresponding to approximately $40.1. However, based on data collected 40.7% (n=71) of the participants included in the sample reported weekly income less than Q213 per week placing them under the national poverty line. These results showed that the mean was boosted by the highest income (median income value Q250), and that an important part of the participants lived in poor living conditions. Furthermore, the range between the lowest value (Q28; $4) and the highest (Q1000; $142.9) was notably broad reflecting important inequalities even in a relatively small sample.

1.2 Anthropometric status

1.2.1 Mayan women were short

The mean height of the sample was 144.8cm which was under the mean national height was 149.39cm in 1996. Results were similar to the results of a cross-sectional study performed in 2016 among rural women living in the department of Sololá (mean height was 145cm) [40], suggesting than women living in the department of Sololá were short. One of the reasons to explain this difference in height for women living in Sololá is ethnic origins, where 96% of the population of the department of Sololá is Maya. A study compared the height of indigenous and non-indigenous women showing that indigenous women were 3.2cm shorter [23]. As mentioned before, the indigenous communities suffer from strong inequalities reflected in nutrition, location, and living conditions.

Access to healthy diet covering key nutrients, particularly during childhood, is fundamental for optimal growth. Among the important nutrient, proteins intake is determinant to provide essential amino acids required for plenty metabolic functions including growth. However, insufficient proteins intakes and/or proteins quality can lead to growth impairment.

Protein quality is not equal if the source is from plants or animals. Studies showed that the animal protein's quality in term of amino-acids and micronutrient compositions (iron, zinc and, vitamin B_{12}), and bioavailability is higher than plant proteins [41]. The location of Guatemala plays a role in determining people's height. A study showed that the height in women was reduced with the altitude which challenge the access to fields and public services [42]. Moreover, access to fresh products such as meat is limited in rural and remote areas, due to poor road infrastructures and preservation challenges [26]. However, a large part of the indigenous population is living in the highlands of Guatemala as shown on the map on **Appendix 10**.

1.2.2 Excess of weight

The mean BMI was 30.1 in the sample, 29% of the participants were overweight and 49% were obese suggesting an excess of weight. The waist circumference revealed that 42% of them were above the cut-off of 83.5, and 84% have a waist-for-height ratio above 0.5. These findings showed that a large part of the participant have excess of weight located in the abdominal region exposing participants to a higher risk for cardio-metabolic diseases. These results were aligned with another study among Tz'utujil women living in Santiago Atitlán (located by the Lake, as well) which showed that 47% of the participants were either overweight or obese. Authors have found a significant association between BMI and higher income, more frequent food shopping, and being married. From their field experience, authors noted that women were more concerned about food security, especially for children, rather about than their own weight, and that food quantity was more important than food diversity. This perception was also experienced by investigators of this current study. Moreover, the same study highlighted that the behavior of buying processed food in local shops was driven by the long distance to the market and the socioeconomic influence of the husband [43].

1.3 Dietary indicators

1.3.1 Traditional diet

Based on diet composition, the participants seemed to have a diet similar to the traditional diet described in several studies. As mentioned, traditional diet is based on high consumption of grains (tortilla), pulses, eggs and coffee, and very low consumption of red meat. Most of the participants have consumed grains (97%), eggs (94%), pulses (90%), sweetened coffee (88%), and low meat intake (20%) the last 24 hours. These findings are aligned with the diet of Tz'utujil Mayan women living in Santiago Atitlán where the main source of energy came from tortilla (grains), black beans and sugar [31]

1.3.1 Healthy dietary habits

The diet composition indicated that the consumption of fruits and vegetables was very common in the sample (other vegetables (88%), dark green leafy vegetables (78%), other fruits (79%), and vitamin-A rich food (71%)). Diets including a large variety of fruits and vegetables are beneficial for health by providing various healthy nutrients such as anti-oxidants, vitamins, minerals, and fibers [44]. Studies showed a positive effect of high fiber consumption to prevent and treat obesity [45]. The food group 7: *dark green leafy vegetables* includes sources of vitamin-A and folate, which can induce positive outcomes during pregnancy and birth, and reduces the risk of all-cause mortality and chronic diseases [46]. *Hierba mora* was the food the most reported in the *dark green leafy vegetables* group, which is a wild-growth green, picked up in the forest and sell at local markets. It is considered as very affordable food.

Finally, the group 8: *vitamin A-rich food* is a source of vitamin A, C, and folate. Vitamin A strengthens the immune system and is involved in reproduction and growth [47]. Results suggested that participants had access to fruits and vegetables which are part of their diet. These positive habits need to be encouraged.

1.3.2 Importance of the meat group

The Group 5: *meat* embraces: organ meat (1), red flesh meat (2), poultry (3), processed meat (4), and fish and seafood (5). Results showed that the group meat as a whole was consumed by 74% of the participants the day before. When the group was further divided in types of meat, fish was the most reported (53%), followed by poultry (30%), red meat (20%), and processed meat (5%). Fish was common in the sample due to the close location to the Lake, and processed meat (chorizo) was uncommon for the participants. Meat group needs a particular focus, because these foods provide high bioavailability proteins, essential amino-acids, minerals (iron and zinc) and vitamins (vitamin B_{12}). As mentioned before, proteins intake is fundamental to ensure optimal growth, and body's functions, and nutrient deficiencies in iron, zinc, and vitamin B_{12} could lead to severe health outcomes (e.g., growth impairment, immune system deficiencies, and anaemia, and are fundamental during pregnancy, childhood, and adolescence windows).

However, several studies reported that those key nutrients need particular attention in Guatemala, particularly among the most vulnerable households (poor, rural, and/or indigenous). Nutritional recommendations suggest that proteins intakes should represent 10 to 15% of the total energy intake in a day [25]. However, in vulnerable households, the protein intake is ensured by high consumption of grains and pulses [34], and proteins from animal origin represent only 9% of the energy intake in rural participants compare to 14% in the urban sample [28]. One study analyzed Guatemala's nutritional situation, focusing on indigenous households; this study reported that one-third of the indigenous household did not meet at least 70% of the nutritional recommendations for iron, and 40% of both indigenous and non-indigenous households did not meet recommendations for zinc [34]. Finally, vitamin B_{12} represents the nutrient with the highest inadequate intake compared to other micronutrients across socio-economic levels [30].

One of the main reasons for the low consumption of animal products, particularly poultry (30%) and red meat (20%), is affordability. These products are considered expensive, and their consumption is correlated with the economic level. Studies showed that the protein intake came mostly from high consumption of beans in poor households [34], which was similar to results in the sample, where pulses consumption was common (90%). Pulses consist of a significant source of proteins especially when animal products are unaffordable. One study assessed the impact of income and food price fluctuations on nutrient intakes among poor and rich households. Vitamin B_{12} is a key nutrient contained only in animal products, which can be used as a tracker to estimate animal product consumption. In this study, the poorest households tended to improve their nutrient intake when incomes were increased. However, when food prices were increasing, households reduced their food expenditure primarily on animal products, and thus, vitamin B_{12} intake dropped down. Moreover, rural areas seemed to be more affected by food price fluctuations than urban ones [30]. Based on the field experience, the participants have also reported a rise of meat prices since the Covid-19 pandemic, worsening the situation. Furthermore, access to fresh products such as meat is limited in rural areas and indigenous communities, due to poor road infrastructures and preservation challenges [26].

1.3.3 Importance of sugar consumption

From the findings, sugar-rich food and beverages were common among participants (sweetened coffee was consumed by 85% of the participants, sweet food by 66%, and other sweetened beverages by 50%). Plenty of studies had provided strong evidence of the association between added sugar in food and beverages and the risk if obesity, diabetes, and cardiovascular diseases [48]. Nutritional recommendations suggest to limiting sugar consumption to 10% of the total energy intake in a day. One study showed that sugar intake represented 13% of the energy intake for rural Guatemala against 11% in urban areas [28]. Another research reported that high consumption of sugar was associated with low incomes and unhealthy food habits of adding sugar to traditional beverages (*atoles*[5], coffee and infusion) in a group of non-pregnant, pregnant, and lactating rural women [40]. Noteworthy, the Guatemalan government had implemented nutritional fortification programmes among staple food, and table sugar is fortified in vitamin A.

1.3.4 Affordability of food

In January 2023, the daily cost of the Basic Food Basket in Guatemala was Q109.63 (15.66$) [1], which was almost two times higher than the mean daily food budget in the study population. Furthermore, 94.2% of the participants spent less than the cost of a Basic Food Basket, and a high proportion of them was living under the poverty line, suggesting a low economic status that challenges them to afford a healthy diet.

One study estimating the cost of a healthy diet (which covers 90-104% of nutritional needs) for a mother and her infant represented 69% of the annual income of an extremely poor household [40]. Another study showed that apart from affordability, accessibility of food, particularly fresh food such as meat in remote areas, seasonality, and cultural beliefs regarding food are reasons to explain why women could not meet a healthy diet [49].

1.3.5 Unexpected *group diversity score*

The *group diversity score* for the sample of 86 Maya women showed that 92% of the participants achieved minimum dietary diversity, and thus, were more likely to cover micronutrient adequacy. However, this result was unexpectedly high when considering the low socio-economic status and ethnicity of the participants. Three other studies measuring food diversity among women in Guatemala have been identified. The first one was conducted in 2015 focusing on the nutrition of 155 Maya pregnant and post-partum women (belonging to the Mam indigenous community) and found that the *group diversity score* was 17.23%. The second study took place in 2018 among 2 076 rural adolescent girls living in the region of East Guatemala (Oriente Guatemala) and found a score of 57.2%. The last study estimated a score of 10% for 50 pregnant women living in Quetzaltenango. These three studies enable the research team to compare the results to the findings of this current study, indicating a very high diversity score suggesting a possible overestimation. Several reasons have been identified that may justify this potential overestimation:

[5] Traditional beverage from Central America made with corn and milk.

1. Misunderstanding of the recall period (last 24 hours). This misunderstanding could be due to the structure of the interview. As mentioned previously, interviews included three questionnaires, by order, the baseline, the food security (HFIAS), and finally the dietary diversity (MDD-W) questionnaire. The HFIAS and MDD-W have two different periods of recall, one with one month of recall, and the other with 24 hours, which could have confused the participants. Thus, they may have reported what they usually consume in a month rather than food consumed the previous day.
2. Language barrier and interpreter bias. The translator had not been trained for the interviews as the proportion of non-Spanish participants was underestimated. Moreover, fieldworkers were not able grade the authenticity of the translation and the correct understanding of the period of recall by the interpreter.
3. Response bias due to social desirability bias which occurs when participants provide answers that they believe will match social norms and beliefs. In nutritional studies, the social desirability bias is important and participants may drive their answers in a way to show healthy food habits [50]. The social desirability bias may also concern unhealthy food in the Guatemalan context. Indeed, consuming processed food, especially soft drinks may be associated with a social status distinction in a society where coffee is part of traditions and where overweight and obesity are perceived as belonging to a higher socio-economic status [31]. Moreover, social desirability bias might be induced by the fact that two interviews were carried out at the same time and participants were relatively closed to each other, potentially influencing their answers.
4. Participants reported consumption of some food without considering the quantity. The MDD-W guidelines state that to be nutritionally significant and reported as a *yes* answer in the questionnaire, each food must be consumed in at least 15 grams per day. However, in practice, it was almost impossible for the participants to estimate all the quantities eaten in a day combined with pictures which not explicitly showed the minimal quantity required for each food. As a result, foods that seemed to be highly consumed by the participants may, in reality, be consumed in small quantities. A study examined this effect in Guatemalan households and, as an example, 90% of them reported having consumed eggs the previous day. However, when authors investigated quantities, only 35g of eggs were eaten daily, which represented half of an egg [25].

2. Comments on the methods

2.2 Representativeness of the sample

The study population was defined as Maya people living around the Lake Atitlán, women from local weaver's organizations were targeted, and finally, 86 participants were sampled in the village of San Pablo la Laguna. The sample size enabled to give a good understanding of the dietary patterns and food diversity of the Maya women aged in 18-49 living in this small village (7 299 inhabitants in 2018), consequently, it was representative of the Maya Tz'utujil group living around the Lake. However, findings cannot be generalizable to other Maya communities of Guatemala due to strong disparities in terms of social and cultural conditions in these communities. For example, three linguistic Mayan populations are in the department of Sololá. The K'iche' language is spoken by 44% of the indigenous people in Sololá, 39% speak Kaqchikel, and only 16% speak Tz'utujil [18]. The Tz'utujil community represents then a small part of the linguistic Mayan mosaic in the region of Sololá, and results cannot be extended to other local communities.

2.3 Recruitment of participants

The recruitment procedure relied on the only community leader involved in this study, who knew the participants and was able to reach them. Based on the sample frame of the previous Lake Atitlán Respiratory Health Pilot Study, 147 women meeting the inclusion criteria were identified and communicated to the community leader, who was in charge of inviting them through home visits. This method of recruitment was slow regarding the limited time dedicated to the fieldwork, and represented a heavy duty for only one community leader who had to go physically to participants' houses regardless of their location in the village. Furthermore, this method led to a certain opacity to the field workers on participants truly reached by the community leader. Field experience reported a gap between the number of persons invited by the community leader, and the number who finally attended and participated. This opacity was one of the reasons to justify the change in recruitment strategy, from invitations to the municipal hall to home visits by the whole team. Noteworthy, the community leader did not report the persons who were not able to be contacted (mainly for reasons such as decease or emigration) and the persons who did not wish to participate.

2.4 Exclusion criteria

One of the exclusion criteria defined by the MDD-W guideline was people living with health conditions that require a specific diet, such as diabetes. However, given the high prevalence of overweight and obesity in this population, and the evidence regarding the limited health care services, the research team suspected an underestimation of participants with diet-related conditions such as diabetes. Furthermore, regarding the low socio-economic status of the participants, there might be a widespread lack of knowledge of the health status due to the economic burden that the diagnosis and treatment could represent to them. The underestimation of diabetes, in addition, would not affect the current study because participants would keep their food habits if they do not know their diagnosis.

2.5 Interviews procedures

2.5.1 Translation

The language barrier has been identified as one of the main challenges of this study. The research team underestimated the proportion of participants who did not speak Spanish on a sufficient level to be able to perform the interviews. The interview procedures had been designed in a way to conduct nutritional and chemical exposure surveys at the same time, with a rotating system of participants between stations (three participants being interviewed at the same time). However, translations were performed by the only community leader involved in the project. As a result, according to the daily attendance flow, interview procedures were slowed down, participants who did not speak Spanish were asked to wait longer, and the burden was increased for the community leader.

2.5.2 Impreciseness of anthropometric measurements

The switch from invitations to the municipal hall to home visits led to a certain degree of impreciseness in the anthropometric measurements. Indeed, during data collection at the municipal hall, conditions for measurement were standardized, where the stadiometer was placed on a fixed point and the scale on a flat floor. During the home visits, however, measurement settings changed at each visited house, leading to random errors in measurements.

Moreover, participants kept their clothes on during measurements leading to potential impreciseness in waist circumference measurements even after adjustments. Investigators suspected an underestimation of the waist circumference because participants tied their belts differently, leading to variation in the reduction of waist circumference.

2.6 The MDD-W list-based questionnaire

2.6.1 Relevance of using pictures

Regarding the important proportion of participants who did not speak Spanish as their first language and the importance of the illiteracy rate (50% of participants had no education), the research team believed that the use of pictures to assist the questionnaire was highly relevant to successfully asses The use of pictures enabled to overcome the language barrier and facilitate the comprehension of each food enumerated by adding visual support. Moreover, regarding the issue of how to classify dishes that include various foods as ingredients, the pictures also included examples of typical dishes as suggestions for ways of consuming the enumerated food.

2.6.2 Classification of food into the MDD-W's groups

The MDD-W guidelines classified foods according to their nutritional profile, however, some groups can be broad, vary significantly across regions, and participants may have different local understandings of food classification. This aspect was particularly important for the unhealthy group *street food*. The previous version of MDD-W (2016) defined this group as food containing mainly fat and simple carbohydrates, high in sodium and with a small amount of meat or vegetables. The interest of this group was to estimate the proportion of women consuming nutrient-poor and energy-dense foods [51]. In the local adaptation of the tool, this group includes fried chicken, *tamales, chuchitos,* and *paches.* However, except for fried chicken which was very uncommon in the sample (due to affordability reasons), these foods are not unhealthy and should have been classified into the group 1: *Starchy food*. For this reason, the tool has been recently updated and the term street food was removed, and authors suggested to classify "street foods" into other categories such as *fast food restaurants*, *fried and salty food* or other.

3. Strengths and limitations

Strengths

First of all, the research team managed to reach the participants known to be sceptics to outsiders, expecting to be exploited, based on an innovative community-led approach. During the previous pilot study on respiratory health and this current study, the research team has built a solid relationship with local collaborators such as leaders from weaver's organizations, and the Centre for the Study of Equity and Governance in Health Systems – Guatemala (CEGSS) who have vast experience in working with indigenous communities. As a result, the research team reported good coordination with the community leader who assisted in the validation of the tools, sampling strategy, and translations. Participants had excellent cooperative attitudes, which showed the importance of the relation built with the local collaborators who were fundamental to reach these indigenous communities.

The use of MDD-W which is a standardized tool, as well as the assistance with pictures, enabled to collect valuable data, gave more robustness to the findings, and because it has been used for years, results could be compared with other studies. Here, the assumption on the potential overestimation of the *group diversity score* came out thank to a comparison with three other studies on similar setting and populations, which strengthen that the assumption might be true.

The MDD-W needed to be adapted to the local diet as there was no pre-existing questionnaire specific to the Tz'utujil community leaving by the Lake Atitlán. MDD-W tool provides detailed guidelines for adaptation, and the research team gained knowledge to perform its adaptation to the local diet. Following the guidelines and the help of the community leader, the research team was able to develop a unique questionnaire (valid for the dry season), tested its local adaptation among 86 participants, and collected data to describe the diet composition of a group of women, representative to Tz'utujil population living by the Lake. This local adaptation of the tool may be used or serve as a basis for future dietary studies in this area.

The baseline questionnaire provided data to describe the socio-economic status of the participants which revealed large inequalities even in a small sample, in agreement with the high inequality national rate in Guatemala. Moreover, close-contact field experience in San Pablo la Laguna enabled to informally document the specific social settings to gain a better understanding of the local living conditions.

Finally, based on this community-led approach and the involvement of a community leader in the sampling strategy, the research team reported the feasibility to perform a research study among this difficult-to-reach and under-studied population living in a remote area, opening for further research in such populations as well as offering visibility to indigenous people in Guatemala.

Limitations

The responses rate was 58%, with a substantial possibility for selection bias. One challenge was the limited time and human resources available for two weeks of data collection. Indeed, only one community leader was involved in the sampling strategy, who had to walk from house to house to invite the 147 eligible participants identified from the baseline pilot study. This strategy was slow and rushed the community leader in her invitation procedure regarding the limited time dedicated to it. This led to a certain opacity in the invitation procedures and could have induced a selection bias. Indeed, the opacity may come from the fact that identified participants might have been selected by the community leader according to who she knew had participated in the previous study and where they lived in the village in terms of walking distance. Loss to follow-up of participants who emigrated or died in between the two pilot studies, constitutes another possibility for selection bias. Thus, the generalization of the results to the Maya population constituted a limitation. Indeed, regarding the large disparities within the Maya populations in terms of cultural factors, locations, living conditions and economic status, the conclusion of this study can be extended only to the Tz'utujil Maya community, specifically those living by the Lake Atitlán.

The language barrier represented a significant limitation of the study, which was underestimated by the research team when planning the study. Indeed, an important part of the participants did not speak Spanish on a sufficient level to perform the interviews, and the community leader was asked to assist the translation from Spanish and Tz'utujil. However, she has not been properly trained for this task, and the research team could not control that her understanding of the questions was correct or the authenticity of the translation, which may have induced impreciseness. The consequences of language problems were, however, limited by the successful use of pictures of foods, thus the dietary patterns observed are likely correct. Further, it will be important to take this experience from the pilot study into account when planning further research.

Cultural differences in the time understanding of time between participants and the research team was not considered during the preparation of the study. This difference in approach of time could have contributed to misunderstanding of the period of recall: 24 hours before the interview, meaning the previous day and night; such misunderstanding might have been a reason for potential overestimation of the *group diversity score*. Moreover, the different cultural approaches to time included the daily routine of participants, was not be considered when planning the details of the fieldwork and could contribute to explain loss to follow-up and irregular flows of attendants. This experience from the pilot study is useful in planning further research

Regarding the validity of the data, anthropometric measurements included some impreciseness from systematic and random errors. Noteworthy, the results of BMI and height were similar to findings of other studies among women living in the department of Sololá. Waist circumference and waist-for-height ratio could not be compared to other studies, because measurements were collected on participant's clothes, leading to possibility for impreciseness even after adjustment. In general, while there has been some imprecision in the measures, the overall conclusions on short stature and overweight/obesity seems true.

CONCLUSION

The overall aim of this study was to use the MDD-W tool to describe the dietary patterns and food diversity of indigenous women from the Tz'utujil community living by the Lake Atitlán, Guatemala. Based on the local adaptation of the tool, the research team was able to characterize that these women had a traditional plant-based diet with a high intake of grains, pulses, fruits, and vegetables. Dietary patterns showed that apart from fish, animal proteins were relatively low in the sample. However, this food is important in a healthy diet to ensure the intake of essential nutrients such as amino acids, zinc, iron, and vitamin B12. These nutrients require a special concern regarding nutrient deficiencies in Guatemala, particularly among the most vulnerable populations. In the sample, the consumption of sweetened beverages including coffee and other traditional drinks was very common, suggesting a high intake of sugar, which contributes to higher risk of NCDs. Affordability of food has been identified as one of the biggest challenges for having a healthy diet, and results showed that 94% of the participants spend less on food that the cost of a Basic Food Basket. Finally, half of the participants had consumed fortified food (Incaparina), reflecting that the region is nutritionally vulnerable and that the participants were used to those products. The *group diversity score* showed that 92% of the participants archived the minimum dietary diversity. However, these unexpected results may be overestimated, possibly due to misunderstanding of the period of recall and/or reporting of very low quantities.

Piloting the MDD-W tool using the list-based method assisted with pictures enabled to describe the dietary patterns and achieve the main objective of the thesis. The local adaption based on a list of local food seemed to fit the participant's diet during the dry season, and could be used or serve as a basis for further studies. The use of pictures was relevant to facilitate comprehension considering the importance of the language barrier, and the low education level of the participants. The research team reported the usefulness of using the MDD-W tool to describe diet composition and dietary patterns at a group level. This tool, however, was apparently not useful in this population to assess food diversity through the *group diversity score.*

The research was able to describe poor social conditions, where half of the participants had no education and 41% were living under the poverty line. Moreover, important economic disparities have been identified even in a relatively small sample in a population expected relatively homogenous (indigenous Maya weaver living in the same village). Finally, the anthropometric analysis showed weight excess, in particular excess of body fat located in the abdominal area, contributing to higher risk of NCDs.

Finally, this pilot study provided new knowledge on nutrition and dietary patterns in an indigenous Maya population, and contributed to gain a better understanding of this Tz'utujil community. The study informed on the feasibility to perform a research study among women of this difficult-to-reach population, and generated valuable field experience to identify strength and limitation of the strategy, which will be considered during the development of the larger-scale study planned in 2024. The experience with the MDD-W tool in this population is valuable, as the use of standardized tools is fundamental to provide evidence for future policies dedicated to improving women's diet and health.

RECOMMENDATIONS

Based on the findings, the research team recommends encouraging the current healthy food habits such as the consumption of fruits and vegetables, promoting and supporting the consumption of red meat considering affordability issues, and advice on unhealthy habits, especially on the consumption of sweetened beverages. One of the advantages of using the MDD-W tool was that it not relied on food quantities difficult to assess and conduct in LMICs. However, the analysis of the food situation in Guatemala showed a gap between the food reported to be consumed and the quantities truly consumed by participants. Results suggested a high food diversity, but the quantities consumed may imply a lower nutritional status. For further nutritional studies among this population, the research team recommends considering the investigation of quantities. Noteworthy, these quantitative studies will require more time, skilled fieldworkers, and funds to be performed.

This pilot study showed the necessity to involve community leaders in the sampling strategy to reach the participants. The research team emphasizes the necessity to consider the language barrier which requires recruiting trained interpreters, and grant the cultural aspects related to conception of time in this community.

CONFLICT OF INTEREST AND FUNDINGS

This master thesis was funded and supported by the Centre of International Health in Bergen, which provided small funds for master studies.

The research team declares that it has no conflicts of interest.

REFERENCES

[1] "Canasta Básica Alimentaria (CBA) Canasta Ampliada (CA), enero 2023," Instituto Nacional Estadisticas, 2023. [Online]. Available: https://www.ine.gob.gt/sistema/uploads/2023/02/07/20230207191955Y1KZ2HK3GnWnOvCP6lkZunmf8PiHYFSH.pdf

[2] A. Sanchez-Villegas and E. Martinez-Lapiscina, "The Prevention of Cardiovascular Disease Through the Mediterranean Diet," 2018. https://www.sciencedirect.com/topics/medicine-and-dentistry/dietary-pattern (accessed Mar. 29, 2023).

[3] Ministerio de Educación and Guatemala, "Guatemala, un País con Diversidad Étnica, Cultural y Lingüística," 2009. https://www.mineduc.gob.gt/digebi/mapaLinguistico.html (accessed Jan. 18, 2022).

[4] I. Castro-Quezada, B. Román-Viñas, and L. Serra-Majem, "The Mediterranean Diet and Nutritional Adequacy: A Review," *Nutrients*, vol. 6, no. 1, pp. 231–248, Jan. 2014, doi: 10.3390/nu6010231.

[5] FAO, "Minimum dietary diversity for women," Rome, Italy, 2021. [Online]. Available: https://www.fao.org/documents/card/en/c/cb3434en

[6] WHO, "Micronutrients," 2021. https://www.who.int/health-topics/micronutrients (accessed Apr. 23, 2022).

[7] WHO, "Malnutrition," 2021. https://www.who.int/news-room/fact-sheets/detail/malnutrition (accessed Mar. 17, 2022).

[8] UN, "Goal 2 | Department of Economic and Social Affairs," 2021. https://sdgs.un.org/goals/goal2 (accessed Apr. 28, 2022).

[9] I. The Lancet, "La Doble Carga de la Malnutrición," Guatemala, 2020. [Online]. Available: http://www.incap.int/index.php/es/noticias/243-serie-the-lancet-doble-carga

[10] Global Nutrition Report, "Inequalities in the global burden of malnutrition," 2020. https://globalnutritionreport.org/reports/2020-global-nutrition-report/inequalities-global-burden-malnutrition/ (accessed May 10, 2022).

[11] A. Arora, "Joint child malnutrition estimates (UNICEF-WHO-The World Bank) - 2021," *UNICEF DATA*, May 03, 2021. https://data.unicef.org/resources/jme-report-2021/ (accessed Mar. 23, 2023).

[12] Institute for Health Metrics and Evaluation, "GBD Compare | IHME Viz Hub," 2019. http://vizhub.healthdata.org/gbd-compare (accessed Mar. 17, 2022).

[13] FANTA, "Guide to anthropometry: a practical tool for program planners, managers, and implementer, modules 5: adults," 2018.

[14] Anne Hatløy, "Food security and Dietary Assessment," presented at the INTH360-Global Nutrition, 2022.

[15] E. C. for L. A. and the C. UN, "Country's demographic profile," Feb. 17, 2021. https://www.cepal.org/en/countrys-demographic-profile (accessed Jan. 16, 2022).

[16] Instituto Nacional de Estatisticas Guatemala, "Portal de Resultados del Censo 2018," 2018. https://www.censopoblacion.gt/mapas (accessed Jan. 17, 2022).

[17] UNDP, "| Human Development Reports," *United Nation Development Programme*, 2019. http://hdr.undp.org/en/countries/profiles/GTM (accessed Jan. 26, 2022).

[18] "Portal de Resultados del Censo 2018: Cuadro A6 - Población maya por comunidad lingüística," 2014. https://www.censopoblacion.gt/explorador (accessed Apr. 24, 2023).

[19] "Guatemala - IWGIA - International Work Group for Indigenous Affairs." https://www.iwgia.org/en/guatemala.html (accessed Apr. 13, 2022).

[20] PAHO, "Health in the America, 2012, Edition Country Volume: Guatemala," 2012. [Online]. Available: https://www3.paho.org/salud-en-las-americas-2012/index.php?option=com_docman&view=download&category_slug=hia-2012-country-chapters-22&alias=132-guatemala-132&Itemid=231&lang=en

[21] PAHO, “Health in the Americas+, 2017 Edition. Summary: Regional Outlook and Country Profiles,” 2017. [Online]. Available: https://iris.paho.org/handle/10665.2/34321
[22] “Guatemala | World Food Programme,” Apr. 26, 2023. https://www.wfp.org/countries/guatemala (accessed May 09, 2023).
[23] A Arriza, M. Hambidge, N. Krebs, A. Channon, and A. Garcés, *Un centímetro en 50 años: talla de mujeres indígenas y no indígenas en Guatemala de 1945 a 1995*. 2019. [Online]. Available: http://www.incap.int/index.php/es/publicaciones-conjuntas-con-otras-instituciones/219-un-centimetro-en-50-anos-talla-de-mujeres-indigenas-y-no-indigenas-en-guatemala-de-1945-a-1995/file
[24] M. Mazariegos, C. Martínez, H. Mendez, A. V. Roman, M. Palmieri, and V. Tomás, “Análisis de la situación y tendencias de los micronutrientes clave en Guatemala, con un llamado a la acción desde las políticas públicas,” INCAP, 2016.
[25] Méndez and Lopez, “Tendencias de la situación alimentaria en Guatemala: análisis secundario de los datos de las Encuestas de Condiciones de Vida (ENCOVI) de Guatemala de los años 2006 y 2014 en el informe Tendencias de la Situación Alimentaria en Guatemala.,” 2022. http://www.incap.int/index.php/es/publicaciones-destacadas/473-tendencias-de-la-situacion-alimentaria-en-guatemala (accessed Dec. 11, 2022).
[26] “Cerrando la Brecha de Nutrientes Guatemala,” WFP, 2018.
[27] A.-L. Mayén *et al.*, “Socioeconomic predictors of dietary patterns among Guatemalan adults,” *Int J Public Health*, vol. 61, no. 9, pp. 1069–1077, Dec. 2016, doi: 10.1007/s00038-016-0863-3.
[28] M. T. Menchú and H. Mendez, “Estudio Complementario al Análisis Secundario de los Datos de la Encuesta Nacional de Condiciones de Vida de Guatemala: Referencia para diseñar intervenciones específicas de micronutrientes,” 2013. http://www.incap.int/sisvan/index.php/es/acciones-estrategicas/547-estudio-complementario-al-analisis-secundario-de-los-datos-de-la-encuesta-nacional-de-condiciones-de-vida-de-guatemala-referencia-para-disenar-intervenciones-especificas-de-micronutrientes (accessed Dec. 11, 2022).
[29] M. Vossenaar, N. W. Solomons, R. Valdés-Ramos, and A. S. Anderson, “Concordance with dietary and lifestyle population goals for cancer prevention in Dutch, Scottish, Mexican, and Guatemalan population samples,” *Nutrition*, vol. 26, no. 1, pp. 40–52, Jan. 2010, doi: 10.1016/j.nut.2009.04.007.
[30] L. L. Iannotti, M. Robles, H. Pachón, and C. Chiarella, “Food prices and poverty negatively affect micronutrient intakes in Guatemala,” *J Nutr*, vol. 142, no. 8, pp. 1568–1576, Aug. 2012, doi: 10.3945/jn.111.157321.
[31] J. M. Nagata, F. K. Barg, C. R. Valeggia, and K. D. W. Bream, “Coca-colonization and hybridization of diets among the Tz’utujil Maya,” *Ecol Food Nutr*, vol. 50, no. 4, pp. 297–318, 2011, doi: 10.1080/03670244.2011.568911.
[32] A. Asfaw, “Does consumption of processed foods explain disparities in the body weight of individuals? The case of Guatemala,” *Health Econ*, vol. 20, no. 2, pp. 184–195, Feb. 2011, doi: 10.1002/hec.1579.
[33] J. P. Lopez Cervantes, “Asthma, respiratory symptoms and lung function across age groups in an indigenous Mayan population in Guatemala, and relation to work in the traditional textile industry: a cross-sectional pilot study,” University of Bergen, 2022.
[34] T. Menchú and H. Méndez, “Análisis de la situación nutricional alimentaria en Guatemala,” INCAP, Guatemala, 2011.
[35] “A healthy lifestyle - WHO recommendations.” https://www.who.int/europe/news-room/fact-sheets/item/a-healthy-lifestyle---who-recommendations (accessed Apr. 06, 2023).
[36] E.-G. Yoo, “Waist-to-height ratio as a screening tool for obesity and cardiometabolic risk,” *Korean J Pediatr*, vol. 59, no. 11, pp. 425–431, Nov. 2016, doi: 10.3345/kjp.2016.59.11.425.
[37] “KoboToolbox,” *KoboToolbox*. https://www.kobotoolbox.org/ (accessed Apr. 03, 2023).
[38] “Incaparina.” https://www.incaparina.com/formula.php (accessed Apr. 11, 2023).

[39] “Republica de Guatemala. Encuesta Nacional de Conditiones de Vida 2014, principales resultados,” Instituto Nacional de Estadística, 2015. [Online]. Available: https://www.ine.gob.gt/sistema/uploads/2015/12/11/vjnvdb4izswoj0ztuivpicaaxet8lzqz.pdf
[40] “Brechas Nutricionales en los Niños y Niñas de 6 a 23 Meses y sus Madres,” INCAP, 2016.
[41] M. Roser, C. Appel, and H. Ritchie, “Human Height,” *Our World in Data*, Oct. 2013, Accessed: Apr. 25, 2023. [Online]. Available: https://ourworldindata.org/human-height
[42] A. R. Pebley and N. Goldman, “Social Inequality and Children’s Growth in Guatemala,” RAND Corporation, Jan. 1994. Accessed: Apr. 25, 2023. [Online]. Available: https://www.rand.org/pubs/drafts/DRU760.html
[43] J. M. Nagata, C. R. Valeggia, F. K. Barg, and K. D. W. Bream, “Body mass index, socio-economic status and socio-behavioral practices among Tz’utujil Maya women,” *Economics & Human Biology*, vol. 7, no. 1, pp. 96–106, Mar. 2009, doi: 10.1016/j.ehb.2009.02.002.
[44] J. L. Slavin and B. Lloyd, “Health Benefits of Fruits and Vegetables1,” *Adv Nutr*, vol. 3, no. 4, pp. 506–516, Jul. 2012, doi: 10.3945/an.112.002154.
[45] M. Dayib, J. Larson, and J. Slavin, “Dietary fibers reduce obesity-related disorders: mechanisms of action,” *Curr Opin Clin Nutr Metab Care*, vol. 23, no. 6, pp. 445–450, Nov. 2020, doi: 10.1097/MCO.0000000000000696.
[46] Y. Bo *et al.*, “Association Between Folate and Health Outcomes: An Umbrella Review of Meta-Analyses,” *Front Public Health*, vol. 8, p. 550753, Dec. 2020, doi: 10.3389/fpubh.2020.550753.
[47] “Office of Dietary Supplements - Vitamin A and Carotenoids.” https://ods.od.nih.gov/factsheets/VitaminA-Consumer/ (accessed May 02, 2023).
[48] J. M. Rippe and T. J. Angelopoulos, “Relationship between Added Sugars Consumption and Chronic Disease Risk Factors: Current Understanding,” *Nutrients*, vol. 8, no. 11, p. 697, Nov. 2016, doi: 10.3390/nu8110697.
[49] “Development of Evidence-Based Dietary Recommendations for Children, Pregnant Women, and Lactating Women Living in the Western Highlands in Guatemala,” FANTA, 2014.
[50] J. Hebert, L. Clemow, L. Pbert, I. Ockene, and J. Ockene, “Social Desirability Bias in Dietary Self-Report May Compromise the Validity of Dietary Intake Measures,” *International journal of epidemiology*, vol. 24, pp. 389–98, May 1995, doi: 10.1093/ije/24.2.389.
[51] “Minimun Dietary diversity for Women: A guide to measurement,” FAO, 2016. [Online]. Available: https://www.fao.org/3/i5486e/i5486e.pdf

APPENDICES

Appendix 1: List of the 10 food groups according to MDD-W classification

NB	Food group	Row	Food group sub-division	Nutrients	Example
1	Grains, white roots and tubers, and plantains	A	Food made from grains	High in carbohydrates (mainly starch) which provides energy. Contain varying amount of certain B vitamins and fibres	Bread, rice, pasta, couscous, tortilla
		B	White roots and tubers or plantains		White potatoes, cassava, taro roots, and plantains
2	Pulses	C		High in proteins and B vitamins	Beas, lentils, peas, and tofu
3	Nuts and seeds	D		Rich in unsaturated fatty acids, proteins, fibres minerals, vitamin A, and phytosterols and phenolic compounds.	Almond, chestnut, macadamia, pumpkin seeds, sunflower and seeds
4	Dairy	E	Milk	Important sources of high-quality protein, potassium and calcium, as well as vitamin B12	Milk
		F	Dairy products		Cheese and yogurt
		G	Organ meats		Heart, and liver
5	Meat, poultry and fish	H	Red flesh meat from mammals	Important sources of high-quality protein and bioavailable micronutrients, notably iron, zinc and vitamin B12	Beef, pork, and lamb
		I	Processed meat		Salami, chorizo, and ham
		J	Poultry and other white meats		Chicken, turkey, and duck
		K	Fish and seafood		Fish, shrimp, and mussels
6	Eggs	L		Source of protein and contain vitamin B12 and a range of bioavailable micronutrients	Chicken eggs
7	Dark green leafy vegetables	M		Rich in vitamin A, folate and other micronutrients	Spinach, broccoli, and cassava greens
8	Vitamin A-rich fruits and vegetables*	N	Vitamin A-rich vegetables or roots	Rich in vitamin A and C, folate and/or other micronutrients	Sweet potatoes, pumpkin, and carrots
		O	Vitamin A-rich fruit		Ripe mango, and ripe papaya
9	Other vegetables	P		Large range of bioactive compounds including phenolics, flavonoids and fibre, and other micronutrients	Cabbage, green paprika, onion, tomato, and zucchini
10	Other fruits	Q		Same as group 9	Citrus, avocado, pineapple, watermelon, grapes, and apple

Source: *MMD-W, FAO, 2021*

Food group	Row	Food group sub-division	Example
Fried and salty food	R	Packaged salty snacks	Chips, puffs, and fried plantains
	S	Deep fried foods	Fried dough, fried bread, and samosa
	T	Instant noodles	Instant noodles, and dry soup
	U	Fast food restaurant foods	Local fast food chain, and street food
Sweet food	V		Pastries, biscuits, ice cream, chocolate, sugar table, breakfast cereals
Sweet beverages	X	Sugar-sweetened beverages	Sodas and soft drinks, energy drinks, and fruit juices
	Z	Sweetened infusions	Sweetened tea and coffee

**This table refers to unhealthy food and do not count for MDD-W*

Source: MMD-W, FAO, 2021

Appendix 2: Baseline questionnaire

Getting ready form for participant's interview

Today's date:_____/_____/_____

Participant number ☐☐

1. General information

1. What is your full name ?

2. What is your date of birth? / /

3. Meeting inclusion criteria ?

Pregnant	Yes	☐	No	☐
Health condition that requires a specific diet	Yes	☐	No	☐
Responsible for food in the household	Yes	☐	No	☐

4. What is your marital status?

Single	☐
Married/relationship	☐
Divorced/separated	☐
Widow	☐
Other	☐

5. How many members does your household count, and how many of those are children ?

Number of household members (under 49 years)	☐
Number of children (under 13 years)	☐

6. What is you educational level ?

Primary incomplete	Yes	☐	No	☐
Primary complete	Yes	☐	No	☐
Secondary incomplete	Yes	☐	No	☐
Secondary complete	Yes	☐	No	☐
High school incomplete	Yes	☐	No	☐
High school complete	Yes	☐	No	☐
University	Yes	☐	No	☐

7. What is the source of income in your household?

Agriculture (husband)	☐
Weaving	☐
Remittances	☐
Other	☐

8. Is weaving your main activity

Yes ☐ No ☐

Specify if no : _____

9. How much do you earn every week approximately?

Approximate earn by the household per week (Q)	☐

Food managment

10. How much do you spend in food every day approximately?

Approximate budget allocated to food per day (Q) ☐

11. Have you received food assistance the previous mouths?

Yes ☐ No ☐

Anthropometric values

12. Anthropometric measurement

Weight (kg) ☐

Height (cm) ☐

Waist circumference (cm) ☐

Appendix 3: Extensive food list for Tz'utujil Mayan women living by the Late Atitlán, Guatemala

NB	Food group	Row	Food group sub-division	Example
1	Grains, white roots and tubers, and plantains	A	Food made from grains	Tortilla (wheat and corn), rice, bread (including *pan francès*), pasta
		B	White roots and tubers or plantains	White potatoes, cassava, taro roots, and plantains, breadfruit, jicama, yam
2	Pulses	C		Beans (all falling under *frijoles*), lentils, peas
3	Nuts and seeds	D		Almond, chestnut, macadamia, pumpkin seeds, sunflower and seeds
4	Dairy	E	Milk	Milk
		F	Dairy foods	Cheese, yogurt, milk powder, concentrated milk
		G	Organ meats	
5	Meat, poultry and fish	H	Red flesh meat from mammals	Beef (bone and boneless), pork,
		I	Processed meat	Cold meat, ham, bacon
		J	Poultry and other white meats	Chicken, turkey
		K	Fish and seafood	Fish, shrimp, seafood
6	Eggs	L		Chicken eggs
7	Dark green leafy vegetables	M		Lettuce, green beans, arugula, spinach, broccoli, cassava greens, okra greens, local greens
8	Vitamin A-rich fruits and vegetables*	N	Vitamin A-rich vegetables or roots	Sweet potatoes, pumpkin, carrots, red paprika
		O	Vitamin A-rich fruit	Ripe mango, ripe papaya, cantaloupe melon, hog plum, loquat, passion fruit, banana (yellow-orange colour)
9	Other vegetables	P		Cabbage, green paprika, onion, tomato, zucchini, cucumber, celery, fresh corn, eggplant, mushroom, okra, others local vegetables
10	Other fruits	Q		Citrus, banana (white-cream colour), avocado, pineapple, watermelon, grapes, apple, chayote, rambutan, soursop, pitaya, coconut flesh, others tropical fruits

Food group	Row	Food group sub-division	Example
Fried and salty food	R	Packaged salty snacks	Chips, puffs, and fried plantains
	S	Deep fried foods	Fried dough, fried bread, other deep fried foods
	T	Instant noodles	Instant noodles, and dry soup
	U	Fast food restaurant foods	Local fast food chain, and street food
Sweet food	V		Pastries, biscuits, ice cream, chocolate, sugar table, breakfast cereals, *pan dulce,* fruits in can with syrup
Sweet beverages	X	Sugar-sweetened beverages	Sodas and soft drinks, energy drinks, and fruit juices
	Z	Sweetened infusions	Sweetened tea and coffee

**The extensive list is not exhaustive*

Source: [34]

Appendix 4: Introduction for the food-list based questionnaire

LIST-BASED LONG INTRODUCTION

"Now I'd like to ask you some yes-or-no questions about foods and drinks that you consumed yesterday during the day or night, whether you had it at home or somewhere else.

First, I would like you to think about yesterday, from the time you woke up through the night. Think about the first thing you ate or drank after you woke up in the morning … Think about where you were when you had any food or drink in the middle of the day … Think about where you were when you had any evening meal … and any food or drink you may have had in the evening or late-night... and any other snacks or drinks you may have had between meals throughout the day or night.

I am interested in whether you had the food items I will mention even if they were combined with other foods.

Please listen to the list of foods, and if you ate or drank any one of them, say yes.

Yesterday during the day or at night, did you eat or drink:"

LIST-BASED SHORT INTRODUCTION

"Now I'd like to ask you about foods and drinks that you consumed yesterday during the day or night, whether you ate or drank it at home or somewhere else. Please think about snacks and small meals as well as main meals.

I will ask you about different foods and drinks, and would like to know whether you ate the food even if it was combined with other foods.

Yesterday during the day or at night, did you eat or drink:"

**Introductions suggested by the Minimum Dietary Diversity for Women guideline*

Source: MMD-W, FAO, 2021

Appendix 5: *Minimum Dietary Diversity-Women*: List-based method questionnaire

The last 24h (during the day/night), did you eat or drink:

1.	Tortilla, bread rice, or pasta?	Yes	□	No	□
2.	Pumpkins, red peppers, or carrots?*	Yes	□	No	□
3.	Potatoes, plantains or cassava ?	Yes	□	No	□
4.	Beans or fava beans?	Yes	□	No	□
5.	Pumpkin seeds, peanuts or sesame seeds?	Yes	□	No	□
6.	Milk, milk in powder or cheese?	Yes	□	No	□
7.	Beef or pork?	Yes	□	No	□
8.	Chicken?	Yes	□	No	□
9.	Chorizo?	Yes	□	No	□
10.	Fish or seafood ?	Yes	□	No	□
11.	Eggs?	Yes	□	No	□
12.	Hierba mora (local edible leaves), lettuce, chard or green beans ?	Yes	□	No	□
13.	Tomatoes, onions, cucumber, cabbage, chiles, fresh corn (*elote*) or guiquil?	Yes	□	No	□
14.	Ripe mangoes, ripe papayas or cantaloupe melon?**	Yes	□	No	□
15.	Apples, bananas, pineapple, citrus (lime, orange, lemon), grapes, avocado or strawberries?	Yes	□	No	□

**Tubers and vegetables rich in vitamin A come first to avoid misclassification, particularly sweet potato as white potato*

***Fruits rich in vitamin A come first to avoid misclassification as other fruits*

Yesterday during the day or at night, did you eat or drink:

16.	Vegetable oil, butter or margarine?	Yes	□	No	□
17.	Chips, crisps, fried plantains chips, puffs or others snacks?	Yes	□	No	□
18.	Rellenitos, French fries, doblada de frijoles?	Yes	□	No	□
19.	Dried soup?	Yes	□	No	□
20.	Tamales, pache, chuchitos, fried chicken?	Yes	□	No	□
21.	Pan dulces, cakes, biscuits, cereals, chocolate or sugar table?	Yes	□	No	□
22.	Frescos, soft drinks, atoll sweetened fruit juices, or chocolate?	Yes	□	No	□
23.	Sweetened coffee or tea/infusion?	Yes	□	No	□
24.	Incaparina	Yes	□	No	□

***Appendix 6**: MDD-W tool list-based method pictures*

1. ¿Tortilla, pan, arroz o pasta?

Tortilla

Pan

Arroz

Pasta

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

2. ¿Formas de calabazas, pimientos rojos, o zanahorias?

Chilacayote, guïcoy

Pimientos rojos

Zanahorias

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

3. ¿Papas, plátanos, raíz de güisquil o yuca?

Papas

Plátanos

Yuca

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

4. ¿Frijoles?

Frijoles

Habas

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

5. ¿Pepitas, manías, ajonjolí, o semillas de marañón?

Pepitas

Manies

Ajonjolí

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

6. ¿Leche, leche en polvo o quesos?

Leche

Leche en polvo

Quesos

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

7. ¿Carne de res o cerdo?

Carne de res

Ejemplos cocinados

En sopa

Churrascos

Cerdo

Ejemplos cocinados

Adobada

Chuleta

Ahumada, asado, frito

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

8. ¿Pollo?

Pollo

Ejemplos cocinados

Caldo de pollo

Pollo loroco

A la plancha

Asado

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

9. ¿Jamón, salchichas, o chorizo?

Chorizo

10. ¿Pescado o marisco?

Pescado

Ejemplos cocinados

Pescado frito

Mariscos

Ejemplos cocinados

Ceviche

Caldo de mariscos

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

11. ¿Huevos?

Huevos

12. ¿Montes, hierba mora (guilete), lechuga, acelga o ejotes?

Hierba morra

Lechuga

Acelga

Ejotes

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

13. ¿Tomates, cebollas, guïsquil, pepino, repollo, chiles (chiltepe) o , elote?

Tomate

Repollo

Cebolla

Chiles

Guisquil

Elote

Pepino

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

14. ¿Mangos, papayas, o melón?

Mango

Papaya

Melón

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

15. ¿Manzanas, bananos, piña, cítricos (naranja, limón), uvas, aguacate o fresas ?

Manzanas

Uvas

Bananos

Aguacate

Piña

Fresas

Cítricos

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

16. ¿Aceite vegetal, mantequilla, margarina, manteca de cerdo o crema?

Aceite vegetal

Mantequilla

Margarina

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

17. ¿Chips, chicharines, plátanos fritos, golosina y otros snacks saladas?

Chucherias

Chicharines

Plátaninas

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

18. ¿Tortilla frita, rellenitos, papas fritas, o doblada de frijoles?

Rellenitos

Papas fritas

Doblada de frijoles

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

20. ¿Sopas chinas?

Sopas chinas

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

19. ¿Tamales, pache, chuchitos o pollo frito?

Tamales

Pache

Chuchitos

Pollo frito

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

21. ¿Pan dulce, pastel, galletas, cereal de desayuno, chocolate o azúcar?

Pan dulce

Cereal de desayuno

Pastel

Chocolate

Galletas

Azúcar

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

22. ¿Frescos, gaseosa, jugo de frutas, bebidas de chocolate, u atol?

Frescos

Gaseosa

Atol

Jugo de fruta

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

23. ¿Té/infusión o café endulzado?

Té o café endulzado

24. ¿Incaparina?

Incaparina

Mínima Diversidad Alimentaria por la Mujeres:
Apoyo ilustrado por el cuestionario basado en la lista definida de alimentos

Appendix 7: Ethical approval from Norwegian committees

REK

REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK nord	Monika Rydland-Nymo	77620756	17.08.2022	203917

Cecilie Svanes

Prosjektsøknad: Lake Atitlan Lungehelseundersøkelse
Søknadsnummer: 203917
Forskningsansvarlig institusjon: Universitetet i Bergen

Prosjektsøknad: Endring godkjennes

Søkers beskrivelse

Studien skal kartlegge forekomst av astma og allergiske sykdommer i en befolkning i Lake Atitlan området i Guatemala, og sammenheng mellom luftveishelse/allergier og a) eksponeringer i den tradisjonelle tekstilindustrien i området, b) eksponering for desinfeksjonsmidler og rengjøringsmidler knyttet til Covid-19 pandemien, og c) foreldres yrkeseksponeringer i tekstilindustrien og andre yrker (pesticider er svært utbredt i jordbruket i området). Studien har som sekundærformål å etablere en dataressurs/biobank som kan benyttes til forskning også på andre relevante helseutfall, slik som diabetes og overvekt som er svært hyppig i denne befolkningen. Studien er utformet i samarbeid med lokale organisasjoner, blant annet organisasjoner av "veversker" - kvinnene i den tradisjonelle tekstilindustrien - og har også som formål å engasjere disse lokale organisasjonene i forskning som er ønsket fra deres samfunn.

Studien skal rekruttere 50 kvinner i tekstilindustrien og 150 kvinner i andre yrker, og deres husstander med foreldre, ektefeller og barn. Informasjon om generelle karakteristika, luftveissymptomer og helseutfall, og relevante eksponeringer, samles via standardiserte intervju. Kliniske målinger innbefatter spirometri, hudprikktest, antropometriske mål og blodtrykk, og det samles biomateriale (blod, urin, faeces).

Vi viser til søknad om prosjektendring mottatt 11.08.2022 for ovennevnte forskningsprosjekt. Søknaden er behandlet av leder for REK nord på delegert fullmakt fra komiteen, med hjemmel i forskningsetikkforskriften § 7, første ledd, tredje punktum. Søknaden er vurdert med hjemmel i helseforskningsloven § 11.

Av endringssøknaden fremgår følgende: *Preliminære funn fra studien viser at særlig kvinnene er korte og overvektige. Vi ønsker derfor å kartlegge diett hos 30 av kvinnene som har deltatt i studien. Det vil være en enkel kartlegging, arbeid for et masterprosjekt, som vil gi tilstrekkelige data til diskusjon i lokalsamfunnet, samt grunnlag for større prosjekt med mer omfattende kartlegging og eventuelt intervensjon.*
Delstudien innbefatter et kort "Getting ready intervju" med måling av høyde, vekt, midje- og hoftemål, samt et intervju med 21 spørsmål om matgrupper (begge vedlegges).
Oppdatert protokoll med merkede endringer, samtykkeskriv for delstudien og

masterprosjektets fulle "additional protocol" for substudien er vedlagt.

Det fremgår videre at masterkandidat Chloë Carpi inngår som medarbeider og leder av delstudien.

REKs vurdering
REK har ingen innvendinger til delstudien men gjør oppmerksom på studenten ikke kan lede den, det er det prosjektleder Svanes som må gjøre. Studenten kan stå som medarbeider i delstudien og gjennomføre intervjuer men det er prosjektleder som må være leder for hele prosjektet, også delstudien.

I skrivet Forespørsel om deltakelse står det i samtykkedelen følgende: «*I understand the purposes of the study and until now my questions have been answered*»

REK aksepterer ikke at man skal skrive under på at man «har forstått» eller at man «har fått svar på alle sine spørsmål» Dette må fjernes.

Med forutsetning om at ovennevnte overholdes har komiteens leder etter fullmakt fattet slikt

Vedtak

Med hjemmel i helseforskningsloven § 11 godkjennes prosjektendringen.
Før delstudien kan igangsettes må det sendes inn revidert informasjonsskriv. Skrivet sendes via prosjektmappen i REK-portalen.

Prosjektet er godkjent frem til 30.11.2024.

Av dokumentasjonshensyn skal opplysningene oppbevares i fem år etter prosjektslutt. Enhver tilgang til prosjektdataene skal da være knyttet til behovet for etterkontroll. Prosjektdata vil således ikke være tilgjengelig for prosjektet. Prosjektleder og forskningsansvarlig institusjon er ansvarlige for at opplysningene oppbevares indirekte personidentifiserbart i denne perioden, dvs. atskilt i en nøkkel- og en datafil.

Etter denne femårsperioden skal opplysningene slettes eller anonymiseres. Komiteen gjør oppmerksom på at anonymisering er mer omfattende enn kun å slette koblingsnøkkelen, jf. Datatilsynets veileder om anonymiseringsteknikker.

Vi gjør oppmerksom på at før prosjektet igangsettes må det foreligge et behandlingsgrunnlag for behandling av personopplysninger. Dette må forankres i egen institusjon.

Sluttmelding
Prosjektleder skal sende sluttmelding til REK på eget skjema via REK-portalen senest 6 måneder etter sluttdato 30.11.2024, jf. helseforskningsloven § 12. Dersom prosjektet ikke starter opp eller gjennomføres meldes dette også via skjemaet for sluttmelding.

Søknad om endring
Dersom man ønsker å foreta vesentlige endringer i formål, metode, tidsløp eller organisering må prosjektleder sende søknad om endring via portalen på eget skjema til REK, jf. helseforskningsloven § 11.

Klageadgang
Du kan klage på REKs vedtak, jf. forvaltningsloven § 28 flg. Klagen sendes på eget skjema via REK portalen. Klagefristen er tre uker fra du mottar dette brevet. Dersom REK opprettholder vedtaket, sender REK klagen videre til Den nasjonale forskningsetiske komité for medisin og helsefag (NEM) for endelig vurdering, jf. forskningsetikkloven § 10 og helseforskningsloven § 10.

Med vennlig hilsen

May Britt Rossvoll
sekretariatsleder

Monika Rydland-Nymo
rådgiver

Kopi til:

Universitetet i Bergen
Ana Lorena Ruano

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	Saksbehandler:	Telefon:	Vår dato:	Vår referanse:
REK nord	Monika Rydland-Nymo	77620756	18.08.2022	203917

Cecilie Svanes

203917 Lake Atitlan Lungehelseundersøkelse

Forskningsansvarlig: Universitetet i Bergen

Søker: Cecilie Svanes

REKs svar på generell henvendelse

Vi viser til prosjektleders svar på merknader i vedtaksbrev dater 17.08.2022 vedlagt revidert informasjons-/samtykkeskriv.

Skrivet er revidert i tråd med REKs merknad.
Delstudien kan igangsettes.

Med vennlig hilsen

Monika Rydland-Nymo
rådgiver

Vennlig hilsen
Regionale komiteer for medisinsk og helsefaglig forskningsetikk

Denne e-posten er sendt automatisk fra REK og kan ikke besvares

REK nord
Besøksadresse: MH-2, 12. etasje, UiT Norges arktiske universitet, Tromsø
Telefon:77 64 61 40 | **E-post**:rek-nord@asp.uit.no
Web:https://rekportalen.no

Appendix 8: Ethical Approval from Guatemalan committees

GOBIERNO de GUATEMALA
DR. ALEJANDRO GIAMMATTEI

MINISTERIO DE SALUD PÚBLICA Y ASISTENCIA SOCIAL

Guatemala 05 de octubre de 2022
CNES-ADQ-025-2022

Doctora
Cecilie Svanes
Investigadora Principal
Estudio No. 29-2020

Respetada Dra. Svanes.

Por este medio enviamos el dictamen de aprobado del sub-estudio de diversidad alimentaria del protocolo "Estudio de Salud Pulmonar Lago Atitlán" (Lake Atitlan Lung Health Study, en inglés).

Adicionalmente, se hacen las siguientes recomendaciones para consideración de los investigadores:

1. En el consentimiento informado, sección 5. Beneficios a su participación, cambiar la frase "... y así poder dar una base para mejorar la alimentación personal..." a "... y así poder dar información que sirva de base para diseñar estrategias para mejorar la alimentación..."

2. Si en caso la diversidad nutricional no es adecuada, recomendar a las autoridades de salud local y comunitarias:

- Evaluación por especialista (Nutricionista)
- Tratamiento médico o nutricional completo y su seguimiento, si el caso lo amerita.
- Capacitación sobre hábitos alimenticios saludables de forma personal y por curso de vida, con énfasis en la niñez y adolescencia.
- Recomendar la ingesta de agua como un hábito saludable.
- Capacitar sobre los métodos de preparación y cocción más saludable de los alimentos. con énfasis en la niñez y adolescencia.
- Recomendar la ingesta de agua como un hábito saludable.
- Capacitar sobre los métodos de preparación y cocción más saludable de los alimentos.
- Capacitación sobre guías de actividad física, necesarios como un hábito esencial para la salud
- Propiciar proyectos con autoridades y líderes locales, para la implementación de espacios adecuados al aire libre, donde se instalen equipos para ejercitarse.

Atentamente

MSc. Renata Mendizabal de Cabrera
Presidente
Comité Nacional de Ética en Salud

COMITE NACIONAL DE ÉTICA EN SALUD Guatemala, C. A.

Dr. Jorge Cifuentes Morales
Secretario
Comité Nacional de Ética en Salud

CC: Archivo
Rmc/jcm/adqg

Trabajando por la salud de Guatemala

Ministerio de Salud Pública y Asistencia social
6 Avenida 3-45 zona 11 Teléfono: 2444-7474
www.mspas.gob.gt

Appendix 9: Informed consent form

University of Bergen
Consent to be part of the sub-study on dietary diversity
Dedicated to participants older than 18-year-old

1. Key information:

Title: Description of the dietary diversity of a group of Mayan women, a sub-study of the Lake Atitlán Respiratory Health Study.
Main investigator: Professor Cecilie Svanes, Department of Global Public Health and Primary care and Centre for International Health University of Bergen
Co-investigators: Associate Professor Ana Lorena Ruano, Department of Global Public Health and Primary care, Centre for International Health, University of Bergen; Mónica Mazariegos, Institute of Nutrition of Central America and Panama; PhD candidate Juan Pablo López Cervantes, Department of Global Public Health and Primary Care, and Centre for International Health, University of Bergen; Master student Chloë Carpi, Centre for International Health University of Bergen; Master student Rafael Duran, Centre for International Health University of Bergen

You are invited to take part in a research sub-study of the Lake Atitlán Respiratory Health Study. The following document includes information about the objective and the proceeding of the study, the risks and benefits related to your participation, the respect to your confidentiality, and the protection of your data. This will help you to decide whether you want to participate or not in this study.

2. The objective of the study:

The objective of this sub-study is to investigate the dietary diversity of Mayan women in Guatemala who previously participated in the Lake Atitlán Respiratory Health Study (July 2021), using a questionnaire which includes a part dedicated to food security using the Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access, and another part dedicated to food diversity using the standardized tool the *Minimum Dietary Diversity for Women* (MDD-W).

3. The study-procedures:

If you give your consent to participate to this study, you will be asked to answer two short interviewer-led questionnaires performed in Spanish or in Tz'utujil and Kaqchikel when necessary. Interviewers will be the co-investigators Chloë Carpi and Rafael Duran, master students from the University of Bergen.

First, you will be asked about general personal information such as age, marital status, educational level, and occupation. This will take **approximately 10 minutes.**

Second, you will be asked 9 questions about food security which will take **approximately 10 minutes.** Additionally, you will be asked 24 questions with yes/no answers about what you ate during the last 24 hours including food, beverages and snacks consumed at home or somewhere else. This questionnaire will last **approximately 30 minutes** and will be assisted with pictures to facilitate the comprehension

Finally, measurements of your weight, height, waist hip circumferences will be collected using a flat scale, a portable stadiometer and a tape. This first part will take **approximately 5 minutes.**

In total, the interview and the measurement will not take more than **35 minutes.**

4. The potential risks:

This study is considered a low-risk activity for the participant, justified by the reasons below:

- Data are collected through a **non-invasive process**. Two short questionnaires will be conducted, and participants are expected to provide simple answers. Only the waist and hip circumference measurements will involve close body contact.
- **Participant's daily routine will not be disturbed** by the study. The participation does not require modifying the diet habits and needs only one hour to complete the two questionnaires.
- **Respect to the participant's privacy and confidentiality**. Refer to section 8.

5. The benefits of your participation:

Your participation will contribute to understanding dietary habits and increase the nutritional knowledge of your local community. The gained knowledge will be communicated to your community, and give a basis to improve the diet of yourself, your family and the community. The gained knowledge will also contribute to further studies and increased knowledge of diet in the Mayan communities of Guatemala.

6. Participation is a voluntary activity:

Your participation to this study is **plainly voluntary**, which means that you are free to withdraw from the study at any time and no justification is expected. Please read carefully this document and do not hesitate to ask questions before deciding to give your consent to participate in the study.

7. Who are the participants:

You are invited to participate if you participated in the Lake Atitlán Respiratory Health Study in July 2021 and are a Mayan woman living in the Sololá region in Guatemala, around the Lake Atitlán, with age between 18 to 49 years, and able to speak Spanish or Tzutujil.

Exclusion criteria: Pregnant women and women with a condition that requires a specific diet, and women not in responsible for the food are excluded from the study.

8. Data protection and diffusion:

Your data will be collected and registered on a paper-based questionnaire by the co-investigator Chloë Carpi, and stored safely on site in a locked place. You will be assigned a unique number to ensure **your anonymity**. Data will be then transferred to a password-protected computer, stored in a safe server of the University of Bergen (SAFE), and kept safe. Access to data will be only granted by the principal investigator of the team in Norway and Guatemala, and allocated to team members only. Results of this sub-study could be published in articles or presentations, however, your anonymity will be kept and no information that enables to identify you will be included. Your name and other information that can directly identify you will be stored securely and separately from the rest of the data. Investigators may contact you again for further purposes as part of this project. Moreover, data may be used or shared for future research studies. However, the data will be de-identified, which significate that information that can directly identify you, will be removed. Your additional consent will be asked if future studies are carried out whatever the purposes.

9. Contact:

You are free to ask questions to the investigators regarding:

- Obtaining more information about the study
- Details on the proceeding and questionnaires
- Report changes in your habitual diet that can influence the results of the study due to pregnancy or health-conditions
- Withdraw from the study

Co-investigator: Chloë Carpi
Email: Chloe.Carpi@student.uib.no
Tel: 37935642

Co-investigator: Rafael Durán Galdo
Email: rafael.duran@student.uib.no
Tel: 37935614

Co-investigator: Juan Pablo López Cervantes
Email: Juan.Lopez@student.uib.no
Tel: +47 4624586010

10. Your consent:

By signing this document, you accept to participate in this study. Two copies of this document will be made, one will be given to you and the other will be kept by the team. If you have any questions before the signature you can contact the team members mentioned in the section 9.

Participate in this study includes to respond to two questionnaires and collecting body measurement. Moreover, by giving your consent you accept that **the data may be used in future studies** with the approval of Ethical committees.

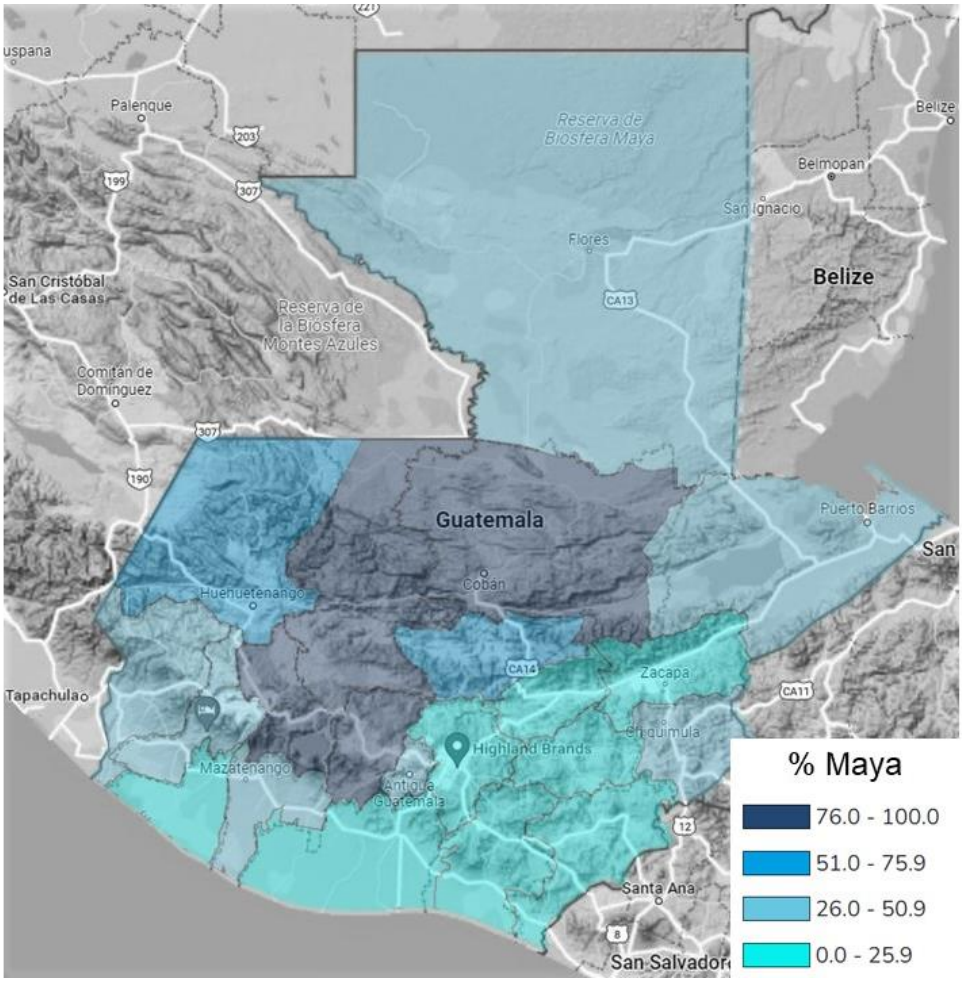
I understand the purposes of the study and until now my questions have been answered. I accept to participate in this study.

Full name:_____

Date (dd/mm/yyyy):_____

Signature:

***Appendix 10**: Map of the distribution of the Maya population and Guatemalan Highland*



Superposition of maps showing the reliefs in Guatemala (source: Goole Maps) and distribution of the Maya population in 2018 (source: [16])