AMERICAN UNIVERSITY OF BEIRUT

FOOD CONSUMPTION PATTERNS AND DIETARY DIVERSITY AMONGST WOMEN OF REPRODUCTIVE AGE IN LEBANON: A NATIONAL STUDY

by
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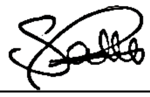

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ABSTRACT
OF THE THESIS OF

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Title: Food Consumption Patterns and Dietary Diversity amongst Women of Reproductive Age in Lebanon: A National Study

Background: Lebanon faces a triple burden of malnutrition (undernutrition, over nutrition, and micronutrient deficiencies), with women of reproductive age (WRA) being particularly vulnerable. Poor diet quality, specifically a lack of dietary diversity, is a key factor driving nutrient inadequacies among this population. The Minimum Dietary Diversity for Women (MDD-W) has been widely used as a proxy measurement of micronutrient adequacy.

Objectives: This study aims to assess dietary diversity amongst women of reproductive age in Lebanon based on the MDD-W score, investigate its association with nutrient adequacy, and identify the socioeconomic and anthropometric factors associated with high MMD-W in the study sample.

Methods: This study used data pertinent to 15-49 year-old women (n=927) from a national cross-sectional survey conducted in 2012-2013 on a representative sample of Lebanese households. Demographic, socioeconomic, anthropometric and eating pattern characteristics were obtained. Dietary intake was assessed using the single 24-hr recall method. Dietary diversity was calculated based on ten food groups with a cut-off point ≥5 groups indicating higher dietary diversity. To calculate the diversity score for each subject, composite recipes were first disaggregated into their constitutive ingredients and food items that were consumed in quantities ≥15 g on the previous day were considered. Associations between MDD-W and women's dietary intake (food groups, energy, and select macro- and micronutrients intakes) were examined. Macro- and micronutrient intakes were compared to age- and lactation status specific dietary reference intakes (DRIs), including Acceptable Macronutrient Distribution Range (AMDR), Estimated Average Requirements (EAR), Adequate Intakes (AI) and Upper limits (UL). Simple and multiple logistic regression analysis were used to explore the associations between MDD-W and various socioeconomic and anthropometric variables as well as meal patterns. The Statistical Package for the Social Sciences (SPSS; version 27) was used for all computations.

Results: Mean ± SE dietary diversity score was 4.91 ± 0.05 and about 38% of the participants did not meet the MDD-W cut-off. The most commonly consumed food groups included grains (95.4%), followed by meat/poultry/fish (68.5%), vitamin A-rich fruits and vegetables (67.2%) and dairy (64.3%), while, the least consumed food groups were eggs (11.2%) as well as nuts and seeds (12.8%). A higher MDD score was found to be associated with a greater consumption of healthy food groups (e.g. fruits, vegetables, pulses, nuts and seeds and dairy products), and higher intakes of protein, monounsaturated fatty acids (MUFAs), omega-3 (alpha-linolenic acid), and omega-6 (linoleic acid) polyunsaturated fatty acids, as well as dietary fiber. Participants with adequate dietary diversity score (MDD ≥ 5) had significantly higher intakes (/1000 kcal) of all assessed micronutrients (except iodine). In addition, a greater proportion of women with adequate dietary diversity met the DRIs for most of the evaluated macronutrients (except total fat and saturated fat) and micronutrients (except iodine and vitamin D). Based on the simple regression analysis, several factors were significantly associated with dietary diversity, including the household's monthly income, house ownership, the participant's educational status, specialization in a health-related major, daily breakfast consumption, and the number of meals consumed per day. In the multiple logistic regression analysis model, significant associations were retained between the participants' dietary diversity and their daily breakfast consumption as well as the number of meals consumed per day.

Conclusion: The study findings showed that women who achieved the MDD-W reported higher micronutrients intakes and higher consumption of healthy food groups, as well as higher intakes of macronutrients that are linked to improved nutritional status in women. These findings are thus a further validation of the MDD-W and support its use as a proxy indicator for higher micronutrient adequacy in large surveys of WRA living in LMICs, and in the nutrition transition context. Nutritional and public health interventions emphasizing the importance of maximizing dietary diversity and thus, micronutrient adequacy among WRA in Lebanon are needed. These may include interventions that promote healthier meal patterns such as regular breakfast intake and the consumption of at least 3 meals per day. Additional interventions should encourage higher consumption of fruits, vegetables, fish, eggs, pulses, nuts, and seeds to achieve optimal dietary diversity and nutritional adequacy among WRA in Lebanon.

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ABBREVIATIONS

MDD-W:	Minimum Dietary Diversity for Women
WDDS:	Women’s Dietary Diversity Score
HDDS:	Household Dietary Diversity Score
WHO:	World Health Organization
EMR:	Eastern Mediterranean Region
MENA:	Middle East and North Africa
FAO:	Food and Agriculture Organization
UN:	United Nations
USAID:	U.S. Agency for International Development
USDA:	U.S. Department of Agriculture
IOM:	Institute of Medicine
WFP:	World Food Programme
FCS:	Food Consumption Score
LMICs:	Low- and middle-income countries
BMI:	Body Mass Index
DBM:	Double burden of malnutrition
TBM:	Triple Burden of malnutrition
MND:	Micronutrient deficiencies
WRA:	Women of Reproductive Age
CDC:	Centers for Disease Control and Prevention
NTDs:	Neural Tube Defects
VAD:	Vitamin A Deficiency
ZD:	Zinc Deficiency
IDDs:	Iodine Deficiency Disorders
IUGR:	Intrauterine growth restriction
DRIs:	Dietary Reference Intakes
AMDR:	Acceptable Macronutrient Distribution Range
EAR:	Estimated Average Requirement
AI:	Adequate Intake
MUFAs:	Monounsaturated fatty acids
FFQ:	Food frequency questionnaire
DHA:	Docosahexaenoic acid
EPA:	Eicosapentaenoic acid
MAR:	Mean Adequacy Ratio
NAR:	Nutrient Adequacy Ratio
SES:	Socio-economic status
CI:	Crowding Index
SDGs:	Sustainable Development Goals
AOR:	Adjusted Odds Ratio
CI:	Confidence Interval
SPSS:	Statistical Package for Social Sciences

To the person I hold dearest in my heart, who was my constant source of support, the one whose eyes would have shone with the greatest pride because of this accomplishment. This is a tribute to your pure and beautiful soul, Dad. May it find eternal peace.

CHAPTER I

INTRODUCTION

Over the past few years, many countries in the Eastern Mediterranean region (EMR) have been experiencing a rapid nutrition transition, characterized by increased intakes of high energy foods in the form of fat (especially animal fat), added sugars and salt, and decreased intakes of nutrient- and fiber-rich foods (Mehio Sibai et al., 2011) (Popkin, 2004). The nutrition transition has been described as being associated with urbanization, mechanization and globalization of food systems, that had resulted in concurrent shifts in diet, body composition and physical activity levels (Atinmo et al., 2009) (World Health Organization, 2017). This transition has translated into a rise in the prevalence of overweight and obesity in the region, where undernutrition remains a public health challenge (Mehio Sibai et al., 2011; Musaiger, 2011; Taleb et al., 2015) and has contributed to the development of the double burden of malnutrition (DBM). The DBM is characterized by the simultaneous manifestation of both undernutrition and overweight and obesity within individuals, households and populations (World Health Organization, 2017), and is highly prevalent in low to middle income countries (LMICs) (Musaiger, 2011) where access to affordable, nutritious food is limited, and emphasis is placed on purchasing low-cost, energy rich foods that are low in micronutrients (Popkin, Corvalan, & Grummer-Strawn, 2020). The double burden of malnutrition is increasingly being accompanied by micronutrient deficiencies, especially in LMICs of the EMR (Hwalla et al., 2016; Taleb et al., 2015; World Health Organization, 2017), resulting in the manifestation of a triple burden of malnutrition

(TBM)(Capacci et al., 2013), placing different communities in the region at various nutrition-related health risks.

With regard to micronutrient intake/status, as commonly reported by many countries of the EMR, the WHO identified particularly deficient and/or inadequate intakes of calcium, iodine, iron and zinc as well as folate, vitamin A and vitamin D, especially among vulnerable groups including children and women of childbearing age. For instance, over one-third of the population in the region is iron deficient or anemic, the majority of which being women (World Health Organization, 2011a). In fact, women of reproductive age group (WRA) represent a particularly nutritionally vulnerable population. This is mainly due to the higher physiological demands related to their reproductive roles, such as an increased need for nutrients during menstruation, pregnancy, and lactation (Marangoni et al., 2016). Additionally, their vulnerability may be further exacerbated by various social and economic disadvantages (Preedy, Hunter, & Patel, 2013) and indeed, micronutrient deficiencies are commonly found amongst WRA especially in low and middle-income countries (LMICs)(Darnton-Hill & Mkparu, 2015; Jiang et al., 2005).

One of the most important factors responsible for maternal micronutrient deficiencies is the poor quality of their diets; particularly, the lack of diet diversity (Custodio et al., 2020). Evidence from developed countries indicates that diet diversity is strongly associated with nutrient adequacy and thus is an essential element of diet quality (Food and Agriculture Organization, 2013; Hu et al., 2022; Ruel, Deitchler, & Arimond, 2010; Yari et al., 2022). A growing evidence from developing countries also supports this association (Arimond et al., 2010; Oladoyinbo, Ugwunna, & Ekerette, 2017; Tavakoli et al., 2016; Yari et al., 2022). This is because the nutrients essential for meeting nutritional recommendations are not usually found in a single food item; instead, the consumption of an appropriate combination of various foods helps ensure nutrient adequacy (Wahlqvist & Hsu-Hage, 1996). The consumption of a diverse and balanced diet is essentially critical during the reproductive years for women, since nutrient inadequacy may affect their current well-being in terms of increased susceptibility to diseases, while also adversely affecting their productivity. In addition, micronutrient deficiencies can affect their future well-being by adversely influencing fertility as well as pregnancy outcomes and may contribute to birth defects, intrauterine growth restriction and infant stunting(Darnton-Hill & Mkparu, 2015; Lassi et al., 2020). Moreover, various studies on WRA have documented an inverse association between diet diversity with general and abdominal obesity(Abris et al., 2018; Azadbakht & Esmaillzadeh, 2011).

The promotion of diverse diets is thus essential to improve micronutrient nutrition for WRA and can contribute to sustainable, healthy diets (Food and Agriculture Organization and World Health Organization, 2019). Although dietary diversity can be measured in many different ways, only a few simple diversity indicators have been promoted for wide population-level use in resource-poor settings amongst WRA, aged 15-49 years. These include the Women Dietary Diversity Score (WDDS) and the Minimum Dietary Diversity for WRA (MDD-W). Both of these indicators are based on 1-day recalls of food consumption and are validated for use as proxies for micronutrient adequacy of women's diet, which is one critical dimension of diet quality(Food and Agriculture Organization and Family Health International 360, 2016). Several organizations have used the 9-point (9 food groups) WDDS in surveys and programs and found consistent associations with adequacy for 11 micronutrients

(Arimond et al., 2010; Food and Agriculture Organization, 2013). While useful, the WDDS failed to identify a single, universal cut-off point that can be expressed in terms of prevalence meeting or not meeting a minimally acceptable level of diversity. Subsequently, demand for a dichotomous indicator grew, particularly in the context of advocacy efforts and for cross-sectoral communication, and resulted in the proposal of the MDD-W indicator, based on a set of 10 food groups (Martin-Prevel et al., 2017).

Lebanon, a middle-income country in the EMR is currently undergoing an early nutrition transition phase, typically characterized by a moderate prevalence of overweight and obesity, moderate levels of undernutrition in specific population groups and persistent micronutrient deficiencies/inadequacies (World Health Organization-Eastern Mediterranean Regional Ofiice (WHO-EMRO), 2023). To date, most studies conducted on WRA in Lebanon have focused on the levels or intakes of few specific essential micronutrients like iron (Asmar et al., 2018; Hwalla, Adra, & JACKSON, 2004) and folate (Al Khatib et al., 2006), while studies tackling their overall dietary consumption patterns are lacking. Moreover, few studies to date have used the MDD-W indicator to assess dietary diversity and thus micronutrient adequacy of the diets of WRA in countries undergoing the nutrition transition, such as Lebanon (Ahmed & Salih, 2019; Brazier et al., 2020; Gómez et al., 2020; Jomaa et al., 2020; Puwanant et al., 2022). In light of this situation, the objectives of the current study are as follows: (1) To assess the dietary diversity amongst women of reproductive age in Lebanon based on the MDD-W score, (2) Assess the macronutrient intake across MDD categories (high vs low), (3) Assess micronutrient intakes across MDD categories (high vs low) and (4) Identify the socioeconomic and anthropometric factors associated with high MMD-W score in the study sample.

The study findings may help in the development of evidence based strategies to improve the micronutrient adequacy amongst WRA, which is necessary to optimize their health and wellbeing as well as the health of future generations.

CHAPTER II

LITERATURE REVIEW

A. Micronutrient deficiencies and nutrition transitions in the Eastern Mediterranean Region (EMR)

The term "micronutrient" encompasses the vital vitamins and minerals required from the diet that are necessary for maintaining nearly all cellular and molecular functions (Regmi, 2013). Although the required amounts of micronutrients are minute, widespread micronutrient deficiencies (MND) are common at a global level, with approximately one-third of the global population estimated to be affected by at least one form of MND (Bailey, West Jr, & Black, 2015; HLPE, 2017). In the Eastern Mediterranean region (EMR), micronutrient deficiencies have been a persistent healthcare problem (Hwalla et al., 2017). Over the past three decades, the region has been experiencing substantial changes in demographic, economic, political and social environment that had imparted challenges associated with diet, nutrition and health (World Health Organization, 2011a). In fact, many countries in the EMR are undergoing a nutrition transition, marked by a shift away from traditional eating patterns towards westernized diet and characterized by a growing prevalence of overweight and obesity whilst still harboring undernutrition and micronutrient deficiencies (World Health Organization, 2011a, 2017). The WHO has divided the EMR region into four broad country clusters with regard to nutrition transition stages and dominant nutrition problems (World Health Organization, 2011a).Countries in the advanced nutrition transition (Saudi Arabia, UAE, Bahrain, Kuwait, Oman and Qatar) have high levels of overweight and obesity, and moderate levels of undernutrition and micronutrient deficiencies in some population subgroups. Countries in the early nutrition transition (Egypt, Jordan, Morocco, Lebanon and Palestine) have moderate levels of overweight and obesity, moderate levels of undernutrition in specific population and age groups, and widespread micronutrient deficiencies. Countries with significant undernutrition (Djibouti, Iraq, Pakistan and Yemen) have particularly high levels of acute and chronic child malnutrition, widespread micronutrient deficiencies, and emerging overweight, obesity and malnutrition of affluence in certain socioeconomic subgroups. Countries in complex emergency situations (Afghanistan, Libya, Somalia, Sudan and Syria) have severe child and maternal undernutrition and widespread micronutrient deficiencies (World Health Organization, 2011a).

B. Women of reproductive age in the EMR: a vulnerable population group for micronutrient deficiencies (MND)

Micronutrient deficiency (MND) can lead to a wide range of negative health consequences and is a significant contributor to the global burden of disease, contributing to increased rates of morbidity and mortality (Han et al., 2022). Among the most vulnerable population subgroups to the effects of micronutrient malnutrition are women of reproductive age (WRA) (aged 15-49 years) (Stevens et al., 2022; World Health Organization, 2011a). This is mainly attributed to their reproductive roles and the physiological demands of pregnancy and lactation (Black et al., 2013; Torheim & Arimond, 2013). These demands create an increased need for nutrients, which varies to some extent during menstruation, pregnancy, and lactation (Torheim & Arimond, 2013).

Despite the limited availability of data on MND amongst WRA in the EMR (Stevens et al., 2022), the WHO identified particularly deficient and/or inadequate intakes of calcium, iodine, iron and zinc as well as folate, vitamin A and vitamin D, among vulnerable population groups including women of childbearing age in the region (World Health Organization, 2011a).

1. Iron, folate, B12 and anemia

Anemia is recognized as a global public health concern affecting vulnerable groups including women or reproductive age (WRA), particularly in low and middle income countries (LMICs) (World Health Organization, 2014, 2020). In the EMR, the prevalence of anemia among WRA ranges from 27% to 69.6% (Al-Jawaldeh et al., 2021). Iron deficiency is the most common cause of nutritional anemia,(Stevens et al., 2013), followed by folate and vitamin B12 deficiencies (Al Khatib et al., 2006), which can lead to low levels of hemoglobin and negative impacts on cognitive and motor development, as well as feelings of fatigue and reduced productivity (Balarajan et al., 2011; Haas & Brownlie IV, 2001). During pregnancy, deficiencies of either iron or folate puts the woman and her fetus at increased risk of perinatal complications such as spontaneous miscarriage, intrauterine growth retardation, premature delivery, stunted growth, low birth weight and neural tube defects (Allen, Casterline-Sabel, & Ramakrishnan, 2001; Krishnaswamy & Nair, 2001; Scholl & Reilly, 2000). In Lebanon, according to the World Health Organization (WHO) country estimates, the latest reported prevalence of anemia among Lebanese WRA was 28.3% in 2019 (The World Bank, 2023). An earlier national study in Lebanon (Food and Agriculture Organization, 2007) identified that 13.4% of anemia cases in WRA were attributable to iron deficiency. Another earlier study by (Al Khatib et al., 2006), examined additional micronutrient deficiencies, finding that 25% of women had folate deficiency (defined as plasma folate <6.6 ng/mL) and 39% had vitamin B12 deficiency (defined as plasma B12 < 300 pg/mL). Among anemic women, 15% had folate deficiency, 29% had vitamin B12 deficiency, and 13% had both (Al Khatib et al., 2006).

2. *Folate and neural tube defects:*

According to the Centers of Disease Control and Prevention (CDC), all WRA should incorporate 400 micrograms (mcg) of folic acid into their daily dietary regimen, in addition to consuming food with folate from a diverse diet (Atlanta, 1993). This practice is essential for reducing the risk of neural tube defects (NTDs), which encompass significant birth defects affecting both the brain (anencephaly) and spinal cord (Spina Bifida) in newborns (Atlanta, 1993). In the EMR, the increased need for folate during pregnancy and lactation is not met by the typical dietary intake (Hwalla et al., 2017). In fact, a systematic review governing 75 countries classified according to the WHO regions and World Bank income classifications, have found that the Eastern Mediterranean region (EMR) had the highest prevalence of NTDs. The reported prevalence ranges and medians for each region were as follows: Eastern Mediterranean (2.1–124.1; 21.9 per 10,000 births), South-East Asian (1.9–66.2; 15.8 per 10,000 births), African (5.2–75.4; 11.7 per 10,000 births), Americas (3.3–27.9; 11.5 per 10,000 births), European (1.3–35.9; 9.0 per 10,000 births) and Western Pacific (0.3–199.4; 6.9 per 10,000 births). In addition, this study found that the presence of a surveillance system for NTD increased with country income level: low income (0%), lower-middle income (25%), upper-middle income (70%), and high income (91%) (Zaganjor et al., 2016). Studies investigating folate deficiency in countries of the EMR are rather scarce. In a survey conducted among 579 mothers in Egypt, the reported prevalence of folate deficiency (<10 nmol/L) was 14.7% (Tawfik, Hanna, & Freig, 2014), while in Lebanon, a cross-sectional survey conducted by Al Khatib et al. on 470 women aged 15-45 found that 25.1% of them had folate deficiency (<6.6 ng/mL) (Al Khatib et al., 2006). Furthermore, research in Lebanon indicates that the level of folic acid awareness and adequate intake remain relatively low among WRA (Nasr Hage et al., 2012).

3. *Vitamin D and calcium*

Vitamin D is an essential fat-soluble vitamin that plays a pivotal role in calcium homeostasis and bone mineralization (Triunfo & Lanzone, 2016). The prevalence of vitamin D deficiency varies significantly across different World Health Organization (WHO) regions, with the EMR demonstrating the highest prevalence (Cui et al., 2023). In the region, the prevalence of vitamin D deficiency and insufficiency is high amongst WRA, ranging from 24% to 72% across several countries (Al-Daghri et al., 2015; El Rifai et al., 2014; Haq et al., 2016). Insufficient levels of vitamin D in WRA may lead to negative reproductive outcomes, including pre-eclampsia, pregnancy-induced hypertension, obstructed labor, vaginosis, and low birth weight in infants (Aghajafari et al., 2013). Additionally, there may be a correlation between vitamin D deficiency and infertility factors, such as chronic anovulation, endometriosis, and even breast cancer (Colonese et al., 2015). Being an essential hormone for regulating calcium metabolism, vitamin D deficiency can cause insufficient intestinal calcium absorption, thereby increasing the need for calcium requirements amongst vitamin D deficient populations (Shlisky et al., 2022). During pregnancy and lactation, the interaction between vitamin D and calcium plays a crucial role in preventing neonatal rickets and reducing the risk of preeclampsia (Roth et al., 2018), gestational diabetes and premature childbirth

(Hofmeyr et al., 2018). In Lebanon, there is scarcity of data regarding the prevalence of vitamin D deficiency specifically amongst WRA. However, a cross-sectional community based study conducted among Lebanese adults (68% females) over 18 years of age have found vitamin D deficiency to be highly prevalent, with about two-thirds being deficient using the Endocrine Society (ES) cut-off of <50 nmol/L, or 39.1% using the more conservative Institute of Medicine (IOM) cut-off of <30 nmol/L. In addition, in this study, the mean 25OHD levels were lower in women in comparison to men (Arabi et al., 2021), similar to the findings of Khalife et al. who found vitamin D to be highly prevalent among Lebanese women, being estimated at 61.7% (Khalife et al., 2017).

4. Vitamin A

Vitamin A is an essential nutrient that humans require in small amounts to support the normal functioning of the visual system and for the maintenance of epithelial cellular integrity, immune function and reproduction (World Health Organization, 2004). Inadequate vitamin A consumption increases the susceptibility of populations to the development of diseases linked to vitamin A deficiency (VAD), such as xerophthalmia, impaired immune and reproductive health, an elevated risk of anemia, and higher rates of morbidity and mortality (World Health Organization, 2004). In EMR, VAD is highly prevalent among women of reproductive age especially in low to middle-income countries (LMICs) (Saad et al., 2021). Vitamin A deficiency in women of reproductive age (WRA) can result in vision impairment as well as a compromised immune system, increasing their vulnerability to infections (Carazo et al., 2021), and can contribute to adverse outcomes such as maternal mortality, fetal loss, preterm birth, and low birth weight (Hamdy, Abdel Aleem, & El-Shazly, 2013). The prevalence of VAD varies across countries in the EMR region, with several being classified as having VAD of severe public health significance. This classification is based on having a prevalence of serum retinol concentrations below 0.70 µmol/L of at least 20% or a prevalence of night blindness of at least 5% (Bagchi, 2008). For instance, from 2011 to 2015, the prevalence of vitamin A deficiency (<0.70 µmol/L retinol) was 14% among pregnant women in Iran (Pouraram et al., 2018), whereas it reached 27.3% among women of reproductive age in Pakistan in 2018 (UNICEF, 2019). To date, there is a scarcity of data regarding the prevalence of Vitamin A deficiency specifically among women of reproductive age (WRA) in Lebanon. Nonetheless, a study conducted by (Obeid et al., 2006) reported a healthy vitamin A status within an urban population of Lebanese adults.

5. Iodine

Iodine deficiency is a global public health concern because iodine plays a crucial role in the synthesis of thyroid hormones and is vital for normal neurological development (Mohammadi, Azizi, & Hedayati, 2018). In women of reproductive age, iodine deficiency may cause several disorders such as congenital anomalies, spontaneous abortion, impaired mental and physical fetal development and infant mortality (Delange et al., 2001; World Health Organization, 2007). Compared to other age groups, iodine deficiency disorders (IDDs) are most common in women, especially in those who are pregnant and lactating (Al Hosani et al., 2003; Knudsen et al., 2002). Despite extensive initiatives aimed at managing iodine deficiency disorders (IDDs), mild to severe IDDs continue to persist in the Eastern Mediterranean Region (EMR).

This persistence can be attributed to the absence of an effective iodine supplementation program, thereby posing a significant public health challenge in certain countries within the region. While Iran, Jordan, Bahrain, and Tunisia have reported adequate iodine statuses, Lebanon, Saudi Arabia, the United Arab Emirates (UAE), Yemen, and Egypt have documented mild to moderate iodine deficiency statuses and severe iodine deficiency was reported in Iraq and Pakistan (Mohammadi, Azizi, & Hedayati, 2018).

6. Zinc

Zinc is a crucial trace mineral that is indispensable for numerous physiological functions and holds significance in reproduction and the immune system (Kumera et al., 2015). Extensive research conducted over the years has presented compelling evidence that zinc deficiency (ZD) poses a significant global public health concern. (Ezzati, 2004; Roohani et al., 2013). According to the World Health Organization (WHO), the estimated prevalence of zinc deficiency varies between 4% and 73% across different regions, with a particularly high prevalence observed in the EMR, where it accounts for 25% to 52% (Ezzati, 2004). Women of reproductive age are highly vulnerable to zinc deficiency, particularly in low to middle-income countries (Gupta, Brazier, & Lowe, 2020). This heightened vulnerability puts them at an increased risk for adverse maternal health and pregnancy outcomes including abortion, preterm delivery, stillbirth, low birthweight, prolonged labor, postpartum hemorrhage, and preeclampsia. Additionally, it can lead to detrimental and irreversible effects on the newborn such as congenital malformations, intrauterine growth retardation (IUGR), cognitive impairment and delayed immune system development (Karimi et al., 2012; Prasad, 2013; Roohani et al., 2013).

C. Diet diversity and micronutrient adequacy among women of reproductive age

Poor quality of diets, particularly the lack of diet diversity, is a major factor contributing to micronutrient deficiencies in women of reproductive age (Custodio et al., 2020). This is because, the nutrients that are essential for meeting nutritional recommendations are not all found in a single food item; instead, the consumption of an appropriate combination of various foods helps ensure nutrient adequacy (Wahlqvist & Hsu-Hage, 1996). Extensive research in developed countries consistently shows a strong association between diet diversity and nutrient adequacy, underscoring its integral role in overall diet quality (Food and Agriculture Organization, 2013; Hu et al., 2022; Yari et al., 2022). Moreover, growing evidence from developing countries supports this link (Oladoyinbo, Ugwunna, & Ekerette, 2017; Tavakoli et al., 2016; Yari et al., 2022). Diet quality encompasses multiple dimensions (Guenther et al., 2013), and the promotion of diverse diets is considered one of several strategies to improve micronutrient nutrition among women of reproductive age. In addition to ensuring micronutrient adequacy, high-quality diets are characterized by a balanced intake of carbohydrates, protein, and fat (Institute of Medicine, 2005) while also emphasizing moderation in the consumption of foods associated with lower nutrient density and increased risk of chronic diseases (George et al., 2014).

D. Dietary diversity indicators

Various methods have been employed to measure dietary diversity in both research and programmatic settings (Food and Agriculture Organization and Family Health International 360, 2016). However, only a few simple dietary diversity indicators have been advocated for use at the population level, and these are based on food groups' diversity indicators They include the Household Dietary Diversity Score (HDDS), the Minimum Dietary Diversity (MDD) and the Women's Dietary Diversity Score (WDDS), whereby the number of food groups included in the indicator vary between 9 and 12 (Table 1) (Food and Agriculture Organization and Family Health International 360, 2016). In addition to the simple food group indicators presented in Table 1, there are several more intricate indicators and indices employed in specific countries or contexts. For instance, the World Food Programme (WFP) utilizes a more complex food group diversity indicator (the Food Consumption Score (FCS)) as part of their food security analyses (World Food Programme, 2008).

Table 1: *Simple food group diversity indicators currently in use or advocated for use at population level (Food and Agriculture Organization and Family Health International 360, 2016)*

	Household level Measure	Individual Level Measures	
	Household Dietary Diversity Score (HDDS)	Women's Dietary Diversity Score	Minimum Dietary Diversity for Women (MDD-W)
Population sampled	Households	Women aged 15-49 years	Women aged 15-49 years
Number of food groups	12	9	10
Recall period	24 hours	24 hours	24 hours
Meaning	Proxy for household food access in terms of kilocalories (dietary energy) – representing one dimension of household food security- as well as socioeconomic status	Proxy for the probability of micronutrient adequacy of women's diet- representing one critical dimension of diet quality	Proxy for the probability of micronutrient adequacy of women's diet- representing one critical dimension of diet quality
Validated against	Kilocalorie availability – as assessed in household level consumption surveys	Micronutrient adequacy- as assessed by multiple 24-hour recalls Superseded by MDD-W	Micronutrient adequacy- as assessed by multiple 24-hour recalls
Dichotomous indicator threshold	No dichotomous indicator	No dichotomous indicator -Continuous indicator that was the basis for the MDD-W (also referred to as the Individual Dietary Diversity Score (IDDS))	5 or more of the 10 food groups
Fats, oils, sweets, all beverages including alcohol included in indicator tabulation?	Yes	No	No
Indicator tabulation includes food consumed outside the home?	No	Yes	Yes

While the Household Dietary Diversity Score (HDDS) is meant to reflect, in a snapshot form, the economic ability of a household to access a variety of foods and food groups, individual dietary diversity scores aim to more accurately reflect nutrient adequacy (Kennedy, Ballard, & Dop, 2011). Of the various food group diversity indicators, the Women's Dietary Diversity Score (WDDS) and the Minimum Dietary Diversity for women (MDD-W) are used to assess dietary diversity at the individual level in women of reproductive age (Food and Agriculture Organization and Family Health International 360, 2016).

1. *Women's Dietary Diversity Score (WDDS)*

The Women's Dietary Diversity Score (WDDS) was derived as a preliminary stage in the progression towards formulating the dichotomous Minimum Dietary Diversity for Women (MDD-W) (FAO & FHI 360, 2016). Earlier research has resulted in the suggestion of several scores that reflected micronutrient adequacy in women of reproductive age. However, none of these scoring systems was put forth as a single, universally applicable metric for global utilization (Arimond et al., 2010). Among these scores, the Food and Agriculture Organization (Food and Agriculture Organization, 2013) detailed a nine-food-group-based score known as the Women's Dietary Diversity Score (WDDS). The WDDS is a continuous indicator that serves as a reliable proxy for assessing micronutrient adequacy of women's diet (Arimond et al., 2010; Food and Agriculture Organization, 2013), and was chosen by the U.S. Agency for International Development (USAID) for implementation in their *Feed the Future* and *Food for Peace* development food assistance programs, alongside other initiatives (Food and Agriculture Organization and Family Health International 360, 2016). However, there was an increasing demand for a dichotomous indicator, especially within the realms of policy-making and advocacy efforts. Subsequently, further research was conducted using expanded data sets, with the objective of creating a dichotomous indicator rather than a continuous one and resulted in the proposal of the Minimum Dietary Diversity for WRA (MDD-W), based on a set of ten food groups (Martin-Prével et al., 2015).

2. *The Minimum Dietary Diversity for Women of Reproductive Age (MDD-W)*

The MDD-W was developed in 2016 by the Food and Agriculture Organization (FAO) of the United Nations to fill the need for a simple, food-based indicator for measuring dietary diversity and micronutrient adequacy, which are key dimensions of diet quality in women of reproductive age (Food and Agriculture Organization and Family Health International 360, 2016). This population level dichotomous indicator measures the proportion of women, aged 15-49 years, who consumed food items (at least 15g) from at least five out of the ten defined food groups (Table 2) during the preceding day or night (Food and Agriculture Organization and Family Health International 360, 2016). The proportion of women who reach this minimum criterion in a population can serve as a proxy indicator for higher micronutrient adequacy, one important dimension of diet quality. It has been associated with a higher probability of nutrient adequacy for 11 micronutrients: vitamin A, thiamine, riboflavin, niacin, vitamin B-6, folate, vitamin B-12, vitamin C, calcium, iron, and zinc (Food and Agriculture Organization, 2021)

Table 2: *The 10 MDD-W Food Groups (FAO, 2021)*

MDD-W Food Groups	
1.	Grains, white roots and tubers, and plantains
2.	Pulses (beans, peas and lentils)
3.	Nuts and seeds
4.	Milk and milk products
5.	Meat, poultry and fish
6.	Eggs
7.	Dark green leafy vegetables
8.	Other vitamin A-rich fruits and vegetables
9.	Other vegetables
10.	Other fruits

The main use of the MDD-W is for assessment at national and/or subnational levels (Food and Agriculture Organization and Family Health International 360, 2016). Although data is collected from individual women, the correct use and interpretation of MDD-W is at the population-level. The indicator thus cannot be used to infer diet quality for an individual, since it is based on a single recall period over a single day and night (24 hours), and hence does not reflect the day-to-day variability for individual intakes (Food and Agriculture Organization and Family Health International 360, 2016). The MDD-W indicator can be used for a variety of different purposes and in different settings. For instance, it could be used to track changes in diets of groups of women over time as well as to compare diets of groups of women in different settings, or based on sociodemographic and other characteristics of interest (Food and Agriculture Organization, 2021).

The MDD-W indicator is primarily collected using one out of two dietary assessment methods: open recall or list-based (Food and Agriculture Organization, 2021). The list-based method requires the enumerator to read to the respondent a list of predefined sentinel food and beverages, categorized under purposely ordered food groups. The respondents should respond “yes” for each food or beverage consumed during the specified recall period of the previous day and night. In contrast, the open 24-hr recall method requires the enumerator to ask a series of standard probing questions to help the respondent recall all foods and beverages consumed the previous day and night, while also probing for the main ingredients in mixed dishes. The food and beverages mentioned by the respondent are recorded on an open-grid and then marked on a pre-defined list by the enumerator (Food and Agriculture Organization, 2021).

The ten food groups that make up the MDD-W are mutually exclusive, i.e. no food or ingredient is placed in more than one food group. However, for the purpose of clarity, three of the 10 food groups have been further subdivided (Table 3). For instance, meat, poultry and fish represent a single MDD-W food group that could be further subdivided into (1) organ meats; (2) red flesh meat from mammals; (3) processed meat; (4) poultry and other white meats and (5) fish or seafood (Food and Agriculture Organization, 2021). This approach aims to facilitate recording, and enhances the questionnaire’s intuitiveness for enumerators. It is also recommended to collect consumption data on additional food groups that may be of interest. Although these additional food groups do not count for the indicator (Table 4), they may provide valuable information. In fact, several of these food groups are considered unhealthy and might therefore be of interest especially within the realms of non-communicable diseases, nutrition transition and multiple burden of malnutrition, as they can offer crucial insights. Additional optional food groups are also incorporated to accommodate situations where certain foods are at risk of being inaccurately categorized within the ten MDD-W groups. For instance, the "Condiments and seasonings" group encompasses a range of diverse food items and ingredients that are typically consumed in quantities too insignificant to be considered part of the 10 MDD-W food groups (Food and Agriculture Organization, 2021). In addition, the fats and oils food group was not included as part of the 10-MDD-W food groups as it does not contribute to the micronutrient density of the diet (Food and Agriculture Organization, 2013). However, in line with FAO recommendations (Food and Agriculture Organization, 2013), the proportion of individuals consuming fats and oils could be calculated as a separate indicator. This is because oil plays a crucial role in enhancing the absorption of carotenoids from plant sources and fat-soluble vitamins, and it serves as a significant contributor to the overall energy density.

Table 3: *MDD-W required food groups and their subdivisions (Food and Agriculture Organization, 2021)*

MDD-W required food groups			
Food groups	**Categorization**	**Food group subdivisions**	**Examples of food items**
1.Grains, white roots, tubers and plantains	A	Foods made from grains	Bread, pasta, rice, porridge, corn flour, cornmeal oats, barley, millet, sorghum
	B	White roots, tubers and plantains	White potatoes, white yams, chicory roots, parsnip, green bananas, plantains, cassava, turnip, water chestnuts
2. Pulses (beans, peas, lentils)	C		Beans, peas, lentils, hummus, tofu, tempeh, soybeans, soy milk, soy cheese
3. Nuts and seeds	D		Cashews, pistachios, almonds, groundnut/peanut, chia seeds, flaxseed
4. Dairy	E	Milk	Fresh whole, low-fat and skim milk, reconstituted milk powder
	F	Dairy foods	Hard and soft cheese, kefir, yogurt/curd
5. Meat, poultry and fish	G	Organ meats	Blood sausage, heart, liver, kidney, gizzard
	H	Red flesh meat from mammals	Beef, goat, lamb, mutton, pork, buffalo, rabbit
	I	Processed meat	Hot dogs, bacon, salami, bologna, mortadella, pepperoni, pastrami
	J	Poultry and other white meats	Chicken, duck, goose, turkey, other wild or domestic birds
	K	Fish and seafood	Fresh, frozen or dried fish, canned fish, shrimp, lobster, clams, mussels, oysters, scallops, clams
6. Eggs	L		Eggs from poultry or other birds
7. Dark green leafy vegetables	M		Lettuce (bibb, romaine), broccoli, kale, spinach, purslane, watercress, chicory greens, Chinese cabbage, Swiss chard

8. Vitamin A rich fruits and vegetables	N	Vitamin A-rich vegetables or roots	Carrots, pumpkin, red pepper (sweet), squash (orange- or dark yellow-fleshed only)
	O	Vitamin-A rich fruits	Ripe mango, ripe papaya, ripe cantaloupe, ripe passionfruit, apricot, peaches, red palm fruit
9. Other vegetables	P		Artichoke, asparagus, beets, Brussels sprouts, cabbage, cauliflower, celery, cucumbers, lettuce, zucchini, radish, tomatoes, palm hearts, mushrooms
10. Other fruits	Q		Apple, banana, avocado, berries grapes, guava, figs, kiwi, litchi, lemon, orange, watermelon, pear, pomegranate, pineapple

Table 4: *Additional food groups that do not count for MDD-W (Food and Agriculture Organization, 2021)*

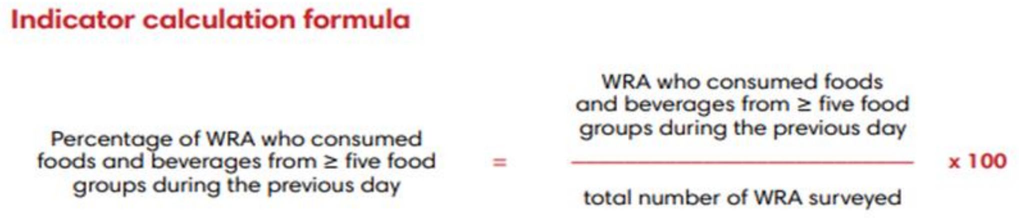
Unhealthy food groups *Not counted in MDD-W score* *Recommended to be included in questionnaire*			
Food groups	**Categorization**	**Food group subdivisions**	**Examples of food items**
Fried and salty foods	R	Packaged salty snacks	Chips, crisps, puffs, crackers
	S	Deep fried foods	Fried bread, doughnuts, samosas
	T	Instant noodles	Instant noodles
	U	Fast food	Foods from local fast food chains
Sweet foods	V		Chocolates, candies, cakes, cookies, jam, honey, halwa, sweetened condensed milk, pastries, pies, ice cream, popsicles
Sweet beverages	X	Sugar-sweetened beverages	Energy drinks, fruit drinks, soft drinks, chocolate drinks
	Z	Sweetened infusions	Coffee and/or tea with sugar, sweetened herbal drinks

Optional food groups *Not counted in MDD-W score* *Inclusion depends on survey's objectives and choice of data collection method*		
Wild foods	Insects and small protein foods	Insects, insect eggs, snails, fish roe
	Wild plants	(Local wild plants)
Red palm oil		Red palm oil
Other oils and fats		Vegetable/fruit/nut/seed oils, butter, ghee, cream, lard, margarine, mayonnaise
Condiments and seasonings		Onion, garlic, parsley, ginger root, dried and fresh spices and herbs, bouillon cubes, soy sauce, ketchup, mustard, tomato paste
Other beverages and foods		Unsweetened coffee/tea/herbal infusions, alcohol, clear broth, olives, pickles

The first step in constructing the MDD-W indicator is to aggregate the food group subdivisions of each respondent into the 10 MDD-W food groups. A respondent will receive a score of 1 if she had consumed any food that falls into any of the subdivisions for a single MDD-W food group (in a quantity that is greater than or equal to 15g/day) (Food and Agriculture Organization, 2021). She does not receive an additional point if she consumed food items from both subdivisions that contribute to the same MDD-W food group. To construct a food diversity score, the 10 MDD-W food groups are summed into a score ranging from 0 to 10; beginning with a score of 0 and adding one point for each food group, if any food in the group was consumed. To construct the MDD-W, each woman would be then coded as yes or no for scoring at least (≥) 5, followed by calculation of the proportion of women who score at least (≥) 5.

The indicator calculation formula is shown in Figure 1 (Food and Agriculture Organization, 2021).

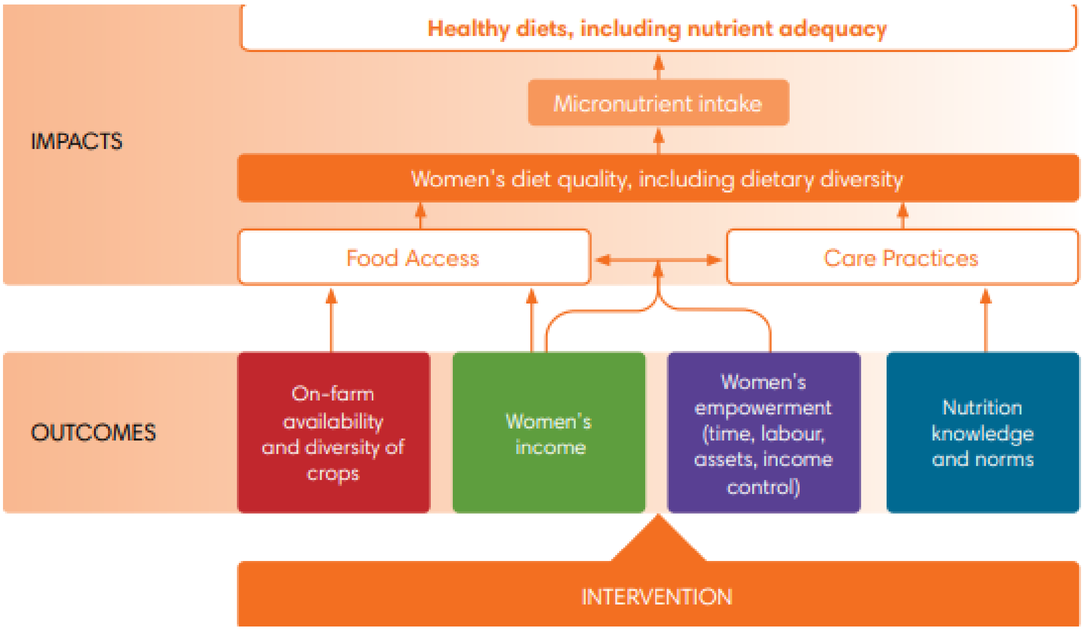
Figure 1: *MDD-W indicator calculation formula (Food and Agriculture Organization, 2021)*



E. Utilizing the MDD-W Indicator to Enhance Women's Dietary Diversity: Pathways, Indicators, and Intervention Strategies

A prerequisite for enhancing women's dietary diversity is establishing a mutual understanding of the pathways that lead to diverse diets (Food and Agriculture Organization, 2021). Once this understanding is in place, it becomes possible to employ appropriate indicators, such as the MDD-W, to consistently track and evaluate the impact of interventions on improving diets within the target population (Food and Agriculture Organization, 2021). When impact pathways suggest the potential to enhance food group diversity and promote healthy diets for women of reproductive age (WRA), the Minimum Dietary Diversity for Women (MDD-W) can serve as a valuable measurement tool within programme and policy contexts (FAO, 2021). Research indicates that interventions targeting specific objectives have the potential to improve dietary diversity. These objectives include empowering women (control over labor, assets, and income) (Galiè et al., 2019; Kassie et al., 2020; Yimer & Tadesse, 2016), increasing women's income (Jones, 2017; Komatsu, Malapit, & Theis, 2018), enhancing nutrition knowledge and norms (Nguyen et al., 2017; Ochieng et al., 2017), and promoting on-farm availability and diversity of crops (Jones, 2017; Sibhatu & Qaim, 2018). Figure 2 presents a framework that outlines four outcome areas within agriculture, rural development, and food systems, which have the potential to impact women's dietary diversity (MDD-W) (Food and Agriculture Organization, 2016; Herforth & Ballard, 2016).

Figure 2: *Simple pathways to women's dietary diversity (Reproduced from: (Food and Agriculture Organization, 2016; Herforth & Ballard, 2016)).*



Aligned with these observations, previous studies have utilized the MDD-W indicator to assess dietary diversity and thus micronutrient adequacy, among various cohorts of women in their reproductive years (Ahmed & Salih, 2019; Islam et al., 2023; Jemal & Awol, 2019; Pal, Paul, & Dasgupta, 2017; Puwanant et al., 2022; Sabuj et al., 2020; Shrestha et al., 2021). Additionally, these studies have explored the association of the MDD-W indicator with factors that could potentially serve as pathways for targeted interventions, aiming to improve dietary diversity and ensure adequate micronutrient intake. (Table 5).

Table 5: *Association between MDD-W score and various independent variables*

Study	Study region and design	Sample size and age	Study objectives	Dietary Assessment	Methodology	Independent variables	Results
(Sabuj et al., 2020)	Community-based cross-sectional study in Noakhali district of Bangladesh	400 lactating mothers of childbearing age	To assess the dietary diversity of lactating mothers and what factors are associated with the mother's dietary diversity	24-h open recall	Minimum dietary diversity score was calculated following the MDD-W guidelines	-Mothers age - Body Mass Index (BMI) -Religion -Mothers education - House ownership -Family type (joint/nuclear) -Monthly income of the family -Number of children	- The mean minimum dietary diversity score of mothers was 4.20; - MDD-W score of mothers ranged 1 to 8 and 64.3% of mothers had dietary diversity score below 5 - Religion, Mothers education, household ownership, family type, monthly income were statistically significant ($p<0.05$) in bivariate analysis model ; house ownership and mother's education were statistically significant in multivariate analysis model
(Pal, Paul, & Dasgupta, 2017)	Community-based cross-sectional study in a Slum of Kolkata, India	182 NPNL (Non-pregnant non- lactating) women, aged 15-49 years	To determine the proportion of WRA attaining	Dietary diversity questionnaire consisting of open recall as well as list	Minimum dietary diversity score was calculated following the	-Mother's age -Religion -Caste	The proportion of WRA" attaining "MDD" was 46.2% On multivariable logistic regression, there was significant association between dietary diversity and

			"MDD" and to explore the predictors affecting "MDD" among WRA	based questions of foods and/or food groups consumed during the past 24 hours.	MDD-W guidelines	-Education - Occupation - SE class - Type of family - Marital status - Number of children - Body mass index (BMI)	small family size (less number of children) adjusted odds ratio (AOR [confidence interval (CI)]): 2.201 (1.046-4.635), upper socioeconomic status AOR (CI): 2.933 (1.473-5.841), higher educational level AOR (CI): 2.835 (1.444-5.567), and occupation other than homemaker AOR (CI): 2.378 (1.138-4.969) Proportions of WRA reaching MDD were 49% in overweight and 14% in obese participants
(Shrestha et al., 2021)	Community-based cross-sectional study in Urban municipality of Baglung district in the western hill region of Nepal	327 pregnant women of childbearing age	To determine the prevalence of low dietary diversity based on MDD-W and associated factors among Nepalese pregnant women	24-h open recall using the five step multi-pass method in conjunction with a photographic food atlas to estimate portion sizes	Minimum dietary diversity score was calculated following the MDD-W guidelines	-Mothers age -Ethnicity - Family structure -Household head -Mothers' and spouse education and employment status -Wealth status -Land ownership	The mean dietary diversity score was 4.76 ± 1.23. Almost 45% (95% CI: 39.6–50.4) of the participants did not consume a diverse diet Multivariable analysis revealed that women with greater empowerment (aOR = 4.3, 95% CI: 1.9–9.9), from wealthier households (aOR = 5.1, 95% CI: 2.7–9.3), joint families (aOR = 2.7, 95% CI: 1.4–5.1), employment (aOR =2.2, 95% CI: 1.2–4.1), and had adequate nutrition knowledge (aOR: 1.9, 95% CI 1.1–3.4) had higher odds of dietary diversity.

						-Women empowerment -Gravida - Pregnancy trimester - Antenatal checkups (ANC) visits - Food taboo practice -Nutritional knowledge	
(Jemal & Awol, 2019)	An institutional cross-sectional study at Alamata General Hospital, Raya Azebo Zone, Tigray Region, Ethiopia	412 pregnant women who were on follow-up from 16 weeks gestational age	To determine prevalence of minimum dietary diversity score (MDDS) and associated factors among pregnant women	List based approach of the food groups consumed during the past 24-hours	Minimum dietary diversity score was calculated following the MDD-W guidelines	-Latrine -Residence -Monthly Income -Education status -Household education status -Eating pattern -Food security -Occupation	61.2% had high MDDS and 38.8% had low MDDS Multivariate analysis revealed that being government employees (AOR = 4.87, CI: 1.70–13.95), merchant (AOR = 4.67, CI: 1.81–12.05), secured food (AOR = 3.85, CI: 2.12–6.97), and eating three meals and above (AOR = 2.66, CI: 1.47–4.82) were significantly associated with high MDDS among pregnant women

(Ahmed & Salih, 2019)		1,700 lactating mothers, aged 15-49 years from five major regions in Saudi Arabia	To evaluate the adequacy of micronutrients in the diets of reproductive women in the KSA using MDD-W guidelines	24h open recall method	Minimum dietary diversity score was calculated following the MDD-W guidelines	- Mothers age(years) -Level of education -Occupation -Monthly income -Knowledge of reproductive women's diets and prenatal and postnatal care factors	54% of mothers achieved the Minimum Dietary Diversity for Women (MDD-W) and consumed an adequate intake of micronutrients There was a positive relationship between the MDD score achieved and the mothers' level of education, income and age (according to trend equations)
(Puwanant et al., 2022)	A cross-sectional study in Southern Thailand	120 healthy women of reproductive age	To determine food group diversity, MDD-W, and micronutrient intake and to clarify the association between MDD-W and mean probability of adequacy (MPA) of 15 micronutrients analyzed	24-h food record using open-ended list for quantitatively and qualitatively assessing the food consumed in the past 24hrs.	-Minimum dietary diversity score was calculated following the MDD-W guidelines -Total intake of each micronutrient from each participant was transformed into the probability of adequacy (PA) and the mean PA (MPA) was	Mean probability of adequacy (MPA)	The average sum of food groups consumed or the MDD-W score of the participants was 5 (range 2–8) The average mean probability of adequacy (MPA) for the 15 micronutrients analyzed was 0.33. MPA significantly correlated with the number of food groups consumed (r=0.46, P<0.001).

					calculated (range 0 to 1).		
(Islam et al., 2023)	A cross-sectional study in St. Martin's Island in Bangladesh	201 women of reproductive age (15-49 years)	To determine dietary diversity of WRA using the MDD-W and micronutrient adequacy in the diets of WRA of St. Martin's island, along with their socio-economic determinants	List-based approach of the food groups consumed during the past 24 hours at the household level (individual intake was then measured using the Adult Male Equivalent (AME) approach.	-Minimum dietary diversity score was calculated following the MDD-W guidelines -Nutrient Adequacy Ratio (NAR) (ratio of an individual's intake to the age- and sex-specific recommendations) was calculated, followed by calculation of the Mean Adequacy ratio (MAR) (average of all truncated NAR Values; range 0 to 1).	-Age -Village -Marital status -Educational level -Occupation -Income quartiles -Household size -Women's decision making role -Body mass index (BMI) -Food security status -Mean adequacy ratio (MAR)	The mean (SD) dietary diversity score was 4.25 (1.17) and about 40.3% of the participants met the MDD-W. Percentages of women consuming all types of food groups, except dairy products, and meat/ fish/poultry were significantly higher among adequate diversified groups compared to the inadequate. The odds of women having adequate diversified diets were higher among those who had at least secondary education compared to those who never attended school (AOR=7.20, 95% CI = 1.84-28.15, p=0.005). Women having decision-making roles in the family had more chance (AOR=2.44, 95% CI = 1.19-5.03, p=0.015) to take diversified foods compared to others MAR was positively associated with adequate dietary diversity. Minimum dietary diversity was a good predictor of the adequacy of micronutrients (Coefficient=0.049, 95% CI= 0.018-0.079, p=0.002).

CHAPTER III

METHODOLOGY

A. Study design and sample

This is a cross-sectional study based on data collected as part of a national survey entitled "Early Life Nutrition and Health in Lebanon, ELNAHL", conducted over a year period from September 2012 to August 2013 (Nasreddine et al., 2017). The survey comprised a representative sample of mother/child dyads (0-5 years old). Details regarding the sampling are published elsewhere (Nasreddine et al., 2017; Nasreddine et al., 2019). Briefly, households were considered as the primary sampling units. The selection of households was conducted based on a stratified cluster sampling strategy, with the six Lebanese governorates constituting the strata, while the clusters were selected further at the level of the districts. The selection of households in each district was based on a probability proportional to size approach, whereby a higher number of participating households were drawn from more populous districts, using systematic sampling. The sample size required for the ELNAHL survey was determined based on an estimated prevalence of 13% of overweight and obesity among children under 5 years of age (De Onis, Blössner, & Borghi, 2010). Consequently, a sample of 1030 under-five children was needed, with a 2% margin of error and a 95% confidence level. To be eligible to participate in the survey, the household ought to include a mother and a child aged 5 years or below. Mothers were excluded from the study if they held a non-Lebanese nationality, had diabetes or hypertension, or were taking medications that could potentially interfere with eating patterns or affect body weight. Of the 1194 eligible households that were visited, 1029 agreed to participate in the survey, with a response rate of 86%. For the present study, data pertinent to mothers/women of reproductive age falling in the age range of 15-49 years was considered (N=927). Those excluded from the current study (n=102) comprised women aged above 50 years (n=19) and those with missing dietary data (n=7). In addition, women who were pregnant at the time of the interview (n=76) were also excluded given that pregnancy may be associated with significant changes in dietary habits and food consumption patterns (Kebbe et al., 2021).

B. Ethical Approval

The design and conduct of the ELNAHL survey was carried out as per the guidelines specified by the Declaration of Helsinki, and all procedures involving human subjects were reviewed and approved by the Institutional Review Board of the American University of Beirut (Protocol number NUT.LN.13). All participating women provided a written informed consent prior to their participation in the study.

C. Data Collection

Data collection was performed in the household setting through face-to-face interviews with the women. Trained nutritionists collected data using a multi-component questionnaire, covering information on demographic, socio-economic, eating habits, anthropometric measurements as well as dietary intakes. The demographic characteristics comprised data about the women’s age (in years), marital status (married/not married), and number of children in the family. The socio-economic factors included the educational level of the woman and her partner (primary or less, secondary level, or college/university) and the household’s monthly income in

Lebanese Pounds, being the most commonly used indicators of socio-economic status (Dinsa et al., 2012) as well as the employment status of the woman and her partner (employed/not employed), house ownership (owned/not owned), and household crowding index (calculated as the ratio of the number of individuals currently living in the household over the number of rooms) (World Health Organization, 2018). Data about whether the woman was specialized in a health-related major was also collected. They were also asked about their eating patterns, including whether or not they eat breakfast every day and the number of meals eaten during a day.

1. Anthropometric Assessment

Anthropometric characteristics including weight, height and waist circumference were measured for all participating women according to standard protocols (Norton, 2019). The woman's height was measured while wearing light clothing and without shoes, using a portable stadiometer (SECA 213) with precision to the nearest 0.5 cm. Weight was measured using a standard clinical balance (SECA 770) with precision to the nearest 0.1 kg. All measurements were taken twice and repeated a third time if the first two measurements differed by more than 0.5 cm for height and 0.3 kg for weight. The average of the measurements was calculated and used for the analysis. To calculate the Body Mass Index (BMI), the average values of weight and height were employed. BMI was computed as the ratio of weight (kilograms) to the square of height (meters) and mothers were classified as underweight (BMI < 18.5 kg/m^2), normal weight (BMI 18.5 to < 25 kg/m^2), overweight (BMI 25 to < 30 kg/m^2) or obese (BMI ≥ 30 kg/m^2) (NIH, 1998). Waist circumference (WC) was measured halfway between the lower rib edge and the upper iliac crest by means of a non-elastic measuring tape. An average of two measurements was recorded to the nearest decimal using standardized protocols (Norton, 2018). Women's waist circumference (WC) was categorized into normal (WC <80 cm) versus elevated (WC ≥ 80 cm)(World Health Organization, 2011b).

2. Dietary Intake Assessment

Dietary intake of participating women was assessed using a single multiple pass 24-hour recall. Although various methods have been developed for assessing dietary consumption, including dietary recalls, food frequency questionnaires (FFQs) and food records (Willett, 2012), the 24-hour open recall approach was selected in this study in accordance with the MDD-W guidelines, which mandate the use of either the list-based approach or the open recall approach for dietary intake assessment (Food and Agriculture Organization, 2021; Food and Agriculture Organization and Family Health International 360, 2016). In the present study, the 24-HR recall was carried using a single, multiple pass five-step approach, as developed by the USDA (Moshfegh et al., 1999). This approach is recommended for use in national surveys and has consistently showed attenuation in the 24-HR's limitations (Moshfegh et al., 2008). The five-steps followed include (1) quick food list recall; (2) forgotten food list probe; (3) time and occasion at which foods were consumed; (4) detailed overall cycle; and (5) a final probe review of the foods consumed. Women were asked to recall and describe all the food and drinks they had consumed in the past 24 hours, including items consumed outside their homes.

The Nutritionist Pro software (version 5.1.0) was used for the analysis of the dietary intake data and for the estimation of energy, macro- and micro-nutrients' intakes of participants. For composite traditional dishes that were not included in the

Nutritionist Pro software, local recipes were added to the Nutritionist Pro software using single-food items. Within the Nutritionist Pro, the USDA database was selected for analysis (SR 24, published September 2011). The food composition of specific Lebanese food that were not included in the Nutritionist Pro database were obtained from the food composition tables for use in the Middle East (Pellet & Shadarevian, 1970).

a. Minimum Dietary Diversity Calculation

Dietary diversity was assessed following the guidelines of the "Minimum Dietary Diversity for Women (MDD-W): An updated guide for measurement" established by the Food and Agriculture Organization (FAO) of the United Nations (Food and Agriculture Organization, 2021). To calculate the diversity score for each subject, composite recipes were first disaggregated into their constitutive ingredients and food items that were consumed in quantities ≥15 g on the previous day were considered. These foods were then categorized into the 10 specified food groups outlined in the MDD-W (Appendix). Each food group was assigned a score of 1 if it was consumed and a score of 0 if it was not. The scores for all 10 food groups were then summed to create a cumulative dietary diversity score, ranging from 0 to 10. The cumulative dietary diversity score was categorized to construct a dichotomized outcome variable: achieving the minimum dietary diversity score (consuming ≥ 5 out of 10 food groups) and not achieving the minimum dietary diversity score (consuming <5 out of 10 food groups).

D. Statistical Analysis

Data entry and analysis was performed using the Statistical Package for Social Sciences (SPSS) version 27.0. Descriptive statistics were reported as means with standard errors (SE) (for continuous normally distributed variables), median and interquartile ranges (for continuous non-normally distributed variables) and as frequencies (n) and proportions (%) for categorical variables.

The distribution of continuous variables was examined by means of visual assessments through histograms and Q-Q plots, along with statistical tests such as the Kolmogorov-Smirnov and Shapiro-Wilk tests of normality. A statistically significant result from these tests indicated that the variables of interest did not follow a normal distribution. In this case, Mann–Whitney U test was used to test for significant differences in these non-normally distributed continuous variables (intakes of food groups (in grams/day and as a percentage of energy intake/day) as well as select macro and micronutrient intakes) across the two MDD categories.

Estimated nutrient intakes were compared to age-specific and lactation status specific Dietary Reference Intakes (DRIs) established by the Institute of Medicine, including the Estimated Average Requirement (EAR), Adequate Intake (AI), and the Acceptable Macronutrient Distribution Range (AMDR) (Meyers, 2006). The upper limit on saturated fat intake was based on the updated guideline established by the WHO (World Health Organization, 2023b). The AMDR for monounsaturated fatty acids (MUFAs) was based on the joint WHO/FAO expert consultation on fats and fatty acids (FAO, 2008). For nutrients with an EAR, the proportion of women with intakes below the EAR (indicating inadequate intake) and those with intakes equal to or greater than the EAR (indicating adequate intake) were calculated. In cases where an EAR value was unavailable, the AI was utilized. The AI represents "a recommended average daily nutrient intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate" (Murphy, Guenther, & Kretsch, 2006). Consequently, a group mean intake at or above the AI suggests a relatively low prevalence of inadequacy (Murphy, Guenther, & Kretsch, 2006). Conversely, if a group's mean intake falls below the AI, it indicates the potential need to increase intakes, although the exact prevalence of inadequacy cannot be precisely quantified (Murphy, Guenther, & Kretsch, 2006). Additionally, the proportions of women with intakes falling within, and outside the upper or lower bounds of the AMDR for carbohydrate, protein, and fat were calculated. The percentage of mothers adhering to DRI was assessed across the two MDD categories using chi-square test or Fischer exact test, as applicable.

To explore the demographic, socioeconomic, anthropometric and eating patterns predictors of achieving the minimum dietary diversity (MDD score ≥ 5), both simple and multiple binary logistic regression analyses were conducted. All variables that showed significance in the simple logistic models were included as independent variables in the final multiple logistic regression models. The presence of multicollinearity between independent demographic and socioeconomic variables was checked using the variance inflation factor (VIF), where a VIF < 10 indicated no collinearity between the variables used in the model. The results from the logistic regression analyses were expressed as odds ratios (OR) or adjusted odds ratios (AOR) with 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant for all analyses.

CHAPTER IV

RESULTS

A. Characteristics of the study population

Table 6 displays the demographic, socioeconomic, anthropometric and eating patterns characteristics of the study participants for the total sample and according to MDD categories. The mean (±standard error) age of participants was 31.64 (± 0.20) years with 54.8% falling within the 26-35 years age range. A majority of women (55%) had 1-2 children. In terms of education, most participants had up to secondary school level (64.1%), while 21.9% had a college/university level education. The majority of women were housewives (81.9%), belonging to the lowest (33.5%) and second (31.5%) income categories, and living in their own houses (61.2%). More than half of the participating women (87.9%) had a crowding index of ≥1 person/room (indicating a lower socioeconomic status). Approximately 58% of the participating women were overweight or obese, with 80.1% having an elevated waist circumference. In terms of eating patterns, approximately two-thirds of women reported having breakfast (64.4%) while less than half reported consuming three or more meals per day (42.8%). When analyzed across MDD categories, significant differences were observed in various socioeconomic characteristics, including monthly household income (p=0.025), house ownership (p=0.003), participants educational status (p=0.007) as well as specialization in a health-related major (p=0.022). Additionally, eating pattern characteristics, including daily breakfast consumption and number of meals consumed per day differed significantly across MDD categories (p<0.001 for both).

Table 6: *Socio-demographic, anthropometric and eating patterns characteristics of the study population (n=927)*

	Total Sample (n=927)	MDD<5 (n=352)	MDD≥5 (n=575)	p-value
		Mean ± SE		
Demographic characteristics				
Age (years)	31.64 ± 0.20	32.14 ± 0.33	32.12 ± 0.26	0.952
Anthropometric characteristics				
Weight (kg)	67.9 ± 0.45	67.70 ± 0.75	68.05 ± 0.57	0.711
Height (cm)	159.4 ± 0.19	158.85 ± 0.33	159.73 ± 0.23	0.025*
Body Mass Index (Kg/m^2)	26.7 ± 0.17	26.84 ± 0.28	26.70 ± 0.22	0.702
Waist Circumference (cm)	89.9 ± 0.42	90.00 ± 0.70	89.99 ± 0.53	0.996
		N (%)		
Demographic characteristics				
Age (years)				
15-25 years	163(17.6)	64(18.2)	99(17.2)	0.863
26-35 years	508(54.8)	189(53.7)	319(55.5)	
36-49 years	256(27.6)	99(28.1)	157(27.3)	
Marital status				
Married	915(98.7)	346(98.3)	569(99)	0.387
Separated/divorced/widowed	12(1.3)	6(1.7)	6(1.0)	
Number of children				
1-2 children	510(55)	201(57.1)	309(53.7)	0.489
3-4 children	341(36.8)	126(35.8)	215(37.4)	
≥ 5 children	76(8.2)	25(7.1)	51(8.9)	
Socioeconomic characteristics				
Monthly Household Income				
≤ 1,000,000 LL	311(33.5)	136(38.6)	175(30.4)	0.025*
1,000,001-2,000,000 LL	292(31.5)	101(28.7)	191(33.2)	
2,000,001-3,000,000 LL	73(7.9)	19(5.4)	54(9.4)	
>3,000,000 LL	80(8.6)	34(9.7)	46(8.0)	
Does not know/refused to answer	171(18.4)	62(17.6)	109(19.0)	
House ownership				
Owned	564(61.2)	192(55)	372(64.9)	0.003*
Not owned	358(38.8)	157(45.0)	201(35.1)	
Mother's educational status				
Illiterate, up to primary	130(14.0)	60(17.0)	70(12.2)	0.007*
Secondary school	594(64.1)	228(64.8)	366(63.7)	
College/university	203(21.9)	64(18.2)	139(24.2)	

Mother's employment status[1]				
Employed	168(18.1)	58(16.5)	110(19.1)	0.309
Unemployed	759(81.9)	294(83.5)	465(80.9)	
Partner's educational status				
Illiterate, up to primary	187(20.5)	77(22.3)	110(19.4)	0.513
Secondary school	590(64.6)	220(63.8)	370(65.1)	
College/university	136(14.9)	48(13.9)	88(15.5)	
Partner's employment status[1]				
Employed	877(95.8)	329(95.4)	548(96.1)	0.568
Unemployed	38(4.2)	16(4.6)	22(3.9)	
Mother specialized in health related major				
Yes	39(4.3)	8(2.3)	31(5.5)	0.022*
No	872(95.7)	338(97.7)	534(94.5)	
Crowding index (CI)				
<1 individual/room	112(12.1)	36(10.2)	76(13.2)	0.175
≥ 1 individual/room	815(87.9)	316(89.8)	499(86.8)	
Anthropometric characteristics				
BMI[2]				
Underweight/Normal	388(42.0)	139(39.5)	249(43.6)	0.218
Overweight/Obese	535(58.0)	213(60.5)	322(56.4)	
Mother's waist circumference (cm)[3]				
Normal	181(19.9)	68(19.5)	113(20.1)	0.835
Elevated	729(80.1)	280(80.5)	449(79.9)	
Eating patterns				
Mother eats breakfast everyday				
Yes	503(64.4)	161(54.6)	342(70.4)	<0.001*
No	278(35.6)	134(45.4)	144(29.6)	
Number of meals eaten				
1 meal	148(16.1)	88(25.1)	60(10.5)	<0.001*
2 meals	378(41.1)	165(47.0)	216(37.7)	
≥ 3 meals	395(42.8)	98(27.9)	297(51.8)	

[1] Unemployed includes those who are not working, retired, looking for a job and/or unable to work
[2]BMI categorization is based on the National Institute of Health clinical guidelines (1998): "Underweight: BMI <18.5; Normal weight: 18.5 ≤ BMI < 25; Overweight: 25 ≤ BMI < 30; Obese: BMI ≥ 30
[3] Waist circumference classification is based on the WHO report "Waist circumference and Waist-Hip ratio" (2008).

B. Dietary Diversity, Food groups and MDD-W

The mean ± SE minimum dietary diversity score for the sample was 4.91 ± 0.05 (range 0-10), based on the consumption of the 10 specified food groups. Out of 927 participants, 575 (62.0%) of women of reproductive age (WRA) achieved the minimum dietary diversity by consuming five or more of the 10 food groups the previous day (at a minimum of 15 g). Figure 3 illustrates the distribution of the sample in terms of the number of foods groups consumed. Notably one participant, constituting 0.1% of the study sample, did not consume any of the MDD-W food groups. Likewise, only one participant (0.1%) consumed all of the 10 food groups and another single participant (0.1%) consumed 9 out of the 10 food groups on the previous day. Very few participants consumed 1 (1.4%), 8 (3.3%) and 2 (5.6%) food groups. Approximately, 12.7%, 13.3% and 18.1% consumed 3, 7 and 8 food groups respectively. The majority of the participants fell between consuming 5 (25.1 %) and 6 (20.1%) food groups on the previous day.

Figure 3: Distribution of the sample (%) based on the number of foods groups consumed

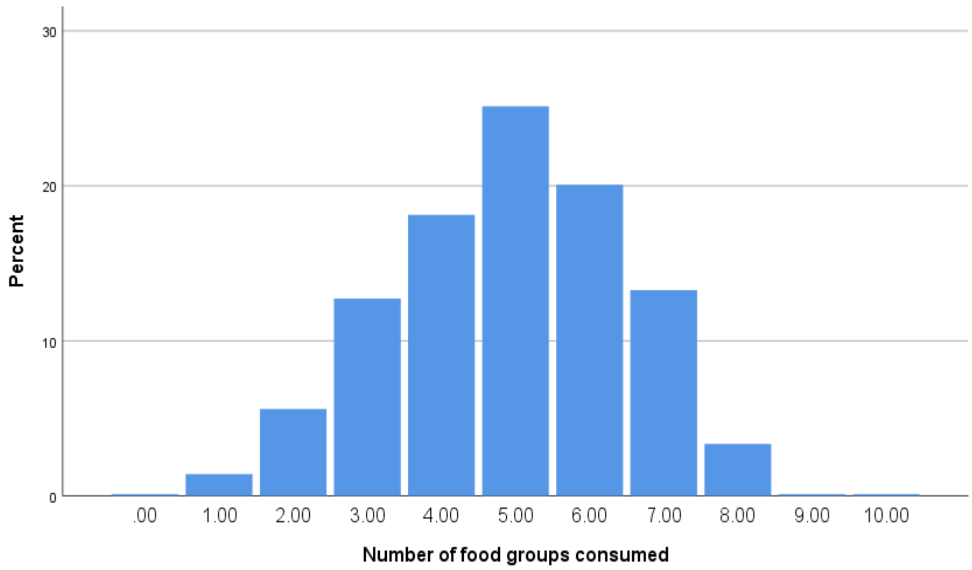


Figure 4 illustrates the prevalence of consumption of each of the 10 food groups among the study participants. The most commonly consumed food group included grains, with an overwhelming 95.4% of participants reporting their consumption. The consumption of meat, poultry, and fish (mainly red meat and poultry) was also quite prevalent, being consumed by 68.5% of the study participants. Similarly, 67.2% of the participating women reported consuming vitamin A rich vegetables or roots, and 64.3% had consumed dairy products (mainly dairy foods) in their diet. Other vegetables and fruits were also popular choices, with 61.6% and 53.8% of participants consuming them, respectively. However, the consumption of dark green leafy vegetables was lower, at 31.3%, while that of pulses was even lower, estimated at 24.9%. The least consumed food groups were nuts and seeds, reported by only 12.8% of participants, and eggs, which were consumed by only 11.2% of participants.

Figure 4: Percentage of WRA consuming each of the ten food groups (N=927)

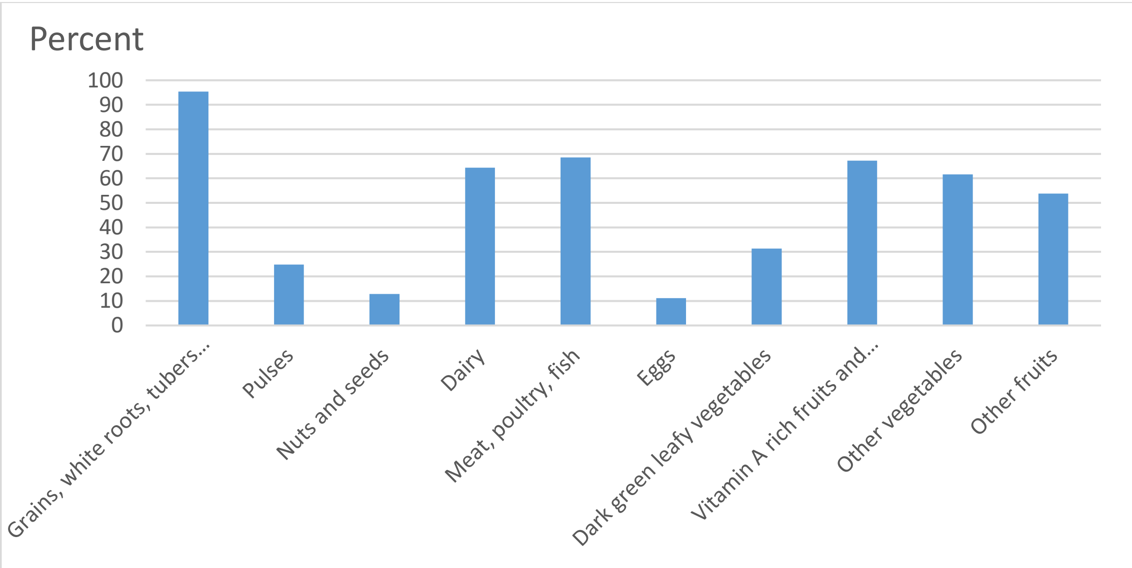


Table 7 and 8 illustrates the intake of the ten MDD food groups in grams/day and %kcal/day, respectively, for the total sample and as categorized based on the MDD scores (MDD≥5 vs MDD<5).

For the total sample, grains were the largest contributors to the participants' daily energy intake (mean ± SE; 25.03±0.46 %kcal/day), followed by the meat, poultry and fish food group (10.52±0.38), and dairy products (especially dairy foods) (8.07±0.31). Eggs had the lowest contribution to the daily energy intake (0.95 ± 0.11). The mean ± SE intake of the fruits, vitamin A rich fruits and vegetables, other vegetables, and dark green leafy vegetables in grams/day were estimated at 146.20±7.22, 101.24±4.04, 63.43±3.05 and 25.17±1.54 respectively.

When analyzed according to the MDD categories, table 7 shows that there was no significant difference in the intake of grains (%EI) between both categories ($p=0.344$). In the meat, poultry and fish food group, only red meat intake differed significantly ($p<0.001$) between MDD categories, with a higher percentage of energy intake in those with adequate dietary diversity score (5.41 ± 0.32 %EI) as compared to those with a low dietary diversity score (4.71 ± 0.50%EI). The intake of all the other food groups were significantly higher among those with adequate dietary diversity as compared to those with a low dietary diversity score, as shown in Table 7 Therefore, participants with an adequate dietary diversity score were found to consume more pulses (beans, peas, lentils), nuts and seeds, dairy products, red meat, eggs, dark green leafy vegetables, vitamin A rich vegetables, other vegetables and other fruits than participants with a low dietary diversity score.

Table 7: *Food group intake amongst Lebanese women, expressed as percentage of energy intake (%EI) by MDD group*

	Mean± SE			Median (IQR)		
	Total sample (n=927)	**MDD<5 (n=352)**	**MDD≥5 (n=575)**	**MDD<5 (n=352)**	**MDD≥5 (n=575)**	**p-value[1]**
Grains, white roots and tubers and plantains	25.03±0.46	25.92±0.90	24.48±0.51	24.92(21.67)	23.87(16.80)	0.344
Foods made from grains	23.98± 0.45	24.45 ± 0.88	23.69 ± 0.500	23.87(22.42)	22.86(16.99)	0.703
White roots and tubers or plantains	1.04± 0.16	1.47 ± 0.36	0.78 ± 0.13	0.00(0.00)	0.00(0.00)	0.895
Pulses (beans, peas or lentils)	1.89 ± 0.16	1.05 ± 0.21	2.40 ± 0.23	0.00(0.00)	0.00(2.28)	<0.001*
Nuts and seeds	2.35 ± 0.26	1.05 ± 0.35	3.14 ± 0.36	0.00(0.00)	0.00(0.00)	<0.001*
Dairy	8.07±0.31	7.25±0.55	8.58±0.38	0.00(12.95)	6.25(13.13)	<0.001*
Milk	0.61 ± 0.07	0.39 ± 0.09	0.75 ± 0.10	0.00(0.00)	0.00(0.00)	0.008*
Dairy foods	7.46± 0.30	6.85 ± 0.54	7.83 ± 0.36	0.00(12.18)	5.78(11.66)	<0.001*
Meat, poultry and fish	10.52±0.38	10.36±0.71	10.62±0.42	5.33(17.28)	8.58(13.42)	0.001*
Organ meats	0.16 ± 0.04	0.13 ± 0.09	0.18 ± 0.05	0.00(0.00)	0.00(0.00)	0.112
Red flesh meat from mammals	5.15± 0.28	4.71 ± 0.50	5.41 ± 0.32	0.00(6.99)	0.00(9.06)	<0.001*
Processed meat	0.55± 0.08	0.52 ± 0.13	0.58 ± 0.09	0.00(0.00)	0.00(0.00)	0.187
Poultry and other white meats	3.38± 0.24	3.76 ± 0.45	3.16 ± 0.28	0.00(0.00)	0.00(3.11)	0.693
Fish and seafood	1.26 ± 0.19	1.23 ± 0.36	1.28 ± 0.22	0.00(0.00)	0.00(0.00)	0.06
Eggs	0.95 ± 0.11	0.55 ± 0.16	1.20 ± 0.14	0.00(0.00)	0.00(0.00)	<0.001*
Dark green leafy vegetables	0.47 ± 0.03	0.21 ± 0.03	0.64 ± 0.04	0.00(0.00)	0.00(0.95)	<0.001*
Vitamin A rich fruits and vegetables	1.82±0.09	1.45±0.17	2.04±0.10	0.00(1.44)	1.12(2.09)	<0.001*
Vitamin A-rich vegetables or roots	0.94 ± 0.042	0.55 ± 0.06	1.18± 0.`05	0.00(0.62)	0.85(1.45)	<0.001*
Vitamin A-rich fruits	0.87± 0.08	0.90 ± 0.15	0.85 ± 0.09	0.00(0.00)	0.00(0.00)	0.038*

Other vegetables	1.37 ± 0.10	1.17 ± 0.19	1.50 ± 0.11	0.00(0.77)	0.73(1.29)	<0.001*
Other fruits	4.90± 0.22	3.65 ± 0.40	5.67 ± 0.25	0.00(4.22)	4.46(8.59)	<0.001*

*Denotes the statistically significant at p<0.005
[1]p-value was extracted using Mann-Whitney U test

Table 8 : *Food group intake amongst Lebanese women expressed in grams/day, by MDD group*

	Mean± SE			Median(IQR)		
	Total sample (n=927)	**MDD<5 (n=352)**	**MDD≥5 (n=575)**	**MDD<5 (n=352)**	**MDD≥5 (n=575)**	**p-value[1]**
Grains, white roots and tubers and plantains	177.25±4.66	143.59±6.20	197.86±6.33	120.00(148.04)	165.32(170.92)	<0.001*
Foods made from grains	161.94 ± 4.37	129.27± 5.85	183.35 ± 5.86	104.14(142.78)	150.0(161.60)	<0.001*
White roots and tubers or plantains	14.67 ± 1.80	14.31± 2.67	14.50 ± 2.34	0.00(0.00)	0.00(0.00)	0.97
Pulses (beans, peas or lentils)	29.76 ± 2.53	11.56± 2.35	40.89± 3.71	0.00(0.00)	0.00(38.45)	<0.001*
Nuts and seeds	11.08 ± 1.68	2.76± 1.07	15.97± 2.55	0.00(0.00)	0.00(0.00)	<0.001*
Dairy	89.83±4.24	66.36±5.84	104.19±5.75	0.00(89.56)	54.00(142.00)	<0.001*
Milk	7.22±1.21	4.47±1.61	8.91±1.68	0.00(0.00)	0.00(0.00)	0.008*
Dairy foods	82.60 ± 4.04	61.89± 5.58	95.28± 5.48	0.00(76.90)	50.00(124.92)	<0.001*
Meat, poultry and fish	80.03±3.29	67.73±5.74	87.56±3.94	31.00(106.13)	60.98(113.47)	<0.001*
Organ meats	1.39 ± 0.38	0.65± 0.42	1.84± 0.55	0.00(0.00)	0.00(0.00)	0.11
Red flesh meat from mammals	32.96 ± 1.84	25.27 ± 2.74	37.66 ± 2.44	0.00(35.49)	0.00(59.98)	<0.001*
Processed meat	4.32 ± 0.53	3.18 ± 0.67	5.01 ± 0.75	0.00(0.00)	0.00(0.00)	0.161
Poultry and other white meats	29.08 ± 2.12	26.65 ± 3.15	30.57 ± 2.83	0.00(0.00)	0.00(32.00)	0.37
Fish and seafood	12.26± 2.11	11.96± 4.31	12.45± 2.15	0.00(0.00)	0.00(0.00)	0.054
Eggs	8.21 ± 0.93	3.37 ± 0.85	11.17± 1.39	0.00(0.00)	0.00(0.00)	<0.001*

Dark green leafy vegetables	25.17± 1.54	8.52 ± 1.45	35.37 ± 2.22	0.00(0.00)	0.00(62.00)	<0.001*
Vitamin A rich fruits and vegetables	101.24±4.04	48.71±4.63	133.39±5.45	0.00(75.51)	101.39(134.86)	<0.001*
Vitamin A-rich vegetables or roots	72.72±3.10	29.70± 3.34	99.06±4.19	0.00(35.53)	77.22(114.00)	<0.001*
Vitamin A-rich fruits	28.51±2.60	19.00 ± 3.10	34.33 ± 3.71	0.00(0.00)	0.00(0.00)	0.013*
Other vegetables	63.43± 3.05	33.89 ± 3.90	81.51 ± 4.14	0.00(30.50)	57.28(93.60)	<0.001*
Other fruits	146.20 ± 7.22	78.36± 9.10	187.73± 9.84	0.00(76.00)	135.00(270.00)	<0.001*

*Denotes the statistically significant at p<0.05
[1]p-value was extracted using Mann-Whitney U test

C. Nutrient intake calculation

1. Macronutrient intakes and adequacy by MDD category

Table 9 illustrates the mean and median dietary macronutrient intakes of participants in grams/day and %kcal/day for the total sample, and as categorized according to their MDD scores. Table 10 compares these intakes with the recommended Dietary Reference Intakes (DRIs).

For the total sample, the mean ± SE caloric intake of participants was 1589.19 ± 25.50 kcal. About half of their energy intake came from carbohydrates, accounting for 49.66±0.38% kcal/day. Furthermore, 54.3% of the participants fell within the Acceptable Macronutrient Distribution range (AMDR) of 45-65% for carbohydrate consumption. The percentage of energy contributed by total sugars was 17.91 ± 0.31 %kcal/day. The average daily fiber intake among all participants was of 14.34 ± 0.3) g/day and a significant majority of 90.1% fell short of meeting the recommended adequate intake for fiber. In terms of protein consumption, a substantial proportion of participants (77.9%)

adhered to the AMDR. Conversely, 58.6% of the participants surpassed the AMDR for total fat intake, with total fat contributing to approximately 37.47 ± 0.33% of their daily caloric intake. The majority of the participants had inadequate intakes of linoleic acid (53.3%) and alpha-linolenic acid (81.9%), and 63.3% of participants consumed less than the AMDR for MUFAs. Additionally, around 40% of the participants exceeded the upper limit for saturated fat intake (10% of total energy intake).

Regarding macronutrient intakes based on MDD categories, those with an adequate dietary diversity score had a significantly higher mean caloric intake of (1787.19±32.79 kcal/day) compared to those with a low dietary diversity (1265.76±34.12 kcal/day) ($p<0.001$). In addition, while those with a low dietary diversity score had a significantly higher contribution of carbohydrates to their total energy intake (51.49±0.70 vs. 48.55±0.43)%kcal/day ($p=0.002$), participants with an adequate dietary diversity score were more likely to meet the Estimated Average Requirement (EAR) for carbohydrates (89.4% vs. 70.5%) ($p<0.001$). The intake of total sugars did not differ significantly between MDD categories. The average daily fiber intake was significantly higher among participants with an adequate dietary diversity score (17.24±0.46 vs. 9.60±0.33 g/day) ($p<0.001$), and a significantly higher proportion met the recommended adequate intake of fiber. Most participants in both MDD categories consumed protein within the AMDR, but significant differences were observed between the MDD categories.

Regarding dietary fat intake, participants with an adequate dietary diversity score had a significantly higher contribution of total fat to their total energy intake (38.48±0.38 %kcal/day) compared to those with a low dietary diversity score (35.81±0.59 %kcal/day) ($p<0.001$). However, in both MDD categories, the intake of total fat exceeded the AMDR, although there were significant differences between the groups. Those with an adequate dietary diversity score had a significantly higher contribution of MUFAs to their total energy intake (14.49±0.26%kcal/day) and a significantly higher proportion of participants with adequate dietary diversity score adhered to the recommended adequate intake for linoleic acid and alpha-linolenic acid (54.1% vs 34.7% (p<0.001); 21.9% vs. 11.9% (p<0.001)) respectively. The percentage of energy contributed by saturated fat did not differ significantly between MDD categories (p=0.816).

Table 9: *Macronutrient intakes amongst Lebanese women by MDD group*

	Mean± SE			Median (IQR)		
	Total sample (n=927)	**MDD<5 (n=352)**	**MDD>=5 (n=575)**	**MDD<5 (n=352)**	**MDD>=5 (n=575)**	**p-value[2]**
Energy (kcal/day)	1589.19±25.50	1265.76±34.12	1787.19±32.79	1171.33(799.51)	1674.30(983.45)	<0.001*
Total Carbohydrates						
g/day	192.06±3.09	157.40±4.15	213.28±4.04	145.69(109.85)	197.99(117.18)	<0.001*
%kcal/day	49.66±0.38	51.49±0.70	48.55±0.43	50.94(16.91)	48.62(14.28)	0.002*
Total sugars						
g/day	67.49±1.38	57.03±2.09	73.89±1.78	48.83(50.61)	67.11(52.28)	<0.001*
%kcal/day	17.91±0.31	19.11±0.62	17.17±0.32	17.51(13.55)	16.07(9.73)	0.093
Fiber						
g/day	14.34±0.33	9.60±0.33	17.24±0.46	8.17(7.40)	14.56(10.55)	<0.001*
Total protein						
g/day	56.27±1.11	43.44±1.54	64.13±1.43	37.18(31.90)	59.41(41.01)	<0.001*
%kcal/day	14.21±0.17	13.76±0.32	14.48±0.20	12.89(6.79)	13.91(5.76)	0.001*
Total fat						
g/day	68.55±1.42	52.61±1.86	78.31±1.88	45.28(40.22)	67.43(51.94)	<0.001*
%kcal/day	37.47±0.33	35.81±0.59	38.48±0.38	35.52(14.15)	38.52(12.90)	<0.001*
Saturated fat						
g/day	17.53±0.39	14.45±0.61	19.42±0.50	11.53(12.81)	16.74(14.90)	<0.001*
%kcal/day	9.69±0.13	9.76±0.25	9.64±0.16	9.07(6.24)	9.16(4.77)	0.816
Monounsaturated fatty acids (MUFA)						
g/day	25.68±0.69	19.1±0.84	29.70±0.95	14.82(16.99)	24.12(21.40)	<0.001*
%kcal/day	13.86±0.21	12.84±0.34	14.49±0.26	11.81(8.47)	13.58(7.90)	<0.001*
n-6 polyunsaturated						

fatty acids (linoleic acid)						
g/day	14.65±0.40	10.69±0.47	17.07±0.55	8.61(11.09)	13.24(14.08)	<0.001*
%kcal/day	7.94±0.14	7.38±0.24	8.28±0.17	6.74(5.45)	7.71(5.50)	<0.001*
n-3 polyunsaturated fatty acids (a-linolenic acid)						
g/day	0.77±0.01	0.63±0.03	0.86±0.02	0.47(0.55)	0.73(0.61)	<0.001*
%kcal/day	0.43±0.01	0.44±0.02	0.43±0.008	0.36(0.25)	0.39(0.22)	0.012*

*Denotes the statistically significant at p<0.005
[1]p-value was extracted using Mann-Whitney U test

Table 10: *Macronutrients intakes amongst Lebanese women (%DRI compliance by MDD category)*

	DRI[1] (AI/EAR/AMDR)					
	15 to 18 years	**19 to 50 years**	**Total sample (n=927)**	**MDD<5 (n=352)**	**MDD≥5 (n=575)**	**p-value[2]**
Total Carbohydrates (% EI)	45-65%	45-65%				
< AMDR			335(36.1)	111(31.5)	224(39.0)	<0.001*
= AMDR			503(54.3)	184(52.3)	319(55.5)	
> AMDR			89(9.6)	57(16.2)	32(5.6)	
Total Carbohydrates (g/day)	100 (NL)[a] ; 160 (L)[b]	100 (NL) ; 160 (L)				
< EAR			165(17.8)	104(29.5)	61(10.6)	<0.001*
≥ EAR			762(82.2)	248(70.5)	514(89.4)	
Dietary fiber (g/day)	26 (NL) ; 29 (L)	25 (NL) ; 29 (L)				
< AI			835(90.1)	342(97.2)	493(85.7)	<0.001*
≥ AI			92(9.9)	10(2.8)	82(14.3)	
Protein (%EI)	10-30% (NL); 10-35 (L)	10-35%				
< AMDR			196(21.1)	98(27.8)	98(17.0)	<0.001*
= AMDR			722(77.9)	249(70.7)	473(82.3)	
> AMDR			9(1.0)	5(1.4)	4(0.7)	
Total fat (%EI)	25-35% (NL) ; 20-35% (L)	20-35%				
< AMDR			39(4.2)	29(8.2)	10(1.7)	<0.001*
= AMDR			345(37.2)	140(39.8)	205(35.7)	

> AMDR			543(58.6)	183(52.0)	360(62.6)	
Linoleic acid (g/day)	11(NL); 13 (L)	12 (NL) ; 13 (L)				
< AI			494(53.3)	230(65.3)	264(45.9)	<0.001*
≥ AI			433(46.7)	122(34.7)	311(54.1)	
Alpha- linolenic acid (g/day)	1.1 (NL) ; 1.3 (L)	1.1 (NL) ; 1.3 (L)				
< AI			759(81.9)	310(88.1)	449(78.1)	<0.001*
≥ AI			168(18.1)	42(11.9)	126(21.9)	
Monounsaturated fatty acids (MUFAs)[3]	15-20%	15-20%				
< AMDR			587(63.3)	240(68.2)	347(60.3)	0.055
= AMDR			184(19.8)	60(17.0)	124(21.6)	
> AMDR			156(16.8)	52(14.8)	104(!8.1)	
Saturated fat † (% EI)	<10%	<10%				
< UL			564(60.8)	211(59.9)	353(61.4)	0.661
≥ UL			363(39.2)	141(40.1)	222(38.6)	

† WHO upper limit of saturated fat (10% of energy intake) for adults
*Denotes the statistically significant at p<0.005
[1]This table (taken from the Institute of Medicine (2006) presents Dietary reference intakes (DRIs) whereby AMDR= Acceptable Macronutrient Distribution Ranges; EAR = Estimated Average Requirements; AI= Adequate Intake.
[2] p-value was calculated using chi-square test or Fischer exact test, as applicable
[3] Monounsaturated fatty acid recommendations was taken from the joint WHO/FAO expert consultation on fats and fatty acids (2008)
[a] and [b] indicates NL (non-lactating) and L (lactating) statuses respectively

2. *Dietary micronutrient intakes and adequacy by MDD category*

Table 11 illustrates the micronutrient intakes of participating women for the total sample and as categorized according to their MDD scores. Table 12 compares these intakes with the recommended Dietary Reference Intakes (DRIs).

An overwhelming proportion of the total sample exhibited inadequate intakes across most of the assessed micronutrients. This was particularly evident for iodine and vitamin D, whereby 99.9% and 98.9% of participants respectively had inadequate intakes. Additionally, a substantial majority demonstrated inadequate intake levels for vitamin A (84.4%), calcium (83.5%), folate (80.6%), zinc (65.0%) and vitamin B12 (63.1%). On the other hand, about half of the proportion of participants (50.6%) had adequate iron intakes, which fared relatively better compared to other micronutrients.

When compared based on their dietary diversity scores, those with an adequate score had significantly higher mean intakes of all micronutrients assessed ($p<0.001$ for all) with the exception of iodine (Table 11). In addition, participants with an adequate dietary diversity score were more likely to meet the recommended intakes for most of the assessed micronutrients (Table 12). Notably, the high MDD group had significantly higher proportions of women meeting recommendations for folate (25.9% vs. 8.8%; $p<0.001$) and vitamin A (20.9% vs. 7.1%; $p<0.001$). Moreover, nearly twice as many participants with an adequate dietary diversity score have met the recommended intake for iron (61.0% vs. 33.5%; $p<0.001$), vitamin B12 (43.3% vs. 26.4%; $p<0.001$), zinc (42.8% vs. 22.2%; $p<0.001$) and calcium (20.7% vs. 9.7%; $p<0.001$) compared to those with a low dietary diversity score. However, a substantial proportion of participants in both dietary diversity (MDD) categories failed to meet the recommended intakes for both iodine and vitamin D, with no significant difference observed between the two groups ($p=0.38$ for iodine and $p=0.099$ for vitamin D).

Table 11: *Micronutrient intakes of Lebanese women, by MDD group*

	Mean± SE			Median (IQR)		
	Total sample (n=927)	MDD<5 (n=352)	MDD≥5 (n=575)	MDD<5 (n=352)	MDD≥5 (n=575)	p-value[1]
Iron						
mg/day	10.62±0.49	7.73±0.71	12.38±0.65	5.58(6.00)	9.37(8.99)	<0.001*
/1000 kcal	6.74±0.27	6.29±0.49	7.02±0.32	4.73(3.63)	5.53(3.56)	<0.001*
Folate (B9)						
(µg DFE/d)	222.06±6.52	136.92±6.75	274.18±9.01	99.86(110.66)	208.95(218.25)	<0.001*
/1000 kcal	141.91±3.62	113.96±5.61	159.01±4.57	83.25(81.35)	127.21(113.96)	<0.001*
Cobalamin (B12)						
µg/d	2.81±0.23	2.12±0.31	3.23±0.32	0.87(1.83)	1.66(2.66)	<0.001*
/1000 kcal	1.79±0.14	1.65±0.20	1.87±0.18	0.78(1.53)	1.00(1.50)	0.001*
Vitamin A						
µg RAE/d	360.29±22.61	211.91±22.48	451.12±33.21	116.22(171.64)	264.07(350.43)	<0.001*
/1000 kcal	245.58±15.82	194.02±27.32	277.15±19.16	94.38(137.14)	160.48(202.91)	<0.001*
Vitamin D						
µg/d	1.09±0.13	0.93±0.30	1.19±0.10	0.18(0.48)	0.30(1.22)	<0.001*
/1000 kcal	0.70±0.07	0.64±0.15	0.74±0.07	0.15(0.42)	0.19(0.68)	0.002*
Calcium						
mg/d	480.83±12.05	350.28±15.92	560.74±15.93	269.18(353.89)	459.53(434.30)	<0.001*
/1000 kcal	309.09±6.49	285.25±10.96	323.69±7.99	226.91(257.80)	273.45(236.25)	<0.001*
Zinc						
mg/d	6.90±0.17	5.28±0.30	7.89±0.20	4.33(4.05)	6.57(5.69)	<0.001*
/1000 kcal	4.38±0.08	4.23±0.20	4.47±0.07	3.56(2.41)	4.08(2.28)	<0.001*
Iodine						
µg/d	1.19±0.39	1.29±0.89	1.13±0.32	0.00(0.00)	0.00(0.00)	0.905
/1000 kcal	0.64±0.20	0.68±0.44	0.61±0.19	0.00(0.00)	0.00(0.00)	0.872

*Denotes the statistically significant at p<0.005
[1]p-value was extracted using Mann-Whitney U test

Table 12: *Micronutrients intakes amongst Lebanese women (%DRI compliance by MDD category)*

	[1]DRI (EAR)					
	15 to 18 years	**19 to 50 years**	**Total sample (n=927)**	**MDD<5 (n=352)**	**MDD≥5 (n=575)**	**p-value[2]**
Iron (mg/d)	7.9 (NL)[a] ; 7 (L)[b]	8.1 (NL) ; 6.5 (L)				
<EAR			458(49.4)	234(66.5)	224(39.0)	<0.001*
≥EAR			469(50.6)	118(33.5)	351(61.0)	
Calcium (mg/d)	1100(NL); 1000 (L)	800				
< EAR			774(83.5)	318(90.3)	456(79.3)	<0.001*
≥EAR			153(16.5)	34(9.7)	119(20.7)	
Zinc (mg/d)	7.3 (NL) ; 10.9 (L)	6.8 (NL) ; 10.4 (L)				
< EAR			603(65.0)	274(77.8)	329(57.2)	<0.001*
≥EAR			324(35.0)	78(22.2)	246(42.8)	
Iodine (µg/d)	95	209				
<EAR			926(99.9)	351(99.7)	575(100)	0.38
≥EAR			1(0.1)	1(0.3)	0(0.00)	
Vitamin A (µg RAE/d)	485 (NL) ; 885 (L)	500 (NL) ; 900 (L)				
< EAR			782(84.4)	327(92.9)	455(79.1)	<0.001*
≥EAR			145(15.6)	25(7.1)	120(20.9)	
Vitamin D (µg/d)	10	10				
< EAR			917(98.9)	351(99.7)	566(98.4)	0.099
≥EAR			10(1.1)	1(0.3)	9(1.6)	
Folate (µg DFE/d)	330 (NL) ; 450 (L)	320 (NL) ; 450 (L)				
<EAR			747(80.6)	321(91.2)	426(74.1)	<0.001*
≥EAR			180(19.4)	31(8.8)	149(25.9)	
Vitamin B12 (µg/d)	2.0 (NL) ; 2.4 (L)	2.0 (NL) ; 2.4 (L)				
< EAR			585(63.1)	259(73.6)	326(56.7)	<0.001*
≥EAR			342(36.9)	93(26.4)	249(43.3)	

*Denotes the statistically significant at p<0.005

[1] This table presents Estimated Average requirements (EAR) as established by the Institute of Medicine (IOM, 2006)

[2] p-value was calculated using chi-square test or Fischer exact test, as applicable

[a] and [b] indicates NL (non-lactating) and L (lactating) respectively

D. Determinants of dietary diversity amongst WRA in Lebanon

In the simple logistic analysis model (Table 13), several factors were significantly associated with dietary diversity, including the household's monthly income, house ownership, the participant's educational status, specialization in a health-related major, daily breakfast consumption, and the number of meals consumed per day ($p<0.05$).

In the multiple logistic regression analysis model (Table 13), significant associations were retained between participants' dietary diversity and their daily breakfast consumption as well as the number of meals consumed per day. Specifically, women who consumed breakfast daily had higher odds of having a diversified diet compared to those who did not (adjusted odds ratio [AOR] = 1.448, 95% confidence interval [CI] = 1.179, 2.846, $p = 0.036$). Furthermore, as the number of meals consumed per day increased, the odds of consuming a diverse diet also increased. Women who consumed two meals per day were 1.8 times more likely to have a diverse diet compared to those who consumed only one meal (AOR = 1.832, 95% CI = 1.179, 2.846, $p = 0.007$). Similarly, women who consumed three or more meals per day were 3.4 times more likely to have a diverse diet compared to those who consumed only one meal (AOR = 3.430, 95% CI = 2.135, 5.511, $p < 0.001$).

Table 13: *Association between MDD-W and various predictor variables among WRA (N=927)*

Variables	AOR (95% CI)	p-value[1]
Age (years)		
15-25 years		
26-35 years		
36-49 years		
Monthly Household Income		
≤ 1,000,000 LL	1	
1,000,001-2,000,000 LL	1.414 (0.963, 2.076)	0.077
2,000,001-3,000,000 LL	1.656 (0.834, 3.289)	0.15
>3,000,000 LL	0.951 (0.511, 1.771)	0.875
Refused to answer	1.045 (0.671, 1.628)	0.846
Mother's marital status		
Married		
Separated/divorced/widowed		
House ownership		
Not owned	1	
Owned	1.150 (0.834, 1.585)	0.393
Mother's educational status		
Illiterate, up to primary	1	
Secondary school	1.343 (0.860, 2.098)	0.194
College/university	1.416 (0.802, 2.499)	0.23
Mother's employment status		
Employed		
Unemployed		
Mother specialized in health related major		
No	1	
Yes	1.882 (0.758, 4.676)	0.173
Number of children		
1-2 children		
3-4 children		
≥ 5 children		
Partner's educational status		
Illiterate, up to primary		
Secondary school		
College/university		
Partner's employment status		
Employed		
Unemployed		
Crowding index (CI)		
<1 individual/room		
≥ 1 individual/room		
BMI		
Underweight/Normal		
Overweight/Obese		
Mother's waist circumference (cm)		

Normal		
Elevated		
Mother eats breakfast everyday		
No	1	
Yes	1.448 (1.024, 2.047)	0.036*
Number of meals eaten		
1 meal	1	
2 meals	1.832 (1.179, 2.846)	0.007*
≥ 3 meals	3.430 (2.135, 5.511)	<0.001*

*Denotes the statistically significant at p<0.005
[1]Multiple logistic regression analysis was run adjusting for significant variables
AOR: Adjusted Odds Ratio; CI: Confidence Interval

CHAPTER IV

DISCUSSION

This study examined the dietary diversity of non-pregnant women of reproductive age (WRA) in Lebanon and showed that more than a third (38%) of the study sample did not meet the MDD. It also showed that women with an adequate dietary diversity score had higher intakes of all 10 defined MDD food groups, except for grains, which were prominent in the diets of participants across both MDD categories. Moreover, those with an adequate dietary diversity score showed higher intakes of fiber, protein, total fats, mono and polyunsaturated fatty acids, as well as higher intakes of 7 out of the 8 assessed micronutrients. Additionally, a greater proportion of women with adequate dietary diversity met the DRIs for most of the evaluated macronutrients (excluding total fat and saturated fat) and micronutrients (excluding iodine and vitamin D). Eating patterns characteristics, including daily breakfast consumption and the number of meals consumed per day were independent predictors of dietary diversity in the study sample.

The study revealed that 62% of Lebanese WRA achieved the MDD. In line with our findings, over 50% of non-pregnant women of reproductive age (WRA) achieved the MDD score in other Middle Eastern countries like Saudi Arabia (54%) (Ahmed & Salih, 2019) and Iran (80%) (Rayyani et al., 2019), despite the differences in global income inequalities among these countries. The higher proportions observed in our study in comparison to the study done in Saudi Arabia may be attributed to variations in dietary consumption patterns between these populations. The Lebanese diet is traditionally a Mediterranean dietary pattern (Naja et al., 2013), which has been reported in literature as a dietary model through which dietary diversity is easily achieved (Dayi et al., 2021). Conversely, the lower proportions observed in our study, compared to the study done in Iran (Rayyani et al., 2019), might be due to the fact that the Iranian study was conducted in Tehran, an urban area. Numerous studies consistently show that urban areas are associated with significantly higher MDD scores compared to periurban and rural locations (Ahmed & Salih, 2019; Brazier et al., 2020; Chakona & Shackleton, 2017). For example, in a rural area of Pakistan, the percentage of WRA reaching the MDD ranged between 26% and 41% across five study time points (Brazier et al., 2020), while in an urban area of Pakistan (Islamabad), it was as high as 89% (Ali, Thaver, & Khan, 2014). Compared to previous studies conducted in Lebanon, our estimate is close to that reported by Abi Khalil et al. (54.5%) (Abi Khalil, Hawi, & Hoteit, 2022), based on a 7-food group diversity score, while being considerably higher than that reported by Jomaa et al. based on data collected in 2014 (38%) (Jomaa et al., 2020).

Our study showed that out of the 10 MDD food groups, the most frequently consumed food groups by WRA in our study were grains, followed by the meat/poultry/fish food group (especially red meat and poultry), and these food groups were also the main contributors to the total energy intake (%EI). Our findings were consistent with previous studies done in other low to middle-income countries (LMICs) (Chakona & Shackleton, 2017; Puwanant et al., 2022; Rayyani et al., 2019; Shumayla et al., 2022), whereby grains were reported as the most frequently consumed food group by WRA. The fact that grains were a main contributor to the total energy intake of WRA in our study reflects that bread is considered a staple food in Lebanon. In fact, in a study by Almedawar et al., bread is considered as the most popular staple food that is heavily consumed (136.8g/day) in the daily diet of the Lebanese population(Almedawar et al., 2015).

In our study, the meat/poultry/fish (especially red meat and poultry), and dairy products food groups were the second and third largest contributors to total energy intake in the diets of WRA respectively. This finding aligns with a previous study done by Nasreddine et al., on Lebanese women (20-59.9 year), where the energy proportions (%EI) from red meat (5.89 ± 0.42), poultry (3.87 ± 0.35) and dairy products (7.59 ± 0.32) closely resembled our study's red meat (5.15± 0.28), poultry (3.38± 0.24) and dairy products (7.46 ± 0.30) contributions (Nasreddine et al., 2020). Moreover, meat/poultry/fish (especially meat and poultry) and dairy products were among the most frequently consumed food groups in the diets of WRA in other Middle Eastern countries like Saudi Arabia and Iran (Ahmed & Salih, 2019; Rayyani et al., 2019). However, it is worth highlighting that the average daily consumption of red meat (in grams/day) among WRA in our study was not low in comparison to the dietary recommendations outlined by the Global Burden of Disease Study (Afshin et al., 2019). According to their study, the range for optimal red meat intake for mitigating all-cause mortality lies between 18-27g of day – a range that is lower than the mean daily intake of red meat (32.96 ± 1.84) g among WRA in our study.

In our study, fruits and vegetables were consumed by 31-68% of the study population, surpassing proportions reported among Saudi Arabian women (20-49%) (Ahmed & Salih, 2019). Discrepancies in these findings are anticipated, given that fruits and vegetables constitute vital components of the traditional Lebanese diet (Naja et al., 2011). Nonetheless, it is important to emphasize that the total mean intake of fruits and vegetables in our study, which amounted to approximately 336.04g, was lower than the

World Health Organization's (WHO) minimum recommended value of 400g/day (World Health Organization, 2003).

As expected, the intake of all food groups were significantly higher among participants with adequate dietary diversity score (MDD≥5) in comparison to those with a low dietary diversity score (MDD<5). One main exception was the grains food group, which was prominent in the diets of participants in both MDD categories, highlighting once again the staple nature of this food group in Lebanon. In line with our findings, a previous study done in rural Mali have reported a correlation between diet diversity scores and the number of food groups consumed (Torheim et al., 2004). Similarly, another study done amongst Sri Lankan adults found that as different dietary diversity scores increased, the percentage of consumption was increased in most of food groups except starches (Jayawardena et al., 2013). It is also worth noting that while participants with an adequate dietary diversity score had higher intakes across all the subdivisions of the meat/poultry/fish food group (including organ meats, red meat, processed meat, poultry, fish and seafood); only red meat intake differed significantly across the MDD categories. Moreover, fish intake did not differ between participants across both MDD categories (12.45± 2.15g/day for MDD≥5 vs. 12.45± 2.15g/day for MDD<5) and was found to be low in both; all participants were found to consume less than 1 serving per week (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2020). This observation is consistent with previous studies done in Lebanon, which have consistently indicated a low level of fish consumption (Nasreddine et al., 2020; Nasreddine et al., 2006). Furthermore, a comprehensive study encompassing 20 countries of the Middle East and North Africa (MENA) region revealed that seafood intake is generally low across the entire region, with the exception of Turkey (Afshin et al., 2019).

Significant differences were also observed in terms of macronutrient intakes across the MDD categories. Those with an adequate dietary diversity score (MDD≥5) exhibited higher intakes (%EI/day) protein, total fats, monounsaturated fatty acids (MUFAs), omega-3 (alpha-linolenic acid), and omega-6 (linoleic acid) polyunsaturated fatty acids, as well as dietary fiber (g/day). These findings are of public health relevance given that these nutrients are tightly linked to improved nutritional status and cardiometabolic health in women (Arimond & Deitchler, 2019). For instance, a higher intake of dietary fiber was associated with increasing gut microbiome diversity, and lower risk of glucose intolerance, pre-eclampsia, excessive weight gain and constipation (Hull et al., 2020; Zerfu & Mekuria, 2019). In addition, an increased intake of omega 3 fatty acids is vital for WRA as it serves as a well-recognized precursor of crucial fatty acids, namely docosahexaenoic (DHA) and eicosapentaenoic (EPA) acids. These fatty acids aids in lowering triglycerides levels and are known for their anti-inflammatory, anti-thrombotic and anti-arrhythmic properties (Christensen et al., 1996), while also playing a pivotal role in the development of the fetal nervous system (Leikin-Frenkel, 2016). Additionally, omega 3 fatty acids have been found to function as a gene-programming regulator, contributing to the prevention of metabolic disorders and the promotion of overall health in offspring (Leikin-Frenkel, 2016). Our study also showed that caloric intake was higher amongst those with adequate dietary diversity. While some studies have presented varying viewpoints on the association between dietary diversity and macronutrient intakes (Gómez et al., 2020; Lander et al., 2019), the majority consistently assert a positive correlation between dietary diversity and energy intake (Gómez et al., 2020; Jayawardena et al., 2013; Lander et al., 2019; Mirmiran, Azadbakht, & Azizi, 2006; Torheim et al., 2004). Considering the established link between dietary diversity and energy intake, a prudent approach would be to recommend dietary diversity within the context of a diet that maintains appropriate energy balance (Mirmiran, Azadbakht, & Azizi, 2006). In our study, participants with a low dietary diversity score (MDD<5) had a significantly higher intakes of carbohydrates. Given that there was no difference in the consumption of grains among participants in both MDD categories, it is possible that the higher carbohydrate intake observed in individuals with low dietary diversity scores could be attributed to elevated consumption of added sugars found in sweets and sugar-sweetened beverages- an aspect not addressed in the current study.

Despite inadequate micronutrient intakes among WRA in our study, significant differences were observed across MDD categories. Those with an adequate dietary diversity score (MDD≥5) had significantly higher intakes (/1000 kcal) of all of the assessed micronutrients compared to those with a low dietary diversity score (MDD<5), with the exception of iodine. Additionally, the proportion of WRA meeting the respective Dietary Reference Intakes (DRIs) were significantly higher among those with an adequate dietary diversity score for iron, folate, calcium, zinc, vitamin A and vitamin B12. These findings are of public health relevance given that micronutrient deficiencies among WRA is consistently recognized as a concern, particularly in low to middle income countries(Brazier et al., 2020; Gernand et al., 2016; Islam et al., 2023; Puwanant et al., 2022). Previous studies done in Lebanon have reported on specific micronutrient inadequacies such as iron, folate, vitamin A and vitamin D among WRA (Al Khatib et al., 2006; Doumani et al., 2021; Gannagé-Yared et al., 2014). Deficiencies in iron, folate and vitamins B12 and A can lead to anemia, with adverse effects on productivity and cognition (World Health Organization, 2023a) while also accounting for 20% of all maternal and perinatal mortality as well as low birth weight (Kozuki et al., 2012; Steer, 2000). Folate deficiency at the time of conception can cause neural tube defects such as spina bifida, in infants (House, Nichols, & Rae, 2021). Vitamin A deficiency (VAD) can lead to impaired vision (e.g., night blindness), weakened immune function, and an increased risk of preterm birth and infant mortality (Bates, 1995; Tielsch et al., 2008). Zinc deficiency has been implicated as a risk factor with adverse long-term effects on the growth, immunity and the metabolic state of the offspring (Karimi et al., 2012). Therefore, implementing strategies aimed at enhancing micronutrient adequacies among WRA is pivotal for their optimal health, in terms of preventing related diseases or conditions, adverse pregnancy outcomes and risk of fetal complications. In our study, the proportions of women meeting the DRIs for iodine and vitamin D did not differ between MDD categories. These findings are not quite surprising. The absence of variance in iodine intake across MDD categories is anticipated, as the intake of fish and seafood, recognized as the richest natural sources of iodine (Julshamn, Dahl, & Eckhoff, 2001), showed no difference between the groups. Furthermore, it is worth noting that our study lacked information regarding the use of iodized salt. Likewise, the absence of variance in the consumption of vitamin D-rich foods, such as fish and organ meat (Dominguez et al., 2021) among participants could elucidate the lack of differentiation in the proportion of women meeting the recommended vitamin D intake levels across MDD categories. Furthermore, eggs, another important source of vitamin D (Dominguez et al., 2021), were the least consumed food group among participants.

Our findings on the association between higher dietary diversity and higher micronutrient intakes are consistent with previous studies done among WRA in LMICs, using the MDD-W (Gómez et al., 2020; Lander et al., 2019). Moreover, other studies have found significant correlations between the Mean Adequacy Ratio (MAR) - a measure of overall nutrient adequacy calculated as the mean of the nutrient adequacy ratios (NARs) - (Torheim et al., 2004) with various indicators of dietary diversity (Islam et al., 2023; Torheim et al., 2004). The significant relationship observed in this study between higher intakes of most micronutrients and higher dietary diversity score is consistent with the validation work of the MDD-W indicator (Arimond et al., 2010; Martin-Prével et al., 2015). Our data supports the use of the MDD-W indicator as a proxy indicator for higher micronutrient adequacy in large surveys of WRA living in LMICs, and in the nutrition transition context (Food and Agriculture Organization, 2021).

The present study also examined the demographic, socioeconomic and anthropometric as well as eating patterns characteristics associated with minimum dietary diversity among non-pregnant WRA in Lebanon. The results showed that, while controlling for potential confounding factors in multiple logistic regression analysis, eating patterns characteristics, including daily breakfast consumption and meal frequency, were the only significant predictors of MDD-W. The odds of having adequate diversified diets were higher among participants who consumed breakfast everyday compared to those who skipped breakfast. This finding is consistent with studies done among young Isfahanian women (aged 18-28) and among Tehranian female adolescents (aged 15-19), where daily breakfast consumers had significantly higher dietary diversity scores in comparison to skippers (Aminianfar et al., 2016;

Azadbakht et al., 2013). The habit of daily breakfast consumption might be related to the socio-economic status (SES) of the women. Several earlier studies have shown that skipping breakfast is especially prevalent among individuals from low SES families (Azadbakht et al., 2013; Keski-Rahkonen et al., 2003; O'Dea & Caputi, 2001). Our study findings also showed that as the frequency of meals consumed by WRA per day increased, the odds of consuming a diverse diet increased proportionally. In line with our findings, various studies have reported a significant association between increased meal frequency and higher dietary diversity scores (Jemal & Awol, 2019; Mulaw, Feleke, & Mare, 2021; Teferi et al., 2023; Yeneabat et al., 2019; Zhou et al., 2022). This could be attributed to the possibility that an increase in meal frequency leads to the incorporation of more food items into the diet (Teferi et al., 2023). Moreover, various studies have related increased meal frequency with a higher household's socioeconomic status (Jemal & Awol, 2019; Sun et al., 2013; Yeneabat et al., 2019) and food security (Mulaw, Feleke, & Mare, 2021). In the present study, participants with higher socio-economic status had higher odds of consuming a diversified diet in the simple logistic regression analysis, but this association lost its significance in the multiple logistic regression analysis. Conversely, many studies conducted among WRA in different parts of the world have found dietary diversity to be related to a higher socioeconomic status (Ahmed & Salih, 2019; Chakona & Shackleton, 2017; Getacher et al., 2020; Pal, Paul, & Dasgupta, 2017; Rayyani et al., 2019; Saaka, Mutaru, & Osman, 2021; Shrestha et al., 2021).

In this study, the prevalence of obesity among WRA (24.3%) (data not shown), is lower than the previously documented obesity rates: 14.8-36.6% among women aged 20-59 years based on data collected from a national survey in 2009 (Nasreddine et al., 2012); 34.27% among females aged 20 years and older in 2016 (Mallat et al., 2016), as well as the recently reported obesity prevalence of 39.9% among females aged 18 years and older, according to the Global Nutrition Report in 2023 (Global Nutrition Report, 2023). Given that the data for this study was collected in the earlier period of 2012-2013, the escalation in obesity prevalence from that period to 2023 suggests a concerning upward trajectory of obesity among Lebanese women. Among participants classified within the underweight/normal weight BMI category, a higher proportion (43.6%) attained the MDD score, compared to 39.5% of participants who did not. However, the association between BMI and dietary diversity did not reach significance in this study, consistent with the findings of a meta-analysis of observational studies where no associations between BMI and dietary diversity scores were found (Salehi-Abargouei et al., 2016).

A. Strengths and limitations

The main strengths of this study comprised the nationally representative design of the survey, the utilization of culturally specific questionnaire for data collection and the actual measurements of anthropometric characteristics rather than relying on self-reported data. In addition, while a previous study has used the MDD-W to indicate the proportion of WRA attaining the MDD score in Lebanon (Jomaa et al., 2020), our study was the first to report the differences in macro- and micro-nutrients intake across MDD categories and examine the predictors associated with attaining an adequate dietary diversity score among WRA in Lebanon. However, the findings of this study ought to be considered in light of the following limitations. First, the cross-sectional design of the survey limits casual inferences between dietary diversity and its correlates. Second, a counterargument might arise concerning the temporal gap between data collection (2012-2013) and the subsequent data analysis performed in this study (2023). This disparity could potentially cast doubt on the applicability of the study's findings to Lebanon's current situation. However, it is worth highlighting that during this time span, no efforts have been made to implement or develop health or nutrition policies/programs targeting the enhancement of dietary diversity and micronutrient adequacy among WRA in Lebanon. This fact is substantiated by the recent Sustainable Development Report of Lebanon (Sachs et al., 2023), which underscores the static nature of progress towards the second and third Sustainable Development Goals (SDG-2; SDG-3) outlined by the United Nations (UN) in 2015 (United Nations, 2015). Moreover, the finding from this study could serve as a crucial baseline, providing a historical perspective on the dietary diversity status of women of reproductive age in Lebanon. Given the present challenges stemming from the recent economic and political crisis, these results offer a valuable reference point for comparing and understanding the changes in nutritional patterns over time. This comparison is particularly pertinent in assessing the impact of the ongoing crisis on the nutritional well-being of women of reproductive age in Lebanon. Third, the dietary data of participating women was assessed using a single 24-h recall, a method that may not fully represent the usual dietary intakes of the participants and could be susceptible to potential recall bias. Nonetheless, this method has been validated for obtaining necessary dietary information to calculate nutrient intake and adequacies (Arsenault et al., 2020). In addition, several measures have been taken by the research team to ensure the accuracy of dietary assessment. These measures included the utilization of a standardized dietary assessment approach, namely the five-step USDA multiple-pass

24-h dietary recall method (Moshfegh et al., 2008) for the collection of 24-hour dietary recalls. Additionally, the dietary recalls were conducted by research nutritionists who underwent extensive training prior to data collection in order to minimize interviewer errors. Lastly, this study did not consider the potential influence of seasonal fluctuations on the dietary diversity score of the participants, but the survey spanned over the period of one year hence seasonal variation was inherently captured.

CHAPTER V

CONCLUSION

This study examined the dietary diversity of non-pregnant women of reproductive age (WRA) in Lebanon and showed that more than a third (38%) of the study sample did not meet the MDD, which raises concerns around the nutritional status of this vulnerable population group. The study also showed that women with an adequate dietary diversity score (MDD≥5) had significantly higher intakes (/1000 kcal) of all of the assessed micronutrients compared to those with a low dietary diversity score (MDD<5), with the exception of iodine. Additionally, the proportion of WRA meeting the respective Dietary Reference Intakes (DRIs) were significantly higher among those with an adequate dietary diversity score for iron, folate, calcium, zinc, vitamin A and vitamin B12. These findings are thus a further validation of the MDD-W and support its use as a proxy indicator for higher micronutrient adequacy in large surveys of WRA living in LMICs, and in the nutrition transition context (Food and Agriculture Organization, 2021). A higher MDD score was also found to be associated with a greater consumption of healthy food groups (e.g. fruits, vegetables, pulses, nuts and seeds and dairy products), and higher intakes of protein, monounsaturated fatty acids (MUFAs), omega-3 (alpha-linolenic acid), and omega-6 (linoleic acid) polyunsaturated fatty acids, as well as dietary fiber. Regarding the predictors of MDD eating patterns characteristics, including daily breakfast consumption and higher meal frequency, were the only significant independent predictors of MDD-W. Nutritional and public interventions emphasizing the importance of maximizing dietary diversity and thus, micronutrient adequacy of the diets of WRA in Lebanon are needed, while controlling for energy intake. Encouraging higher consumption of fruits, vegetables, fish, eggs, pulses, nuts, and seeds is crucial to achieving optimal dietary diversity and nutritional adequacy among WRA in Lebanon. Considering the cost and the complexity involved in conducting national food consumption surveys, MDD-W serves as a valuable tool to indirectly assess the adequacy of micronutrients in the in the diets of people living in low- and middle-income countries. Additionally, it plays a significant role in the monitoring and evaluation of intervention programs and public health policies aimed towards achieving the Sustainable Development Goals set forth by the United Nations in 2015. Future research employing the MDD-W indicator should consider the intakes of the additional food groups that do not count towards the MDD score. This approach will provide a more comprehensive understanding of the extent to which unhealthy food groups are being consumed among WRA. Such insights are crucial for developing more effective recommendations aimed at encouraging healthier dietary choices and enhancing the nutritional well-being of women of reproductive age in Lebanon.

APPENDIX

THE 10 MDD-W FOOD GROUPS (FOOD AND AGRICULTURE ORGANIZATION, 2021)

MDD-W Food Groups	
1.	Grains, white roots and tubers, and plantains
2.	Pulses (beans, peas and lentils)
3.	Nuts and seeds
4.	Milk and milk products
5.	Meat, poultry and fish
6.	Eggs
7.	Dark green leafy vegetables
8.	Other vitamin A-rich fruits and vegetables
9.	Other vegetables
10.	Other fruits

REFERENCES

Abi Khalil, H., Hawi, M., & Hoteit, M. (2022). Feeding patterns, mother-child dietary diversity and prevalence of malnutrition among under-five children in Lebanon: a cross-sectional study based on retrospective recall. *Frontiers in Nutrition*, *9*, 161.

Abris, G. P., Provido, S. M. P., Hong, S., Yu, S. H., Lee, C. B., & Lee, J. E. (2018). Association between dietary diversity and obesity in the Filipino Women's Diet and Health Study (FiLWHEL): A cross-sectional study. *PLoS One*, *13*(11), e0206490.

Afshin, A., Sur, P. J., Fay, K. A., Cornaby, L., Ferrara, G., Salama, J. S., Mullany, E. C., Abate, K. H., Abbafati, C., & Abebe, Z. (2019). Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *393*(10184), 1958-1972.

Aghajafari, F., Nagulesapillai, T., Ronksley, P. E., Tough, S. C., O'Beirne, M., & Rabi, D. M. (2013). Association between maternal serum 25-hydroxyvitamin D level and pregnancy and neonatal outcomes: systematic review and meta-analysis of observational studies. *Bmj*, *346*.

Ahmed, A., & Salih, O. (2019). Assessment of the minimum dietary diversity of reproductive women in Saudi Arabia. *Pakistan Journal of Nutrition*, *18*(7), 615-622.

Al-Daghri, N. M., Al-Saleh, Y., Aljohani, N., Alokail, M., Al-Attas, O., Alnaami, A. M., Sabico, S., Alsulaimani, M., Al-Harbi, M., & Alfawaz, H. (2015). Vitamin D deficiency and cardiometabolic risks: a juxtaposition of Arab adolescents and adults. *PLoS One*, *10*(7), e0131315.

Al-Jawaldeh, A., Taktouk, M., Doggui, R., Abdollahi, Z., Achakzai, B., Aguenaou, H., Al-Halaika, M., Almamary, S., Barham, R., & Coulibaly-Zerbo, F. (2021). Are countries of the eastern mediterranean region on track towards meeting the world health assembly target for anemia? A review of evidence. *International Journal of Environmental Research and Public Health*, *18*(5), 2449.

Al Hosani, H., Osman, H., Abdel Wareth, L., Saade, D., & Salah, M. (2003). Prevalence of iodine deficiency disorders in the United Arab Emirates measured by raised TSH levels. *EMHJ-Eastern Mediterranean Health Journal, 9 (1-2), 123-130, 2003*.

Al Khatib, L., Obeid, O., Sibai, A.-M., Batal, M., Adra, N., & Hwalla, N. (2006). Folate deficiency is associated with nutritional anaemia in Lebanese women of childbearing age. *Public health nutrition*, *9*(7), 921-927.

Ali, F., Thaver, I., & Khan, S. A. (2014). Assessment of dietary diversity and nutritional status of pregnant women in Islamabad, Pakistan. *Journal of Ayub Medical College Abbottabad*, *26*(4), 506-509.

Allen, L., Casterline-Sabel, J., & Ramakrishnan, U. (2001). Prevalence and causes of nutritional anemias. *Nutritional anemias*, 7-21.

Almedawar, M. M., Nasreddine, L., Olabi, A., Hamade, H., Awad, E., Toufeili, I., Arnaout, S., & Isma'eel, H. A. (2015). Sodium intake reduction efforts in Lebanon. *Cardiovascular diagnosis and therapy*, *5*(3), 178.

Aminianfar, A., Siassi, F., Qorbani, M., Koohdani, F., Daryabeygi-Khotbesara, R., Yamrali, I., Khajehnasiri, F., Doostan, F., & Sotoudeh, G. (2016). Breakfast intake is associated with higher dietary diversity score, weight satisfaction and lower body mass index in girl adolescents. *Journal of Nutritional Sciences and Dietetics*.

Arabi, A., Chamoun, N., Nasrallah, M. P., & Tamim, H. M. (2021). Vitamin D deficiency in Lebanese adults: Prevalence and predictors from a cross-sectional community-based study. *International Journal of Endocrinology, 2021*.

Arimond, M., & Deitchler, M. (2019). Measuring diet quality for women of reproductive age in low-and middle-income countries: towards new metrics for changing diets. *Washington, DC: Intake–Center for Dietary Assessment/FHI, 360*.

Arimond, M., Wiesmann, D., Becquey, E., Carriquiry, A., Daniels, M. C., Deitchler, M., Fanou-Fogny, N., Joseph, M. L., Kennedy, G., & Martin-Prevel, Y. (2010). Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. *The Journal of nutrition*, *140*(11), 2059S-2069S.

Arsenault, J. E., Moursi, M., Olney, D. K., Becquey, E., & Ganaba, R. (2020). Validation of 24-h dietary recall for estimating nutrient intakes and adequacy in adolescents in Burkina Faso. *Maternal & Child Nutrition*, *16*(4), e13014.

Asmar, M. K., Zablit, C. G., Daou, R., Yéretzian, J. S., Daoud, H., Rady, A., Hamadeh, R., & Ammar, W. (2018). Prevalence of anemia and associated factors in women of childbearing age in rural Lebanon. *Journal of Public Health*, *26*, 39-49.

Atinmo, T., Mirmiran, P., Oyewole, O. E., Belahsen, R., & Serra-Majem, L. (2009). Breaking the poverty/malnutrition cycle in Africa and the Middle East. *Nutrition reviews*, *67*(suppl_1), S40-S46.

Atlanta, G. (1993). From the Centers for Disease Control and Prevention. Recommendations for use of folic acid to reduce number of spina bifida cases and other neural tube defects. *JAMA*, *269*(10), 1233-1238.

Azadbakht, L., & Esmaillzadeh, A. (2011). Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. *Public health nutrition*, *14*(1), 62-69.

Azadbakht, L., Haghighatdoost, F., Feizi, A., & Esmaillzadeh, A. (2013). Breakfast eating pattern and its association with dietary quality indices and anthropometric measurements in young women in Isfahan. *Nutrition*, *29*(2), 420-425.

Bagchi, K. (2008). Nutrition in the eastern Mediterranean region of the World Health Organization. *EMHJ-Eastern Mediterranean Health Journal*, *14 (Supp.), S107-S113, 2008*.

Bailey, R. L., West Jr, K. P., & Black, R. E. (2015). The epidemiology of global micronutrient deficiencies. *Annals of Nutrition and Metabolism*, *66*(Suppl. 2), 22-33.

Balarajan, Y., Ramakrishnan, U., Özaltin, E., Shankar, A. H., & Subramanian, S. (2011). Anaemia in low-income and middle-income countries. *The Lancet*, *378*(9809), 2123-2135.

Bates, C. (1995). Vitamin A. *The Lancet*, *345*(8941), 31-35.

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., De Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., & Martorell, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, *382*(9890), 427-451.

Brazier, A. K., Lowe, N. M., Zaman, M., Shahzad, B., Ohly, H., McArdle, H. J., Ullah, U., Broadley, M. R., Bailey, E. H., & Young, S. D. (2020). Micronutrient status and dietary diversity of women of reproductive age in rural Pakistan. *Nutrients*, *12*(11), 3407.

Capacci, S., Mazzocchi, M., Shankar, B., & Traill, B. (2013). The triple burden of malnutrition in Europe and Central Asia: a multivariate analysis FAO Regional Office for Europe and Central Asia Policy Studies on Rural Transition, No. 2013–7. Food and Agriculture Organization of the United Nations: 2013. In: Food and Agriculture Organization Rome.

Carazo, A., Macáková, K., Matoušová, K., Krčmová, L. K., Protti, M., & Mladěnka, P. (2021). Vitamin A update: forms, sources, kinetics, detection, function, deficiency, therapeutic use and toxicity. *Nutrients*, *13*(5), 1703.

Chakona, G., & Shackleton, C. (2017). Minimum dietary diversity scores for women indicate micronutrient adequacy and food insecurity status in South African towns. *Nutrients*, *9*(8), 812.

Christensen, J. H., Gustenhoff, P., Korup, E., Aaroe, J., Toft, E., Moller, T., Rasmussen, K., Dyerberg, J., & Schmidt, E. B. (1996). Effect of fish oil on heart rate variability in survivors of myocardial infarction: a double blind randomised controlled trial. *Bmj*, *312*(7032), 677-678.

Colonese, F., Lagana, A. S., Colonese, E., Sofo, V., Salmeri, F. M., Granese, R., & Triolo, O. (2015). The pleiotropic effects of vitamin D in gynaecological and obstetric diseases: an overview on a hot topic. *BioMed research international*, *2015*.

Cui, A., Zhang, T., Xiao, P., Fan, Z., Wang, H., & Zhuang, Y. (2023). Global and regional prevalence of vitamin D deficiency in population-based studies from 2000 to 2022: A pooled analysis of 7.9 million participants. *Frontiers in Nutrition*, *10*, 1070808.

Custodio, E., Kayikatire, F., Fortin, S., Thomas, A. C., Kameli, Y., Nkunzimana, T., Ndiaye, B., & Martin-Prevel, Y. (2020). Minimum dietary diversity among women of reproductive age in urban Burkina Faso. *Maternal & Child Nutrition*, *16*(2), e12897.

Darnton-Hill, I., & Mkparu, U. C. (2015). Micronutrients in pregnancy in low-and middle-income countries. *Nutrients*, *7*(3), 1744-1768.

Dayi, T., Soykut, G., Ozturk, M., & Yucecan, S. (2021). Mothers and children adherence to the Mediterranean diet: evidence from a Mediterranean country. *Progress in Nutrition*, *23*(2).

De Onis, M., Blössner, M., & Borghi, E. (2010). Global prevalence and trends of overweight and obesity among preschool children. *The American journal of clinical nutrition*, *92*(5), 1257-1264.

Delange, F., de Benoist, B., Pretell, E., & Dunn, J. T. (2001). Iodine deficiency in the world: where do we stand at the turn of the century? *Thyroid*, *11*(5), 437-447.

Dinsa, G. D., Goryakin, Y., Fumagalli, E., & Suhrcke, M. (2012). Obesity and socioeconomic status in developing countries: a systematic review. *Obesity reviews*, *13*(11), 1067-1079.

Dominguez, L. J., Farruggia, M., Veronese, N., & Barbagallo, M. (2021). Vitamin D sources, metabolism, and deficiency: available compounds and guidelines for its treatment. *Metabolites*, *11*(4), 255.

Doumani, N., Maalouly, J., Bou-Maroun, E., Sok, N., Cayot, P., & Tueni, M. (2021). Iron intake among Lebanese women: sociodemographic factors, iron-rich dietary patterns, and preparation of hummus, a Mediterranean dish. *Food & Nutrition Research*, *65*.

El Rifai, N. M., Abdel Moety, G. A. F., Gaafar, H. M., & Hamed, D. A. (2014). Vitamin D deficiency in Egyptian mothers and their neonates and possible related factors. *The Journal of Maternal-Fetal & Neonatal Medicine*, *27*(10), 1064-1068.

Ezzati, M., Lopez, Alan D, Rodgers, Anthony A & Murray, Christopher J. L,. (2004). *Comparative quantification of health risks : global and regional burden of disease attributable to selected major risk factors / edited by Majid Ezzati ... [et al.]*. W. H. Organization. https://apps.who.int/iris/handle/10665/42770

FAO, W. (2008). Interim summary of conclusions and dietary recommendations on total fat & fatty acids. *From the joint FAO/WHO expert consultation on fats and fatty acids*.

Food and Agriculture Organization. (2007). *Nutrition country profile: Lebanese Republic 2007*. https://www.fao.org/documents/card/en?details=c36226a8-8af2-4957-a420-5714129f572c%2f

Food and Agriculture Organization. (2013). *Guidelines for measuring household and individual dietary diversity*. https://www.fao.org/3/i1983e/i1983e00.pdf

Food and Agriculture Organization. (2016). *Compendium of nutrition-sensitive indicators in agriculture*. F. a. A. Organization. https://www.fao.org/documents/card/en?details=644881b0-22f4-476c-8fdb-a79c75a9ecf4%2f

Food and Agriculture Organization. (2021). *Minimum dietary diversity for women*. https://doi.org/10.4060/cb3434en

Food and Agriculture Organization and Family Health International 360. (2016). *Minimum Dietary Diversity for Women: A Guide to Measurement*. http://www.fao.org/3/a-i5486e.pdf

Food and Agriculture Organization and World Health Organization. (2019). *SUSTAINABLE HEALTHY DIETS GUIDING PRINCIPLES*. http://www.fao.org/3/ca6640en/CA6640EN.pdf

Galiè, A., Teufel, N., Girard, A. W., Baltenweck, I., Dominguez-Salas, P., Price, M. J., Jones, R., Lukuyu, B., Korir, L., & Raskind, I. (2019). Women's empowerment, food security and nutrition of pastoral communities in Tanzania. *Global Food Security*, *23*, 125-134.

Gannagé-Yared, M.-H., Helou, E., Zaraket, V., Abi Akl, S., Antonios, L., Moussalli, M.-L., & Wakim, S. (2014). Serum 25 hydroxyvitamin D in employees of a Middle Eastern university hospital. *Journal of endocrinological investigation*, *37*, 541-546.

George, S. M., Ballard-Barbash, R., Manson, J. E., Reedy, J., Shikany, J. M., Subar, A. F., Tinker, L. F., Vitolins, M., & Neuhouser, M. L. (2014). Comparing indices of diet quality with chronic disease mortality risk in postmenopausal women in the Women's Health Initiative Observational Study: evidence to inform national dietary guidance. *American journal of epidemiology*, *180*(6), 616-625.

Gernand, A. D., Schulze, K. J., Stewart, C. P., West Jr, K. P., & Christian, P. (2016). Micronutrient deficiencies in pregnancy worldwide: health effects and prevention. *Nature Reviews Endocrinology*, *12*(5), 274-289.
Getacher, L., Egata, G., Alemayehu, T., Bante, A., & Molla, A. (2020). Minimum dietary diversity and associated factors among lactating mothers in Ataye district, North Shoa zone, Central Ethiopia: a community-based cross-sectional study. *Journal of nutrition and metabolism*, *2020*.
Global Nutrition Report. (2023). *Country Nutrition Profiles: Lebanon*. Retrieved 20 September from https://globalnutritionreport.org/resources/nutrition-profiles/asia/western-asia/lebanon/
Gómez, G., Nogueira Previdelli, Á., Fisberg, R. M., Kovalskys, I., Fisberg, M., Herrera-Cuenca, M., Cortes Sanabria, L. Y., Yépez García, M. C., Rigotti, A., & Liria-Domínguez, M. R. (2020). Dietary diversity and micronutrients adequacy in women of childbearing age: results from ELANS study. *Nutrients*, *12*(7), 1994.
Guenther, P. M., Casavale, K. O., Reedy, J., Kirkpatrick, S. I., Hiza, H. A., Kuczynski, K. J., Kahle, L. L., & Krebs-Smith, S. M. (2013). Update of the healthy eating index: HEI-2010. *Journal of the Academy of Nutrition and Dietetics*, *113*(4), 569-580.
Gupta, S., Brazier, A., & Lowe, N. (2020). Zinc deficiency in low-and middle-income countries: prevalence and approaches for mitigation. *Journal of Human Nutrition and Dietetics*, *33*(5), 624-643.
Haas, J. D., & Brownlie IV, T. (2001). Iron deficiency and reduced work capacity: a critical review of the research to determine a causal relationship. *The Journal of nutrition*, *131*(2), 676S-690S.
Hamdy, A., Abdel Aleem, M., & El-Shazly, A. (2013). Maternal vitamin A deficiency during pregnancy and its relation with maternal and neonatal hemoglobin concentrations among poor Egyptian families. *International Scholarly Research Notices*, *2013*.
Han, X., Ding, S., Lu, J., & Li, Y. (2022). Global, regional, and national burdens of common micronutrient deficiencies from 1990 to 2019: A secondary trend analysis based on the Global Burden of Disease 2019 study. *EClinicalMedicine*, *44*.
Haq, A., Svobodová, J., Imran, S., Stanford, C., & Razzaque, M. S. (2016). Vitamin D deficiency: A single centre analysis of patients from 136 countries. *The Journal of steroid biochemistry and molecular biology*, *164*, 209-213.
Herforth, A., & Ballard, T. J. (2016). Nutrition indicators in agriculture projects: Current measurement, priorities, and gaps. *Global Food Security*, *10*, 1-10.
HLPE. (2017). *Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and*
Nutrition of the Committee on World Food Security. https://www.fao.org/3/i7846e/i7846e.pdf
Hofmeyr, G. J., Lawrie, T. A., Atallah, Á. N., & Torloni, M. R. (2018). Calcium supplementation during pregnancy for preventing hypertensive disorders and related problems. *Cochrane database of systematic reviews*(10).
House, S. H., Nichols, J. A., & Rae, S. (2021). Folates, folic acid and preconception care–a review. *JRSM open*, *12*(5), 2054270420980875.
Hu, B., Tang, S., Wang, Z., Chen, Y., Chen, X., Zhao, Q., Jiang, Y., Shen, M., Zhang, C., & Kaliszewski, C. (2022). Dietary diversity is associated with nutrient

adequacy, blood biomarkers and anthropometric status among preschool children in poor ethnic minority area of Northwest China. *Frontiers in Nutrition*, *9*, 948555.

Hull, H. R., Herman, A., Gibbs, H., Gajewski, B., Krase, K., Carlson, S. E., Sullivan, D. K., & Goetz, J. (2020). The effect of high dietary fiber intake on gestational weight gain, fat accrual, and postpartum weight retention: a randomized clinical trial. *BMC pregnancy and childbirth*, *20*(1), 1-10.

Hwalla, N., Adra, N., & JACKSON, R. T. (2004). Iron deficiency is an important contributor to anemia among reproductive age women in Lebanon. *Ecology of food and nutrition*, *43*(1-2), 77-92.

Hwalla, N., Al Dhaheri, A. S., Radwan, H., Alfawaz, H. A., Fouda, M. A., Al-Daghri, N. M., Zaghloul, S., & Blumberg, J. B. (2017). The prevalence of micronutrient deficiencies and inadequacies in the Middle East and approaches to interventions. *Nutrients*, *9*(3), 229.

Hwalla, N., Weaver, C. M., Mekary, R. A., & El Labban, S. (2016). Public health nutrition in the Middle East. In (Vol. 4, pp. 33): Frontiers Media SA.

Institute of Medicine. (2005). *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*. The National Academies Press. https://doi.org/doi:10.17226/10490

Islam, M. H., Jubayer, A., Nowar, A., Nayan, M. M., & Islam, S. (2023). Dietary diversity and micronutrients adequacy among the women of reproductive age at St. Martin's island in Bangladesh. *BMC nutrition*, *9*(1), 52.

Jayawardena, R., Byrne, N. M., Soares, M. J., Katulanda, P., Yadav, B., & Hills, A. P. (2013). High dietary diversity is associated with obesity in Sri Lankan adults: an evaluation of three dietary scores. *BMC public health*, *13*(1), 1-8.

Jemal, K., & Awol, M. (2019). Minimum dietary diversity score and associated factors among pregnant women at Alamata General Hospital, Raya Azebo Zone, Tigray Region, Ethiopia. *Journal of nutrition and metabolism, 2019*.

Jiang, T., Christian, P., Khatry, S. K., Wu, L., & West Jr, K. P. (2005). Micronutrient deficiencies in early pregnancy are common, concurrent, and vary by season among rural Nepali pregnant women. *The Journal of nutrition*, *135*(5), 1106-1112.

Jomaa, L. H., Naja, F. A., Kharroubi, S. A., Diab-El-Harake, M. H., & Hwalla, N. C. (2020). Food insecurity is associated with compromised dietary intake and quality among Lebanese mothers: findings from a national cross-sectional study. *Public health nutrition*, *23*(15), 2687-2699.

Jones, A. D. (2017). Critical review of the emerging research evidence on agricultural biodiversity, diet diversity, and nutritional status in low-and middle-income countries. *Nutrition reviews*, *75*(10), 769-782.

Julshamn, K., Dahl, L., & Eckhoff, K. (2001). Determination of iodine in seafood by inductively coupled plasma/mass spectrometry. *Journal of AOAC International*, *84*(6), 1976-1983.

Karimi, A., Bagheri, S., Nematy, M., & Saeidi, M. (2012). Zinc deficiency in pregnancy and fetal-neonatal outcomes and impact of the supplements on pregnancy outcomes. *Iranian Journal of Neonatology IJN*, *3*(2), 77-83.

Kassie, M., Fisher, M., Muricho, G., & Diiro, G. (2020). Women's empowerment boosts the gains in dietary diversity from agricultural technology adoption in rural Kenya. *Food Policy*, *95*, 101957.

Kebbe, M., Flanagan, E. W., Sparks, J. R., & Redman, L. M. (2021). Eating behaviors and dietary patterns of women during pregnancy: Optimizing the universal 'teachable moment'. *Nutrients*, *13*(9), 3298.

Kennedy, G., Ballard, T., & Dop, M. C. (2011). *Guidelines for measuring household and individual dietary diversity*. Food and Agriculture Organization of the United Nations.

Keski-Rahkonen, A., Kaprio, J., Rissanen, A., Virkkunen, M., & Rose, R. J. (2003). Breakfast skipping and health-compromising behaviors in adolescents and adults. *European journal of clinical nutrition*, *57*(7), 842-853.

Khalife, H., Khalife, H., Omyri, H., Khalife, H., & Abdel-Sater, F. (2017). Vitamin D deficiency among the healthy population in Lebanon. *World J. Pharm. Pharm. Sci*, *6647*, 69-80.

Knudsen, N., Laurberg, P., Perrild, H., Bülow, I., Ovesen, L., & Jørgensen, T. (2002). Risk factors for goiter and thyroid nodules. *Thyroid*, *12*(10), 879-888.

Komatsu, H., Malapit, H. J. L., & Theis, S. (2018). Does women's time in domestic work and agriculture affect women's and children's dietary diversity? Evidence from Bangladesh, Nepal, Cambodia, Ghana, and Mozambique. *Food Policy*, *79*, 256-270.

Kozuki, N., Lee, A. C., Katz, J., & Child Health Epidemiology Reference, G. (2012). Moderate to severe, but not mild, maternal anemia is associated with increased risk of small-for-gestational-age outcomes. *The Journal of nutrition*, *142*(2), 358-362. https://doi.org/10.3945/jn.111.149237

Krishnaswamy, K., & Nair, K. M. (2001). Importance of folate in human nutrition. *British Journal of Nutrition*, *85*(S2), S115-S124.

Kumera, G., Awoke, T., Melese, T., Eshetie, S., Mekuria, G., Mekonnen, F., Ewunetu, T., & Gedle, D. (2015). Prevalence of zinc deficiency and its association with dietary, serum albumin and intestinal parasitic infection among pregnant women attending antenatal care at the University of Gondar Hospital, Gondar, Northwest Ethiopia. *BMC nutrition*, *1*(1), 1-11.

Lander, R. L., Hambidge, K. M., Westcott, J. E., Tejeda, G., Diba, T. S., Mastiholi, S. C., Khan, U. S., Garcés, A., Figueroa, L., & Tshefu, A. (2019). Pregnant women in four low-middle income countries have a high prevalence of inadequate dietary intakes that are improved by dietary diversity. *Nutrients*, *11*(7), 1560.

Lassi, Z. S., Padhani, Z. A., Rabbani, A., Rind, F., Salam, R. A., Das, J. K., & Bhutta, Z. A. (2020). Impact of dietary interventions during pregnancy on maternal, neonatal, and child outcomes in low-and middle-income countries. *Nutrients*, *12*(2), 531.

Leikin-Frenkel, A. I. (2016). Is there a role for alpha-linolenic acid in the fetal programming of health? *Journal of clinical medicine*, *5*(4), 40.

Mallat, S., Geagea, A. G., Jurjus, R., Rizkallah, A., Oueidat, D., Matar, M., Tawilah, J., Berbari, A., & Jurjus, A. (2016). Obesity in Lebanon: a national problem. *World Journal of Cardiovascular Diseases*, *6*(06), 166.

Marangoni, F., Cetin, I., Verduci, E., Canzone, G., Giovannini, M., Scollo, P., Corsello, G., & Poli, A. (2016). Maternal diet and nutrient requirements in pregnancy and breastfeeding. An Italian Consensus Document. Nutrients. 2016; 8 (10): 629. In.

Martin-Prével, Y., Allemand, P., Wiesmann, D., Arimond, M., Ballard, T., Deitchler, M., Dop, M.-C., Kennedy, G., Lee, W. T., & Moursi, M. (2015). Moving

forward on choosing a standard operational indicator of women's dietary diversity.
Martin-Prevel, Y., Arimond, M., Allemand, P., Wiesmann, D., Ballard, T. J., Deitchler, M., Dop, M. C., Kennedy, G., Lartey, A., & Lee, W. T. (2017). Development of a dichotomous indicator for population-level assessment of dietary diversity in women of reproductive age. *Current developments in nutrition*, *1*(12), 1012001.
Mehio Sibai, A., Nasreddine, L., Mokdad, A. H., Adra, N., Tabet, M., & Hwalla, N. (2011). Nutrition transition and cardiovascular disease risk factors in Middle East and North Africa countries: reviewing the evidence. *Annals of Nutrition and Metabolism*, *57*(3-4), 193-203.
Meyers, L. (2006). DRI, dietary reference intakes: the essential guide to nutrient requirements/Jennifer J. Otten, Jennifer Pitzi Hellwig, Linda D. Meyers, editors. In: Washington, DC: National Academies Press, c2006.
Mirmiran, P., Azadbakht, L., & Azizi, F. (2006). Dietary diversity within food groups: an indicator of specific nutrient adequacy in Tehranian women. *Journal of the American college of nutrition*, *25*(4), 354-361.
Mohammadi, M., Azizi, F., & Hedayati, M. (2018). Iodine deficiency status in the WHO Eastern Mediterranean Region: A systematic review. *Environmental geochemistry and health*, *40*, 87-97.
Moshfegh, A. J., Borrud, L., Perloff, B., & LaComb, R. (1999). Improved method for the 24-hour dietary recall for use in national surveys. *FASEB J*, *13*(4), A603.
Moshfegh, A. J., Rhodes, D. G., Baer, D. J., Murayi, T., Clemens, J. C., Rumpler, W. V., Paul, D. R., Sebastian, R. S., Kuczynski, K. J., & Ingwersen, L. A. (2008). The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. *The American journal of clinical nutrition*, *88*(2), 324-332.
Mulaw, G. F., Feleke, F. W., & Mare, K. U. (2021). Only one in four lactating mothers met the minimum dietary diversity score in the pastoral community, Afar region, Ethiopia: a community-based cross-sectional study. *Journal of Nutritional Science*, *10*, e41.
Murphy, S. P., Guenther, P. M., & Kretsch, M. J. (2006). Using the dietary reference intakes to assess intakes of groups: pitfalls to avoid. *Journal of the American Dietetic Association*, *10*(106), 1550-1553.
Musaiger, A. O. (2011). Overweight and obesity in eastern mediterranean region: prevalence and possible causes. *Journal of obesity*, *2011*.
Naja, F., Nasreddine, L., Itani, L., Adra, N., Sibai, A., & Hwalla, N. (2013). Association between dietary patterns and the risk of metabolic syndrome among Lebanese adults. *European journal of nutrition*, *52*, 97-105.
Naja, F., Nasreddine, L., Itani, L., Chamieh, M. C., Adra, N., Sibai, A. M., & Hwalla, N. (2011). Dietary patterns and their association with obesity and sociodemographic factors in a national sample of Lebanese adults. *Public health nutrition*, *14*(9), 1570-1578.
Nasr Hage, C., Jalloul, M., Sabbah, M., & Adib, S. M. (2012). Awareness and intake of folic acid for the prevention of neural tube defects among Lebanese women of childbearing age. *Maternal and child health journal*, *16*, 258-265.
Nasreddine, L., Chamieh, M. C., Ayoub, J., Hwalla, N., Sibai, A.-M., & Naja, F. (2020). Sex disparities in dietary intake across the lifespan: the case of Lebanon. *Nutrition journal*, *19*, 1-18.

Nasreddine, L., Hwalla, N., Saliba, A., Akl, C., & Naja, F. (2017). Prevalence and correlates of preschool overweight and obesity amidst the nutrition transition: findings from a national cross-sectional study in Lebanon. *Nutrients, 9*(3), 266.

Nasreddine, L., Hwalla, N., Sibai, A., Hamzé, M., & Parent-Massin, D. (2006). Food consumption patterns in an adult urban population in Beirut, Lebanon. *Public health nutrition*, *9*(2), 194-203.

Nasreddine, L., Naja, F., Chamieh, M. C., Adra, N., Sibai, A.-M., & Hwalla, N. (2012). Trends in overweight and obesity in Lebanon: evidence from two national cross-sectional surveys (1997 and 2009). *BMC public health*, *12*(1), 1-11.

Nasreddine, L., Shatila, H., Itani, L., Hwalla, N., Jomaa, L., & Naja, F. (2019). A traditional dietary pattern is associated with lower odds of overweight and obesity among preschool children in Lebanon: a cross-sectional study. *European journal of nutrition*, *58*, 91-102.

Nguyen, P. H., Kim, S. S., Sanghvi, T., Mahmud, Z., Tran, L. M., Shabnam, S., Aktar, B., Haque, R., Afsana, K., & Frongillo, E. A. (2017). Integrating nutrition interventions into an existing maternal, neonatal, and child health program increased maternal dietary diversity, micronutrient intake, and exclusive breastfeeding practices in Bangladesh: results of a cluster-randomized program evaluation. *The Journal of nutrition*, *147*(12), 2326-2337.

Norton, K. I. (2018). Standards for anthropometry assessment. *Kinanthropometry and exercise physiology*, *4*, 68-137.

O'Dea, J. A., & Caputi, P. (2001). Association between socioeconomic status, weight, age and gender, and the body image and weight control practices of 6-to 19-year-old children and adolescents. *Health education research*, *16*(5), 521-532.

Obeid, O. A., Al-Ghali, R. M., Al-Ghali, R. M., & Hwalla, N. (2006). Vitamins A and E status in an urban Lebanese population: A case study at Dar Al-Fatwa area, Beirut. *International journal for vitamin and nutrition research*, *76*(1), 3-8.

Ochieng, J., Afari-Sefa, V., Lukumay, P. J., & Dubois, T. (2017). Determinants of dietary diversity and the potential role of men in improving household nutrition in Tanzania. *PLoS One*, *12*(12), e0189022.

Oladoyinbo, C., Ugwunna, U., & Ekerette, N. (2017). Dietary diversity and nutrient intake adequacy among women in Iwo Local Government Area, Osun State Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, *17*(4), 12641-12656.

Pal, M., Paul, B., & Dasgupta, A. (2017). Dietary diversity among women of reproductive age: new evidence from an observational study in a slum of Kolkata. *Int J Med Sci Public Health*, *6*(8), 1302-1307.

Pellet, P., & Shadarevian, S. (1970). Food composition. Tables for use in the Middle East. *Food composition. Tables for use in the Middle East.*(Edn. 2).

Popkin, B. M. (2004). The nutrition transition: an overview of world patterns of change. *Nutrition reviews*, *62*(suppl_2), S140-S143.

Popkin, B. M., Corvalan, C., & Grummer-Strawn, L. M. (2020). Dynamics of the double burden of malnutrition and the changing nutrition reality. *The Lancet*, *395*(10217), 65-74.

Pouraram, H., Djazayery, A., Mohammad, K., Parsaeian, M., Abdollahi, Z., Motlagh, A. D., Djalali, M., Khodaverdian, K., Sotoudeh, G., & Yarparvar, A. (2018). Second national integrated micronutrient survey in Iran: Study design and preliminary findings. *Archives of Iranian medicine*, *21*(4), 137-144.

Prasad, A. S. (2013). Discovery of human zinc deficiency: its impact on human health and disease. *Advances in nutrition*, *4*(2), 176-190.

Preedy, V. R., Hunter, L.-A., & Patel, V. B. (2013). *Diet Quality: An Evidence-Based Approach, Volume 2*. Springer Science & Business Media.

Puwanant, M., Boonrusmee, S., Jaruratanasirikul, S., Chimrung, K., & Sriplung, H. (2022). Dietary diversity and micronutrient adequacy among women of reproductive age: a cross-sectional study in Southern Thailand. *BMC nutrition*, *8*(1), 1-11.

Rayyani, E., Siassi, F., Djafarian, K., Qorbani, M., Pak, N., & Sotoudeh, G. (2019). Associations of the Dietary Diversity Score and Food Variety Score with Serum Magnesium and Ferritin Status. *Journal of Nutrition, Fasting and Health*, *7*(3), 151-159.

Regmi, K. (2013). Book Review: Michael H Merson, Robert E Black and Anne J Mills (eds), Global Health: Diseases, Programs, Systems and Policies. In: Sage Publications Sage UK: London, England.

Roohani, N., Hurrell, R., Kelishadi, R., & Schulin, R. (2013). Zinc and its importance for human health: An integrative review. *Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences*, *18*(2), 144.

Roth, D. E., Abrams, S. A., Aloia, J., Bergeron, G., Bourassa, M. W., Brown, K. H., Calvo, M. S., Cashman, K. D., Combs, G., & De-Regil, L. M. (2018). *Global prevalence and disease burden of vitamin D deficiency: a roadmap for action in low-and middle-income countries* (0077-8923).

Ruel, M. T., Deitchler, M., & Arimond, M. (2010). Developing simple measures of women's diet quality in developing countries: overview. *The Journal of nutrition*, *140*(11), 2048S-2050S.

Saad, F., Rogers, L., Doggui, R., & Al-Jawaldeh, A. (2021). Assessment of vitamin A supplementation practices in countries of the Eastern Mediterranean Region: Evidence to implementation. *Journal of Nutritional Science and Vitaminology*, *67*(1), 1-12.

Saaka, M., Mutaru, S., & Osman, S. M. (2021). Determinants of dietary diversity and its relationship with the nutritional status of pregnant women. *Journal of Nutritional Science*, *10*, e14.

Sabuj, M. P., Chowdhury, R., Al Mamun, M. A., Kabir, M. R., Ghosh, S., Alam, M. R., Halima, O., & Alam, S. S. (2020). Assessment of dietary diversity of mothers (0-2 years childbearing) in Noakhali District of Bangladesh. *Journal of Noakhali Science and Technology University (JNSTU)*, *4*(1&2), 1-11.

Sachs, J. D., Lafortune, G., Fuller, G., & Drumm, E. (2023). Sustainable Development Report 2023: Implementing the SDG Stimulus.

Salehi-Abargouei, A., Akbari, F., Bellissimo, N., & Azadbakht, L. (2016). Dietary diversity score and obesity: a systematic review and meta-analysis of observational studies. *European journal of clinical nutrition*, *70*(1), 1-9.

Scholl, T. O., & Reilly, T. (2000). Anemia, iron and pregnancy outcome. *The Journal of nutrition*, *130*(2), 443S-447S.

Shlisky, J., Mandlik, R., Askari, S., Abrams, S., Belizan, J. M., Bourassa, M. W., Cormick, G., Driller-Colangelo, A., Gomes, F., & Khadilkar, A. (2022). *Calcium deficiency worldwide: Prevalence of inadequate intakes and associated health outcomes* (0077-8923).

Shrestha, V., Paudel, R., Sunuwar, D. R., Lyman, A. L. T., Manohar, S., & Amatya, A. (2021). Factors associated with dietary diversity among pregnant women in the western hill region of Nepal: A community based cross-sectional study. *PLoS One*, *16*(4), e0247085.

Shumayla, S., Irfan, E., Kathuria, N., Rathi, S. K., Srivastava, S., & Mehra, S. (2022). Minimum dietary diversity and associated factors among lactating mothers in Haryana, India: a community based cross-sectional study. *BMC pediatrics*, *22*(1), 525.

Sibhatu, K. T., & Qaim, M. (2018). Meta-analysis of the association between production diversity, diets, and nutrition in smallholder farm households. *Food Policy*, *77*, 1-18.

Steer, P. J. (2000). Maternal hemoglobin concentration and birth weight. *The American journal of clinical nutrition*, *71*(5), 1285S-1287S.

Stevens, G. A., Beal, T., Mbuya, M. N., Luo, H., Neufeld, L. M., Addo, O. Y., Adu-Afarwuah, S., Alayón, S., Bhutta, Z., & Brown, K. H. (2022). Micronutrient deficiencies among preschool-aged children and women of reproductive age worldwide: a pooled analysis of individual-level data from population-representative surveys. *The Lancet Global Health*, *10*(11), e1590-e1599.

Stevens, G. A., Finucane, M. M., De-Regil, L. M., Paciorek, C. J., Flaxman, S. R., Branca, F., Peña-Rosas, J. P., Bhutta, Z. A., & Ezzati, M. (2013). Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995–2011: a systematic analysis of population-representative data. *The Lancet Global Health*, *1*(1), e16-e25.

Sun, J., Yi, H., Liu, Z., Wu, Y., Bian, J., Wu, Y., Eshita, Y., Li, G., Zhang, Q., & Yang, Y. (2013). Factors associated with skipping breakfast among Inner Mongolia Medical students in China. *BMC public health*, *13*(1), 1-8.

Taleb, Z. B., Bahelah, R., Fouad, F. M., Coutts, A., Wilcox, M., & Maziak, W. (2015). Syria: health in a country undergoing tragic transition. *International journal of public health*, *60*, 63-72.

Tavakoli, S., Dorosty-Motlagh, A. R., Hoshiar-Rad, A., Eshraghian, M. R., Sotoudeh, G., Azadbakht, L., Karimi, M., & Jalali-Farahani, S. (2016). Is dietary diversity a proxy measurement of nutrient adequacy in Iranian elderly women? *Appetite*, *105*, 468-476.

Tawfik, A. A., Hanna, E. T., & Freig, S. A. (2014). Folate status in Egypt. *IOSR J Nurs Health Sci*, *3*(2), 32-36.

Teferi, T., Endalk, G., Ayenew, G. M., & Fentahun, N. (2023). Inadequate dietary diversity practices and associated factors among postpartum mothers in Gambella town, Southwest Ethiopia. *Scientific Reports*, *13*(1), 7252.

The World Bank. (2023). *Prevalence of anemia among women of reproductive age (% of women ages 15–49) - Lebanon*. Retrieved 18 September from https://data.worldbank.org/indicator/SH.ANM.ALLW.ZS?locations=LB

Tielsch, J. M., Rahmathullah, L., Katz, J., Thulasiraj, R., Coles, C., Sheeladevi, S., & Prakash, K. (2008). Maternal night blindness during pregnancy is associated with low birthweight, morbidity, and poor growth in South India. *The Journal of nutrition*, *138*(4), 787-792.

Torheim, L. E., & Arimond, M. (2013). Diet quality, micronutrient intakes and economic vulnerability of women. *Diet Quality: An Evidence-Based Approach, Volume 1*, 105-115.
Torheim, L. E., Ouattara, F., Diarra, M. M., Thiam, F. D., Barikmo, I., Hatløy, A., & Oshaug, A. (2004). Nutrient adequacy and dietary diversity in rural Mali: association and determinants. *European journal of clinical nutrition*, *58*(4), 594-604.
Triunfo, S., & Lanzone, A. (2016). Potential impact of maternal vitamin D status on obstetric well-being. *Journal of endocrinological investigation*, *39*, 37-44.
U.S. Department of Agriculture and U.S. Department of Health and Human Services. (2020). *Dietary Guidelines for Americans, 2020-2025*. https://www.dietaryguidelines.gov/
UNICEF, G. o. P. a. (2019). *National Nutrition Survey 2018 - Key Findings Report*. https://www.unicef.org/pakistan/reports/national-nutrition-survey-2018-key-findings-report
United Nations. (2015). *Transforming our World: The 2030 Agenda for Sustainable Development*. https://sustainabledevelopment.un.org/post2015/transformingourworld/publication
Wahlqvist, M., & Hsu-Hage, B. (1996). Food variety of adult Melbourne Chinese: A case study of a population in transition. *Dietary patterns of selected countries, tea and coffee: metabolic consequences. World review of nutrition and dietetics*, *79*.
Willett, W. (2012). *Nutritional epidemiology*. Oxford university press.
World Food Programme. (2008). *Food consumption analysis: Calculation and use of the food consumption score in food security analysis. Technical Guidance Sheet*.
World Health Organization-Eastern Mediterranean Regional Ofiice (WHO-EMRO). (2023). *Nutrition Country Profile-Lebanon*. https://applications.emro.who.int/docs/WHOEMNUT298E-eng.pdf?ua=1
World Health Organization. (2003). *Diet, nutrition and the prevention of chronic diseases : report of a joint WHO/FAO expert consultation, Geneva, 28 January - 1 February 2002*. https://iris.who.int/handle/10665/42665
World Health Organization. (2004). *Vitamin and mineral requirements in human nutrition, second edition*.
https://apps.who.int/iris/handle/10665/42716
World Health Organization. (2007). *Assessment of iodine deficiency disorders and monitoring their elimination : a guide for programme managers, 3rd ed*. https://apps.who.int/iris/handle/10665/43781
World Health Organization. (2011a). *Regional strategy on nutrition 2010–2019 and plan of action*. https://apps.who.int/iris/handle/10665/116694
World Health Organization. (2011b). *Waist circumference and waist-hip ratio : report of a WHO expert consultation, Geneva, 8-11 December 2008*. W. H. Organization. https://apps.who.int/iris/handle/10665/44583
World Health Organization. (2014). *Global nutrition targets 2025: anaemia policy brief (WHO/NMH/NHD/14.4)*. https://apps.who.int/iris/handle/10665/148556
World Health Organization. (2017). *The double burden of malnutrition: policy brief*. https://www.who.int/publications/i/item/WHO-NMH-NHD-17.3

World Health Organization. (2018). *WHO Housing and health guidelines*. https://www.who.int/publications/i/item/9789241550376
World Health Organization. (2020). *Global anaemia reduction efforts among women of reproductive age: impact, achievement of targets and the way forward for optimizing efforts*. https://www.who.int/publications/i/item/9789240012202
World Health Organization. (2023a). *Micronutrients*. Retrieved 2023 from https://www.who.int/health-topics/micronutrients#tab=tab_1
World Health Organization. (2023b). *Saturated fatty acid and trans-fatty acid intake for adults and children: WHO guideline*. W. H. Organization. https://www.who.int/publications/i/item/9789240073630
Yari, Z., Amini, M., Rasekhi, H., Nikooyeh, B., Doustmohammadian, A., Ghodsi, D., Rabiei, S., & Neyestani, T. R. (2022). Dietary diversity and its relationship with nutritional adequacy in 24 to 59 months old children in Iran: study protocol. *BMC nutrition*, *8*(1), 1-4.
Yeneabat, T., Adugna, H., Asmamaw, T., Wubetu, M., Admas, M., Hailu, G., Bedaso, A., & Amare, T. (2019). Maternal dietary diversity and micronutrient adequacy during pregnancy and related factors in East Gojjam Zone, Northwest Ethiopia, 2016. *BMC pregnancy and childbirth*, *19*(1), 1-9.
Yimer, F., & Tadesse, F. (2016). *Synopsis: Women's empowerment in agriculture and dietary diversity in Ethiopia*.
Zaganjor, I., Sekkarie, A., Tsang, B. L., Williams, J., Razzaghi, H., Mulinare, J., Sniezek, J. E., Cannon, M. J., & Rosenthal, J. (2016). Describing the prevalence of neural tube defects worldwide: a systematic literature review. *PLoS One*, *11*(4), e0151586.
Zerfu, T. A., & Mekuria, A. (2019). Pregnant women have inadequate fiber intake while consuming fiber-rich diets in low-income rural setting: Evidences from Analysis of common "ready-to-eat" stable foods. *Food Science & Nutrition*, *7*(10), 3286-3292.
Zhou, Y., Wang, J., Duan, Y., Luo, X., Wan, Z., Luo, Y., Li, Y., Wang, Y., & Xie, J. (2022). Dietary diversity and determinants of young adults in central China: A cross-sectional study from 2015 to 2020. *Frontiers in Nutrition*, *9*, 931107.