“Inflammatory potential of the diet and its association with physical, mental, and gut health among Lebanese adults: A cross-sectional study”

By

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To my supportive family
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Inflammatory potential of the diet and its association with physical, mental, and gut health among Lebanese adults: A cross-sectional study

Taima Anastasiou Bountoktzi

ABSTRACT

Objective: Chronic inflammatory conditions are now well acknowledged as major causes of mortality and morbidity. More than 50% of all-cause mortalities were attributed to inflammatory diseases like stroke, cardiovascular diseases, cancer, neurodegenerative diseases, or chronic kidney disease. Moreover, diet was found to be associated with major inflammatory biomarkers like C-reactive protein, or adiponectin. From there findings demonstrated through its inflammatory potential diet is associated to several aspects of health, like chronic diseases, gut health and mental health. Recent meta-analyses, found in fact a correlation between a higher dietary inflammatory score and risks of cardiovascular diseases and Type 2 Diabetes. Also, a similar association is seen for mental health, a more inflammatory diet was found to be associated with a 28% higher risk of depression, and 27% higher risk of anxiety. A pro-inflammatory diet was further associated with a higher probability of having gastrointestinal symptoms like finding mucus or liquid in the stools. Unfortunately, Lebanon has been witnessing a shift to a more inflammatory dietary pattern since 2011. Also, due to the current crises affecting all sectors in Lebanon today, physical, mental and gut health are deteriorating. It is therefore timely, to evaluate the association between the diet’s inflammatory capacity and the prevalence of chronic diseases, mental health status, and gut health status in Lebanese adults.

Methods: A total of 75 Lebanese people between the ages of 45 and 65 were recruited from several governorates in Lebanon (including Beirut, South Lebanon, and Mount Lebanon) through different social media platforms to participate in this
pilot cross-sectional study. Dietary intake was evaluated using a validated 61 items food frequency questionnaire and the Empirical Dietary Inflammatory Index (eDII) was used then used to determine the inflammatory potential of their diets. The gastrointestinal health of the adults was examined using 9-items from the validated Structured Assessment of Gastrointestinal Symptom (SAGIS). The participants' physical health was assessed by self-reported chronic diseases. Mental health was evaluated by assessing depression and anxiety prevalence through the Patient Health Questionnaire (PHQ-9) and the 7-item Generalized Anxiety Disorder (GAD-7), respectively. STATA version 13 was used to analyze the data. The associations between eDII, mental health, physical health, and gut health, were examined using logistic regression models that were adjusted for sociodemographic and clinical factors.

**Results:** The study sample included 68 Lebanese adults with a mean age of 25.72 (±4.38) years of whom 70.59 percent were women (n=48). Nearly all of the participants were married (n=56; 82.35%) and had either a bachelor's degree or higher from an accredited university (n=40; 60.29%). After correcting for age, gender, education, medication, physical health, and BMI, the logistic regressions showed no significant association between eDII and physical health (OR=0.91; 95%CI:0.64-1.29; p=0.596), eDII and mental health (OR=0.80, 95%CI:0.57-1.12; p=0.191) and eDII and gut health (OR=1.1, 95%CI:0.85-1.42, p=0.476).

**Conclusion:** To conclude, our study showed that the inflammatory potential of the diet was not associated with all three aspects of health (mental, physical, and gut) among a sample of Lebanese adults. Future longitudinal studies with a larger sample size are needed to further explore these associations. In the meantime, encouraging the consumption of vegetables and more specifically dark yellow vegetables and leafy green vegetables is essential for their anti-inflammatory potential, noting that both food groups are major components of the Lebanese diet.

**Keywords:** Empirical Inflammatory Index, Gut Health, Physical Health, Mental Health, Inflammatory Potential, Depression, Anxiety
# TABLE OF CONTENT

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I- Literature Review</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Overview of the inflammation</td>
<td>1</td>
</tr>
<tr>
<td>1.2 The Development of a scale to examine the Inflammatory Potential of a Diet</td>
<td>4</td>
</tr>
<tr>
<td>1.3 Inflammatory Potential of the Diet and Mental Health</td>
<td>5</td>
</tr>
<tr>
<td>1.4 Inflammatory Potential of the Diet and Chronic Diseases</td>
<td>7</td>
</tr>
<tr>
<td>1.5 The Diet’s potential for inflammation and Gut Health</td>
<td>8</td>
</tr>
<tr>
<td>II- Aims and Hypothesis</td>
<td>11</td>
</tr>
<tr>
<td>2.1 Problematic</td>
<td>11</td>
</tr>
<tr>
<td>2.2 Hypothesis and Objectives</td>
<td>13</td>
</tr>
<tr>
<td>III- Methodology</td>
<td>14</td>
</tr>
<tr>
<td>3.1 Study Design</td>
<td>14</td>
</tr>
<tr>
<td>3.2 Participants</td>
<td>14</td>
</tr>
<tr>
<td>3.3 Diet Assessment</td>
<td>16</td>
</tr>
<tr>
<td>3.4 Assessment of Inflammatory Potential</td>
<td>17</td>
</tr>
<tr>
<td>3.5 Assessment of Physical Health</td>
<td>20</td>
</tr>
<tr>
<td>3.6 Assessment of Mental Health</td>
<td>20</td>
</tr>
<tr>
<td>3.6.1 Assessment of Depression</td>
<td>21</td>
</tr>
<tr>
<td>3.6.2 Assessment of Anxiety</td>
<td>22</td>
</tr>
<tr>
<td>3.7 Assessment of Gut Health</td>
<td>22</td>
</tr>
<tr>
<td>3.8 Assessment of Confounding Variables</td>
<td>24</td>
</tr>
<tr>
<td>IV- Statistical Analysis</td>
<td>26</td>
</tr>
<tr>
<td>V- Results</td>
<td>28</td>
</tr>
<tr>
<td>5.1: Sample Size</td>
<td>28</td>
</tr>
</tbody>
</table>
5.2: Participants Characteristics based on physical, mental and gut health........... 29
5.3: Clinical and Dietary Characteristics: ................................................................. 31
5.4: Average consumption of the different food items ......................................... 35
5.5: Correlation between the diet’s capacity for inflammation and Physical Health ........................................................................................................................................ 37
5.6: Correlation between the diet’s capacity for inflammation and Mental Health ........................................................................................................................................ 38
5.7: Correlation between the diet’s capacity for inflammation and Gut Health ... 39
VI- Discussion.................................................................................................................. 41
VII- Conclusion ............................................................................................................... 49
VIII- References ............................................................................................................ 51
LIST OF TABLES

Table 1: Socio-demographic characteristics of the whole sample of Lebanese adults and stratified by physical health, mental health and gut health .................. 30

Table 2: Clinical and Dietary characteristics of the whole sample of Lebanese adults and stratified by Physical Health, Gut Health, Mental Health. ................. 33

Table 3: Intake of each food item of the inflammatory index by our participants .......................................................... 35

Table 4: Correlation between physical health measured by the presence of chronic diseases and the diet’s inflammatory capacity among Lebanese adults. . 38

Table 5: Correlation between mental health measured using GAD-7 and PHQ-9 of chronic diseases and the diet’s inflammatory capacity among Lebanese adults ........................................................................................................... 38

Table 6: Correlation between gut health measured using SAGIS and the diet’s inflammatory capacity among Lebanese adults ................................................................. 40
LIST OF FIGURES

Figure 1: Flow Chart of the included participants in the study ......................... 28
LIST OF ABBREVIATIONS

MeDi: Mediterranean Diet

eDII or EDII: Empirical Dietary Inflammatory Index

SAGIS: Structured Assessment of Gastrointestinal Symptom

IPAQ: International. Physical Activity Questionnaire

PHQ-9: Patient Health Questionnaire (9 items)

GAD-7: Generalized Anxiety Disorder (7 items)

CI: Confidence Interval

OR: Odds Ratio
Chapter One

Literature Review

1.1 Overview of the inflammation

Chronic inflammatory diseases have been recognized as leading contributors to mortality and morbidity worldwide (GBD 2017 Causes of Death Collaborators, 2018). The World Health Organization highlights chronic diseases as the greatest threat to human health (GBD 2017 Causes of Death Collaborators, 2018). More than 50% of all-cause mortalities were attributed to inflammatory diseases like stroke, cardiovascular diseases, cancer, neurodegenerative diseases, or chronic kidney disease (Roth et al., 2018). Our target group of interest is adults between 45 and 65 years old, we will however review the literature found for all adults.

Indeed, a position paper reviewing all the latest research evidence on inflammation, its modulation, and health, found a role for inflammation in the pathophysiology of some chronic conditions such as metabolic syndrome, and non-alcoholic fatty liver disease (NAFLD), type 2 diabetes mellitus, and cardiovascular diseases. As an example, a pro-inflammatory state might lead to hepatic inflammation through the activation of macrophages which can lead to cellular senescence and eventually cirrhosis (Minihane et al., 2015). In 2018, a meta-analysis including 14 studies (11 prospective studies, 1 cross-sectional study and 2 case-control studies), found that the highest versus lowest category of the of the
inflammatory index was found to be associated with a 36% increased risk of cardiovascular disease incidence and related mortality (CI 95%; p<0.001) (Shivappa et al., 2018). More recently in 2020, a metaanalysis of 48 cohorts, highlighted a positive correlation between the consumption of inflammatory diets and the prevalence of Type 2 Diabetes in high-quality studies that appeared to have the best selection, comparability, and assessment of outcome (Motamedi et al., 2022).

A case-control study aiming to examine the association between diet-associated inflammation and the risk of knee arthritis included 208 Lebanese participants, divided into 3 groups: those with diagnosed knee osteoarthritis (N = 78); those with knee symptoms but that has not been diagnosed with knee osteoarthritis before (N = 60); and controls matched on age, sex, and sociodemographic characteristics (N = 70). The diet-induced inflammation was estimated using the energy-adjusted dietary inflammatory index score evaluated through 24-hour dietary recalls. The authors observed that a higher dietary inflammatory index score in the group with undiagnosed knee osteoarthritis compared to the control (0.53 ± 1.028 vs 0.04 ± 1.580; p = 0.04) (El Ali et al., 2021).

Further evidence proves that neuroinflammation may contribute to the development of depression, cognitive decline, and dementia (Miller & Spencer, 2014) where a positive association between levels of highly sensitive C-reactive protein and the risk of depression and anxiety was observed (Salari-Moghaddam et al., 2019). Furthermore, diet is one of the major lifestyle factors found to modulate
inflammation and findings suggest a relationship between diet and certain inflammatory biomarkers, like interleukin 6 (IL-6), C-reactive protein (CRP), tumor necrosis factor α (TNF-α), and fibrinogen (Hart et al., 2021). Moreover, individual nutrients are found to have anti-inflammatory properties, such as omega-3 fatty acids and polyphenols, but additionally different dietary patterns have been shown to be either pro-inflammatory or anti-inflammatory (Hart et al., 2021; Nani et al., 2021). In fact, the risk of depression has been found to increase with energy-dense diets, or diets high in sugar and/or fat, as well as diets rich in processed and red meats, alcohol, and refined grains while it decreases with healthy diets high in fruit, vegetables, whole grains, fish, and lean meats (Phillips et al., 2019). The above-cited food items that appeared to be beneficial for mental health, were also recognized by the index that measures inflammation in food as anti-inflammatory (Tabung et al., 2016).

Moreover, it was demonstrated that eating a high-fat diet, also recognized as highly inflammatory food, changes the location and quantity of various microbial species in the gut (Fritsche, 2015). In a cross-sectional study, among 101 cancer-free people, the diet’s potential for inflammation as assessed by the empirical dietary inflammatory index (E-DII) score, was linked with differential composition of particular microorganisms of the gut microbiome. In the overall analysis, patients with the most anti-inflammatory diets, were found to have more microbes associated modulating systemic inflammation in the host (Zheng et al., 2020). Using data collected from 2005 to 2014, the relationships between the dietary
inflammatory index and signs of gastrointestinal disturbances were investigated cross-sectionally. When the diet was considered pro-inflammatory, the probability of finding mucus or liquid in the stools, the probability of having a stomach illness increased and the likelihood of having a diarrhea increased. Whereas the consumption of anti-inflammatory diets seemed to increase bowel movements (Worth et al., 2019).

Thus, inflammatory processes appear to be at the center of both mental and physical health problems causing death (Furman et al., 2019).

1.2 The Development of a scale to examine the Inflammatory Potential of a Diet

To examine the inflammatory potential of a diet, Tabung et al. (2016), have developed a hypothesis-driven dietary inflammatory index; the Dietary Inflammatory Index (DII). This index examines how the consumption of certain foods affects the concentrations of major inflammatory biomarkers, including the IL-6, CRP, TNF-α receptor, and adiponectin. The DII is the sum of 18 food groups, 9 of which were found to be anti-inflammatory (Beer, Wine, Tea, Coffee, Dark yellow vegetables, Leafy green vegetables, Snacks, Fruit Juices, Pizza), while the other 9 were proven pro-inflammatory (Red Meat, Processed Meat, Organ Meat, Not Dark-Meat Fish, Other Vegetables, High Energy Beverages, Low Energy Beverages, Tomatoes). This index was based on the results of linear regression models where a significant positive association between a few food items like tomatoes or a hamburger patty and inflammatory markers and a
significant negative association was also detected between food items like pizza, carrots or sweet potatoes and inflammatory markers (Tabung et al., 2016). A few years later, Kanauchi et al. (2019), made minor modifications to re-invent a newer and simpler version of the index, the empirical dietary inflammatory index (eDII), which was developed using the Mediterranean diet. It includes 16 food groups among which are red meats, leafy green vegetables, and oily fish. The index was later validated in a longitudinal Japanese study when compared to the inflammatory aging disease score, and in a large epidemiological when compared to healthy diet quality scores like the World Health Organization's healthy diet indicator (WHO-HDI) (Kanauchi et al., 2019). This index is used in several recent studies attempting to measure the diet's pro-inflammatory potential (Belliveau et al., 2022; Piyathilake et al., 2021).

1.3 Inflammatory Potential of the Diet and Mental Health

In Lebanon, data about the prevalence of mental health conditions is scarce, but in 2009 a study carried out on a nationally representative sample of the Lebanese population found that one-fourth of the adults have at least one mental disorder (Karam et al., 2009). Anxiety was the most prevalent mental illness seen in Lebanese adults. Moreover, according to a report done by the WHO in 2009, Lebanon is a country that constantly suffers from economic, social, and political instability, which accentuates the high prevalence of mental health disorders (Chahine & Chemali, 2009). Considering the numerous instabilities that the country is facing, the incidence of mental health conditions is expected to increase. A recent cross-sectional study further confirms this presumption by stating that in 2020,
around one-third of Lebanese adults were suffering from mental distress (Obeid et al., 2020). Therefore, it is timely to examine the factors that aggravate mental health problems, and in particular, their associations with inflammation, as severe mental illnesses, including major depressive disorder, have been associated with increased inflammation (Firth et al., 2019).

In fact, a meta-analysis published in 2021, comprising 5 cohort studies, 10 cross-sectional studies and 1 case-control study examined the association between the inflammatory potential of a diet and mental health. In total 92,242 men and women were included from Asia, Europe, America, and Australia. The results showed that a more inflammatory diet, as estimated by the Dietary Inflammatory Index, is significantly associated with symptoms of depression (OR = 1.28, 95% CI: 1.17–1.39, p=0.06), anxiety (OR = 1.27, 95% CI: 1.08–1.49, p=0.12), and distress (OR = 1.85, 95% CI: 1.43–2.40, p=0.40) (Chen et al., 2021). This association was further observed in a cross-sectional study conducted in university dormitories in the United Arab Emirates during Spring 2019. The study included 260 undergraduate females and used 24-h dietary recalls to evaluate the inflammatory potential of their diet. The analysis concluded that each point increase in the score of the Energy Adjusted Dietary Inflammatory Index is associated with signs of stress (OR = 1.41; 95% CI: 1.12–1.77; p = 0.003) and anxiety (OR = 1.35; 95% CI: 1.07–1.69; p = 0.01) (Attlee et al., 2022). Also, a representative sample of adult women in Mitchelstown Ireland, who are following a more pro-inflammatory diet, characterized by a higher consumption of several food groups like saturated fat or trans-fat, were found to have higher risks of developing depressive symptoms or
anxiety (Phillips et al., 2018). Furthermore, a systematic review of 22 empirical quantitative studies covering Europe, Oceania, and the United States of America, with a total number of 455,781 adult participants aged 18 to 86 years old points out that a high adherence to an anti-inflammatory diet, the intake of magnesium, folic acid, fatty acids and fish reduces the risk of depression (Ljungberg, T., Bondza, E., & Lethin, C., 2020). Lastly, a cross-sectional study conducted among 7083 Iranian adults aged 35 to 65 years, measured the inflammatory potential of their diet using the DII score and categorized it into quartiles with Q1 representing the most anti-inflammatory diet and Q4 the most pro-inflammatory diet. The results concluded that compared to women in Q1, women in the higher quartiles, consuming a more pro-inflammatory diet, had a significantly higher prevalence of depression as assessed by the Beck Depression Inventory II (Q3: OR=1.41, 95% CI: 1.06–1.88, p-values< 0.05 and Q4: OR=1.37, 95% CI: 1.03–1.83, p-values< 0.05) (Ghazizadeh et al., 2020). Therefore, strong evidence highlights a positive association between inflammatory food and the prevalence of mental health problems.

1.4 Inflammatory Potential of the Diet and Chronic Diseases

Reduced inflammatory indicators upon the consumption of certain food elements, like omega 3 fatty acids, or dietary patterns containing anti-inflammatory food has been thoroughly examined in numerous observational studies. These studies were further reviewed in a recent umbrella review which summarized the findings from meta-analyses of observational studies looking at the relationship between the DII and any existing health condition and classified
the results from no evidence to convincing evidence. It found an elevated risk for 71% of the included health outcomes, when consuming a pro-inflammatory dietary pattern - characterized by a westernized-style diet rich in trans- and saturated fatty acids. Myocardial infarction risk received convincing (Class I) evidence, while all-cause mortality, overall cancer risk, and several site-specific malignancies obtained very suggestive (Class II) evidence (Marx et al., 2021). Moreover, a strongly pro-inflammatory diet, defined by a DII score higher than 3, was linked to a modest increase in the risk of hypertension among 46,652 women aged 40-65 years who participated in a French prospective cohort that started in 1990. When comparing the highest quintile of the DII to the lowest, evidence shows the strongest relationship between inflammation and risk of hypertension in women with BMIs between 18.5-21.0 (HR:1.17, CI:1.06-1.29) (MacDonald et al., 2020). These results are in line with those observed in a systematic review and meta-analysis including 5 studies from the US, Iran, and Mexico looked at 14,987 participants with mean ages between 31.0 and 52.3 years, to explore the relationship between the diet's potential for inflammation and the risk of diabetes. A higher DII score, indicating a more pro-inflammatory diet, was found to be associated with a higher risk of acquiring diabetes (OR:1.32, 95% CI:1.01–1.72, p 0.05) (Tan et al., 2021). In Summary, the consumption of pro-inflammatory food, has been found to be linked to certain chronic diseases.

1.5 The Diet’s potential for inflammation and Gut Health

Furthermore, recent speculations suggest that inflammatory foods can change the composition and function of the gut microbiome, which can modulate
the occurrence of inflammation and put the person at a greater risk of developing chronic diseases (Zheng et al., 2020). The frequent consumption of an inflammatory diet seems to additionally increase gut disturbances, like bloating or constipation, which may lead to the development of Inflammatory Bowel Syndrome or Diseases (IBS, IBD). A cross-sectional study including 329 adults aged 18 years or older diagnosed with either Ulcerative Colitis or Crohn’s Disease, suggests that IBD patients, particularly those with Crohn's disease, would benefit from a diet rich in anti-inflammatory nutrients like fiber, n-3 fatty acids, vitamins, and minerals. Even after controlling for covariates, the DII was found to be positively correlated with disease activity in Crohn's disease (p = 0.008) (Lamers, C. R., De Roos, N. M., & Witteman, B. J., 2020). In addition, a case-control study, conducted on several outpatients in Iran, showed a positive association between the consumption of pro-inflammatory foods, as evaluated by the DII, and the risk of IBS, hence suggesting that anti-inflammatory foods can be beneficial in preventing some cases of IBS (Eslampour et al., 2021).

Finally, a 1-year interventional study gave a personalized Mediterranean-style diet called the NU-AGE diet to a group of older adults aged 65 to 79 years. The study included 612 older adults from five European countries (UK, France, Netherlands, Italy, and Poland), from which 323 participants adhered to the intervention while the control group was asked to follow their habitual diet. The researchers discovered that following the intervention diet led to an increase in different taxa that are negatively correlated with cytokines and biomarkers which are markers of inflammation (Ghosh et al., 2020).
In summary, the capacity of inflammation induced by food appears to affect the gut health, as observed in the gastrointestinal symptoms and the gut microbiota composition.
Chapter Two

Aims and Hypothesis

2.1 Problematic

In the past three years, the Lebanese population has been enduring from cumulative adversities impacting the economy, the health sector, safety and security and much more (Farran, 2021). This has greatly impacted the mental health of the population. In fact, following the Beirut explosion, the Lebanese NGO “Embrace” gathered information from 903 people and observed that among them, 83% reported a feeling of depression and lack of enjoyment during their favorite activities; and 78% reported feeling insecure and frightened every day. Also, a month later, 55% of these respondents were found to have signs of depression (Embrace, 2020).

A nationwide representative sample of 2671 Lebanese people, aged 18 and older, was used by the ministry of public health to examine the prevalence of non-communicable diseases. The results showed that the majority (65.4%) of those over 50 years old had at least one chronic disease, and that the most prevalent disease for that age group is high blood pressure (41.3%) (Sibai et al., 2019).

Lastly, an increased prevalence of inflammatory bowel syndrome (IBS) is detected in the Lebanese population, which comprises several gastrointestinal symptoms including bloating, diarrhea and/or constipation. An observational
population-based study, that examined the prevalence of IBS in Lebanese adults aged 18 to 65 years old, found a 20.1% prevalence among the sample of 553 participants (Chatila et al., 2017).

Taking into consideration the aforementioned prevalence, it seems of primal necessity to find a way to prevent the deteriorating health of the Lebanese population. Inflammation appeared to be at the center of all three aspects of health (mental, physical, and gut) and can be modulated by the diet and specifically by anti-inflammatory dietary patterns (Minihane et al., 2015).

Lebanon, being a Middle Eastern country with a large coastal area, is expected to have high rates of adherence to a Mediterranean-type diet. Controversially, a study conducted by Naja et al. (2011) examining dietary patterns followed by the Lebanese population, highlighted an inclination towards the adoption of a western dietary pattern. Also, a recent cross-sectional study conducted on a representative sample of 352 Lebanese older adults above 60 years old, examined the different dietary patterns they consumed. Even though most of the participants adhered to the Mediterranean diet, a significant 11.9% of the participants were found to consume a Westernized-type dietary pattern characterized by high sugar and jam intake, as well as an elevated refined flour intake. (Yaghi et al., 2021).

Therefore, it is crucial to investigate the diet’s inflammatory potential of the Lebanese adult population, noting that their dieting is shifting towards a more
pro-inflammatory pattern which will harm further their physical and mental health.

To date only few studies have examined the inflammatory potential of the Lebanese Diet. Also, to our knowledge, no study in Lebanon has inspected the association between the dietary inflammatory index and the prevalence of chronic diseases, gut disturbances, and mental health problems.

2.2 Hypothesis and Objectives:

We hypothesize that:

A high inflammatory diet increases the prevalence of mental, physical, and gut health of Lebanese adults.

Having established the relationship between inflammatory dietary patterns and the potential development of chronic diseases our aim is to:

- Explore the possible association between the inflammatory potential of the Lebanese diet and physical health, by examining the prevalence of chronic diseases.
- Examine the possible association between the inflammatory potential of the Lebanese diet and mental health, by examining the prevalence of anxiety and depression.
- Evaluate the association between the diet’s inflammatory capacity and the gut health of the Lebanese adult population, by examining the prevalence of gastrointestinal symptoms.
Chapter Three

Methodology

3.1 Study Design:

This is a pilot cross-sectional study that was conducted among Lebanese men and women aged between 45 and 65 years old, living in different Lebanese governorates, including Beirut, South Lebanon, and Mount Lebanon. Participants received an online invite to our study that was sent on social media platforms (WhatsApp and Instagram). The recruitment happened as well by word of mouth. We aimed to collect data through an online survey of 25 minutes that we put together aiming to evaluate its feasibility for future bigger studies of that kind. The study was approved by the Institutional Review Board at the Lebanese American University (IRB #: LAU.SAS.BR1.12/Sep/2021).

3.2 Participants:

We initially anticipated a sample size of 196 participants. This number was calculated using the “A- priori Sample Size Calculator for Multiple regression” with a medium level anticipated effect size (f2) of 0.15, a statistical power level of 0.8, 13 predictors and a probability level of 0.05. This specification resulted in a total sample size of 131. The missing data is accounted for by
inflating the sample size by 1.2 and the non-response is accounted for by inflating the sample size by 1.25, leaving a final sample size of 196 participants.

An invitation to participate in our study was shared on social media platforms allowing adults all over Lebanon to participate. Participants that were eligible to participate in this study were 45-65 years old, English or Arabic literate, residing in Lebanon, and digital literate (to be able to fill the survey online). Participants were excluded from the study if they had previous bariatric surgeries, chronic kidney disease (CKD), or were currently diagnosed cancer patients undergoing chemotherapy.

Participants were sent an online invite to our study through different social media platforms (WhatsApp and Instagram), in which information on dietary intake, depression, anxiety, and gut health was collected. Initially, participants were provided with an informed consent that included the purpose and benefits of the study and ensures anonymity. Participants were asked to read the informed consent carefully and had access to the online survey after their agreement.

We anticipated that the development of the online survey will be completed by June and then data collection will start. Nevertheless, we encountered a difficulty adapting the validated questionnaires into online formats, noting that these questionnaires were made to be initially filled during face-to-face interviews. The FFQ more specifically took a good amount of work to be adjusted into the simplest online format possible. Facing all those problems delayed the questionnaire development till November. Therefore, data collection started in
November 2021 and lasted till February 2022. By the end of February, we had to stop the data collection, noting the response was not as expected and that we needed to account for enough time for data analysis. Unfortunately, the convenient sample reached was 75 Lebanese adults due to the difficulty of reaching out to people in that age range during the covid pandemic, enabling us from having direct face-to-face contact. The survey was challenging if filled online and might have been much more efficient if done during live interviews.

### 3.3 Diet Assessment:

Dietary intake was assessed by a 61-item semi-quantitative FFQ derived from previous studies conducted among the Lebanese population. The validity and clarity of this FFQ have been previously tested (Naja et al., 2015). The FFQ consists of 61 items for the commonly consumed foods in Lebanese households. The food items are divided into groups of breads and cereals, dairy products, fruits and juices, vegetables, meat and alternates, fats and oil, sweets and desserts, beverages and miscellaneous (such as manaeesh, falafel etc…). Subjects were asked to indicate the frequency of consumption (per day, per week, per month, per year, or never) with the standard portion size (1 cup, 1 piece, 1 teaspoon…) over the past year. The participants were asked to provide information about the portion size using typical household measurements (teaspoons, tablespoons, and cups), with the help of a validated two-dimensional (2D) food portion visual chart. This visual aid was validated on adults aging between 20 years old up to 70 years old which suits our population (Posner et al.,
Participants were provided pictures of common kitchenware found in every Lebanese household to determine the exact portion size consumed. The FFQ was self-administered in an online format.

3.4 Assessment of Inflammatory Potential:

To examine the inflammatory capacity of the diet, the empirical dietary inflammatory index (eDII), developed using the Mediterranean diet, was used (Kanauchi et al., 2019). The scoring system comprises 8 pro-inflammatory food components and 8 anti-inflammatory food components, detailed in the tables below. Based on how often a food was consumed daily or weekly, pro-inflammatory foods received 0, 1, or 2 points, whereas anti-inflammatory foods received 0, -1, or -2 points (asked about the frequency of cups consumed daily or weekly). The detailed scores presented in the below tables. The red background denotes the pro-inflammatory food groups whereas the green background denotes the anti-inflammatory food groups. Based on a dose-response meta-analysis, that examined the effect of moderate and heavy alcohol consumption on cardiovascular health, Kanauchi et.al decided to set an upper limit for alcohol consumption (Kanauchi et al., 2019; Mostofsky et. Al, 2016) because it was observed that the heavy consumption of alcohol was associated with a higher cardiovascular risk whereas the moderate consumption was found to be protective from ischemic stroke (Mostofsky et. Al, 2016).

Lastly, according to the EDII scoring system, a total score, ranging from -16 to +16, would reveal the inflammatory aptitude of a diet: the higher the score the higher the inflammation. Tables below detail further the scoring system.
Scoring system of the 8 pro-inflammatory foods using the empirical dietary inflammatory index

<table>
<thead>
<tr>
<th>Food items</th>
<th>Score</th>
<th>+2 points</th>
<th>+1 point</th>
<th>0 points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>≥7 times per week</td>
<td>2 to 6 times per week</td>
<td>&lt;2 times per week</td>
</tr>
<tr>
<td>1. Red Meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥7 times per week</td>
<td>2 to 6 times per week</td>
<td>&lt;2 times per week</td>
</tr>
<tr>
<td>2. Processed Meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥7 times per week</td>
<td>2 to 6 times per week</td>
<td>&lt;2 times per week</td>
</tr>
<tr>
<td>3. Organ Meat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥7 times per week</td>
<td>2 to 6 times per week</td>
<td>&lt;2 times per week</td>
</tr>
<tr>
<td>4. Other Fish</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥7 times per week</td>
<td>5 to 6 times per week</td>
<td>&lt;5 times per week</td>
</tr>
<tr>
<td>5. Eggs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥7 times per week</td>
<td>5 to 6 times per week</td>
<td>&lt;5 times per week</td>
</tr>
<tr>
<td>6. Sugar Sweetened</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beverages</td>
<td></td>
<td>≥7 times per week</td>
<td>5 to 6 times per week</td>
<td>&lt;5 times per week</td>
</tr>
<tr>
<td>7. Tomatoes</td>
<td></td>
<td>≥7 times per week</td>
<td>5 to 6 times per week</td>
<td>&lt;5 times per week</td>
</tr>
<tr>
<td>Food items</td>
<td>Score</td>
<td>-2 points</td>
<td>-1 point</td>
<td>0 points</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------</td>
<td>--------------------</td>
<td>--------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>1. Leafy Green Vegetables</td>
<td>≥14 times per week</td>
<td>7 to 13 times per week</td>
<td>&lt;7 times per week</td>
<td></td>
</tr>
<tr>
<td>2. Dark Yellow Vegetables</td>
<td>≥7 times per week</td>
<td>5 to 6 times per week</td>
<td>&lt;5 times per week</td>
<td></td>
</tr>
<tr>
<td>3. Fruit Juice</td>
<td>≥5 times per week</td>
<td>2 to 4 times per week</td>
<td>&lt;2 times per week</td>
<td></td>
</tr>
<tr>
<td>4. Oily Fish</td>
<td>≥5 times per week</td>
<td>2 to 4 times per week</td>
<td>&lt;2 times per week</td>
<td></td>
</tr>
<tr>
<td>5. Coffee</td>
<td>≥2 cups per day</td>
<td>1 cup per day</td>
<td>&lt;1 cup per day</td>
<td></td>
</tr>
</tbody>
</table>

Scoring system of the 8 anti-inflammatory foods using the empirical dietary inflammatory index.
6. **Tea**

<table>
<thead>
<tr>
<th></th>
<th>≥2 cups per day</th>
<th>1 cup per day</th>
<th>&lt;1 cup per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. <strong>Wine</strong></td>
<td>7 to 20 glasses per week</td>
<td>2 to 6 glasses per week</td>
<td>&lt;2 glasses per week, ≥21 glasses per week</td>
</tr>
<tr>
<td>8. <strong>Beer or other alcoholic beverages</strong></td>
<td>7 to 13 bottles per week</td>
<td>5 to 6 bottles per week</td>
<td>&lt;5 bottles per week, ≥14 bottles per week</td>
</tr>
</tbody>
</table>

### 3.5 Assessment of Physical Health:

Physical health was assessed by the prevalence of chronic diseases. The participants were provided with a list of common chronic diseases like diabetes and hypertension and are requested to self-report if they have any of these diseases or any additional not mentioned disease. We regrouped the answers as: no prevalent chronic disease reported, 1 or more prevalent chronic disease. The participants were additionally asked to state if they have a family history of the disease they cited, if any.

### 3.6 Assessment of Mental Health:

The mental health of the Lebanese adults will be evaluated by determining the prevalence of depression and anxiety using validated tools. To measure depression and anxiety respectively, the Patient Health Questionnaire (PHQ-9) (Kroenke et al., 2001) and the General Anxiety Disorder (GAD-7) (Spitzer et al., 2006). Both tools are validated among the Lebanese adults and will be
administered in the survey both in English and Arabic versions (Sawaya et al., 2016). Both tools are usefully used together to examine some aspects of mental health over a period of time (Spitzer et al., 2006). In order to assess for general mental health, we grouped together anxiety and depression scores and created a variable for mental health. We classified our participants with no mental health problems if they didn’t seem to have neither anxiety or depression, and the rest were considered to have mental health complications if they had at least anxiety or depression.

**3.6.1 Assessment of Depression:**

Depression was assessed using the PHQ-9 that is a self-administered 9-item questionnaire developed by Kroenke et al., in 2001. It is a reliable and valid tool to measure depression severity and is part of the full Patient Health Questionnaire (PHQ) (McEwen et al., 2018). This diagnostic instrument also has a high sensitivity and specificity (Kroenke et al., 2001) and is validated in Arabic (Sawaya et al, 2016). It is composed of 9 items each presenting one possible disturbance or problem that a person might have faced over the last 2 weeks. The participants are asked on a scale from “not at all” to “nearly every day”, respectively scored as 0 and 3, how often they have been bothered by the 9 suggested problems. One of the items for example is “Little interest or pleasure in doing things”. The total scores range from 0 to 27, scores less than 5 indicate the absence of a depressive disorder; scores of 5 through 9 indicate a mild depression; scores of 10 through 14 reflect a moderate depression; and scores of 15 or more reflect major depression (Kroenke et al, 2001). We regrouped our
sample in two categories for the analysis, those scoring <5 have no or minimal depression and those scoring >5 have a mild to severe depression.

3.6.2 Assessment of Anxiety:

Anxiety was assessed using the GAD-7, which is a 7 items tools with a strong criterion validity and reliability used to screen for Generalized Anxiety Disorder (GAD), and assess its severity (Spitzer et al., 2006). In this study, the validated Arabic version was used (Sawaya et al, 2016). The questionnaire, similar to the PHQ-9, asks the participants to report how frequently in the past 2 weeks they were bothered by the 7 anxiety symptoms suggested. The symptoms are chosen in accordance with the criteria mentioned in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). The participants are asked to answer either “not at all,” “several days,” “more than half the days,” or “nearly every day,” scored respectively as 0, 1, 2, and 3. The total score ranges between 0 and 21, and a score of 5 or higher would indicate a mild to severe GAD. Therefore, we classified our sample into two categories: minimal GAD if they scored lower than 5, and mild to severe GAD if they scored 5 or higher.

3.7 Assessment of Gut Health:

Gastrointestinal health of the Lebanese adults was evaluated using 9 questions from the validated Structured Assessment of Gastrointestinal Symptom (SAGIS) by Koloski. NA, et al. (2017). This questionnaire was used as a proxy for gut
health since fecal testing was not available. A previous study had used this questionnaire as a proxy for gut dysbiosis (Sundaram et al, 2022).

The SAGIS questionnaire supports the clinical assessment and symptom-based categorization of patients with a wide spectrum of gastrointestinal symptoms. It includes 22 gastrointestinal symptoms scored on a five-point Likert scale from no problem, mild (can be ignored when you do not think about it), moderate (cannot be ignored but does not influence daily activities), severe (influencing your concentration on daily activities), and very severe (markedly influences your daily activities &/or requires rest) problem. In addition, the SAGIS asks about the presence of selected non-gastrointestinal symptoms including depression and anxiety.

After that symptom domain score was calculated as the following (Koloski. et al, 2017):

Diarrhea and Discomfort scores: Q8 (pain defecation), Q11 (loose stool), Q12 (incontinence), Q13 (urgency), Q14 (diarrhea), and Q21 (gas) were summed together. The diarrhea score can range from 0 to 20. Higher scores will indicate higher severity of the disease.

Constipation score: Q9 (difficult defecation) and Q10 (constipation) are summed together. The constipation score can range from 0 to 8. Higher scores will indicate higher severity of the disease.
We added the bloating score where we extracted it using Q20 (feeling of swelling of the abdomen and excessive gas in the abdomen). The bloating score can range from 0 to 4. Higher scores will indicate higher severity of the disease.

Finally, we added the scores of the above domains and dichotomized gut health based on the mean score following previous studies (Sameul et al, 2021, Koloski et al, 2017). The categories were as follow: below mean ≤4, above mean >4 with scores above the mean indicating greater severity of symptoms.

3.8 Assessment of Confounding Variables:

Moreover, general questions were asked to collect additional needed information and due to the small sample size we regrouped the answers as follows: gender (female/male), age (in years), marital status (single and windowed; married), level of education (intermediate school or below or 9th grade or high school graduate or with a diploma or the equivalent; trade/technical/vocational training, and bachelor’s degree or a higher university degree), and average monthly income (Answered with a specific number; I don’t have an income; I prefer not to say). The participants were also asked to report their weight and height; accordingly, we calculated the Body Mass Index (BMI) and used the recognized cut-off values to categorize the participants as underweight, normal weight, overweight or obese (World Health Organization, 2010). Participants were also asked to report the presence of chronic diseases (Yes/No). According to the literature, it is also important to account for the intake of medications, antibiotics, supplements, and probiotics if any. Therefore, we
asked the participants to report if they are taking any medication or took any antibiotic in the previous 6 months (Yes/No); if they are taking any supplements (Yes/No); and if they are taking any probiotic (Yes/No). Physical activity was assessed using the validated International Physical Activity Questionnaire (IPAQ) (Lee et al., 2011).
Chapter Four

Statistical Analysis

Statistical analysis was completed after data collection via STATA version 13, with a confidence interval of 95% and a significance level of p<0.05. Descriptive statistics were assigned by mean and standard deviations for continuous variables and percentage and frequencies for categorical variables. The independent variable is the inflammatory potential of the diet assessed using the EDII scoring system, the higher the score indicates a higher inflammatory potential (Kanauchi et al., 2019). While the dependent variables are mental health, physical health and gut health. Each was dichotomized respectively into no mental health problem (0, reference category) and having either anxiety or depression or both (1); no prevalent chronic disease (0, reference category) and at least one prevalent chronic disease (1); below mean gut health problems (0, reference category) and having above mean gut health problems (1).

Independent student t-test and Chi-square test were used to compare continuous and categorical variables respectively. Moreover, logistic regressions were performed to assess the relationship between the inflammatory potential of the diet and gut health, physical health, and mental health while adjusting for the confounding variables. The level of significance was set as p<0.05. These variables were chosen based on their clinical significance in the literature, and if they appeared to have a significant relationship with our independent variable in
the bivariate analysis (p<0.02). We used two models; model 1 was adjusted for gender, age, and education and model 2 additionally adjusted for medications, BMI, and physical activity. These variables were chosen based on clinical significance. Statistical analysis was carried out using STATA version 13.
Chapter Five

Results

5.1: Sample Size

Among the 75 participants recruited for our study, 6 participants were excluded from the analyses because stopped filling the survey after consenting. An additional participant was excluded because they were ineligible by being below the specified age range. Therefore, the final sample of our study was 68 participants.

![Flow Chart of the included participants in the study]

Figure 1: Flow Chart of the included participants in the study
5.2: Participants Characteristics based on physical, mental and gut health

The study sample included 68 Lebanese participants aged 45 and above, among which 70.59% were females (n=48) and the mean age of the whole sample was 55.15 (±5.5) years, with no significant difference between genders. Almost all participants achieved Trade, technical, vocational training or bachelor’s degree or a higher university degree (n=40 (60.29%)) and were married (n=56 (82.35%)).

As detailed in Table 1, the socio-demographic characteristics, including the level of education, the mean age and the gender distribution were all presented and additionally the sample was stratified by the physical, mental and gut health statuses. No significant difference was found between any of the groups.
Table 1: Socio-demographic characteristics of the whole sample of Lebanese adults and stratified by physical health, mental health and gut health

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Whole Sample n=68</th>
<th>&lt;1 chronic disease n=24</th>
<th>≥1 chronic disease n=33</th>
<th>p-value c</th>
<th>Without a Mental Health Disorder n=17</th>
<th>With a Mental Health Disorder n=45</th>
<th>p-value c</th>
<th>Below the mean Gut Health n=41</th>
<th>Above the mean Gut Health n=21</th>
<th>p-value c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender n (%) b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20 (29.41)</td>
<td>8 (33.33)</td>
<td>8 (24.24)</td>
<td>0.45</td>
<td>3 (17.65)</td>
<td>17 (37.78)</td>
<td>0.13</td>
<td>15 (36.59)</td>
<td>4 (19.05)</td>
<td>0.16</td>
</tr>
<tr>
<td>Female</td>
<td>48 (70.59)</td>
<td>16 (66.67)</td>
<td>25 (75.76)</td>
<td></td>
<td>14 (82.35)</td>
<td>28 (62.22)</td>
<td></td>
<td>26 (63.41)</td>
<td>17 (80.95)</td>
<td></td>
</tr>
<tr>
<td>Age (mean ±SD) a</td>
<td>55.15 ± 5.5</td>
<td>55.13 ± 5.29</td>
<td>55.96 ± 5.43</td>
<td>0.57</td>
<td>56 ± 5.77</td>
<td>54.84 ± 5.56</td>
<td>0.47</td>
<td>55.25 ± 5.57</td>
<td>54.53 ± 5.41</td>
<td>0.63</td>
</tr>
<tr>
<td>Education n (%) b</td>
<td></td>
<td></td>
<td></td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school graduate, diploma or below</td>
<td>27 (39.71)</td>
<td>8 (33.33)</td>
<td>15 (45.45)</td>
<td></td>
<td>6 (35.29)</td>
<td>19 (42.22)</td>
<td></td>
<td>16 (39.02)</td>
<td>9 (42.86)</td>
<td>0.77</td>
</tr>
<tr>
<td>Technical or University degree</td>
<td>40 (60.29)</td>
<td>16 (66.67)</td>
<td>18 (54.55)</td>
<td></td>
<td>11 (64.71)</td>
<td>26 (57.78)</td>
<td></td>
<td>25 (60.98)</td>
<td>12 (57.14)</td>
<td></td>
</tr>
<tr>
<td>Marital status n (%) b</td>
<td></td>
<td></td>
<td></td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.97</td>
</tr>
<tr>
<td>Single /Widowed</td>
<td>12 (17.65)</td>
<td>3 (12.50)</td>
<td>5 (15.15)</td>
<td></td>
<td>3 (17.65)</td>
<td>8 (17.78)</td>
<td></td>
<td>8 (19.51)</td>
<td>4 (19.05)</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>56 (82.35)</td>
<td>21 (87.50)</td>
<td>28 (84.85)</td>
<td></td>
<td>14 (82.35)</td>
<td>37 (82.22)</td>
<td></td>
<td>33 (80.49)</td>
<td>17 (80.95)</td>
<td></td>
</tr>
</tbody>
</table>

Differences between Mental Health status, Gut Health status and Physical Health status were tested by: a independent t test; b Chi-square, and c significance level at <0.05.
5.3: Clinical and Dietary Characteristics:

Our sample had an average BMI of 25.72 (±4.38), 46.27% of the participants had a normal BMI (n=31) and 34.33% were classified as overweight (n=23). Almost half of the participants reported having chronic diseases (n=24, 42.11%) and the majority have family history of chronic diseases (n=46 (69.70%)) and took medications and/or antibiotics in the last 6 months (n=44 (65.67%)). Only 6 participants (9.09%) reported taking medications for anxiety and depression and 5 participants (7.47%) reported taking probiotics. On the contrary, only 24 participants reported never taking supplements (35.29%). On average, the participants score -0.25 ± 2.52 on the inflammatory index, indicating a consumption of anti-inflammatory food. Among the 68 participants, 41 adults (66.13%) scored less than the average on the gut health score. Moreover, half of our sample have mild to severe depression (n=31 (50.82%)) and more than half have mild to severe anxiety (n=39 (60.94%)).

When it comes to smoking status and physical activity, two third of the participants (n=43 (64.18%)) were nonsmokers and a little bit more than half reported moderate physical activity (n=35 (51.47%)).

Table 2 shows the clinical and dietary characteristics based on physical, gut and mental health of the participants. First looking at the general overview we note that 72.58% of our participants have mental health problems, and 57.89% have chronic diseases, while only 33.87% were diagnosed with gut health problems. Examining the differences between the group with and without chronic
diseases; there is no significant difference in the BMI scores between the two groups with both being on average overweight (without chronic diseases: 25.81 ± 4.62; with chronic diseases: 26.06 ± 4.16). No significant differences were observed regarding their intake of supplements, or probiotics (respectively p=0.55; p=0.68). The group diagnosed with either anxiety or depression or both seemed to have a higher intake of medications and antibiotics (p=0.032), compared to the group that does not have a mental health problem. Similarly, the adults with a chronic disease took more medications than the group free of chronic diseases (p=0.001).

No significant difference was detected at the level on the inflammatory potential between all the groups.
Table 2: Clinical and Dietary characteristics of the whole sample of Lebanese adults and stratified by Physical Health, Gut Health, Mental Health.

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Whole Sample n=68</th>
<th>&lt;1 chronic disease n=24</th>
<th>≥1 chronic disease n=33</th>
<th>p-value&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Without a Mental Health Disorder n=17</th>
<th>With a Mental Health Disorder n=45</th>
<th>p-value&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Below the mean Gut Health n=41</th>
<th>Above the mean Gut Health n=21</th>
<th>p-value&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMI (mean ±SD)&lt;sup&gt;a&lt;/sup&gt;</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.72± 4.38</td>
<td>25.81 ± 4.62</td>
<td>26.06 ± 4.16</td>
<td>0.83</td>
<td>24.78 ± 4.69</td>
<td>26.28 ± 4.19</td>
<td>0.23</td>
<td>25.33 ± 3.86</td>
<td>26.49 ± 4.88</td>
<td>0.31</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>31 (46.27)</td>
<td>9 (39.13)</td>
<td>15 (45.45)</td>
<td></td>
<td>8 (47.06)</td>
<td>0 (0)</td>
<td>20 (48.78)</td>
<td>8 (38.10)</td>
<td></td>
<td>0.71</td>
</tr>
<tr>
<td>Underweight</td>
<td>1 (1.49)</td>
<td>1 (4.35)</td>
<td>0 (0)</td>
<td></td>
<td>1 (5.88)</td>
<td>19 (42.22)</td>
<td>1 (2.44)</td>
<td>0 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>23 (34.33)</td>
<td>10 (43.48)</td>
<td>11 (33.33)</td>
<td></td>
<td>6 (35.29)</td>
<td>17 (37.78)</td>
<td>13 (31.71)</td>
<td>9 (42.86)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obesity</td>
<td>12 (17.91)</td>
<td>3 (13.04)</td>
<td>7 (21.21)</td>
<td></td>
<td>2 (11.76)</td>
<td>9 (20)</td>
<td>7 (17.07)</td>
<td>4 (19.05)</td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td><strong>Current intake of medications and/or antibiotics, in the last 6 months n (%)&lt;sup&gt;b&lt;/sup&gt;</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
<td></td>
<td></td>
<td>0.032</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>No</td>
<td>23 (34.33)</td>
<td>12 (52.17)</td>
<td>4 (12.12)</td>
<td></td>
<td>9 (52.94)</td>
<td>11 (24.44)</td>
<td>15 (37.50)</td>
<td>7 (33.33)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44 (65.67)</td>
<td>11 (47.83)</td>
<td>29 (87.88)</td>
<td></td>
<td>8 (47.06)</td>
<td>34 (75.6)</td>
<td>25 (62.50)</td>
<td>14 (66.67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intake of supplements n (%)&lt;sup&gt;b&lt;/sup&gt;</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.55</td>
<td></td>
<td></td>
<td>0.78</td>
<td></td>
<td></td>
<td>0.49</td>
</tr>
<tr>
<td>No</td>
<td>24 (35.29)</td>
<td>6 (25.00)</td>
<td>14 (42.42)</td>
<td></td>
<td>5 (29.41)</td>
<td>19 (42.22)</td>
<td>14 (34.15)</td>
<td>10 (47.62)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44 (64.70)</td>
<td>18 (75.00)</td>
<td>19 (57.57)</td>
<td></td>
<td>12 (70.59)</td>
<td>26 (57.78)</td>
<td>27 (65.86)</td>
<td>11 (52.37)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intake of probiotics n (%)&lt;sup&gt;b&lt;/sup&gt;</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.68</td>
<td></td>
<td></td>
<td>0.81</td>
<td></td>
<td></td>
<td>0.58</td>
</tr>
<tr>
<td>No</td>
<td>62 (92.54)</td>
<td>36 (90)</td>
<td>20 (95.24)</td>
<td></td>
<td>16 (94.12)</td>
<td>41 (93.18)</td>
<td>36 (90)</td>
<td>20 (95.24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>5 (7.47)</td>
<td>4 (10)</td>
<td>1 (4.76)</td>
<td></td>
<td>1 (5.88)</td>
<td>3 (4.82)</td>
<td>4 (10)</td>
<td>1 (4.76)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cigarettes/ Narghileh smoking n (%)&lt;sup&gt;b&lt;/sup&gt;</strong></td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td>0.64</td>
<td></td>
<td></td>
<td>0.90</td>
</tr>
<tr>
<td>Never Smoked</td>
<td>43 (64.18)</td>
<td>13 (54.17)</td>
<td>25 (78.13)</td>
<td></td>
<td>13 (54.17)</td>
<td>25 (78.13)</td>
<td>26 (65)</td>
<td>14 (66.67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoked either one or both</td>
<td>24 (35.82)</td>
<td>11 (45.83)</td>
<td>7 (21.88)</td>
<td></td>
<td>11 (45.83)</td>
<td>7 (21.88)</td>
<td>14 (35)</td>
<td>7 (33.33)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
All data are presented as n (%) except for BMI and Inflammatory Index where mean (±SD) was presented. Differences between physical, mental and gut health tested by: a independent t test; b Chi-square, and c significance level at <0.05

<table>
<thead>
<tr>
<th>Physical Activity n (%)</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>30 (44.12)</td>
<td>14 (58.33)</td>
<td>12 (36.36)</td>
<td>8 (47.06)</td>
<td>20 (44.44)</td>
<td>16 (39.02)</td>
<td>11 (52.38)</td>
<td>35 (51.47)</td>
<td>9 (37.50)</td>
<td>19 (57.58)</td>
<td>8 (47.06)</td>
<td>24 (53.33)</td>
<td>23 (56.10)</td>
<td>9 (42.86)</td>
<td>3 (4.41)</td>
<td>1 (4.17)</td>
<td>2 (6.06)</td>
<td>1 (5.88)</td>
<td>1 (2.22)</td>
<td>2 (4.88)</td>
<td>1 (4.76)</td>
</tr>
<tr>
<td>Inflammatory Index (mean ±SD)</td>
<td>-0.25 ± 2.52</td>
<td>0.33 ± 2.46</td>
<td>-0.15 ± 2.05</td>
<td>0.46</td>
<td>0.07 ± 1.94</td>
<td>-0.15 ± 2.72</td>
<td>0.78</td>
<td>-0.42±2.62</td>
<td>0.33± 2.54</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of chronic diseases n(%)</td>
<td>33 (57.89)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>9 (64.29)</td>
<td>24 (61.54)</td>
<td>0.86</td>
<td>16 (51.61)</td>
<td>15 (75)</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of mental disorders n(%)</td>
<td>45 (72.58)</td>
<td>15 (38.46)</td>
<td>24 (61.54)</td>
<td>0.86</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>25 (59.52)</td>
<td>17 (40.48)</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Anxiety n(%)</td>
<td>39 (60.94)</td>
<td>13 (39.39)</td>
<td>20 (60.61)</td>
<td>0.75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>21 (58.33)</td>
<td>15 (41.67)</td>
<td>0.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Depression n(%)</td>
<td>31 (50.82)</td>
<td>11 (40.74)</td>
<td>16 (59.26)</td>
<td>0.73</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>15 (51.72)</td>
<td>14 (48.28)</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of Gut health problem n(%)</td>
<td>21 (33.87)</td>
<td>5 (25)</td>
<td>15 (75)</td>
<td>0.10</td>
<td>3 (15)</td>
<td>17 (85)</td>
<td>0.12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
5.4: Average consumption of the different food items

The eDII is composed of 16 food items, presented in Table 3, with the average consumption of each food item by the participants. If we examine the consumption of pro-inflammatory food, Tomatoes have the highest weekly consumption of approximately 1 medium tomato daily (8.03 ± 6.44). The participants consume approximately 3 palm-sized (90g) pieces of red meat weekly (3.18 ± 5.10). Another food item that is consumed more once daily is white rice, on average the participants consume more than 9 cups of cooked rice weekly, thus more than 1 cup daily (9.88 ± 11.49).

Concerning the anti-inflammatory food items, the highest consumption is of vegetables. Participants are consuming on average 1 cup of leafy green vegetables (like hindbeh, spinach, lettuce) daily (6.98 ± 5.98), and approximately ½ cup of dark yellow vegetables (like carrots, sweet potatoes, pumpkin) daily (4.05 ± 5.42 weekly).

Table 3: Intake of each food item of the inflammatory index by our participants

<table>
<thead>
<tr>
<th>Food items</th>
<th>Portion size</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean (±SD)</th>
<th>Median</th>
<th>Frequency of consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pro-inflammatory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red Meat</td>
<td>90g</td>
<td>0.125</td>
<td>42</td>
<td>3.18 (±5.10)</td>
<td>3</td>
<td>Weekly</td>
</tr>
<tr>
<td>Processed Meat</td>
<td>Sausages, makanek, hot dogs (30g)/ 1</td>
<td>0.25</td>
<td>8.5</td>
<td>1.69 (±2.07)</td>
<td>0.625</td>
<td>Weekly</td>
</tr>
<tr>
<td>Item</td>
<td>Serving Size</td>
<td>Calories</td>
<td>Total Saturated Fat</td>
<td>Weekly Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>--------------------</td>
<td>----------</td>
<td>---------------------</td>
<td>-----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>slice of Luncheon Organ Meat</td>
<td>1 cup</td>
<td>0.125</td>
<td>3</td>
<td>0.125 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Fish*</td>
<td>90g</td>
<td>0.125</td>
<td>7</td>
<td>0.5 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>1 whole</td>
<td>0.125</td>
<td>17.5</td>
<td>1 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSB*</td>
<td>1 can = 1.5 cup</td>
<td>0.375</td>
<td>52.5</td>
<td>1.125 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td>1 medium</td>
<td>0.5</td>
<td>31.5</td>
<td>7 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refined Grains:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Rice</td>
<td>1 cup cooked</td>
<td>0.625</td>
<td>59.5</td>
<td>7.5 Daily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Bread White Pasta</td>
<td>1 slice, 1/2 medium Arabic loaf, 1/2 small baguette</td>
<td>0.17</td>
<td>4.5</td>
<td>0.65 (±0.98)</td>
<td>0.42 Weekly</td>
<td></td>
</tr>
<tr>
<td>Leafy Green Vegetables</td>
<td>1 cup raw</td>
<td>0.5</td>
<td>31.5</td>
<td>7 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark yellow vegetables</td>
<td>1 cup raw</td>
<td>0.125</td>
<td>31.5</td>
<td>3 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit Juices</td>
<td>1 cup</td>
<td>0.125</td>
<td>17.5</td>
<td>0.5 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oily fish*</td>
<td>90g</td>
<td>0.125</td>
<td>7</td>
<td>0.5 Weekly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>1 small cup = 1/4 cup</td>
<td>0.017</td>
<td>6</td>
<td>1.46 (±1.42)</td>
<td>1 Daily</td>
<td></td>
</tr>
<tr>
<td>Tea</td>
<td>1 cup</td>
<td>0.017</td>
<td>6</td>
<td>1 Daily</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Weekly frequency: 0.5, 1, 7, 3, 0.5, 1 Daily
<table>
<thead>
<tr>
<th>Wine</th>
<th>½ cup</th>
<th>0.125</th>
<th>7</th>
<th>0.65 (±1.20)</th>
<th>0.125</th>
<th>Weekly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer or other</td>
<td>1 can or 1/6 cup for liquor (one exchange)</td>
<td>-2</td>
<td>0</td>
<td>-0.76</td>
<td>0</td>
<td>Weekly</td>
</tr>
</tbody>
</table>

*All the data reported in the table are in portion size (according to the portion proposed in the FFQ), and the frequency of consumption is either measured weekly or daily according to the scoring system of the eDII.

Other Fish: Non-Fatty Fish (including canned tuna, fresh tuna, shrimp, lobster, scallops...); SSB: sugar sweetened beverages; Oily fish: Fatty Fish (mackerel, herring, salmon and lake trout).

5.5: Correlation between the diet’s capacity for inflammation and Physical Health

Logistic regression analysis was completed to evaluate the association between the inflammatory index scores (eDII) and the Physical Health status as presented in Table 4. The results were not statistically significant (OR = 0.86; 95% CI: 0.64-1.14; p = 0.287), when adjusting for age, gender, and education. Even after adjusting for other variables in model 2, the results were still not significant (OR = 0.91; 95% CI: 0.64-1.29; p = 0.596).
Table 4: Correlation between physical health measured by the presence of chronic diseases and the diet’s inflammatory capacity among Lebanese adults.

<table>
<thead>
<tr>
<th>DIETARY INFLAMMATORY INDEX SCORE</th>
<th>eDII score</th>
<th>Crude Model OR (95% CI)</th>
<th>P</th>
<th>MODEL 1 OR (95% CI)</th>
<th>P</th>
<th>MODEL 2 OR (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants with physical health problem</td>
<td>-0.15 ± 2.05</td>
<td>0.9 (0.69-1.18)</td>
<td>0.456</td>
<td>0.86 (0.64-1.14)</td>
<td>0.287</td>
<td>0.91 (0.64-1.29)</td>
<td>0.596</td>
</tr>
</tbody>
</table>

OR: odds ratio, CI confidence intervals; eDII: empirical dietary inflammatory index
Model 1: Adjusted for age, gender, and education
Model 2: Model 1+ Adjusted for BMI, intake of medications and physical activity

5.6: Correlation between the diet’s capacity for inflammation and Mental Health

Using logistic regressions, the relationship between the inflammatory capacity of the diet and the prevalence of anxiety and/or depression as measured by PHQ-9 and GAD-7 was determined and is shown in Table 5. After adjusting for the age, gender and education, the correlation between the inflammatory index and mental health disorders appeared to be statistically non-significant (OR = 0.89; 95% CI: 0.67-1.17; p = 0.393). The results were still non-significant when we additionally adjusted for the number of medications and physical activity.

Table 5: Correlation between mental health measured using GAD-7 and PHQ-9 of chronic diseases and the diet’s inflammatory capacity among Lebanese adults
<table>
<thead>
<tr>
<th></th>
<th>eDII</th>
<th>Crude Model OR (95% CI)</th>
<th>p</th>
<th>MODEL 1 OR (95% CI)</th>
<th>p</th>
<th>MODEL 2 OR (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without MH problem</td>
<td>0.07 ± 1.94</td>
<td>Ref</td>
<td></td>
<td>Ref</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>With MH problem</td>
<td>-0.15 ± 0.72</td>
<td>0.97 (0.76-1.22)</td>
<td>0.775</td>
<td>0.89 (0.67-1.17)</td>
<td>0.393</td>
<td>0.80 (0.57-1.12)</td>
<td>0.191</td>
</tr>
</tbody>
</table>

OR: odds ratio, CI confidence intervals; MH: mental health; Ref: Reference

With or Without MH problem= no anxiety and depression; with anxiety and/or depression
eDII: empirical dietary inflammatory index
Model 1: Adjusted for age, gender, and education
Model 2: Model 1+ Adjusted for intake of medications and physical activity

### 5.7: Correlation between the diet’s capacity for inflammation and Gut Health

The correlation between the inflammatory potential of the diet and the prevalence of gut health problems, as evaluated by the SAGIS scoring system, is shown in

**Table 6.** The logistic regressions showed that the inflammatory index and gut health are not significantly associated after correcting for all covariates (age, gender, education, medication and physical activity) (OR = 1.1, 95% CI: 0.87-1.42; p = 0.476).
**Table 6:** Correlation between gut health measured using SAGIS and the diet’s inflammatory capacity among Lebanese adults

<table>
<thead>
<tr>
<th>DIETARY INFLAMMATORY INDEX SCORE</th>
<th>eDII</th>
<th>Crude Model OR (95% CI)</th>
<th>p</th>
<th>MODEL 1 OR (95% CI)</th>
<th>p</th>
<th>MODEL 2 OR (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than mean ≤ 4</td>
<td>−0.42±2.62</td>
<td>Ref</td>
<td></td>
<td>Ref</td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Higher than mean &gt; 4</td>
<td>0.33±2.54</td>
<td>1.12 (0.89-1.4)</td>
<td>0.318</td>
<td>1.12 (0.88-1.43)</td>
<td>0.346</td>
<td>1.1 (0.85-1.42)</td>
<td>0.476</td>
</tr>
</tbody>
</table>

OR: odds ratio, CI confidence intervals; GH: gut health; Ref: Reference

eDII: empirical dietary inflammatory index

Model 1: Adjusted for age, gender, and education

Model 2: Model 1+ Adjusted for intake of medications and physical activity
Chapter Six

Discussion

To the best of our knowledge, this is the first cross-sectional study to examine the relationship between the diet's pro-inflammatory propensity and the physical, gut, and mental health among Lebanese adults aged 45 to 65. The results of the logistic regressions showed that there were no significant correlations between the inflammatory capacity of the diet of the participants and their mental, physical, and gut health. Different methodologies including study designs, sample sizes, food groups included in the DII score, dietary intake assessment, and tools evaluating physical, mental and gut health may explain the discrepancy between our results and those observed in the literature.

The current study demonstrated that our participants were consuming an anti-inflammatory diet. Previous studies examining the dietary capacity of inflammation of Lebanese adults are scarce, but our results seem to be in line with a study conducted in 2017, examining the role of inflammation on Metabolic Syndrome among Lebanese Adults. This study found that the DII’s mean score for Lebanese individuals according to various sociodemographic and lifestyle factors was mostly, indicating the consumption of an anti-inflammatory diet. (Naja et al., 2017)
Several studies have shown that the inflammatory potential of the diet might have an important role in the prevalence of chronic diseases (Minihane et al., 2015), site-specific cancer and all-cause mortality ((Farazi, M., Jayedi, A., & Shab-Bidar, S. 2021). Nevertheless, a recent review covering 15-meta-analyses concluded that there is a weak or no association between most of the chronic diseases examined and the inflammatory potential of the diet (Marx et al., 2021). These results are in line with ours since the current study observed no significant association between eDII and physical health. An important factor to note is that the most reported prevalent chronic disease in our population was hypertension, and according to a study including 46,652 women aged 40 to 65 years examining the association between DII and the incidence of hypertension and the link to the DII, there was small borderline significant increase in risk for incident hypertension, only after adjustment for BMI (HR=1.03; 95%CI: 0.99-1.06; p=0.10) (MacDonald et al., 2020). Much stronger associations between inflammation and chronic diseases that were not reported by our sample are more evident. Taking for example, the significant relationship linking a pro-inflammatory diet to a higher incidence of metabolic Syndrome, mortality, and cardiometabolic illnesses (Aslani et al., 2020). Also, the absence of significance can be explained by the underreporting of chronic diseases where 7% of our population reported taking medications while not reporting any chronic disease.

Furthermore, our results also showed no significant relationship between the inflammatory potential of the diet and the Mental Health of patients while previous studies have found an association (Chen et al., 2021). In fact, a cross-
sectional study comprised of 3363 Iranians adults found a greater severity of mental problems linked to pro-inflammatory aspects of the diet. (Haghighatdoost et al., 2019). When assessing the current mental health status of the Lebanese population, Farran describes it to be “Tomorrow’s Silent Epidemic”. She further highlights the actual data on the severity of the impact of several disasters, such as the inflation, the economic crisis, the COVID-19 pandemic, and the 4th of August Beirut Port Explosion on the mental health of the Lebanese population (Farran, 2021). Therefore, our results might have been insignificant due to other more robust risk factors impacting the mental health that we could not account for. This was further proven in an evidence-based atlas that included 14 umbrella reviews of studies published between 1995 and 2020, in total comprising 390 meta-analyses. When examining the strongest risk factors of mental health, and specifically depression, showing that social factors like job related stress (OR=1.77, 95%CI: 1.46-2.13, class I evidence) and childhood abuse (OR= 2.42, 95%CI:1.94-3.02, class II evidence) were most significant but not diet itself (RR=0.76; 95%CI: 0.68-0.86; class III evidence – low quality) (Arango et al., 2021). We can, hence, presume that the disasters that are taking place these two years in Lebanon might be overpowering the dietary effect on mental health. Another important factor that might have impacted the results is the consumption of oily fish, which is strongly found to be protective of the brain (Grosso et al., 2014). Our participants had a low mean consumption of oily fish, on average 90g weekly which equals a palm-sized piece of fish. Due to the inflation, the prices of fish locally have increased tremendously in the past few years, which might be
decreasing the consumption. Generally, the Lebanese Cedar Food Guide, which is representative of a typical healthy Lebanese Mediterranean diet focuses on five food groups, which are cereals and grains, fruits, vegetables, low-fat milk and dairy products, and protein rich foods and doesn’t account for the consumption of fish noting that it was found to be minimal in the Lebanese Population (Hwalla et al., 2013). However, a moderate consumption of 83 to 112g per day was found to reduce the risk of mental health disorders by more than 30% (Sanchez-Villegas et al., 2007).

Regarding the Gut health, our results were non-significant. Early findings suggesting an association between gut health and inflammation (Minihane et al., 2015). A case-control published in 2021, examined the relationship between the inflammatory potential of the diet and the prevalence of Irritable Bowel Syndrome (IBS), which is generally characterized by several gut health problems like inconsistent bowel movement, bloating to name a few. It included 155 IBS cases and 310 healthy controls (aged 18 years old or above) who were age and sex-matched and deduced after several covariate adjustments a significant association between pro-inflammatory pattern food and the prevalence of IBS (OR = 1.38; 95%CI:1.2–1.56; p=<0.001) (Eslampour et al., 2021). Therefore, we speculate that the absence of association in the present study might be due to not having enough statistical variability in terms of gut health problems since the majority of the participants were considered as having a good gut health. Furthermore, measuring the gut health using a questionnaire does not cover for the diversity of the microbiota which can only be checked for using fecal testing.
Also, the Inflammatory index does not consider the consumption of whole grain, or high fiber grains, it only asks for the refined grains. A six-week intervention trial on healthy adults aged 19 to 46 years old aimed to ascertain if offering healthy whole grains instead of refined grains will alter health-related parameters like bowel movement. It found that bowel movements became more frequent, on week 6 as the whole grain consumption increased (Cooper et al., 2017).

Accordingly, looking at the consumption of bulgur, which is a known Lebanese whole grain cereal, in our sample, the average appeared to be 0.5 exchange weekly, which is very minimal, therefore rendering the consumption of whole grains low.

In reference to the previous mentioned accumulation of stress, anxiety and depression endured by the Lebanese population, we should also examine the impact mental health might be having on the gut health which also might explain our insignificant results. A review of case-control studies confirms further these speculations by deducing a correlation between anxiety and depression and IBS (Shah et al., 2014).

Although we found no significant association between the inflammatory potential of the diet of Lebanese adults and their mental, physical, and gut health available evidence reinforces the consumption of anti-inflammatory foods and their health benefits. Previous studies examining the impact inflammatory potential of the diet on health had sample sizes ranging from 331 to 23,138 participants (respectively: Naja et al., 2017; Farhangi et al. 2018), whereas our sample was much small, that might not allow us to reach statistical power.
Despite the absence of significant associations in our study, several strengths should be mentioned. To the best of our knowledge, our study is the first to examine the association between the diet's pro-inflammatory propensity and the mental, physical, and gut health among the Lebanese community. The only previous study we are aware of is a study done by Naja et al., (2017) that assessed the association between the inflammatory capacity of the westernized-type diet, using the DII, and its association with Metabolic Syndrome among 331 Lebanese adults (Naja et al., 2017). There is a certain novelty value in our approach, as most of the Lebanese studies focus on the adherence to the Lebanese Mediterranean Diet (LMD), considering it to be an anti-inflammatory dietary pattern. Once we take a closer look at the elements of the inflammatory index score, we can note that they differ, and this might give us a new perspective on the effect of food choices on health. A good example is the consumption of tomatoes, which appears to be a staple vegetable consumed on a daily basis in our sample, and which increases the inflammatory capacity of the diet but that is not separately accounted for in the LMD index.

We also transformed a validated and culture specific FFQ to make it accessible online and in the simplest way possible. We used visual aids of common kitchenware to increase the accuracy of the reported quantities. We also developed the survey in Arabic to reach the non-English speakers. Furthermore, all the tools used in the data collection, including the IPAQ, the PHQ-9 and the GAD-7 are validated among the Lebanese population in previous studies, therefore strengthening the reliability of the results.
Nevertheless, there are several limitations to our study that need to be considered, including the cross-sectional design’s limitations on drawing any causal inferences. Furthermore, our methodology has several limitations. First, we were not able to collect fecal samples but the proxy we used was shown to be a good indicator of gut health and analyze to have a better overview of the gut microbiota. Also, we were not able to correlate the inflammatory potential of diet to inflammatory biomarkers.

As discussed earlier, this is the first time this survey is given in an online format, but due to political unrest and the COVID-19 outbreak, we were unable to gather the data in-person and had to abide to the online data collection. This hindered us from filling the survey during interviews with our participants, which might have led to more accurate results specially on the FFQ being filled by licensed dietitians, but also it would have allowed us to fill the needed information in shorter period. The length of the survey, and the difficulty to fill it on the screens of mobile phones have led to missing data. Additionally, another drawback to the survey being filled online is that the participants might have poor digital literacy, especially for that age group and it limits those who do not have access to social media, smartphones, or mobile internet from entering our study. This may have limited the generalizability of our findings by limiting the people we were able to contact to those with a particular level of education, digital literacy and socioeconomic status. The sample size was not large enough to enable us to identify significance.
Furthermore, we cannot dismiss the social desirability bias, which tends to overreport healthy eating habits while underreporting problematic behaviors, food consumption, and the presence of depression or anxiety. This bias might have affected our results. Nevertheless, we would have observed considerably better anti-inflammatory diet adherence and better consumptions overall if overreporting of healthy lifestyles had been the case. Therefore, there are two possible outcomes in this situation: either the participants' diet quality is significantly poorer than what was reported, or underreporting was limited because the questionnaire was anonymous, which reduced the social desirability bias. The findings in both cases show that the diet quality of our sample is unhealthy, and much work needs to be done at the national level to raise knowledge of healthy eating habits and their overall positive effects on preventing chronic diseases.

To confirm the link between gut, physical and mental health, and pro-inflammatory food, future studies are needed with a bigger and more random sample. Future research should focus on interviewing the participants during live interviews and use fecal genetic testing to assess the microbiota. Also, more longitudinal studies are needed to evaluate the causality of the association.
Chapter Seven

Conclusion

In conclusion, when examining the association between the inflammatory capacity of food and physical or mental or gut health, we found no significant relationship. In fact, the eDII appeared to be not significantly related to gastrointestinal symptoms, as well as the presence of chronic diseases, and the occurrence of either anxiety and/or depression. Nevertheless, the prevalence of mental health distress, chronic diseases and gastrointestinal symptoms is rising among Lebanese adults. Also, Lebanon is going through a lot of instabilities and stressors which are grave and may have influenced our findings. Several previous studies have highlighted the relationship between the inflammation induced by food and health. Unfortunately, our sample size renders our results underpowered and not clinically significant.

To further understand the connection between the eDII, and the different aspects of health more longitudinal and randomized studies with a larger sample size are required. Nonetheless, anti-inflammatory food consumption’s advantages are well proven in the literature. As a result, policies should be focused on promoting healthy eating in general and anti-inflammatory food, since it is crucial to reintroduce this lifestyle among the Lebanese population. The Lebanese diet is shifting toward the westernized diet, which has several detrimental effects on
health. Given that mental and physical health problems are rising in Lebanon, this study may help highlight the value of leading a healthy lifestyle and consuming the different anti-inflammatory food items present in a traditional Lebanese Mediterranean diet. As a result, future efforts should concentrate on lowering the prevalence of these illnesses.
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