UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Diet and Mental Wellbeing:

Within a biopsychosocial framework and a planetary health rationale

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Many factors can impact mental health and wellbeing, diet being one of them. Plant-based diets are of special interest because they have a significantly smaller environmental footprint than our current diets. This MSc/SEEDS study explores the role (plant-based) diet plays in students' mental wellbeing. It does so within a sustainability and planetary health rationale and provides recommendations for UBC to achieve both a more sustainable food system and a healthy campus for its community.

Diet and mental wellbeing

Within a biopsychosocial framework and a planetary health rationale

Verena Rossa-Roccor, MD, MSc
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List of Abbreviations

BISS	Body Image States Scale
BMI	Body mass index
CDC	Centers for Disease Control
CHD	Coronary heart disease
DALY	Disability-adjusted life years
DASS	Depression Anxiety Stress Scale
DHA	Docosahexaenoic acid
DII®	Diet Inflammatory Index
DSQ	Dietary Screening Questionnaire
EPA	Eicosapentaenoic acid
EPDS	Edinburgh Postnatal Depression Scale
FFQ	Food frequency questionnaire
FIPPA	Freedom of Information and Protection of Privacy Act
GAD-7	General Anxiety Disorder Questionnaire
HEI-2010	Healthy Eating Index 2010
HR	Hazard ratio
MBDI	Modified Beck Depression Inventory
M-CIDI	Munich Composite International Diagnostic Interviews
MDS	Mediterranean Diet Score
MLR	Multivariate linear regression
NCD	Non-communicable disease
NCHA-II	National College Health Assessment II
NHANES	U.S. National Health and Nutrition Examination Survey
OR	Odds ratio
PCA	Principal component analysis
PHQ-9	Patient Health Questionnaire
PROMIS®	Patient-Reported Outcomes Measurement Information System Scale
QoL	Quality of life
RCT	Randomized controlled trial
RR	Risk ratio
SEEDS	Social Ecological Economic Development Study
SF-36	Short Form Health Survey
WHOQOL	WHO Quality of Life Questionnaire
YLD	Years lived with disability

Glossary

The following terms are being used in this report to describe different dimensions of diet. Although there are no universally agreed upon definitions for these terms, the following will outline how they are defined for the purpose of this study:

Diet preference: An approach to describe diet through different categories based on food groups that are typically included in or excluded from an individual's diet. This does not contain detailed information about the exact composition of an individual's diet. The following are understood as categories of diet preference:

> **Omnivore:** Diet preference category that does not exclude any animal products; currently the dominant diet preference in Western cultures. Herein also referred to as **'mainstream diet'.**
>
> **Vegan:** Diet preference category that is assumed to exclude all animal products, especially meat, seafood, poultry, eggs, and dairy products.
>
> **Vegetarian:** Diet preference category that is assumed to exclude all animal flesh (including fish); dairy products and eggs are typically consumed.
>
> **Pescatarian:** Diet preference category that is assumed to exclude animal flesh with the exception of fish; dairy products and eggs are typically consumed.
>
> **(Predominantly) plant-based diet(s):** More recent term to describe the continuous spectrum of diet preferences that emphasize the intake of plant foods rather than the exclusion of animal foods. It is often understood that a (predominantly) plant-based diet emphasizes minimally processed foods ('whole foods'; Ostfeld, 2017). The aforementioned categories vegan, vegetarian, and pescatarian all fall on this spectrum although they do not necessarily "require consumption of whole foods or restrict fat or refined sugar" (Tuso, Ismail, Ha, & Bartolotto, 2013). In general, 'plant-based' is often used interchangeably with 'vegan' as a less deterring term since 'plant-based' emphasizes the health reason for limiting or eliminating animal foods from one's diet while veganism is defined as "a way of living which seeks to exclude, as far as is possible and practicable, all forms of exploitation of, and cruelty to, animals for food, clothing or any other purpose" (The Vegan Society, n.d.). In this thesis,

'(predominantly) plant-based' is used as an umbrella term for all animal-reducing diets on the spectrum without making assumptions about the healthfulness of the actual food intake.

Non-mainstream diets: Umbrella term for vegan, vegetarian, pescatarian, (predominantly) plant-based diet(s) as a way to distinguish these preferences from the culturally-dominant preference ('mainstream diet').

Diet(ary) pattern: In general, a dietary pattern is defined as "the quantity, variety, or combination of different foods and beverage in a diet and the frequency with which they are habitually consumed" (Sánchez-Villegas & Martínez-Lapiscina, 2018). Herein, this term is specifically used to distinguish from diet preference (see above) in that it includes a more detailed assessment of actual food intake (as measured with a food frequency questionnaire and analyzed via principal component analysis) rather than self-categorization into the abovementioned diet preference categories.

Mental wellbeing is described using two distinct terms in this report:

Mental wellbeing: Describes the overall mental wellbeing of participants with an understanding that mental wellbeing is not merely described by the absence or presence of a mental health disorder. For example, when the term mental wellbeing is used, this generally includes the variable of quality of life.

Mental health: A term that describes a narrower understanding of the mental state of the participants and is mostly understood as a more clinical term. It is herein mostly used to talk about the variables of depression and anxiety.

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I am both grateful for and excited about being a student at a university that seeks to push the boundaries of what traditionally constitutes 'academic success' by providing a program such as UBC SEEDS. This allows students and the campus community as a whole to conduct research that aims to contribute to the public good.

1. Executive Summary

Project goals

This project employed a community-cation oriented research framework and included stakeholders from the University of British Columbia (UBC) throughout the entire research process. The stakeholder group was comprised of staff members and management from UBC Student Housing and Hospitality Services (first and foremost UBC Food Services), UBC Wellbeing, UBC Sustainability. Relevant to the stakeholder audience at UBC in particular, this study describes trends of dietary choices and behaviours as well as mental health and wellbeing in the university's undergraduate student population. This study further addresses a gap in the research literature by assessing whether plant-based diets are associated with mental health and wellbeing in a population of young adults under careful consideration of a biopsychosocial framework that is nested within the idea of planetary boundaries thus linking human health to the health of the planet.

The purpose of this project is to integrate the specific findings of the study into a broader understanding of what constitutes a sustainable and healthy food system on campus. Based on stakeholders' and researchers' subject expertise, an extensive literature review and the specific findings of this study, this report provides actionable recommendations on diet and mental wellbeing in students while applying a sustainability lens.

Background and rationale

Climate change is now recognized as the biggest threat to human health in the 21st century (Watts et al., 2015). Opportunely, there exist various co-benefits for both human and planetary health if mitigation of anthropogenic environmental impacts were made a policy priority (Haines et al., 2009). One of the most significant pathways to achieve such co-benefits is that of a "Great Food Transformation" (Willett et al., 2019, p.448) – a transition of the global food system away from unsustainably produced, unhealthy foods to healthy, predominantly plant-based diets from sustainable food systems (Willett et al., 2019). A 'win-win' situation for these diets (e.g. vegetarian, vegan) has been identified for planetary and somatic health (Willett et al., 2019) but potential mental health impacts have largely been ignored in the development of the current recommendations.

Mental and behavioural disorders are crucial to consider because they are the leading cause of years lived with disability worldwide (Whiteford et al., 2013). Mental illness often develops into a chronic, lifelong health issue that can have profound and devastating effects on an individual's life trajectory by impacting and disrupting social functioning and capital (Silva, McKenzie, Harpham, & Huttly, 2005), educational attainment (Breslau, Lane, Sampson, & Kessler, 2008), economic output (Trautmann, Rehm, & Wittchen, 2016), and overall quality of life (QoL; Alonso et al., 2004).

University students in particular are highly vulnerable for depression, anxiety, and substance use disorders (Castillo & Schwartz, 2013; Ibrahim, Kelly, Adams, & Glazebrook, 2013). However, this developmental stage also offers great potential for preventive and early intervention efforts (Patton & Viner, 2007). From a life course perspective, this is extremely relevant because health-related behaviours that are adapted during adolescence and young adulthood contribute substantially to the development of (chronic) non-communicable diseases in later stages of life (Sawyer et al., 2012). It is thus promising that this student generation is in fact the first to adopt plant-based diets in rapidly growing rates (Thomson, 2018).

However, studies on the relationship between diet and mental health are scarce. Although results are quite heterogenous, the trend seems to point towards better mental heath among those following traditional, whole-foods based diets and worse mental health among those following a 'Western' diet high in animal and processed foods (Jacka et al., 2010). However, one limitation that all previous studies have in common is their narrow focus on primarily biomedical pathways. Neither mental wellbeing nor dietary behaviours exist in a vacuum and yet factors such as social support that are known predictors for mental health outcomes and are associated with diet as well have not been included in previous assessments.

Methods

This study was a cross-sectional, observational study. Data were collected through an online self-report survey. The main outcome variables of interest were quality of life (QoL), depression, and anxiety. The main explanatory variable was diet as assessed through both, dietary patterns and through self-reported diet preference. The 82-item survey was co-constructed with substantial input from the UBC stakeholder group. It contained items on social support, health behaviours and status,

body image, stress, stressful life events, and socioeconomic data; the majority of items in the survey were taken from previously validated instruments. Participants were recruited among undergraduate students at UBC through convenience sampling. There were no specific exclusion criteria for participation. Out of a total of 440 respondents who accessed the survey, a final sample of n=339 respondents was used for data analysis after missing data was imputed via multiple imputation.

Statistical analysis included bivariate comparison (Kruskal-Wallis H test, Pearson chi-square test and independent samples t-test) to explore between-group differences of diet preference in terms of both the outcome variables and the covariables. Dietary patterns were analysed through Principal Component Analysis. The association between diet and mental health and wellbeing was assessed through hierarchical multiple regression modelling.

Results

Participant characteristics

The total sample consisted of n=339 participants, of which 66.1% identified as female (n=224), 32.1% as male (n=109), and 1.8% as other, i.e. non-binary (n=6). The average age was 19.5 years with; 65.2% of participants identified as White (n=156) with the second largest ethnicity being Asian (n=135, 39.8%) and 14.2% (n=48) other ethnicities. Due to the data collection process which was primarily focused on first- year undergraduate students, this population was overrepresented in this sample with 62.2% (n=211), followed by n=64 (18.9%), second year, n=28 (8.3%) third year, n=19 (5.6%) fourth year, and n=9 (2.7%) higher than fourth year undergraduate students. Therefore, most participants lived either on campus in a residence hall (n=244, 72%) or off-campus with their parents (n=34, 10%); 35.4% (n=120) of participants classified as international students and 65.2% indicated they spoke English as a second language (n=221). Most participants were enrolled in a Natural Science degree (n=96, 28.3%), followed by Engineering and Computer Science (n=59, 17.4%), and Arts and Humanities (n=46, 13.6%).

Mental health and wellbeing

Mental health outcomes assessed in this study were QoL, depression, and anxiety. More than half of the participants (56.3%, n=193) reported their overall QoL to be either very good or excellent with a mean score of 2.58 (±0.96) out of 5. The prevalence of clinically-relevant levels of depression

and anxiety was high in this sample of 339 undergraduate students; 20.4% scored within the moderately severe or severe depression categories of the PHQ-9 while 15.6% scored above the cut-off for severe anxiety in the GAD-7.

Diet

Almost one third of students (28.1%, n= 95) indicated to self-identify as either pescatarian, vegetarian, vegan or other on a spectrum of plant-based diets (e.g. reducetarian). The group identifying as vegans was the largest among the non-mainstream diets with 10.8% (n=37) of the total sample and 38.4% of non-mainstream diets only, respectively.

In this sample, three dietary components emerged. Component 1) was high in plant-based foods and non-animal-based dairy and meat alternatives as well as whole grains. Component 2 was high in animal-based foods such as different meats and dairy products. Component 3 was high in processed foods, snacks and candies. These diet patterns render information about how certain food groups correlate with each other and make up main components in a diet.

Covariables

Variables of interest that were included in the regression models as covariables were health behaviours (physical activity and sleep), body image, overall stress, stressful life events, and social support. Overall, it was found that almost none of the students (96.1%, n=326) managed to meet the recommended amount of physical activity of moderate activity for 30min/day in the previous week. Three quarters of the participants (76.7%, n=260) only had enough sleep to feel rested on a maximum of four days in the previous week. Two thirds of the students (66.6%, n=226) experienced more than average or even tremendous stress over the 12 months preceding the survey. Approximately half of the students were somewhat, very or extremely satisfied with their weight (52.6%, n=178). Stressful life events that would cause moderate or severe stress affected 76.3% (n=259) of the students. Conversely, the majority of participants (80.4%, n=272) reported to have good, very good or excellent satisfaction with their social relationships and activities.

Subgroup analysis: students following plant-based diets

In compliance with the conceptual framework underpinning this study, it was of interest to explore trends of mental wellbeing and other factors among those students who already follow a

plant-based diet. The tests showed that there was a statistically significant between-group difference only in terms of social support and, not surprisingly, in dietary patterns (i.e. PCA scores): Vegetarians reported to have significantly more social support than those following an omnivorous diet (z=3.39, p≤.05), pescatarians (z=3.01, p≤.05), and vegans (z=3.04, p≤.05). In terms of dietary patterns, the test showed that both pescatarians and vegans (but not vegetarians) have significantly higher PCA scores for the plant food component than those eating the mainstream diet (z=3.88, p≤.001 and z=5.88, p≤.001, respectively). Conversely, the mainstream diet is significantly higher in the animal-based food component than pescatarian (z=5.06, p≤.001), vegetarian (z=6.67, p≤.001), vegan (z=9.41, p≤.001), and other (z=4.37, p≤.001) diets. Lastly, vegetarians scored significantly higher in the junk food component than the omnivore (z=3.11, p≤.05), vegan (z=4.08, p≤.001), and other (z=3.02, p≤.05) diet preference groups. There was no statistically significant between-group difference in any of the other variables of interest.

Association between diet and mental health and wellbeing

The results of this study showed that - if this association is viewed within a biopsychosocial framework and is extended beyond a narrow biomedical approach - categorization into certain diet preferences such as vegetarian or vegan seems to be in fact irrelevant for one's mental wellbeing. However, this study did demonstrate that a diet pattern high in processed and junk foods is indeed negatively associated with mental health, even after controlling for a multitude of confounding variables and the effect size was comparable to other known predictors such as social support:

QoL: After adjusting for all covariables, statistically significant associations were found between Asian ethnicity, stress, physical activity, weight satisfaction, and social support with QoL.

Depression: After adjusting for all covariables, statistically significant associations were found between sleep, stress, weight satisfaction, social support, and the processed/junk food dietary component (β=.21 increase in depression score (p≤.001) for diet component along) with depression.

Anxiety: After adjusting for all covariables, statistically significant associations were found between female gender, stress, stressful life events, social support, and the processed/junk food dietary component (β=.14; p=.002) with anxiety.

Variables of specific interest to stakeholders

1. *Is there a difference in social support between first year students and others?*

There seems to be a trend showing that first-year students report to have the highest satisfaction with their social relationships and support and that this satisfaction decreases with each additional year of study. However, these differences were not statistically significant.

2. *Is there a difference in diet patterns between students who live on campus compared to those who live off campus?*

Students who live on campus differ from students who live off campus as follows: On average, students who live on campus score significantly lower on the plant food component (p=.002), non-significantly higher on the animal food component (p=.06), and significantly higher on the junk food component (p=.04).

3. *Is there a difference in mental health and wellbeing between international and domestic students?*

On average, domestic students report higher QoL and score lower on both the depression and anxiety screening. However, only the difference in QoL is statistically significant

4. *What is the percentage of students who report to be suffering from an eating disorder?*

In reply to the question *'Do you currently suffer with or have you ever suffered in the past with an eating disorder?',* n=281 (83%) students said 'no' while n=53 (16%) students said 'yes'; n=5 (1%) students preferred not to answer the question.

5. *What is the prevalence of food allergies?*

No food allergies were reported by n=254 (67.4%) of students. The most commonly reported food allergy is lactose (n=35, 9.4%).

6. *What is the prevalence of tobacco, marijuana, and alcohol use?*

In general, the use/consumption of tobacco, marijuana, and alcohol is relatively low in this sample; 92.5% (n=308) reported to never smoke cigarettes; 76.2% (n=254) reported to never use marijuana; 72.8% (n=244) students reported to drink alcohol either never or less than 1x/week.

General conclusions

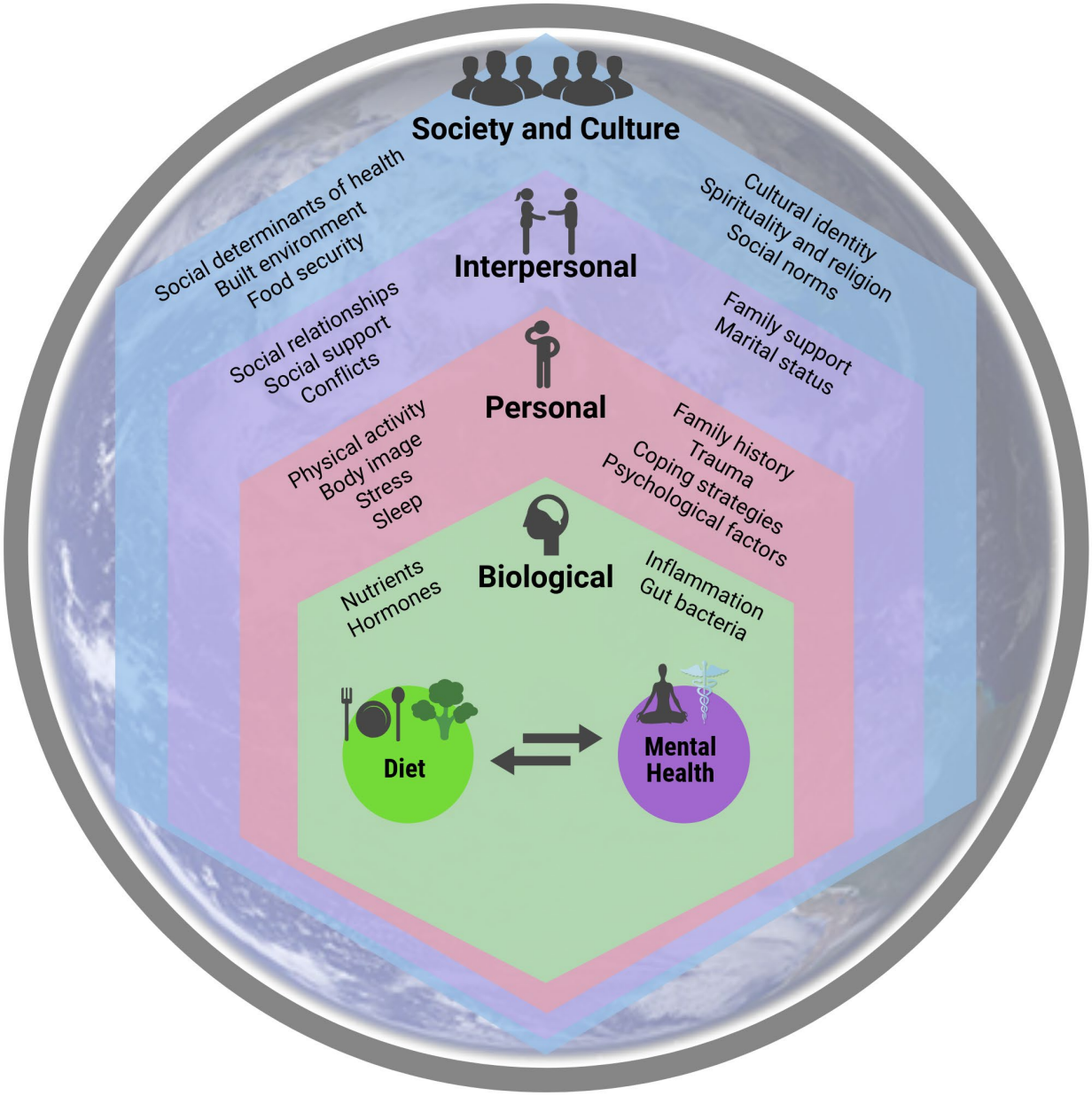
The high prevalence rates of mental health issues in this study add to the body of literature which shows that mental wellbeing in university students is in dire straits and that universities must address the wellbeing of their students to the same degree as they do their academic performance. Integrated health promotion and literacy programs that target not only specific behaviours such as diet or provide downstream treatment for already manifested disorders but include other health behaviours and foster social connections and relationships are warranted. Beyond interventions targeted at the individual level, universities and other entities such as municipalities must aim to create a healthy environment that provides equitable opportunities for all to reach their full potential – this must include provision of environmentally sustainable, affordable, accessible, healthy foods; barriers to unhealthy foods; an environment conducive to a healthy work-life balance and physical activity; and lastly an inclusive (campus) community that provides social support for everyone.

The student population who chooses and prioritizes plant-based foods is already large with predictions seeing this population grow exponentially within the next 5 years. By further exploring trends among those who eat predominantly plant-based compared to those who do not, this study shed light onto characteristics of this rapidly expanding population. Future studies may choose to re-evaluate these and previous findings on characteristics, health behaviours, and social connectedness of those following a plant-based diet, especially given that this lifestyle is evolving from a fringe to a mainstream social movement which may in turn have changing meaning for one's health and wellbeing. Particular emphasis may be placed on the different motives of why someone chooses to live plant-based as the underlying values and psychological mechanisms associated with these motives may differ greatly and may thus impact mental wellbeing differently.

Diet is not merely a health behaviour or personal choice but rather a construct of intertwined intra- and interpersonal conditions, not least socioeconomic and cultural influences. See graphic below for biopsychosocial model within planetary health boundaries. Future research would greatly be enhanced if socioeconomic and cultural determinants would be considered. For example, the issue of food security greatly impacts one's ability to access healthy foods and has been associated with major depressive disorder in US women (Beydoun & Wang, 2010). In addition, the ability to procure

culturally-appropriate foods, which has been nearly eliminated by a colonial food system, is an issue of great extent for Indigenous communities in Canada and food traditions across the globe. How this may interact with mental wellbeing is of great importance but is certainly neglected in the public health literature at this point. Integrating research from social sciences, community action and participatory research, and findings from qualitative studies will play a pivotal role if a more complete picture is to be painted.

[Specific actionable recommendations for UBC will follow in the next section]



Biopsychosocial model within planetary health boundaries

2. UBC SEEDS project

In academia, there is now increasing awareness about the importance of conducting research that will ultimately contribute to the public good. However, the gap between the knowledge generator and the knowledge user persists and knowledge translation activities in academia are often ineffective. Therefore, this study included a significant knowledge-to-action component in that it employed a community-based action research framework and included stakeholders from the University of British Columbia (UBC) throughout the entire research process.

Universities and colleges are in a unique position to impact and shape the health and wellbeing of their students while leading by example as environmentally sustainable institutions – these two areas must not be mutually exclusive. The time when young adults attend university presents a crucial phase during which many important health-related behaviours take shape (Sawyer et al., 2012). UBC has recognized its responsibility for its students' wellbeing and in October 2016 became one of the first universities in the world to sign and adopt the Okanagan Charter. The Charter is a framework co-developed by 45 universities around the world, the World Health Organization, and UNESCO, that guides institutions in their efforts to become health and wellbeing promoting campuses for people, places, and the planet. UBC Wellbeing has therefore developed its strategy around six priority areas: physical activity; built and natural environments; social connection; food and nutrition; mental health and resilience; and collaborative leadership. A particular focus hereby lies on preventive measures that would increase wellbeing and quality of life before specific treatment for established disorders becomes necessary. UBC is therefore interested in gathering insight into the health and wellbeing of its students in order to foster protective and beneficial behaviours and circumstances and to develop interventions that would be auxiliary in achieving the goals of the Okanagan Charter. In line with UBC's 20 Year Sustainability Strategy and UBC's Strategic Plan 'Shaping UBC's Next Century', sustainability is an overarching principle for the University across all areas spanning from research and teaching to community and operations.

This present study showed promise to contribute to this effort and was selected as a Master's project for UBC Sustainability Office's SEEDS (Social Ecological Economic Development Study) program. As such, this project employed a community-based action research framework and applied

project management principles in order to "develop strategies for achieving the university's operational environmental and social sustainability goals by leveraging student academic research and expertise" (SEEDS Sustainability Program, 2019). The involved stakeholders were UBC Student Housing and Hospitality Services (first and foremost UBC Food Services), UBC Wellbeing, UBC Sustainability.

2.1 Recommendations for UBC

This study touches on the following two priority areas which can be found in several Strategic Plans and Frameworks across the UBC campus system as depicted in Figure 1.

- Sustainability and Food
- Mental Wellbeing and Food/Nutrition

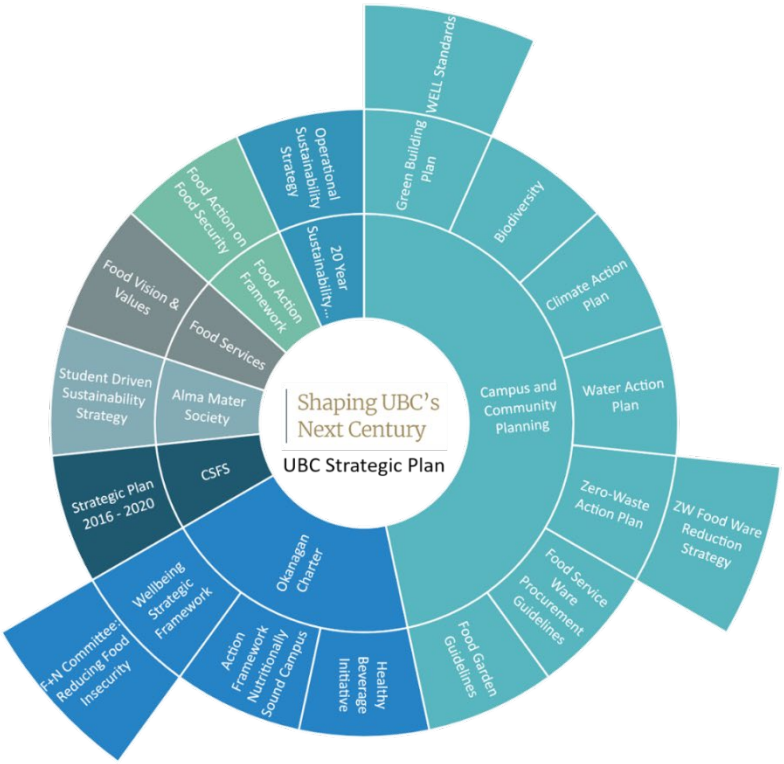


Figure 1 - Alignment of research project topics with UBC Strategic Plans and Frameworks (Credit: UBC SEEDS)

I argue that these topics are not mutually exclusive, in fact, they are inextricably linked. **Continuous collaborative leadership** (as identified by UBC Wellbeing as new addition to the 6 Priority Areas) will be necessary to coordinate the existing and future initiatives in order to achieve the desired impact. This will help make UBC a global leader in sustainability and wellbeing.

Based on an extensive literature review on the topics, the area expertise by both stakeholders and research team as well as the findings of this particular study, my recommendations for UBC are as follows:

Area 1: Sustainability and Food

This study showed that a considerable proportion of the undergraduate student body tries to eliminate or has already eliminated environmentally-taxing animal-based foods from their diet. In order to cater better to this growing population, UBC would be well-advised to increase the offerings, availability, accessibility and taste of the pant-based foods. There is now scientific consensus that a global shift towards sustainable diets by 2050 is essential for humanity's survival (Springmann et al., 2018; Tilman & Clark, 2014). We have reached a point where neither the United Nations' Sustainable Development Goals nor the target of the Paris Agreement of keeping global warming below 2˚Celsius are achievable without the 'Great Food Transformation' – which is a global shift towards predominantly plant-based diets (Willett et al., 2019).

UBC has ambitious climate goals such as carbon neutrality (i.e. 100% Greenhouse Gas Emissions reduction) by 2050 (see UBC Climate Action Plan). I argue that this goal will not be attainable without prioritizing the campus' food system.

Therefore, my first recommendation is:

I – Prioritize reduction of greenhouse gas emissions due to the food system by moving towards a predominantly plant-based campus food system.

This may be achieved through the following actions:

1) Integrate and prioritize the goal of a predominantly plant-based campus into all strategic plans. For example:

a) Include the reduction of red meat consumption as a key target within the UBC Wellbeing Strategic Framework Priority Area 3: Food and Nutrition.

b) Integrate the food system into the Climate Action Plan, for example by including a shift in diet towards predominantly plant-based foods in the Behaviour Change component of the Plan.

c) Move the food system from the Complementary Opportunities in the Climate Action Plan into the priority areas.

2) Create a campus-wide food policy. Thereby, promote best practices, and actions on campus that will contribute to a shift in the current social norm in order to create greater acceptance of a predominantly plant-based campus. These are suggestions for such interventions and policy components:

a) Make plant-based foods the default option in food establishments by specifically labelling foods that contain animal foods rather than plant-based foods.

b) All catered events on campus are plant-based by default, dietary restrictions are 'flipped' – if animal products are wanted, this needs to be indicated specifically as a 'dietary restriction'.

c) All catered events that have a sustainability focus are to be plant-based only ('lead by example').

d) Make it a goal to 'veganize' as many food items as possible in order to reduce environmental footprint but also meet the projected growing demand of vegan foods. Many items sold on campus are almost vegan but have one or two remaining animal-based ingredients that could easily be replaced with plant-based alternatives, for example honey, eggs/egg whites or butter.

e) Provide continuing training for chefs and kitchen personnel to further improve taste and quality of plant-based offerings in order to make these foods more appealing to the consumers.

Area 2: Mental Wellbeing and Food/Nutrition

This study confirms the notion that mental health issues are highly prevalent in the UBC undergraduate student population. It further corroborates that certain health behaviours that are known to improve mental and physical wellbeing such as physical activity remain below recommended levels.

Based on the understanding that mental wellbeing is embedded in a multi-layered model (see Figure 2), an integrated approach to promoting and fostering wellbeing for students is advisable. UBC is already embracing this idea as can be seen by the six interconnected Priority Areas within the UBC Wellbeing Strategic Framework. The Student Mental Health Strategy reflects this as well by having identified the creation of a supportive environment for all students as a key strategy to prevent mental health issues. Specific recommendations for mental health issues may include:

I - Given the high prevalence of depression and anxiety symptoms that call for further evaluation, consider **implementing a screening process for all students** (e.g. at the beginning of each academic year)

II - The importance of social support in particular was shown in this study. A key recommendation would be to incorporate social support fostering activities in student wellbeing initiatives and make the improvement of social support an explicit objective of activities

Recommendations for **diet-specific strategies to promote (mental) wellbeing** are as follows:

I – Encourage accessibility and intake of whole foods

1) Implement policies that make the access to whole foods easier (e.g. decrease price, increase accessibility, convenience, and marketing/presentation of these foods).

2) Increase health literacy among students/consumers on the benefits of whole foods.

II - Limit accessibility and intake of processed foods

1) Implement policies that make the access to highly processed foods more difficult (e.g. increase price, reduce convenience and availability).

2) Increase health literacy among students/consumers on the impact of highly processed foods on health and wellbeing.

3. Background

3.1 Environmental rationale: Connecting human and planetary health through diet

Holistic health fields such as Planetary Health conceptualize human health as embedded in a complex system of interrelations between individual, social, cultural, and environmental factors. Pathways through which ecological determinants impact health outcomes have been uncovered to a degree that climate change is now recognized as the biggest threat to human health in the 21st century (Watts et al., 2015). Opportunely, there exist various co-benefits for both human and planetary health if mitigation of environmental destruction such as climate change were made a policy priority (Haines et al., 2009). One of the most significant pathways to achieve such co-benefits is that of a "Great Food Transformation" (Willett et al., 2019, p.448) – a transition of the global food system away from unsustainably produced, unhealthy foods to healthy diets from sustainable food systems (Willett et al., 2019).

The food system is one of the main drivers of the anthropogenic pressure on Earth's natural systems. Current estimates show that global agriculture occupies more than 40% of the world's land mass (Foley et al., 2005). Food production further contributes up to 30% of all greenhouse gases, 70% of freshwater use while being the greatest driver in loss of biodiversity and water pollution (Foley et al., 2005). Within agriculture, the livestock sector (i.e. animal agriculture) is by far the biggest culprit (McMichael, Powles, Butler, & Uauy, 2007; Steinfeld et al., 2006). Moving forward, food production systems and consumption patterns must stay within the so-called 'planetary boundaries' which are defined as "the safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystems of processes" (Rockström, 2009, p.472).

Global food production is driven by an ever-growing demand for environmentally-damaging foods, most notably meat (Henchion, McCarthy, Resconi, & Troy, 2014). Traditional, local diets are being increasingly replaced by the 'Standard American Diet' which largely consists of animal products, processed, and unhealthy foods that are generally lower in vitamins and minerals and higher in saturated fats, sugar, and salt (World Health Organization [WHO], 2016). Humanity is therefore facing another unprecedented global crisis: The double burden of malnutrition which describes the coexistence of undernutrition and overweight, obesity, and non-communicable diseases (NCDs) that

are related to diet (WHO, 2016). Almost one third of the world's population suffers from diet-related health issues; in 2014, approximately 1.9 billion people were overweight (of which more than 600 million fulfilled the criteria for obesity), while 462 million adults were underweight (WHO, 2016). The drivers behind this development are multi-faceted and complex and include inequality and poverty, the built environment, aggressive marketing of food industry conglomerates, epigenetics, or lifestyle factors. This has led to a drastic increase in NCDs which include diabetes, cancer, and cardiovascular disease (Beaglehole et al., 2011; Willett et al., 2019). The burden of disease due to NCDs has taken on such large dimensions that they are now associated with two thirds of annual deaths globally (Beaglehole et al., 2011). Mental and behavioural disorders are especially crucial to consider because they are the leading cause of years lived with disability (YLDs) worldwide (Whiteford et al., 2013). In Canada, lifetime prevalence for those age 15 and older is as high as 33% for at least one major mental health disorders; 12-month prevalence is 10% (Statistics Canada, 2019). Mental illness often develops into a chronic, lifelong health issue that can have profound and devastating effects on an individual's life trajectory by impacting and disrupting social functioning and capital (Silva, McKenzie, Harpham, & Huttly, 2005), educational attainment (Breslau, Lane, Sampson, & Kessler, 2008), economic output (Trautmann, Rehm, & Wittchen, 2016), and overall quality of life (QoL; Alonso et al., 2004).

From a holistic, systems-level perspective, it is therefore reasonable to conclude that diet inextricably links human health and global environmental sustainability which makes this an important field of research. There is now scientific consensus that a global shift towards sustainable diets by 2050 is essential for humanity's survival (Springmann et al., 2018; Tilman & Clark, 2014). We have reached a point where neither the United Nations' Sustainable Development Goals nor the target of the Paris Agreement of keeping global warming below 2˚Celsius are achievable without the Great Food Transformation (Willett et al., 2019).

Until recently, the challenge has been to define a universal healthy reference diet that would meet these ambitious prerequisites. In March 2019, the EAT Lancet Commission on Healthy Diets from Sustainable Food Systems published its Landmark Report which puts forward just that (Willett et al., 2019). Based on the framework of the planetary boundaries which provides clear scientific targets for policy makers, Willet et al. (2019) propose a "safe operating space for food systems that

encompasses human health and environmental sustainability" (Willett et al., 2019, p.451). This reference space includes two sets of recommendations: On the one hand, it specifies food intake ensuring human health and on the other hand, it suggests specific planetary boundaries for food production. The authors state that "when viewed together as an integrated human health and environmental sustainability agenda, 'win-win' diets, that fall within the safe operating space for food systems, will help to achieve global human health and environmental sustainability goals" (Willett et al., 2019, p.452). When looking at these recommendations, one cross-cutting principle becomes very clear: The lower the animal component, the better – with the caveat that meat be replaced with increased intake of whole grains, legumes, fruits, and vegetables rather than processed, sugary foods to avoid micronutrient deficiencies (Garnett, 2016). Hence, a global shift towards predominantly plant-based diets seems to be the recommended way forward. While this 'win-win' situation has been identified for planetary and somatic health (Willett et al., 2019), potential mental health impacts have largely been ignored in the development of the current recommendations. This is largely due to the fact that very little is known about the effect of diet on mental wellbeing and even less is known about specific diets such as plant-based diets. This study thus sought to address this gap in the literature by assessing whether plant-based diets are associated with mental wellbeing in a population of young adults.

3.2 The vulnerability of young adults (i.e. undergraduate students)

Although the life phase of entering university may be associated with the prospect of positive personal, professional, and social development, the prevalence of mental health issues and disorders in this population is actually quite high. For example, it has been found that almost half of all college students in a representative sample in the U.S. (n=2188) had had a psychiatric disorder within the past 12 months but treatment rates were very low (Blanco et al., 2008). More specifically, the 12-month prevalence rates for mood and anxiety disorders were 11% and 12%, respectively (Blanco et al., 2008). Moreover, the general age-of-onset for many major mental disorders such as phobias, anxiety and mood disorders, substance use disorders, and psychosis is early in life with half of all lifetime mental disorders beginning by the age of 14 (Kessler, Amminger, et al., 2007; Kessler, Angermeyer, et al., 2007; Patton & Viner, 2007).

However, this developmental stage also offers great potential for preventive and early intervention efforts as it is accompanied by drastic brain development with elevated neural plasticity which allows for interventions to potentially redirect earlier adversities and set up individuals for improved emotional functioning and a healthier future (Patton & Viner, 2007). From a life course perspective, this is extremely relevant because health-related behaviours that are adapted during adolescence and young adulthood contribute substantially to the development of (chronic) non-communicable diseases in later stages of life (Sawyer et al., 2012).

To close the circle back to dietary shifts and the co-benefits to both human and planetary health, it is also important to note that today's young adults are the first generation to adopt plant-based diets in rapidly growing rates. Current estimates see approximately 7% of Canada's population self-identifying as vegetarian or vegan (compared to only 2% in 2003; Flanagan, 2018) – with those under the age of 35 being three times more likely than older generations to identify as vegetarian or vegan while predictions see this number increasing rapidly (Thomson, 2018). The numbers of those who do not completely abstain from meat or other animal-based products but aim to eat substantially less meat, particularly environmentally-taxing red meats, are even higher. According to recent consumer polls, 43% of Canadians are aiming to incorporate more plant-based foods into their diets (The Nielsen Company, 2017) which is reflected in a constant decline of overall per capita meat consumption in Canada over the last three decades (Weersink, von Massow, & Gallant, 2019).

With the rise of veganism in this population, the reasons and motives to adopt a plant-based diet have also changed. Less than 10 years ago, most vegetarians or vegans would put forward concerns for animal rights and welfare as their main motivation to follow a plant-based diet, followed by those who did it mostly for personal health benefits (Fox & Ward, 2008; Hoffman, Stallings, Bessinger, & Brooks, 2013). In very recent years, the proportion of those who prioritize a concern for the environment or name a combination of the main motives, has increased substantially (Janssen, Busch, Rödiger, & Hamm, 2016). This carries immense promise for the 'Great Food Transformation' and thereby the alleviation of the food system's environmental footprint as well as the amelioration of the global burden of disease.

3.3 Diet and mental wellbeing in the literature

Plant-based diets have been shown to have great potential in preventing, alleviating symptoms of, or even reversing chronic diseases. For example, a review by Fraser (2009) on the association between of vegetarian diets and chronic diseases found consistent results among different populations for coronary heart disease (CHD), diabetes, and colon cancer. A review by Pawlak (2017) on vegetarian diets and type-2 diabetes found that vegetarian diets seem to not only be associated with lower incidence of type-2 diabetes but that dietary interventions that had patients adhere to vegan or vegetarian diets were successful in significantly lowering long-term blood glucose levels. Furthermore, there is now scientific consensus that red and processed meat consumption is associated with an increased risk of colon cancer. In fact, this has been given the highest level of evidence as classified as 'convincing, strong evidence' by the World Cancer Research Fund and has thus been integrated into their cancer prevention recommendations (World Cancer Research Fund, 2018).

Given these findings of plant-based diets and somatic health, the hypothesis there may also be an association with mental wellbeing stands to reason. The approach to assessing the relationship between diet and mental wellbeing has changed over time. In earlier research, there was a focus on individual food groups or nutrients such as fruit and vegetables or omega-3 fatty acids. Recognizing that food is more than a conglomeration of individual nutrients, a more recent approach assesses dietary patterns which take into consideration possible interaction between nutrients and foods and also acknowledge the reality of diet – namely that we do not simply eat one nutrient or food at a time but that our diet is composited of many different components. Simultaneously, a path of research on the mental health and wellbeing of vegetarians vs. non-vegetarians evolved. The findings of all of these approaches are summarized in the following:

3.3.1 Nutrients, individual food groups and mental health

Based on a primarily biomedical concept of the association between diet and mental health, work in this area of research began by focusing on individual micronutrients such as omega-3 fatty acids and assessing their respective role in mental health disorders. For example, in a review conducted by Freeman (2000), the author concluded that enough evidence exists to justify further research on the potential of omega-3 fatty acids as an effective alternative to psychotropic

medication in the treatment of major depressive or bipolar disorder, schizophrenia, dementia, and for mental health issues arising during pregnancy and post-partum. Vitamin B_{12} has also received a lot of attention in this field as it is assumed to be the only nutrient that strict vegans cannot get from a well-balanced diet and have to supplement in order to avoid deficiency. Penninx et al. (2000) found an OR=2.05 (95% CI 1.22-3.44) for participants with vitamin B_{12} deficiency to be severely depressed compared to non-deficient participants, albeit after adjusting only for socioeconomic variables and physiological parameters.

Even in more recent studies, the explanatory dietary factor has often been limited to a specific food group, most notably fruit and vegetables. The framework and hypothesized pathways of a causal relationship remained limited to a biological model. For example, a large cross-sectional study in Canada using five waves of the Canadian Community Health Survey (n=296,121) found that those with the highest fruit and vegetable intake had significantly lower odds of suffering from depression than those in the category of lowest fruit and vegetable intake (OR=0.85, 95% CI 0.78-0.92; McMartin, Jacka, & Colman 2013). However, Rooney, McKinley, and Woodside (2013) concluded in their literature review that the results on the role of fruit and vegetable intake in psychological wellbeing remain inconclusive.

3.3.2 Diet preferences and mental health

A parallel path of research in the diet and mental health arena has developed which categorizes diet based on certain dietary preference groups or habits, i.e. vegetarian vs. non-vegetarian. Seven studies have been published that assessed the association between vegetarian diets and mental health outcomes, mostly depression and anxiety. The results from these studies comparing vegetarians to non-vegetarians are inconsistent and conclusions from the results should be drawn cautiously. Except for one, these studies were all cross-sectional, observational studies. Two of the observational studies found a positive association between a vegetarian diet and good mental health (Beezhold, Johnston, & Daigle, 2010; Beezhold, Radnitz, Rinne, & DiMatteo, 2015), four found a negative association, i.e. worse mental health among vegetarians (Baines, Powers, & Brown 2007; Burkert, Muckenhuber, Großschädl, Rásky, & Freidl, 2014; Hibbeln, Northstone, Evans, & Golding, 2018; Michalak, Zhang, & Jacobi, 2012). One workplace intervention study found significantly

improved symptoms of depression and anxiety after an 18-week low-fat vegan diet work-place intervention (Agarwal et al., 2015).

These studies had significant methodological limitations, not least the lack of analytic approaches that would go beyond bivariate comparisons and the assessment of diet that was restricted to diet preference categories rather than a more detailed assessment of diet quality. Furthermore, most authors (except for Michalak et al.) employed self-report measures to assess mental health. The social dimension of both diet and mental health was neglected in all of these studies. On the other hand, some authors did attempt to match subsamples from representative, population-based surveys and acknowledged in their discussion the importance of further research in this field. Interesting points were raised about reverse temporality of the association, factors beyond the biomedical understanding of the impact of diet on mental health were suggested, and a more complete – albeit likely outdated by now – picture of people following a vegetarian/vegan diet was gained. These insights will have to be addressed in further research. The following paragraph will outline how one such pathway, namely the more detailed assessment of diet, has gained traction in this field.

3.3.3 Dietary patterns, diet quality and mental health

Advances in nutritional research acknowledge the complexity of interactions of nutrients and food groups. Researchers have thus begun to assess diet through composite measures such as dietary patterns and diet quality indices which allow conclusions about the quality of one's overall diet without focusing narrowly on macro – or micronutrients and individual food items (Hu, 2002). There are two possible ways of analysis: Dietary patterns can be extracted in an *a posteriori* approach from the empirical data through statistical methods such as principal component analysis. Conversely, the use of dietary indices is an *a priori* approach as these indices were created based on previous knowledge and hypotheses about the healthfulness of certain foods and thus pre-determine assumptions about 'healthy' and 'unhealthy' dietary components (Hu, 2002). An example for a diet quality index that is widely used is the Healthy Eating Index 2010 (HEI-2010) which was developed based on the Dietary Guidelines for Americans (Guenther et al., 2013). Notably, there is currently no diet quality index that has been developed for mental health specifically.

A recent review and meta-analysis which included 21 studies (total n=117,229) from 10 countries found two predominant diet patterns: What authors labeled as 'healthy' pattern included high intake of fruit, vegetables, whole grains, olive oil, fish, low-fat dairy, and antioxidants and low intake of other animal foods; whereas the 'Western' pattern was high in red and processed meat, refined grains, sweets, high-fat dairy products and butter, and potatoes and was low in fruit and vegetables (Li et al., 2017). Overall, the highest category of the 'healthy' pattern showed a decreased risk for depression compared to the lowest category (OR=0.64, 95% CI 0.57-0.72). The highest category of the 'Western' pattern was associated with an increased risk of depression compared to the lowest category (OR=1.18, 95% CI 1.05-1.34). However, the findings of individual studies differed greatly and differences in study populations, measurements as well as included confounding variables likely contributed to these inconsistent findings.

Lassale et al. (2018) conducted a meta-analysis of studies that used dietary quality indices (i.e. the *a priori* approach) exclusively. They found that adherence to a Mediterranean diet index was associated with the lowest depression incidence (RR=0.67, 95% CI 0.55-0.82 for highest vs. lowest adherence category; based on 4 longitudinal studies). The Dietary Inflammatory Index (DII®, an index developed to measure the inflammatory potential of a diet; Shivappa, Steck, Hurley, Hussey, & Hébert, 2014) was also associated with increased depression incidence (RR=0.76, 95% CI 0.63-0.92 for lower vs. higher index; based on 4 longitudinal studies). Lastly, 'healthy' diet as defined through the HEI-2010 (see p.36) was also inversely associated with depression (RR=0.65, 95% CI 0.50-0.84; based mostly on observational studies).

In summary, the more recent approach to measure diet through composite scores and to analyze diet in terms of quality indices provides a more nuanced picture with respect to actual food intake, composition of dietary patterns based on several food groups, and especially overall diet quality than the two previously discussed approaches. However, even though some authors adjusted their analyses for covariates such as physical activity, socioeconomic factors, and alcohol and tobacco use, this approach is currently still largely anchored in a biological concept of the relationship between diet and mental health and thereby likely fails to do justice to the true complexity of this relationship.

3.4 A biopsychosocial perspective of the relationship between diet and mental wellbeing

Based on an underlying holistic epistemology, an integrated model for the relationship between diet and mental wellbeing was used as a biopsychosocial framework within planetary boundaries.

As human beings, we do not exist in isolation and can therefore not be reduced merely to our biological functions. Rather, we are part of micro- and macrounits of society which inevitably impact our life trajectories; our perceptions, attitudes, behaviours; and ultimately our health. The variables that were included in this study thus emerged from an understanding that the pathways through which diet and mental health are connected go beyond biological mechanisms but include factors from the personal, interpersonal, and socioeconomic layers of human life – and all of these have to be understood within the planetary boundaries if we wish to live sustainable lives. An integrated model for the relationship between diet and mental health was developed as outlined in Figure 2. Further reasoning on the choice of the specific covariables included in this study (body image, physical activity, sleep, stress, stressful life events, and social support) can be found in Appendix A.

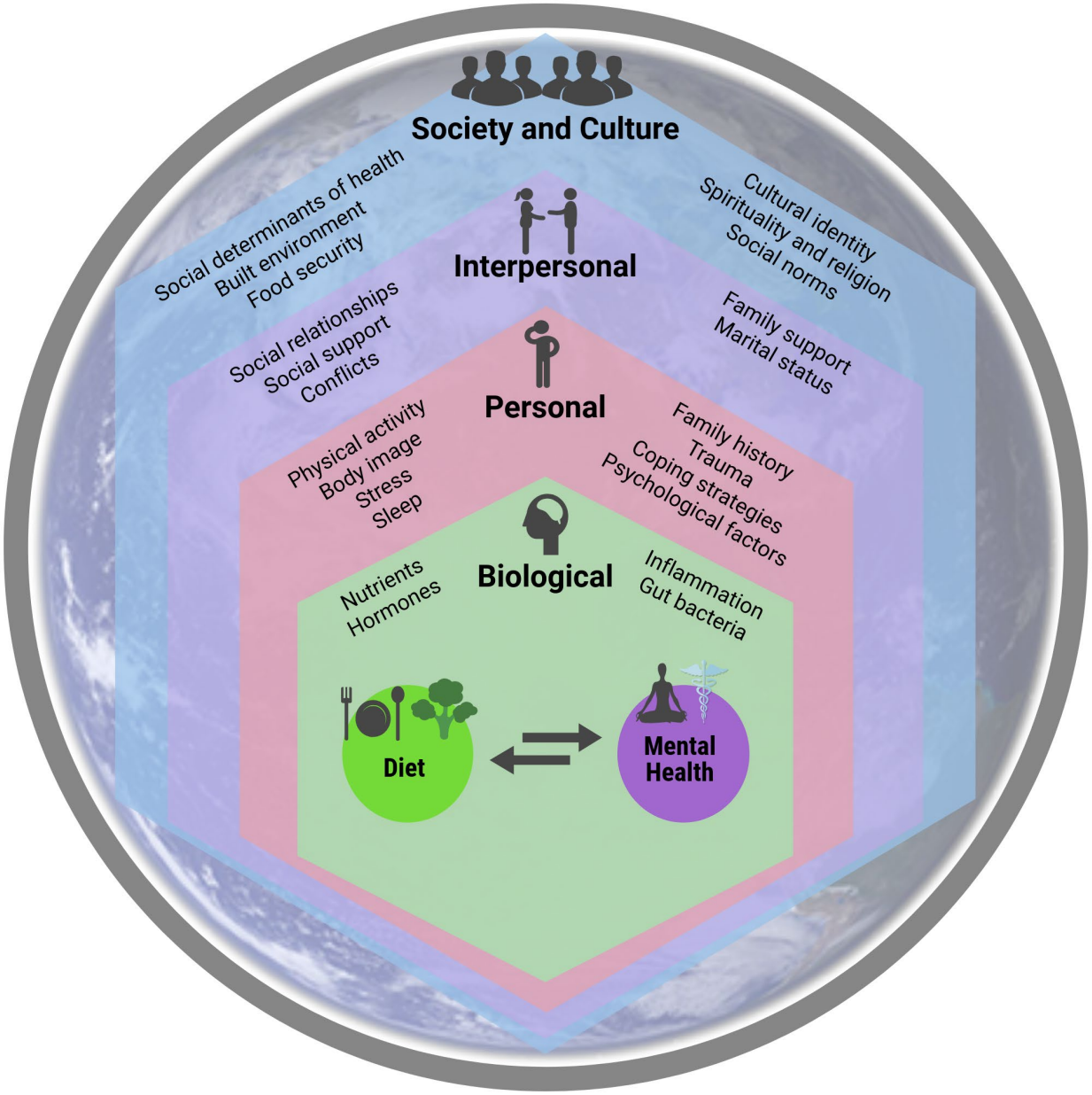


Figure 2 - Integrated model for the association between diet and mental wellbeing

3.5 Research questions and objectives of the SEEDS project

This study sought to answer the following research questions and meet the following objectives which were to be assessed in a population of young adults (i.e. undergraduate students) under careful consideration of the covariables body image, physical activity, sleep, stress, stressful life events, and social support within an integrated biopsychosocial framework:

I. Is there is an association (and if so, what is its direction and effect size) between

Ia. dietary patterns (independent of diet preference) and (1) overall QoL; (2) depression; (3) anxiety?

Ib. diet preference (controlled for diet pattern) and (1) overall QoL; (2) depression; (3) anxiety?

II. Exploration of trends: Do those following predominantly plant-based diets differ from each other (and from omnivores) in terms of social support, dietary pattern, body image, stress, stressful life events, physical activity, sleep, and motives to follow a plant-based diet?

III. Specific objectives for campus stakeholders:

IIIa. Several descriptive measures such as: What is the prevalence of mental health issues in the undergraduate student sample? What are emerging diet patterns? How many students follow plant-based diets? What are the motives for choosing a plant-based diet? What is the status of health behaviours such as physical activity, sleep, substance use in this sample? How do first year students differ from the rest of the undergraduate students in these characteristics? Are international students differently affected compared to domestic students?

IIIb. Actionable recommendations for a sustainable, healthy food system on campus.

The following hypotheses were stipulated:

Ia. Diet patterns are significantly associated with mental wellbeing outcomes even after controlling for covariables of the biopsychosocial framework.

Ib. Diet preference is not significantly associated with mental wellbeing outcomes.

II. These research questions were posed to gather more nuanced and updated descriptive information on pescatarians, vegetarians, and vegans as they differ from each other and from omnivores. Previous research in this field is inconclusive and has suggested both higher and lower rates of depression and anxiety in vegetarians and vegans, less social support, lower QoL, higher and lower diet quality, higher physical activity, and better sleep.

III. These questions were posed by the stakeholders to gather a better understanding of mental wellbeing, health behaviours, and diet preferences of the undergraduate student population and to receive actionable recommendations based on the findings of this study and the review of the literature on this topic.

4. Methods

4.1 Study design

This study was a cross-sectional, observational study. Data were collected through an online self-report survey. The main outcome variables of interest were quality of life (QoL), depression, and anxiety. The main explanatory variable was diet as assessed through either dietary patterns or through self-reported diet preference. The survey further contained additional items on social support, health behaviours and status, body image, stress, stressful life events, and socioeconomic data. Data collection was done from March to April of 2018.

4.2 Participant recruitment

Participants were recruited among undergraduate students at UBC through convenience sampling. Recruitment material see Appendix B. There were no specific exclusion criteria for participation. Out of a total of 440 respondents who accessed the survey, a final sample of n=339 respondents was used for data analysis (response rate for complete surveys vs. survey access: 77%). A general 'rule of thumb' for the minimum sample size required to obtain a reliable effect size model states that one should have a sample size of 104+*k* (with *k*=number of predictors; Green, 1991). In this study, 12 (15 in the alternative models, respectively) predictors were included in the final model, therefore a sample size of n=339 is considered adequate to reliably detect an effect (Field, 2013). Missing data was imputed via multiple imputation and a pooled data set was used for analysis.

4.3 Survey

The questionnaire used for this study was comprised of a total of 82 items (see Appendix C for the full questionnaire). The main variables of interest were assessed using validated measures (see below). Moreover, an effort was made to adapt further items from previously validated surveys in order to maintain consistency and comparability with similar measures and studies. Therefore, the item on social support was taken from the Patient-Reported Outcomes Measurement Information System Scale version 1.2 (PROMIS®). The PROMIS® is a measure to assess patient-reported health outcomes and previous research has shown evidence for its reliability and precision in measuring health-related symptoms and functioning (Cella et al., 2010).

Stressful life events were measured with the College Student's Stressful Event Checklist. This checklist contains 32 items which had been modified from its original version for adults, the Social Readjustment Rating Scale (Holmes & Rahe, 1967), to reflect appropriate events in the population of college students. Each item is assigned a specific value that corresponds to the potential stress magnitude of the event (Holmes & Rahe, 1967). Values are summed up to calculate an overall score which reflects mild (total score <150), moderate (total score between 150 and 300) or severe stress (total score >300) due to these events. Despite its dated origin, this measure and its adapted versions continue to be among the most widely used and cited instruments to measure stressful life events and have been found to be a robust measure to identify events that may lead to stress-related outcomes (Scully, Tosi, & Banning, 2000).

Items on overall stress, physical activity, sleep, satisfaction with one's weight (as a proxy for body image), and sociodemographic variables were adapted from the National College Health Assessment II (NCHA-II) of the American College Health Association. The NCHA-II is a survey that collects data on student health status and behaviours as well as factors influencing academic performance in order to provide universities with information on students' health needs and previous research has shown evidence for adequate reliability and validity of the measure (American College Health Association [ACHA], 2013).

4.3.1 Measures of mental health and wellbeing

QoL as a measure for overall mental wellbeing was assessed through a single-item measure ("In general, would you say your quality of life is…") with responses rated on a 5-point Likert scale (0=poor, 1=fair, 2=good, 3=very good, 4=excellent). This single-item measure is one of the most widely used items to measure QoL and has been included in routinely used assessment tools such as the PROMIS®.

Depression was measured using the 9-item Patient Health Questionnaire (PHQ-9). This instrument is based on the criteria for a major depressive episode as described in the American Psychiatric Association's Diagnostic and Statistical Manual for Mental Disorders IV (Frances, Pincus, & First, 1994). This instrument has been widely used in both clinical and research settings and has been validated for a variety of populations to detect and assess severity of depression. Respondents are

asked to report both frequency and severity of several symptoms over the course of the previous two weeks. The total severity score ranges from 0 to 27 and is calculated by assigning scores from 0 to 3 to each item depending on the frequency of their presence (from “not at all” to “nearly every day”). PHQ-9 scores of ≥10 have been reported to have a sensitivity of 88% and a specificity of 88% for major depression (Kroenke, Spitzer, & Williams, 2001). In this study, the PHQ-9 severity score as continuous variable was used as the outcome measure in the regression model for depression. For clinical and diagnostic purposes, the measure can further be used to assess severity of symptoms applying cut-off scores. Cut-off scores for mild, moderate, moderately severe, and severe depression were found to be 5, 10,15, and 20, respectively (Kroenke et al., 2001). In general, a score ≥10 means that further clinical evaluation is indicated while a score ≥20 indicates that the individual may require psychotherapy and/or medication.

Anxiety was measured using the 7-item General Anxiety Disorder Questionnaire (GAD-7). Similar to the PHQ-9, this is a standard instrument to detect and assess the severity of anxiety disorder used widely for both clinical and research practices. Although originally designed to detect general anxiety disorder, it has been found that the GAD-7 is useful as a screening instrument for related anxiety disorders such as post-traumatic stress disorder, social anxiety disorder, and panic disorder (Kroenke, Spitzer, Williams, Monahan, & Löwe, 2007). Respondents are asked to report both frequency and severity of several symptoms over the course of the previous two weeks. The total severity score ranges from 0 to 21 and is calculated by assigning scores from 0 to 3 to each item depending on the frequency of their presence (from “not at all” to “nearly every day”). For GAD-7 scores ≥10, sensitivity and specificity were above 80% (Spitzer, Kroenke, Williams, & Löwe, 2006). The continuous variable of the GAD-7 severity score was used as the outcome variable for the regression model for anxiety. Much like the PHQ-9, the GAD-7 can further be used to assess severity of symptoms applying cut-off scores. Cut-off scores for mild, moderate, and severe anxiety were found to be 5, 10, and 15, respectively (Spitzer et al., 2006). In general, a score ≥10 means that further clinical evaluation is indicated while a score ≥15 indicates that the individual may require psychotherapy and/or medication.

4.3.2 Measures of diet

Diet and nutrition can be measured through different approaches such as diet records, multiple 24hr recalls, or food frequency questionnaires (FFQ). Any of these options would have increased respondent burden disproportionately to the purpose of this study. The focus of this study was to assess overall dietary patterns rather than a thorough evaluation of nutrient intake. Therefore, the instrument of choice was a dietary screening instrument which is a sub-form of an FFQ that includes only certain food groups of interest. The U.S. National Cancer Institute's Dietary Screening Questionnaire (DSQ) was chosen because it included most food groups that were of interest for this study, it has been widely used and the trade-off between information and respondent burden is minimal. In its original version, the DSQ includes 26 items which screen for the following dietary factors, i.e. food groups: fruits and vegetables, added sugars (from both foods and sugar-sweetened beverages), dairy, whole grains, calcium, fiber, red meat, and processed meat. After consulting with both stakeholders from UBC Food Services as well as nutrition expert and committee member Dr. Rachel Murphy, the screening questionnaire used for this present study was slightly altered in order to make it more fitting to the local context (e.g. it was decided to take out the items on popcorn and tomato salsa as these are not considered main food groups in Canada) and to include items that were relevant to this study such as consumption of poultry, additional dairy products or vegetarian meat alternatives. The final version used in this study thus had 28 items. The DSQ has been used to screen food intake in the U.S. National Health and Nutrition Examination Survey (NHANES) since 2009. Evaluations have shown good agreement between estimates of intakes between the DSQ and multiple 24hr recalls (as the current gold standard for dietary intake assessment) with differences in means <2% and differences in prevalence <16% (Thompson, Midthune, Kahle, & Dodd, 2017).

In addition, an item asking for dietary preference was included. Participants were asked if they identified as one of the following: a) Pescatarian (you eat fish, eggs, and dairy but no meat or poultry); b) Vegetarian (you eat eggs and dairy but no fish, meat or poultry); c) Vegan (you don't eat any animal products); d) Other (please specify); e) None of the above. This was done to compare associations between diet and mental health based on diet patterns vs. diet preference and to compare subgroups of the sample who follow plant-based diets vs. those who do not in terms of several variables, e.g. social support and diet patterns.

4.4. Statistical analysis

4.4.1 Univariate and bivariate analysis

Univariate analysis was conducted for descriptive purposes of individual items. For continuous variables, the mean and standard deviation (SD) were reported; for categorical variables, frequencies were reported.

Bivariate analysis was conducted to explore between-group differences of diet preference in terms of both the outcome variables and the covariables. This was done in order to gather a better understanding of biopsychosocial trends within these subgroups to contribute to the development of the framework applied in this study as well as serve as the basis for further research implications in this field. Since group sizes differed quite substantially (with n=244 in the largest, i.e. mainstream, and n=14 in the smallest, i.e. pescatarian, group) and some cells had n<30, it could not be assumed that the parametric test of choice for continuous outcome variables (one-way ANOVA) would have been robust enough even if assumptions of normality and homogeneity of variance were violated (Field, 2013; Wilcox, 2011). Assumption testing (Shapiro-Wilk test; normal Q-Q plots) indeed revealed that the normality assumption for at least one group's set of observed values was violated for all variables of interest. Therefore, the non-parametric Kruskal-Wallis H test was conducted (Field, 2013). Post-hoc pairwise comparison was done through Dunn's test applying a Bonferroni correction. For categorical outcomes (gender, ethnicity), the Pearson chi-square test was conducted.

Further bivariate analysis was conducted to compare means of different continuous variables across different subgroups of the student population as requested by stakeholders (see 3.7). The test of choice was independent samples t-test as assumptions for this test (independent samples, normality, homogeneity) were met for all variables of interest.

4.4.2 Principal Component Analysis (PCA) of DSQ

PCA with varimax rotation was used as a data reduction approach for the evaluation of the DSQ. Since there was no missingness in individual items before conducting the PCA (due to the stepwise approach to missing data analysis, see 2.5.1), no deletion method was necessary as all respondents included in the analysis had a complete DSQ. PCA was chosen based on previous work on assessing dietary patterns as described by R.L. Bailey et al. (2007), Jacka et al. (2010), and Akbaraly et

al. (2009). These studies had a similar goal to that of this present study of assessing dietary patterns based on comparable dietary screening questionnaires. The goal for this present study was to reduce responses to all 28 individual DSQ items to describe emerging dietary patterns within the sample. The decision on how many components would be retained was based on considering the combination of interpretability and conceptual reasoning of the emerging components, the eigenvalues (>1), the scree plot, and the percentage of variance explained by the components. The cut-off for component loadings to be included in the patterns was determined at ≥0.4. Varimax rotation was chosen as orthogonal rotation method since it was assumed that emerging components would not be highly correlated with each other; this method was also used in previous work in this field (Akbaraly et al., 2009; R. L. Bailey et al., 2007; Jacka et al., 2010). The extracted PCA component scores were then included in the regression models as main explanatory variable for the relationship between diet and mental health outcomes.

4.4.3 Hierarchical multiple linear regression models

Three models were built for the main explanatory variable (dietary patterns) – one for each outcome variable of interest: Model 1: QoL; Model 2: Depression; Model 3: Anxiety. Three alternative models were built for the same outcomes but dietary preference as main explanatory variable, controlled for diet pattern. All three outcome variables of interest were treated as continuous variables. Therefore, multiple linear regression (MLR) was applied to all three models. Statistical significance was determined *a priori* at $\alpha \leq .05$.

4.4.3.1 Choice of covariables

Covariables that were to be included in the regression models were selected based on previous work and conceptual reasoning of a biopsychosocial framework. As described in an extensive body of research, stress, stressful life events, body image, physical activity, sleep, and social support are all predictors for mental health and wellbeing outcomes (see 1.1.4.1). Simultaneously, these factors are conceptually related to diet and therefore fulfill the criteria of presenting possible confounders (see 1.1.4.2). The sociodemographic variables included in the models were age, gender, and ethnicity.

4.4.3.2 Approach to model building

Since a theoretical framework and conceptual understanding of the association between diet and mental wellbeing underpinned this study, regression models were built using a hierarchical, i.e. block-wise, approach (Field, 2013). For each of the three models, the sociodemographic factors were entered first. In a second step, the block of person-related factors (physical activity, sleep, weight satisfaction, stress, stressful life events) was added. Thirdly, social support as a known large individual contributor to mental wellbeing was included in the model. Finally, the main explanatory variable of interest - as represented either by PCA component scores or, in the alternative models, by self-reported dietary preference - was entered to assess the additional contribution of diet to mental health when adjusted for other known predictors. In the alternative models which assessed diet preference of main independent variable of interest, PCA scores for diet pattern were added in an additional step (before main variable was entered). The goodness of fit (for each hierarchical step) was assessed through adjusted R^2 values.

4.4.3.3 Assumptions

Assumptions were checked as follows: Independence of cases was given due to the study design (each observation exists only once, is not paired with an observation in another group nor is it influenced by another observation). Collinearity was assessed through VIF values (largest VIF should be <10; average VIF should not be substantially >1) and tolerance statistics (which should be >0.2; Field, 2013). Normality was assessed through the normal probability plots of the residuals. Homoscedasticity and linearity were checked through residuals vs. fitted plots.

5. Results

5.1 Participant characteristics

The total sample consisted of n=339 participants, of which 66.1% identified as female (n=224), 32.1% as male (n=109), and 1.8% as other, i.e. non-binary (n=6). The average age was 19.5 years with a standard deviation of ±1.9 years. The majority of participants identified as heterosexual (n=257, 75.8%), followed by 9.7% bisexual (n=33), 8.3% other (n=28), and 1.8% gay or lesbian (n=6). Approximately two thirds of respondents (n=221, 65.2%) reported to be single, 28% (n=95) were in a relationship and 3.5% (n=12) were unsure about their relationship status; 65.2% of participants identified as white (n=156) with the second largest ethnicity being Asian (n=135, 39.8%) and 14.2% (n=48) other ethnicities. Due to the data collection process which was primarily focused on first- year undergraduate students, this population was overrepresented in this sample with 62.2% (n=211), followed by n=64 (18.9%), second year, n=28 (8.3%) third year, n=19 (5.6%) fourth year, and n=9 (2.7%) higher than fourth year undergraduate students. Therefore, most participants lived either on campus in a residence hall (n=244, 72%) or off-campus with their parents (n=34, 10%); 35.4% (n=120) of participants classified as international students and 65.2% indicated they spoke English as a second language (n=221). Most participants were enrolled in a Natural Science degree (n=96, 28.3%), followed by Engineering and Computer Science (n=59, 17.4%), and Arts and Humanities (n=46, 13.6%). More details can be found in Table 1. Although convenience sampling was used, this study sample is indeed comparable to the overall UBC undergraduate student population in terms of its demographics (UBC Planning and Institutional Research, 2019). According to the 2017/2018 Annual Report on Enrolment, 56% of UBC undergraduate students were female (vs. 66% in this sample); 87% were younger than 25 (98% in this sample due to over-sampling of first year students); and 11% were international students (compared to 35% in this sample; Office of the Provost and Vice-President Academic, 2018). In a voluntary survey in 2012, 39% of first year UBC students identified as Chinese, 35% were White, 9% were South Asian, 5% Korean (here: 40% Asian, 46% White; Todd, 2014). The differences in age and international student proportion could be explained due to the targeted recruitment strategy in on-campus residences where first year and international students are overrepresented.

Table 1 - Participant characteristics

Characteristic	Item categories	mean (±SD)	n	%
Age		19.5 (±1.9)		
Gender identity	Female		224	66.1
	Male		109	32.1
	Other (trans, queer, other)		6	1.8
Sexual orientation[1]	Heterosexual		257	75.8
	Bisexual		33	9.7
	Gay/Lesbian		6	1.8
	Other		28	8.3
Relationship status[1]	Not in a relationship		221	65.2
	In a relationship		95	28.0
	Not sure		12	3.5
Ethnicity	White		156	46.0
	Asian		135	39.8
	Other		48	14.2
Year in school[1]	1st year		211	62.2
	2nd year		64	18.9
	3rd year		28	8.3
	4th year		19	5.6
	Higher than 4th year undergrad		9	2.7
	Not seeking a degree		1	0.3
International student[1]	Yes		120	35.4
	No		213	62.8
ESL[1]	Yes		221	65.2
	No		112	33.0
Field of study[1]	Undeclared		4	1.2
	Arts/Humanities/Languages		46	13.6

Characteristic	Item categories	mean (±SD)	n	%
	Social Sciences/Education		30	8.8
	Health Sciences		42	12.4
	Natural Sciences		96	28.3
	Engineering/Computer Science		59	17.4
	Business/Economics		35	10.3
Residence[1]	Campus residence		244	72.0
	University other		4	1.2
	Parents		34	10.0
	Off-campus alone/with roommates/other		48	14.2

[1]this variable was not imputed, therefore the total n<339 for this variable

5.2 Covariables

Variables of interest that were included in the regression models as covariables were health behaviours (physical activity and sleep), body image, overall stress, stressful life events, and social support. Detailed information on these variables can be found in Table 2. Overall, it was found that almost none of the students (96.1%, n=326) managed to meet the recommended amount of physical activity of moderate activity for 30min/day in the previous week. Three quarters of the participants (76.7%, n=260) only had enough sleep to feel rested on a maximum of four days in the previous week. Two thirds of the students (66.6%, n=226) experienced more than average or even tremendous stress over the 12 months preceding the survey. Approximately half of the students were somewhat, very or extremely satisfied with their weight (52.6%, n=178). Stressful life events that would cause moderate or severe stress affected 76.3% (n=259) of the students. Conversely, the majority of participants (80.4%, n=272) reported to have good, very good or excellent satisfaction with their social relationships and activities.

Table 2 - Health behaviours, stress, stressful life events, weight satisfaction, social support

Item	Item scale	mean (±SD)	n	%
Physical activity continuous (0 to 8)		2.08 (±1.98)		
Physical activity ordinal	never		94	27.6
	1 day/week		68	20.1
	2 days/week		55	16.3
	3 days/week		44	12.9
	4 days/week		31	9.0
	5 days/week		25	7.4
	6 days/week		9	2.7
	every day		12	3.6
	more than once a day		1	0.3
Sleep continuous (0 to 7)		3.00 (±2.08)		
Sleep ordinal	never		51	15.0
	1 day/week		41	12.1
	2 days/week		53	15.6
	3 days/week		53	15.7
	4 days/week		62	18.3
	5 days/week		36	10.4
	6 days/week		16	4.7
	every day		27	8.0
Weight satisfaction (0 to 4)		1.65 (±1.09)		
Weight satisfaction ordinal	not satisfied at all		51	15.0
	slightly unsatisfied		110	32.4
	somewhat satisfied		101	29.9
	very satisfied		61	18.0
	extremely satisfied		16	4.7
Stress continuous (0 to 4)		2.8 (±0.89)		

Item	Item scale	mean (±SD)	n	%
Stress ordinal	no stress		4	1.2
	less than average stress		21	6.2
	average stress		88	26.0
	more than average stress		152	44.8
	tremendous stress		74	21.8
Stressful life events continuous (0 to 2)		1.08 (±0.75)		
Stressful life events ordinal	mild stress		81	23.8
	moderate stress		149	44.1
	severe stress		109	32.2
Social support continuous (0 to 4)		2.3 (±1.06)		
Social support ordinal	poor		23	6.8
	fair		44	12.8
	good		118	34.9
	very good		115	34.0
	excellent		39	11.5

5.3 Exploration of trends among those following plant-based diets

In compliance with the conceptual framework underpinning this study, it was of interest to explore trends of mental wellbeing and other factors among those students who follow a non-mainstream diet. To assess whether the groups of students following certain non-mainstream diets differ from each other and from those eating a mainstream diet in terms of personal factors (health behaviours and body image), stress, and social support, the Kruskal Wallis H test and post-hoc Dunn's test with Bonferroni correction were conducted. For categorical outcomes (gender, ethnicity, motives for diet preference), the Pearson Chi-square test was conducted. The tests showed that there was a statistically significant between-group difference only in terms of social support and, not surprisingly,

in dietary patterns (i.e. PCA scores). There was no statistically significant between-group difference in any of the other variables of interest. For better readability, Table 3 only reports the significant between-group differences of the Kruskal Wallis H test.

Table 3 - Kruskal Wallis H test for significant between-group differences (in terms of diet preference)

Variable with significant between-group difference	Test statistic	dF	*p*
Social support	13.16	4	≤.05
PCA plant foods	49.76	4	≤.001
PCA animal foods	145.78	4	≤.001
PCA junk foods	18.28	4	≤.001

Dunn's post-hoc test showed significant between-group differences for pairwise comparisons as shown in Table 4 (only significant pairwise differences included). Vegetarians reported to have significantly more social support than those following the mainstream diet (z=3.39, p≤.05), pescatarians (z=3.01, p≤.05), and vegans (z=3.04, p≤.05). In terms of dietary patterns, the test showed that both pescatarians and vegans (but not vegetarians) have significantly higher PCA scores for the plant food component than those eating the mainstream diet (z=3.88, p≤.001 and z=5.88, p≤.001, respectively). Conversely, the mainstream diet is significantly higher in the animal-based food component than pescatarian (z=5.06, p≤.001), vegetarian (z=6.67, p≤.001), vegan (z=9.41, p≤.001), and other (z=4.37, p≤.001) diets. In addition, the group of other preferences is still significantly higher in animal-based foods than the vegan diet (z=3.65, p≤.05). Lastly, vegetarians scored significantly higher in the junk food component than the mainstream (z=3.11, p≤.05), vegan (z=4.08, p≤.001), and other (z=3.02, p≤.05) diet preference groups.

Table 4 - Dunn's post-hoc test for significant between-group differences (in terms of diet preference)

	Test statistic	SE of test statistic	Standardized test statistic (z)	Adjusted p[1]
Social support				
Vegetarian – Mainstream	76.20	22.51	3.39	≤.05
Vegetarian – Pescatarian	100.38	33.35	3.01	≤.05

	Test statistic	SE of test statistic	Standardized test statistic (*z*)	Adjusted *p*[1]
Vegetarian – Vegan	80.32	24.43	3.04	≤.05
PCA plant foods				
Pescatarian – Mainstream	105.98	27.29	3.88	≤.001
Vegan – Mainstream	102.89	17.50	5.88	≤.001
PCA animal foods				
Mainstream – Pescatarian	138.88	27.29	5.06	≤.001
Mainstream – Vegetarian	157.03	23.54	6.67	≤.001
Mainstream – Vegan	164.95	17.50	9.41	≤.001
Mainstream - Other	87.51	20.02	4.37	≤.001
Other – Vegan	92.26	25.30	3.65	≤.05
PCA junk foods				
Vegetarian – Mainstream	73.30	23.57	3.11	≤.05
Vegetarian – Vegan	114.05	27.97	4.08	≤.001
Vegetarian – Other	89.28	29.61	3.02	≤.05

[1]Bonferroni correction applied

5.4 Mental health and wellbeing

Mental health outcomes assessed in this study were QoL, depression, and anxiety. As can be seen in Table 5, more than half of the participants (56.3%, n=193) reported their overall QoL to be either very good or excellent with a mean score of 2.58 (±0.96) out of 5. The mean score for depression was 9.28 (±6.13) out of 27; the mean score for anxiety was 7.86 (±5.77) out of 21. In terms of clinical relevance, the number of students who scored above the cut-off for recommended further evaluation concerning symptoms of depression (75%, n=254) or anxiety (65.1%, n=221) was high. Of

those who scored above 10 points for depression (n=142), 16% (n=23) should be referred to receive psychotherapy and/or medication; for those who scored above 10 points for anxiety (n=110) this proportion is even higher with 48% (n=53).

Table 5 - Mental health and wellbeing status

Mental health item	Item categories	mean (±SD)	n	%
QoL continuous (0 to 5)		2.58 (±0.96)		
QoL ordinal	poor		10	2.8
	fair		31	9.2
	good		105	31.1
	very good		138	40.1
	excellent		55	16.2
Depression score (0 to 27)		9.28 (±6.13)		
Depression severity	no depression		85	25.0
	mild depression[1]		112	32.9
	moderate depression		73	21.7
	moderately severe depression		46	13.6
	severe depression[2]		23	6.8
Anxiety score (0 to 21)		7.86 (±5.77)		
Anxiety severity	no anxiety		118	34.8
	mild anxiety[1]		111	32.7
	moderate anxiety		57	16.8
	severe anxiety[2]		53	15.6

[1]cut-off for further evaluation
[2]psychotherapy and/or medication are indicated

5.5 Diet

In order to contribute a more differentiated assessment of diet to the current body of knowledge on the association between diet and mental health, diet was assessed in two different ways in this study which would then be compared in terms of their association with mental health outcomes. First, food intake was assessed quantitatively through the DSQ which allowed for analysis

of dietary patterns through PCA. Additionally, participants were asked to indicate whether they identified as pescatarian, vegetarian, vegan or other dietary preference (herein also referred to as non-mainstream diets or plant-based diets). The reference group were those not identifying as any of the aforementioned (herein also referred to as mainstream diet). In an effort to explore emerging trends within those who follow non-mainstream diets, participants were also asked to indicate their primary motive as to why they are following a (predominantly) plant-based diet.

5.5.1 Diet patterns

The PCA was conducted on the items of the DSQ and three dietary components emerged in this sample. Component 1 (hereafter also referred to as plant foods) was high in plant-based foods and non-animal-based dairy and meat alternatives as well as whole grains. Component 2 (hereafter also referred to as animal foods) was high in animal-based foods such as different meats and dairy products. Component 3 (hereafter also referred to as junk foods) was high in processed foods, snacks and candies.

Based on the condition of eigenvalues >1, six principal components emerged from the sample; analysis of the scree plot suggested to retain 3 principal components. The final decision on retaining three principal components was made based on the conceptual understanding of how certain food items may be grouped together to form a component. The three retained components saturated these hypothesized groups and additional components merely separated these groups into smaller subsets, e.g. a fourth pattern contained cookies, chocolate, ice cream, and donuts separately from the other 'junk' foods that were included in the third component. The total variance explained by the retained three components was 40.6%.

Details on loadings per component for each food item/group after varimax rotation can be seen in Table 6. To achieve a clearer component set, food items/groups that did not score above 0.4 on either of the components (namely, potatoes, tomato sauce, and fruit juice) were removed from the final analysis. In addition, cross loadings below 0.4 were omitted from the table to improve readability.

Table 6 - PCA components and component loadings for dietary patterns after varimax rotation

Food item/group	Component 1 (plant foods)	Component 2 (animal foods)	Component 3 (junk foods)
Brown rice and whole grains	.70		
Beans and legumes	.68		
Nuts and seeds	.66		
Green leafy vegetables	.66		
Other vegetables	.64		
Fruit	.63		
Vegetarian/vegan meat alternatives	.53	-.46	
Non-dairy milk	.51	-.41	
Whole grain bread	.49		
Cereal	.43		
Poultry		.80	
Red meat		.75	
Processed meat		.68	
Fish and seafood		.61	
Cheese		.56	
Yoghurt		.50	
Diary milk		.49	
Cookies, cake, pie			.65
Ice cream			.61
Donuts etc.			.60
Chocolate and candy			.60
Soda			.54
Pizza			.51
Fried potatoes			.50

Food item/group	Component 1 (plant foods)	Component 2 (animal foods)	Component 3 (junk foods)
Coffee or tea with sugar			.41

5.5.2 Diet preference and motives

Almost one third of students (28.1%, n= 95) indicated to self-identify as either pescatarian, vegetarian, vegan or other (which were mostly on a spectrum of non-mainstream preferences such as reducetarian or flexitarian). Remarkably (and in line with current population estimates, see 1.1.2.1), the group identifying as vegans was the largest among the non-mainstream diets with 10.8% (n=37) of the total sample and 38.4% of non-mainstream diets only, respectively. See Table 7 for details.

Table 7 - Diet preference

Diet preference	n	%
Pescatarian	13	4.0
Vegetarian	19	5.5
Vegan	37	10.8
Other	26	7.8
Do not identify as any of the above	244	71.9

Among those who reported to follow a non-mainstream diet (n=69 pescatarian, vegetarian and vegan; the 'other' category was not asked their motive due to the skip logic of the questionnaire), the leading primary motivation was ethical concerns for animals (33.3%, n=23), followed by environmental considerations (29.0%, n=20), other reasons (which were mostly a combination of ethical, environmental, and health motives; 1.03%, n=9), cultural/religious (7.2%, n=5), health (4.3%, n=3), and lastly weight loss (2.9%, n=2). See details in Table 8.

Table 8 - Diet preference motives among pescatarians, vegetarians and vegans

Diet preference motives[1]	n	%
Ethical	23	33.3

Diet preference motives[1]	n	%
Environmental	20	29.0
Other[2]	9	13.0
Cultural/religious	5	7.2
Health	3	4.3
Weight loss	2	2.9

[1]This item was not imputed, thus missing values exist for n=7 out of n=69 respondents who follow a non-mainstream diet
[2]Those who indicated they had other motives to follow a non-mainstream diet mostly listed a combination of the other motives as they did not want to indicate only one primary reason.

5.6 Association between diet and mental wellbeing

5.6.1 Models for dietary pattern as explanatory variable of interest

The unadjusted simple linear regression analysis showed a significant positive association between the plant food dietary component and QoL (β=.20, p≤.001) and between the junk food dietary component and depression β=.26, p≤.001) as well as anxiety (β=.18, p=.001). After adjusting for all covariables, the association between the plant food component and QoL did not remain significant. Table 9 shows the detailed results for the three hierarchical multiple linear regression models that examined the association between dietary patterns and mental wellbeing outcomes controlling for covariables that reflected a biopsychosocial understanding of the relationship. The assumptions (independence, no collinearity, normality, homoscedasticity) for multiple linear regression were met.

Model 1: After adjusting for all covariables, statistically significant associations were found between Asian ethnicity, stress, physical activity, weight satisfaction, and social support with QoL. Asian ethnicity was associated with a β[1]=-.29 decrease in QoL score compared to Caucasian ethnicity (p=0.003). Physical activity was associated with a β=.12 (p=0.01) increase in QoL score per one unit increase in physical activity. Stress was associated with a β=-.16 decrease in QoL score per one unit increase in stress score (p≤.001). Weight satisfaction was associated with β=.10 increase in QoL score (p=0.02). Social support showed the strongest association for QoL with a β=.51 increase in QoL score with each unit increase in social support score (p≤.001). The adjusted R^2 values were as follows: For

[1] All numeric variables were standardized, the unit for β is thus standard deviation (SD)

step 1 (age, gender, ethnicity), adj. R^2=.08; for step 2 (included variables of step 1 + sleep, physical activity, stress, stressful life events), adj. R^2=.21 (Δ=.13); for step 3 (included variables of step 2 + social support), adj. R^2=.44 (Δ=.23); and for step 4 (included variables of step 3 + PCA scores), adj. R^2=.44 (Δ=.00).

Model 2: After adjusting for all covariables, statistically significant associations were found between sleep, stress, weight satisfaction, social support, and the processed/junk food dietary component with depression. Sleep was associated with a *β*=-.17 ($p \leq .001$) decrease, social support was associated with a *β*=-.23 ($p \leq .001$) decrease, and weight satisfaction was associated with a *β*=-.17 ($p \leq .001$) decrease in depression score. Conversely, stress was associated with a *β*=.27 ($p \leq .001$) increase in depression score. Finally, the main explanatory variable of interest showed a significant association between the dietary component high in processed and junk foods with a *β*=.21 increase in depression score ($p \leq .001$). The changes in adjusted R^2 values were as follows: For step 1 (age, gender, ethnicity), adj. R^2=.01; for step 2 (included variables of step 1 + sleep, physical activity, stress, stressful life events), adj. R^2=.31 (Δ=.30); for step 3 (included variables of step 2 + social support), adj. R^2=.35 (Δ=.04); and for step 4 (included variables of step 3 + PCA scores), adj. R^2=.39 (Δ=.04).

Model 3: After adjusting for all covariables, statistically significant associations were found between female gender, stress, stressful life events, social support, and the processed/junk food dietary component with anxiety. Social support was the only variable associated with a decrease in anxiety score (*β*=-.18; $p \leq .001$). Compared to male gender, female gender was associated with a *β*=.22 (p=0.04) increase in anxiety score. Stress and stressful life events were also associated with an increase in anxiety score (*β*=.36; $p \leq .001$ and *β*=.11; p=0.02, respectively). Finally, the dietary component high in processed/junk foods (*β*=.14; p=.002) was significantly associated with a higher anxiety score. The changes in adjusted R^2 values were as follows: For step 1 (age, gender, ethnicity), adj. R^2=.02; for step 2 (included variables of step 1 + sleep, physical activity, stress, stressful life events), adj. R^2=.29 (Δ=.27); for step 3 (included variables of step 2 + social support), adj. R^2=.31 (Δ=.02); and for step 4 (included variables of step 3 + PCA scores), adj. R^2=.32 (Δ=.01).

Table 9 - Hierarchical multiple regression models

	Model 1: QoL			Model 2: Depression			Model 3: Anxiety		
	Beta	SE Beta	Standardized Beta (*β*)	Beta	SE Beta	Standardized Beta (*β*)	Beta	SE Beta	Standardized Beta (*β*)
Step 1									
Constant	3.72	0.52	.08	3.58	3.36	-.10	3.31	3.15	-.25
Age	-0.05	0.03	**-.11***	0.26	0.17	.09	0.16	0.16	.05
Female gender[1]	0.20	0.12	.21	-0.10	0.71	-.02	1.31	0.67	**.23***
Other gender[1]	-0.52	0.42	-.55	4.57	2.80	.75	4.68	2.62	.81
Asian ethnicity[2]	-0.50	0.11	**-.52****	1.34	0.72	.22	0.79	0.68	.14
Other ethnicity[2]	-0.02	0.16	-.02	0.73	1.02	.12	1.40	0.96	.24
Step 2									
Constant	3.55	0.54	-.03	5.62	3.13	.05	0.85	3.00	-.12
Age	-0.03	0.03	-.07	0.08	0.14	.03	0.02	0.14	.01
Female gender[1]	0.26	0.10	**.27***	-0.84	0.60	-.14	0.63	0.58	.11
Other gender[1]	-0.11	0.40	-.11	1.10	2.36	.18	1.49	2.26	.26
Asian ethnicity[2]	-0.40	0.10	**-.41****	0.56	0.62	.09	0.35	0.60	.06
Other ethnicity[2]	0.07	0.14	.07	0.04	0.86	.01	0.76	0.82	.13
Sleep	0.04	0.02	.09	-0.58	0.15	**-.20****	-0.32	0.14	**-.12***
Physical activity	0.07	0.02	**.14***	-0.36	0.15	**-.12***	-0.19	0.14	-.07
Stress	-0.30	0.06	**-.27****	2.16	0.34	**.31****	2.55	0.33	**.39****
Stressful life events	0.02	0.07	.02	0.72	0.40	.09	1.02	0.39	**.13***
Weight satisfaction	0.11	0.04	**.12***	-1.15	0.27	**-.20****	-0.54	0.26	**-.10***
Step 3									
Constant	1.74	0.48	.06	10.54	3.24	.01	4.43	3.13	-.15
Age	-0.01	0.02	-.01	-0.01	0.14	-.01	-0.04	0.14	-.02
Female gender[1]	0.06	0.09	.06	-0.30	0.60	-.05	1.02	0.58	.18
Other gender[1]	-0.22	0.33	-.23	1.40	2.30	.23	1.70	2.23	.30
Asian ethnicity[2]	-0.28	0.09	**-.30***	0.26	0.60	.04	0.13	0.59	.02

	Model 1: QoL			Model 2: Depression			Model 3: Anxiety		
Other ethnicity[2]	0.11	0.12	.11	-0.06	0.83	-.01	0.69	0.81	.12
Sleep	0.01	0.02	.03	-0.50	0.14	**-.17****	-0.19	0.14	-.09
Physical activity	0.06	0.02	**.13***	-0.35	0.14	**-.11***	-0.19	0.14	-.07
Stress	-0.17	0.05	**-.16****	1.84	0.34	**.27****	2.31	0.33	**.36****
Stressful life events	0.05	0.06	.04	0.65	0.39	.08	0.96	0.38	**.13***
Weight satisfaction	0.09	0.04	**.10***	-1.10	0.26	**-.19****	-0.50	0.26	**-10***
Social support	0.46	0.04	**.51****	-1.26	0.28	**-.22****	-0.92	0.27	**-.17****
Step 4									
Constant	1.77	0.49	.07	10.30	3.22	-.02	4.20	3.15	-.17
Age	-0.01	0.02	-.01	0.01	0.14	.01	-0.04	0.14	-.01
Female gender[1]	0.04	0.10	.04	-0.02	0.63	-.01	1.28	0.62	**.22***
Other gender[1]	-0.23	0.34	-.24	1.41	2.26	.23	1.73	2.22	.30
Asian ethnicity[2]	-0.28	0.09	**-.29***	0.23	0.60	.04	0.08	0.60	.01
Other ethnicity[2]	0.11	0.12	.12	0.02	0.82	.01	0.72	0.80	.12
Sleep	0.01	0.02	.02	-0.49	0.14	**-.17****	-0.25	0.14	-.09
Physical activity	0.06	0.02	**.12***	-0.25	0.15	-.08	-0.10	0.15	-.04
Stress	-0.17	0.05	**-.16****	1.82	0.33	**.27****	2.30	0.33	**.36****
Stressful life events	0.05	0.06	.04	0.42	0.38	.05	0.81	0.39	**.11***
Weight satisfaction	0.09	0.04	**.10***	-0.96	0.26	**-.17****	-0.42	0.25	-.08
Social support	0.46	0.04	**.51****	-1.36	0.28	**-.23****	-0.97	0.27	**-.18****
PCA plant foods	0.04	0.04	.05	-0.07	0.30	-.01	-0.19	0.29	-.03
PCA animal foods	0.01	0.04	.01	-0.15	0.28	-.02	-0.14	0.28	-.02
PCA junk foods	-0.01	0.04	-.01	1.26	0.27	**.21****	0.83	0.27	**.14***

[1]Reference category: Male gender; [2]Reference category: Caucasian ethnicity

**p≤.05*

*** p≤.001.*

Note Model 1: Adjusted R^2 =.08 for Step 1; Δ adj R^2 =.13 for Step 2; Δ adj R^2 =.23 for Step 3; Δ adj R^2 =.00 for Step 4

Note Model 2: Adjusted R^2 =.01 for Step 1; Δ adj R^2 =.30 for Step 2; Δ adj R^2 =.04 for Step 3; Δ adj R^2 =.04 for Step 4

Note Model 3: Adjusted R^2 =.02 for Step 1; Δ adj R^2 =.27 for Step 2; Δ adj R^2 =.02 for Step 3; Δ adj R^2 =.01 for Step 4

5.6.2 Models for diet preference as explanatory variable of interest

The same three models as described in 4.6.1 were fitted with diet preference as main explanatory variable of interest (instead of PCA component scores). Results showed that diet preference is not significantly associated with either of the outcome variables when adjusted for all other covariables, including PCA component scores. The assumptions (independence, no collinearity, normality, homoscedasticity) for multiple linear regression were met. Variables that showed significant associations with the respective outcome in these models were consistent with those found in the models discussed above in 4.6.1.

5.7 Other variables of interest to stakeholders

Specific questions about characteristics and variables present in the study population were generated in collaboration with stakeholders. These variables were not included in the final model but are reported in the following. [2]

7. *Is there a difference in social support between first year students and others?*

See Table 10. There seems to be a trend showing that first year students report to have the highest satisfaction with their social relationships and support and that this satisfaction decreases with each additional year of study. However, these differences were not statistically significant.

Table 10 - Social support per year of study

Year of study (undergraduate)	Mean value social support (± SD) (with 0=poor, 1=fair, 2=good, 3=very good, 4=excellent)
1st year (n=211)	2.41 (1.05)
2nd year (n=64)	2.22 (0.98)
3rd year (n=28)	2.14 (1.15)
4th year (n=19)	2.00 (1.05)
>4th year (n=9)	2.00 (1.00)

[2] Please note that these results are to be interpreted as preliminary since group sizes were small and analysis was limited to bivariate analysis but they may function as baseline for further studies.

8. *Is there a difference in diet patterns between students who live on campus compared to those who live off campus?*

Students who live on campus differ from students who live off campus as follows: On average, students who live on campus score significantly lower on the plant food component (*p*=.002), non-significantly higher on the animal food component (*p*=.06), and significantly higher on the junk food component (*p*=.04). For details on mean standardized PCA scores, see Table 11.

Table 11 - Differences in mean component scores for on campus compared to off campus students

PCA component	Average PCA component score on campus students (n=248)	Average PCA component score off campus students (n=82)	p-value (t-test)
Plant foods	-.10	.28	.002*
Animal foods	.06	-.17	.08
Junk foods	.06	-.17	.04*

*statistically significant

9. *Is there a difference in mental health and wellbeing between international and domestic students?*

On average, domestic students report higher QoL and score lower on both the depression and anxiety screening. However, only the difference in QoL is statistically significant. Details see Table 12.

Table 12 - Differences in mean mental health scores for domestic compared to international students

Mental health	Average score domestic students (n=213)	Average score international students (n=120)	p-value (t-test)
QoL (with 0=poor, 1=fair, 2=good, 3=very good, 4=excellent)	2.68	2.43	.025*
Depression (0 to 27)	8.90	9.68	.26
Anxiety (0 to 21)	7.68	7.97	.66

*statistically significant

10. What is the percentage of students who report to be suffering from an eating disorder?

In reply to the question *'Do you currently suffer with or have you ever suffered in the past with an eating disorder?',* n=281 (83%) students said 'no' while n=53 (16%) students said 'yes'; n=5 (1%) students preferred not to answer the question.

11. What is the prevalence of food allergies?

No food allergies were reported by n=254 (67.4%) of students. Table 13 depicts the reported food allergies (several answers could be reported). The 'other' category included citrus fruits, tomatoes, peaches, apples, eggplant, and coconut.

Table 13 - Frequency of food allergies

Food allergy	n[1]	%
Peanuts	9	2.4
Tree nuts	10	2.7
Eggs	5	1.3
Lactose	35	9.3
Wheat	6	1.6

Food allergy	n[1]	%
Gluten	10	2.7
Sesame	2	0.5
Soy	2	0.5
Mustard	0	0.0
Fish	2	0.5
Shellfish	6	1.6
Other	28	7.5

[1]this variable was not imputed and respondents could indicate more than one answer, therefore the total n≠339

12. What is the prevalence of tobacco, marijuana, and alcohol use?

In general, the use/consumption of tobacco, marijuana, and alcohol is relatively low in this sample. Details see Tables 14 to 16.

Table 14 - Frequency of tobacco (cigarettes) use

Tobacco	n[1]	%
Never	308	92.5
1-5 cigarettes/week	16	4.8
6-15 cigarettes/week	3	0.9
About a pack/week	6	1.8

[1]this variable was not imputed, therefore the total n<339

Table 15 - Frequency of marijuana use

Marijuana	n[1]	%
Never	254	76.2
Less than 1 day/week	51	15.1
1-2 days/week	15	4.4
3-6 days per week	9	2.6
Every day	6	1.7

[1]this variable was not imputed, therefore the total n<339

Table 16 - Frequency of alcohol use

Alcohol	n[1]	%
Never	118	35.2
Less than 1 day/week	126	37.6
1-2 days/week	79	23.6
3-6 days per week	12	3.6
Every day	0	0.0

[1]this variable was not imputed, therefore the total n<339

6. Discussion

This study sought to assess whether diet (as measured through either diet patterns or diet preference) was associated with mental wellbeing (particularly QoL, depression, and anxiety) in an undergraduate student population. It further aimed to shed light on the characteristics of those who have adopted predominantly plant-based diets. In line with an underlying holistic epistemology, this was done within a conceptual framework that departed from a narrow biomedical understanding of both diet and mental health.

6.1 Mental wellbeing

The prevalence of clinically-relevant levels of depression and anxiety was high in this sample of 339 undergraduate students; 20.4% scored within the moderately severe or severe depression categories of the PHQ-9 while 15.6% scored above the cut-off for severe anxiety in the GAD-7 (no moderately severe category existent for GAD-7). Based on findings from previous research on the mental health of students, these prevalence rates are – sadly – not surprising. Full-scale epidemiological studies on the mental health and wellbeing of university students in Canada are lacking. However, Price, McLeod, Gleich, and Hand (2006) found that 17% of the male and 15% of the female students screened positive for major depressive disorder and 12.5% for males and 28.9% in females screened positive for major anxiety disorders, respectively (sample size n=686 at a Canadian university with 22% international students). In comparison, in the 2002 Canadian Community Health Survey, only 6.8% of those 15 to 24 years of age in the general population met the criteria for major depressive disorder (as assessed through clinical interview and thus more likely to exclude subthreshold depression than the PHQ-9; Statistics Canada, 2018b). The prevalence of mental health issues therefore seems to be higher in university students than in the general population. There are several hypotheses why this may be the case: The typical age-of-onset of many psychiatric disorders overlaps with entry into university (Kessler, Amminger, et al., 2007); transition into university presents a stressful life event which is accompanied by homesickness, potentially social isolation, financial burden and pressure, and stress – all of which are risk factors for the development of depression and anxiety (Beiter et al., 2015).

Conversely, more than half of the participants (56.3%, n=193) also reported their overall QoL to be either very good or excellent. While this may at first seem counterintuitive, this is actually in line with the concept of QoL being a measure of a full continuum of (mental) wellbeing wherein the presence of symptoms of a disorder such as depression and anxiety merely present one dimension. It has been found, for example, that factors such as self-esteem or social support mitigate the role of depressive symptoms on QoL (Kuehner & Buerger, 2005). Fahy, Kent, Tattan, Horn, and White (1999) also found that the strongest predictors for QoL in people with severe mental illness were unmet basic, social, and functional needs (in combination with symptom severity). Thus, assessing QoL in addition to screening for depression and anxiety provided a more complete picture of mental wellbeing and its associated factors in this study.

6.2 Diet

Through *a posteriori* analysis of dietary composition, three distinct patterns were uncovered in this sample: one high in whole plant-based foods, one high in animal foods, and one high in processed/junk foods and sweets. These diet patterns rendered information about how certain food groups correlated with each other and made up main components in a diet which were then in turn used to learn which components were associated with better or worse mental wellbeing. Interestingly, previous research on this topic that assessed dietary components usually found two patterns rather than three – one was typically labeled 'healthy' or 'traditional' and was high in fruit, vegetables, whole grains, and fish and low in other animal foods; and a 'Western' pattern which was high in red and processed meat, refined grains, sweets, high-fat dairy products and potatoes while low in fruit and vegetable intake (Li et al., 2017; Rahe, Unrath, & Berger, 2014). Conversely, in this study, there were three distinct patterns that have not been described in the literature previously. It is hypothesized that this was due to the specific study population of young adults and the very current trends in their diet choices. None of the previous studies focused on the population of young adults exclusively. In fact, only 8 out of 21 studies even included this age period, most were focused on older adults, and some only included children up to 18 years of age (Li et al., 2017). As

discussed, the population of young adults is most likely to substantially change their eating behaviour for it to be in line with their values around animal welfare and especially environmental concerns. The emergence of a third diet pattern which separates the previously labelled 'healthy' or 'traditional' component into two categories (one that excludes all animal foods and one that is high in all animal foods) is likely a reflection of this recent trend. This was underlined by the high prevalence of self-reported non-mainstream diet preferences in this sample which cumulatively was as high as 28%.

Some authors have used *a priori* diet quality indices to assess their association with mental health outcomes (see review by Lassale et al., 2018). These diet quality indices have been developed based on previous findings from nutritional science and epidemiology on what foods are conducive and detrimental, respectively, for somatic health outcomes or are in line with dietary guidelines. Examples for such diet quality indices are the Healthy Eating Index 2010 (HEI-2010) which is based on the 2010 Dietary Guidelines for Americans (Guenther et al., 2013) or the Mediterranean Diet Score (MDS; Trichopoulou, Costacou, Bamia, & Trichopoulos, 2003). I argue, however, that the use of dietary quality indices may not be without its limitation in this specific research area. As Hu (2002) states: "The dietary index approach is limited by current knowledge and an understanding of the diet-disease relationship, and can be fraught with uncertainties in selecting individual components of the score and subjectivity in defining cut-off points. Typically, dietary indices are constructed on the basis of prevailing dietary recommendations, some of which may not represent the best available scientific evidence". I therefore argue that this approach is valid for research on somatic health outcomes where an abundance of information on what constitutes a healthy diet exists, however for mental health outcomes, the information at hand may still be too inconclusive and scarce to assume that the same diet quality indices could be used to assess mental healthfulness of the diet. Thus, research first needs to generate a more thorough understanding of what is a healthy diet for mental health and needs to develop new specific indices. In addition, the specific interest was to assess whether distinctions could be made between plant and animal foods in terms of their

role in mental wellbeing which is not reflected in any of the existing *a priori* diet indices as they usually subsume these categories within one.

6.3 Exploration of trends among those who follow plant-based diets

Young adults are increasingly choosing to follow a plant-based diet and it will be important to uncover more of the characteristics of this growing population moving forward even if nutritional epidemiology is moving away from assessing diet simply based on self-categorization into a certain diet preference. With the plant-based lifestyle becoming more accepted and mainstream, the characteristics of this population are likely changing over time. In this study, it was found that those following a predominantly plant-based diet (pescatarians, vegetarians, vegans, or others) did not differ significantly from their peers in terms of mental wellbeing, body image, health behaviours, gender, ethnicity or stress. Not surprisingly, their diet patterns did differ, although it was shown that being a vegetarian did not equal eating a healthy diet as vegetarians were the group that scored significantly higher than all others on the junk food component. This is in line with my rationale to assess diet through dietary patterns rather than based on diet preference alone – being vegetarian or vegan does not automatically mean eating a healthy, whole foods, plant-based diet but may very well mean high intake of processed foods as was seen in this sample. In contrast, vegetarians were also the subgroup that reported to have significantly more social support than their peers which may offset the effect of the unhealthy diet and may point at the necessity to consider a social dimension when developing health promotion programs. Identifying as vegan or, to a lesser degree, as vegetarian can place someone outside of the societal norm and thus lead to social isolation. Conversely, I hypothesize that veganism can also be seen as an expanding cultural and social movement – the year 2019 has even been dubbed the "Year of the Vegan" (Cappiello, 2018). This may offer a growing, supportive social network and a way to have one's own values recognized and reinforced by those who share similar values. Arguably, this may positively impact mental wellbeing, especially in this age group for whom positive social relationships are of particular importance (Collins & Laursen, 2004).

Moreover, the motives why someone would become vegan or vegetarian may hint at existing third factors as to how diet and diet preference may be connected with mental wellbeing. In this study, the most prevalent motive to adopt a plant-based diet were ethical considerations for animal welfare and rights, closely followed by environmental concerns which is important when talking about the Great Food Transformation – which this generation is most likely to realize. Furthermore, different subgroups of pescatarians, vegetarians, and vegans did not differ from each other in terms of their motives to choose a certain diet preference in this study. However, ethical, environmental, and health-motivated individuals have been described to differ from each other in their value systems. For example, Lindeman and Sirelius (2001) found that those eating plant-based because of environmental concerns tended to have a humanist world view whereas those eating plant-based for personal health reasons endorsed a normative view of the world. Chuck, Fernandes, and Hyers showed that diet choices can even be an expression of political activism (2016) which has in turn been hypothesized to be associated with mental health issues (Gorski, 2015). Individuals who are willing to change their lifestyle for it to be in line with their morals and values may have internalized the magnitude of issues such as the threat posed by climate change or the degree of animal suffering associated with food production and may feel helpless and hopeless. This may arguably have a negative impact on one's mental wellbeing. On the other hand, making choices that are in line with one's values may provide a sense of empowerment and therefore lead to better wellbeing, especially when combined with social support from like-minded peer groups.

The results discussed in this section need to be interpreted with caution as sample and group sizes were small and the intention was merely to portray trends and lay the basis for future research questions in this field.

6.4 Association between diet and mental wellbeing

Research question Ia asked whether there is an association (and if so, what is its direction and effect size) between dietary patterns (independent of diet preference) and (1) overall QoL; (2) depression; (3) anxiety. In the unadjusted bivariate analysis, a statistically significant positive association between the plant food component and QoL was found (β=.20,

p≤.001). However, this association did not remain significant after controlling for covariables thus underlining the conceptual framework which argues for the inclusion of non-diet related factors when analyzing these relationships. In the adjusted full models, it was shown that a component which subsumed processed and junk foods was associated with depression and anxiety while there was no significant association between the plant food component or the animal food component and any of the outcomes. It is noteworthy that the effect size of the processed food component on mental wellbeing remained small (β[3]=.21 for depression; β=.14 for anxiety with a mere adj. $R^2\Delta$=.04 and adj. $R^2\Delta$=.01 compared to the full model without the PCA component scores, respectively). There are two possible explanations for this: In line with the understanding that mental health and diet exist within a biopsychosocial framework, food intake actually only plays a small role and is overshadowed by more powerful predictors such as social support and relationships. Second, it has been found that self-reported data on diet typically leads to an underestimation of associations (Subar et al., 2015). The possibility of a type II error and thus underestimation of the association is therefore likely present in this study which would mean that the true effect size may be larger or that there actually is an association between the other two components and the outcomes as well.

There are several systematic reviews and meta-analyses that assess the association between dietary pattern and depression (Lai et al., 2014; Lassale et al., 2018; Li et al., 2017; O'Neil et al., 2014). Overall, the findings seem to present evidence for an inverse relationship between what is generally labelled 'healthy' or 'Mediterranean' (assessed either through *a priori* or *a posteriori* dietary pattern analysis) and depression while the trend for 'unhealthy' or 'Western' diet patterns points in the opposite direction although findings are even more inconclusive. However, all authors of the review articles acknowledged the inconsistency in findings across studies and hypothesize that these stem from the use of different measures, different study populations, and different included covariables. Indeed, this is in line with the framework applied in this study which conceptualizes diet as merely one part in a complex

[3] Recall: Standardized z-scores were used, thus the unit of β is SD.

system of biological, personal, interpersonal, and sociocultural components. Many important variables have never been accounted for, thus the true relationship remains largely unknown.

By adjusting for important confounders which have not previously been included in this kind of analysis (namely social support), this present study corroborates the finding that 'unhealthy' dietary patterns are associated with depression and anxiety. However, compared to previous studies, the 'unhealthy' pattern here (processed/junk food component) was different in that it included only processed and snack foods whereas patterns in previous studies were more heterogenous. One possible pathway through which these foods may negatively impact mental health is that of inflammatory reactions and oxidative stress (Kaplan, Rucklidge, Romijn, & McLeod, 2015). Processed foods high in trans fats and sugar have previously been found to be highly inflammatory (Nettleton et al., 2006) and since the component consists of these food only, its effect may not be diluted by the presence of other, less impactful foods, hence the significant finding.

Other authors have already discussed the possible presence of a reverse causality (Michalak et al., 2012) and one prospective cohort study has shown probable evidence for reverse causality between depression and a healthy diet pattern (Le Port et al., 2012). Because plant-based diets are increasingly perceived as healthy forms of diet, it can be hypothesized that a change in dietary behaviour could follow the onset of mental health issues as a form of 'self-medication'. Conversely, the 'self-medication' may also take on the form of an unhealthy diet consistent of foods high in sugar and fat to feel instant gratification.

On the other hand, this present study did not find a significant association in the adjusted models between neither the plant-based food component nor the animal food component and mental wellbeing. There have been no other studies that found dietary components consistent of plant foods or animal foods alone. Previous studies have mostly focused on fruits and vegetables only without looking at overall diet composition and according to a review, the findings remain inconclusive (Rooney et al., 2013). The non-existing significant association in this study is thus to be interpreted as a preliminary finding and needs further

exploration, especially considering the possibility of unaccounted confounders. However, the three emerging patterns that separate plant foods from animal foods are in line with expected eating behaviours in this population.

Furthermore, the aim of this study was to answer the question whether there was an association (and if so, what is its direction and effect size) between diet preference (controlled for diet pattern) and (1) overall QoL; (2) depression; (3) anxiety (research question Ib). Previous research on vegetarian diets had mostly found a negative association (i.e. vegetarianism was associated with increased risk of depression), however, these studies (Baines et al., 2007; Burkert et al., 2014; Hibbeln et al., 2018; Michalak et al., 2012) were all presented with severe limitations, most notably a lack of information on actual food intake and control for important covariables such as social support. It was thus hypothesized that diet preference would in fact not be associated with mental health outcomes. This hypothesis was confirmed which provided further support for the necessity to assess actual food intake rather than assuming the composition of participants' diets based on preferences such as vegetarian or vegan.

6.5 Limitations and challenges

This study employed a cross-sectional design with n=339 participants from an undergraduate student population at UBC. Data was collected via a self-report online questionnaire; the sampling strategy was convenience sampling. There were several limitations and challenges that have to be considered when interpreting the findings of this study.

6.5.1 Study design and representativeness of the sample

The most important limitation inherent to cross-sectional study design is its limited information on causal or temporal inference between explanatory and outcome variables. This limitation is mitigated by a thorough conceptual understanding of the relationship between exposure and outcome and the inclusion of confounding variables. In this, the present study was an advancement over previous studies on this topic. In addition, the assessment of age-of-onset vs. age at adoption of a certain diet points at reverse temporality of the association.

Nevertheless, in order to eliminate temporal ambiguity, confounding, and response biases, more sophisticated study designs will be needed in the future.

According to Green's rule of thumb ($n \geq 104+k$ with k=number of predictors), the sample size of n=339 could be considered appropriate for regression analysis (1991). However, it may have only be sufficient to detect a large or medium effect, small effects may require sample sizes of well over n=600 (Field, 2013). This means that some effects of the explanatory variables may have remained uncovered in this study and that a type II error (false negative) for these effects was present. This may have been amplified by the finding that self-reported data on diet typically leads to an underestimation of associations (Subar et al., 2015). A larger sample size would thus have been conducive to greater statistical power which would have allowed for consideration of interaction terms in the regression analysis in this study. For example, it would have been interesting to see if social support was an effect modifier of the relationship between diet and mental wellbeing (i.e. the effect depends on the level of social support) rather than, or in addition to, being a confounder. Lastly, sample size is related to the generalizability of results. The larger the sample size, the greater the possibility that existing variabilities in the overall population be represented in the study sample, i.e. increased external validity. Related to this, the issue of representativeness of the sample needs to be discussed. The sampling strategy in this study was a non-probability sampling method (convenience sampling). As its name implies, the obvious advantage lies in its convenience; because of its limited need of resources and time, it is a very commonly used approach (Acharya, Prakash, Saxena, & Nigam, 2013; Hedt & Pagano, 2011). Its most important disadvantage is that the resulting sample may not be representative of the general population and therefore biases are introduced that prohibit generalization beyond the sample. In this present study, all participants were undergraduate students at UBC. The external validity of this study beyond the student population was thus limited as university students differ from their non-student peers and the general population in several characteristics. For example, it has been found that university students are, on average, from higher income families, compared to their non-student peers (M. J. Bailey & Dynarski, 2011). In terms of health behaviours, studies have

shown that university students tend to drink more heavily but score lower in their use of cocain, marijuana, and tobacco than their non-university-attending peers (O'Malley & Johnston, 2002). Most importantly perhaps for this study, this population has started to make very different dietary choices than older generations. In relation to the local context at UBC, this sample was however fairly representative as its sociodemographic composition was comparable with that of the overall undergraduate student population.

6.5.2 Data collection and measures

All collected information was exclusively self-reported which introduced several biases: First, non-response bias was likely present, i.e. those who participated in the study differ from those who did not. One such example would be the 'healthy volunteer effect' whereby the participants were healthier than the general population. The opposite may have also been the case whereby participants had a specific interest in sharing their experience of mental health issues with the motivation to contribute to improvements of the conditions on campus. The fact that the study sample was similar in health behaviours and outcomes to comparable populations and to the target population in terms of sociodemographic characteristics, this bias may have been of reduced magnitude here. Second, recall bias is usually a problem in self-reported data and especially when collecting retrospective subjective information on food intake. It has been found that self-reported food intake is often underreported because people tend to underestimate how much they actually eat (Schoeller, 1990; Subar et al., 2015). Third, reporting bias such as social desirability bias is present in surveys that ask about personal health behaviours, especially diet, and/or issues that are highly stigmatized such as mental health. In the present study, these biases likely led to an underestimation of the true prevalence of mental health issues, underreporting of food intake, especially unhealthy foods, and an underestimation of the association (Subar et al., 2015).

In this study, an FFQ was used to assess the frequency of food intake over the previous 12 months. Other measures of self-reported food intake include 24hr dietary recall or multi-week dietary records which are to a lesser degree subject to recollection bias (Satija, Yu, Willett, & Hu, 2015). However, the goal here was to derive long-term dietary patterns rather

than assess exact nutrient intake within a shorter period of time. Together with the consideration that limited resources for data collection were available and respondent burden needed to be kept low in order to obtain a larger sample size, the FFQ was the most reasonable compromise. FFQs and other self-reported diet data have been deemed adequate and superior to non-self-reported measures such as biomarkers especially when analyzing diet patterns as they provide more complete information on the composition of the overall diet (Subar et al., 2015).

Lastly, self-reported mental health issues are highly subjective and information on mental health diagnoses are obviously very prone to both recall and social desirability biases. To mitigate the subjectivity and biased information from self-reported mental health issues, this study included validated screening instruments (1-item QoL scale, PHQ-9, GAD-7). While answers are still self-reported, these measures provide a more objective and comparable metric.

It is important to mention that the different measures in this study assessed variables within different time frames. The FFQ asked about food intake within the past 12 months whereas the PHQ-9 and GAD-7 assessed symptoms in the past two weeks. Other items evaluating covariables did not consider a specific time frame at all (e.g. In general, would you say your quality of life is…) or asked about lifetime prevalence (e.g. Have you ever been diagnosed or treated by a professional for any of the following?). Hence, based on the measures and the cross-sectional study design, inferences can only be made about the prevalence of the exposures and the outcomes and the relationship between these at one point in time.

7. Conclusions

Grounded in a planetary health and environmental nutrition rationale, this study sought to investigate whether plant-based diets have the potential to benefit or harm mental wellbeing in young adults. This study brought forward evidence that categorization into certain diet preferences such as vegetarian or vegan seems to be in fact irrelevant for one's mental wellbeing when this association is viewed within a biopsychosocial framework and is extended beyond a narrow biomedical approach. However, this study did demonstrate that a diet pattern high in processed and junk foods is indeed negatively associated with mental wellbeing, even after controlling for a multitude of confounding variables, albeit the effect size remained rather small. This further justifies the approach in nutritional epidemiology which employs dietary pattern analysis.

The high prevalence rates of mental health issues in this study add to the body of literature which shows that mental wellbeing in university students is in dire straits and that universities must address the wellbeing of their students to the same degree as they do their academic performance. Integrated health promotion and literacy programs that target not only specific behaviours such as diet or provide downstream treatment for already manifested disorders but include other health behaviours and foster social connections and relationships are warranted. Beyond interventions targeted at the individual level, universities and other entities such as municipalities must aim to create a healthy environment that provides equitable opportunities for all to reach their full potential – this must include provision of environmentally sustainable, affordable, accessible, healthy foods; barriers to unhealthy foods; an environment conducive to a healthy work-life balance and physical activity; and lastly an inclusive (campus) community that provides social support for everyone.

By further exploring trends among those who eat predominantly plant-based compared to those who do not, this study shed light onto characteristics of this rapidly expanding population. Future studies may choose to re-evaluate these and previous findings on characteristics, health behaviours, and social connectedness of those following a plant-based diet, especially given that this lifestyle is evolving from a fringe to a mainstream social

movement which may in turn have changing meaning for one's health and wellbeing. Particular emphasis may be placed on the different motives of why someone chooses to live plant-based as the underlying values and psychological mechanisms associated with these motives may differ greatly and may thus impact mental wellbeing differently. However, this study was only able to include a very limited number of factors that exist within the layers of the proposed model (see Figure 2).

7.1 Future inquiry

In order to develop definitive recommendations on diet that benefit both the planet and human mental health, more information is needed. Future research may want to finesse the study design and methodology in several possible ways. First, studies of a larger magnitude will be able to provide more generalizable results. This means including larger sample sizes in observational studies as well as expanding the focus beyond specific populations such as university students. It may also mean a different sampling strategy that will allow for larger group sizes among plant-based diets, matched in certain characteristics to a comparison group of mainstream diet individuals. Cross-sectional study designs are inherently limited in that they curtail conclusions about causal relationships between variables however strongly they may be associated with each other. Randomized-controlled trials (RCTs) are generally seen as providing the strongest evidence in health sciences. However, they are not without criticism, especially in terms of their efficacy and adequacy for nutritional epidemiology (Satija et al., 2015). RCTs, per definition, require a limited time frame, hard endpoints, and controlled interventions – all of which are impractical or even inappropriate when trying to answer questions about long-term effects of a complex exposure on a complex outcome such as diet and mental health. While RCTs thus certainly have their place in assessing specific dietary intervention programs in clinical psychiatry, for example, they may not be the most appropriate way to assess the research questions of this study or related inquiries. In contrast, large-scale, prospective cohort studies would allow for more unbiased inferences about temporal and causal relationships between diet and mental wellbeing. This study approach has been employed for a long time in

nutrition research but so far, only two have focused specifically on mental health outcomes. Therefore, there is still tremendous potential for scientific advances in this field.

Furthermore, the measures that were applied in this study to assess exposure, outcome, and covariables have several limitations and future studies could contribute to the field by using more advanced instruments. The self-report approach could further be extended and/or complemented by more objective measures that are subject to fewer biases. Such measures could include clinical records to verify mental health diagnoses or biomarkers to indirectly monitor food intake. Covariables could be assessed with more detailed validated measures such as the WHOQOL (The WHOQOL Group, 1998) or the Body Image States Scale (BISS; Cash, Fleming, Alindogan, Steadman, & Whitehead, 2002) that go beyond the single-item scales that were used in this present study. Lastly, the interpretation of food-related data in particular could include developing specific diet quality indices for mental health.

The outmost layer of the model depicted in Figure 2 (see 2.4) is certainly the most neglected in this present study. Diet is not merely a health behaviour or personal choice but rather a construct of intertwined intra- and interpersonal conditions, not least socioeconomic and cultural influences. Future research would greatly be enhanced if socioeconomic and cultural determinants would be considered. For example, the issue of food security greatly impacts one's ability to access healthy foods and has been associated with major depressive disorder in US women (Beydoun & Wang, 2010). In addition, the ability to procure culturally-appropriate foods, which has been nearly eliminated by a colonial food system, is an issue of great extent for Indigenous communities in Canada and food traditions across the globe. How this may interact with mental wellbeing is of great importance but is certainly neglected in the public health literature at this point. Moreover, most of the studies on this topic have thus far been conducted in North America, Europe, or Australia. Insights from countries and cultures other than Western would be helpful in understanding cross-cultural differences. Integrating research from social sciences, community action and participatory research, and findings from qualitative studies will play a pivotal role if a more complete picture is to be painted.

I argue for an interdisciplinary approach to this topic and therefore do not deny the importance of advances in the life sciences. Emerging research on body-mind connections continue to uncover exciting insights. One such example is the role of the human gut microbiome in immune system reactions (Gill & Finlay, 2011) that have in turn been linked to somatic NCDs and depression (Dash, Clarke, Berk, & Jacka, 2015). As a core driver for equilibrium or disruption of the gut microbiome, diet is an important point of entry when aiming to further shed light on these pathways (O'Neil et al., 2015). Previous work has also suggested that different biological pathways may underlie different disorders (Lamers et al., 2013) which could mean that diet (and other covariables) affects these disorders in different ways. Future research could thus focus on a more distinct understanding of the mental disorders and differentiate between different subtypes of depression or anxiety as well as include other disorders such as bipolar disorders or psychosis.

In summary, future inquiry may seek to extend research in both directions: An ever-more holistic concept of how diet impacts mental health and vice versa; and an ever-more detailed understanding of the microcosmos that is the human mind-body connection. The key aspect will be the understanding that those are inextricably linked and that there is no 'silver bullet answer'.

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Willem Kuyken on behalf of the WHOQOL Group. The WHOQOL group comprises a coordinating group, collaborating investigators in each of the field centres and a panel of consultants. Dr. J. Orley directs the project. The work reported on here was carried out in the 15 initial field centres in which the collaborating investigators were: Professor H. Herrman, Dr. H. Schofield and Ms. B. Murphy, University of Melbourne, Australia; Professor Z. Metelko, Professor S. Szabo and Mrs. M. Pibernik-Okanovic, Institute of Diabetes, Endocrinology and Metabolic Diseases and Department of Psychology, Faculty of Philosophy, University of Zagreb, Croatia; Dr. N. Quemada and Dr. A. Caria, INSERM, Paris, France; Dr. S. Rajkumar and Mrs. Shuba Kumar, Madras Medical College, India; Dr. S. Saxena and Dr. K. Chandiramani, All India Institute of Medical Sciences, New Delhi, India; Dr. M. Amir and Dr. D. Bar-On, Ben-Gurion University of the Negev, Beer-Sheeva, Israel; Dr. Miyako Tazaki, Department of Science, Science University of Tokyo, Japan and Dr. Ariko Noji, Department of Community Health Nursing, St. Luke's College of Nursing, Japan; Professor G. van Heck and Dr. J. De Vries, Tilburg University, The Netherlands; Professor J. Arroyo Sucre and Professor L. Picard-Ami, University of Panama, Panama; Professor M. Kabanov, Dr. A. Lomachenkov and Dr. G. Burkovsky, Bekhterev Psychoneurological Research Institute, St. Petersburg, Russia; Dr. R. Lucas Carrasco, University of Barcelona, Spain; Dr. Yooth Bodharamik and Mr. Kitikorn Meesapya, Institute of Mental Health, Bangkok, Thailand; Dr. S. Skevington, University of Bath, U.K.; Professor D. Patrick, Ms. M. Martin and Ms. D. Wild, University of Washington, Seattle, U.S.A. and Professor W. Acuda and Dr. J. Mutambirwa, University of Zimbabwe, Harare, Zimbabwe. In addition to the expertise provided from the centres, the project has benefited from considerable assistance from: Dr. M. Bullinger, Dr. A. Harper, Dr. W. Kuyken, Professor M. Power and Professor N. Sartorius.1. *Social Science & Medicine*, *46*(12), 1569–1585. https://doi.org/10.1016/S0277-9536(98)00009-4

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Appendix

Appendix A – Rationale for choice of covariables

A.1 Biopsychosocial understanding of mental health

The biopsychosocial model of mental health was first put forward by George Engel (1980). He therein criticized the prevailing but reductionist approach in psychiatry that was mostly based on a biomedical understanding of mental health and disease. He put forward a series of considerations that should shape our view of the concept of mental health. These assumptions included:

> (1) Mental disorders (like other medical conditions) emerge within individuals who are part of a whole system. (2) This whole system has physical elements, which are both sub-personal (a nervous system containing organs and networks comprised of cells, which in turn are comprised of molecules and atoms) and supra-personal. The latter entail individuals existing in a psychosocial context of increasing complexity (two-person, family, community, culture, society and biosphere). (3) The elements just described can be conceptualised as an organised systems' hierarchy. Lower levels of organisation are necessary for higher ones to exist but they are not sufficient to describe, or explain, their nature. With each higher level of organisation emergent characteristics appear, which are not present at lower levels. Holistic epistemologies should reflect this complex ontology and thereby avoid reductionism. (4) Attempts at accounting for mental disorder, which only refer to sub-personal factors (the biomedical model in psychiatry), will be reductionist (Engel, 1980; as summarized in Pilgrim, 2002, p.585-586).

The discussion about the usefulness of defining mental health as a brain science is ongoing. For example, Ioannidis (2019) recently argued that the treatment effects of psychotropic medication, especially antidepressants, remain meagre despite intense research and development efforts and that this should be cause to depart from the reductionist view. He suggested that "instead of thinking of mental disease as a narrow problem of brain tissue, brain cells, and brain molecules, we may need to think of it as an evolving, ever-changing challenge for society at large" (Ioannidis, 2019).

This is in line with the WHO's definition of (mental) health which states that

> Health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity. Mental health is a state of wellbeing in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community (World Health Organization, 2018).

Importantly, mental health is not merely the absence of mental disorders such as depression or anxiety, it is a state of wellbeing. To do this understanding of mental wellbeing justice and focus on the full continuum of health, the present study included the concept of QoL as an outcome measure for mental wellbeing.

A vast body of evidence exists that links mental health and wellbeing to factors of one's social, labour, economic, financial, and/or overall health conditions and environment (Allen, Balfour, Bell, & Marmot, 2014). One of the strongest predictors for wellbeing is the presence of positive and supportive social relationships (Diener & Seligman, 2002). This present study thus controlled for satisfaction with social relationships and support (herein mostly referred to as social support) in the assessment of the relationship between diet and mental wellbeing.

Further individual-level factors (although arguably highly influenced by external conditions) associated with mental wellbeing that are considered in the present study are body image, physical activity, sleep, stress, and stressful life events.

It has been shown that lower body image or dissatisfaction with one's weight and body is associated with low self-esteem in adolescents (Tiggemann, 2005). Furthermore, negative body image predicts depression, especially in female adolescents as was shown in a longitudinal study with n=645 participants by Holsen, Kraft, and Røysamb (2001).

Physical activity has consistently been shown to be associated with better mental health outcomes across the lifespan and for a variety of disorders (Paluska & Schwenk, 2000). Among college students, it was found that those who met recommendations for frequency of vigorous

exercise were less likely to have poor mental health (as measured by SF-36; adj. OR=0.79, 95% CI 0.69-0.90; VanKim & Nelson, 2013).

There is further evidence that sleep (both in terms of sufficient quantity and quality) is critical for mental wellbeing and sleep deficit has indeed been linked to depression and anxiety (Martin, Dixon, & Thomas, 2017).

Finally, stress is another factor that has extensively been researched in terms of its effect on mental wellbeing. Stress is a complex construct of which a detailed discussion is well beyond the scope of this thesis. In short, stress encompasses how one perceives, appraises and reacts to certain events or stimuli that are emotionally or physiologically difficult (Karatsoreos & McEwen, 2011). In the population of interest, university students, a large proportion frequently reports to be suffering from high levels of perceived stress. In a large national sample in the U.S., 34% of students indicated that stress was the most important factor impacting academic success (ACHA, 2009). Exposure to stress, especially when combined with a lack of coping strategies and social support, can further contribute to lower QoL and poor mental health outcomes (Chao, 2012). This is also true for exposure to stressful life events which can be "either negative or positive and are changes that occur suddenly in one's life and might have a severe impact on one's mental health" (Sokratous, Merkouris, Middleton, & Karanikola, 2013, p.2). Stressful life events have been shown to be associated with subsequent development of mental health disorders, especially depression (Kessler, 1997).

A.2 Biopsychosocial understanding of (plant-based) diets

When looking beyond the health sciences, there is an abundance of research on the important roles that our food choices and diets play in our lives. So much of today's culture evolves around enjoying and sharing food with others by which we fulfill basic human needs like connectedness to those around us and a sense of community and belonging (Maslow, 1968). In a review on how young people use everyday food practices to build and negotiate social relationships, the authors found that food practices greatly impact young people's social lives (Neely, Walton, & Stephens, 2014). They infer that these insights could be helpful in future

nutrition research as there is increasing evidence about the health-promoting benefit of good social relationships, including improved healthful dietary behaviour (Conklin et al., 2014). Food has a social dimension (Fischler, 2011) which encompasses so much more than its nutritional value. This is particularly true if an individual's food choices put them outside of the societal mainstream and norm – as identifying as vegan or, to a lesser degree, as vegetarian would usually do. As Greenebaum wrote so poignantly: "Identifying as a vegan is a public declaration of one's identity, morals and lifestyle. Veganism is more than a diet; it is a philosophy and ethic" (2012). This may lead to social isolation, lack of social support, confrontation and exposure to dismissive language (Cole & Morgan, 2011) which in turn may negatively impact the mental health of those following a non-mainstream diet. Indeed, the self- and external perception of vegetarians and vegans has historically been negative (Back & Glasgow, 1981).

In this study, the social dimension of diet was considered in the main analysis by controlling for satisfaction with social relationships in the association between diet and mental health. The additional covariables body image, physical activity, sleep, stress, and stressful life events were also understood to be associated with diet as they are with mental health and were thus included as potential confounders. For example, research has confirmed that stress exposure is associated with an increased consumption of foods that tend to be unhealthy and high in calories (Leigh Gibson, 2006). Unhealthy eating patterns have also been associated with stress due to increased academic load in young adults (Weidner, Kohlmann, Dotzauer, & Burns, 1996) which is of particular interest given the study population of this present study. Moreover, it has been shown that health behaviours seem to be intercorrelated (Aarø, Laberg, & Wold, 1995) which would mean that physical activity and sleep are conceptually associated with diet as well. Finally, body image may be associated with diet although the actual relationship has been shown to be somewhat counter-intuitive. In a longitudinal study of n=2516 adolescents in the U.S., Neumark-Sztainer, Paxton, Hannah, Haines, and Story (2006) found that lower body satisfaction does not necessarily lead to increased health behaviour but does in fact drive unhealthy weight control efforts and a decrease in fruit and vegetable intake.

Appendix B – Recruitment Material

Appendix C – Questionnaire

UBC FOOD and MOOD STUDY

Questionnaire

Thank you for deciding to participate in this study, we greatly appreciate it!

In this first part of the survey, you will be asked about your mental wellbeing. Please note that some of the questions ask about a certain time frame (e.g. ***in the last 2 weeks*** or ***during the past month***), others ask if you have ***ever*** experienced certain things. Please make sure you read the questions carefully.

Remember that answering these questions is voluntary. If you choose not to answer a certain question, please check the box "prefer not to say" in order to move on to the next question.

Some of the questions might make you sad or make you remember difficult times in your life. Should you experience any stress as a result from this survey, please do not hesitate to contact either one of the study staff or UBC Counselling Services located in Room 1040 in Brock Hall, 1874 East Mall or Empower Me 1-844-741-6389 (toll-free). For crisis or after-hours support services, please contact the service you are most comfortable with from this list.

1. In general, would you say your quality of life is:
   - Excellent
   - Very good
   - Good
   - Fair
   - Poor
   - Prefer not to say

2. In general, how would you rate your satisfaction with your social activities and relationships?
   - Excellent
   - Very good
   - Good
   - Fair
   - Poor
   - Prefer not to say

3. I am able to balance my academic time (in class, study time, etc.) and non-academic time (work, exercise, socializing, care for dependents etc.)
   - Strongly agree
   - Agree
   - Somewhat agree
   - Somewhat disagree
   - Disagree
   - Strongly disagree
   - Prefer not to say

4. I am confident that I will succeed in all of my courses
   - Strongly agree
   - Agree
   - Somewhat agree
   - Somewhat disagree
   - Disagree
   - Strongly disagree
   - Prefer not to say

5. Within the last 12 months, how would you rate the overall level of stress you have experienced?
   - No stress
   - Less than average stress
   - Average stress
   - More than average stress
   - Tremendous stress
   - Prefer not to say

6. Over ***the last 2 weeks***, how often have you been bothered by any of the following problems?

	Not at all	Several days	More than half the days	Nearly every day	Prefer not to say
Little interest or pleasure in doing things					
Feeling down, depressed, or hopeless					
Trouble falling or staying asleep, or sleeping too much					
Feeling tired or having little energy					
Poor appetite or overeating					
Feeling bad about yourself or that you are a failure or have let yourself or your family down					
Trouble concentrating on things, such as reading the newspaper or watching television					

Moving or speaking so slowly that other people could have noticed. Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual					
Thoughts that you would be better off dead or of hurting yourself					

7. If you checked off any of the problems under question 1, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

	Not difficult at all	Somewhat difficult	Very difficult	Extremely difficult	Prefer not to say

8. Over the ***last 2 weeks***, how often have you been bothered by the following problems?

	Not at all	Several days	More than half the days	Nearly every day	Prefer not to say
Feeling nervous, anxious, or on edge					
Not being able to stop or control worrying					
Worrying too much about different things					
Trouble relaxing					
Being so restless that it's hard to sit still					
Becoming easily annoyed or irritable					
Feeling afraid as if something awful might happen					

9. If you checked off any of the problems under question 2, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

	Not difficult at all	Somewhat difficult	Very difficult	Extremely difficult	Prefer not to say

10. Have you ***ever*** been diagnosed or treated ***by a professional*** for any of the following? Check all that apply.

    - Depression
    - Anxiety
    - Eating disorder
    - Panic attacks
    - Substance use
    - Phobia
    - Obsessive compulsive disorder
    - Schizophrenia/Psychosis
    - Personality disorder
    - Other, please specify:
    - I have never been diagnosed with any of the above-mentioned disorders
    - Prefer not to say

11. How old were you when you were ***first*** diagnosed with [automatic insert of indicated responses from above]?

12. Have you ***ever*** struggled with mental health issues that were ***not*** diagnosed by a professional?

    - Depression
    - Anxiety
    - Eating disorder
    - Panic attacks
    - Substance use
    - Phobia
    - Obsessive compulsive disorder
    - Schizophrenia/Psychosis
    - Personality disorder
    - Other, please specify:
    - I have never been diagnosed with any of the above-mentioned disorders
    - Prefer not to say

13. How old were you when you ***first*** struggled with [automatic insert of indicated responses from above]?

14. Does anyone in your family have a history of mental? Check all that apply.

- ○ Mother
- ○ Father
- ○ Brother(s)
- ○ Sister(s)
- ○ Grandmother(s)
- ○ Grandfathers(s)
- ○ Aunt(s)
- ○ Uncle(s)
- ○ Cousin(s)
- ○ Others, please specify:
- ○ Don't know
- ○ No one in my family has a history of mental illness
- ○ Prefer not to say

15. Are you satisfied with your eating patterns?

- ○ Yes
- ○ No
- ○ Prefer not to say

16. Do you ever eat in secret?

- ○ Yes
- ○ No
- ○ Prefer not to say

17. Does your weight affect the way you feel about yourself?

- ○ Yes
- ○ No
- ○ Prefer not to say

18. Have any members of your family suffered with an eating disorder?

- ○ Yes
- ○ No
- ○ Prefer not to say

19. Do you currently suffer with or have you ever suffered in the past with an eating disorder?

- ○ Yes
- ○ No
- ○ Prefer not to say

20. How do you describe your weight?

- ○ very underweight
- ○ slightly underweight
- ○ about the right weight
- ○ slightly overweight
- ○ very overweight
- ○ Prefer not to say

21. How satisfied are you with your current weight?

    - not satisfied at all
    - slightly unsatisfied
    - somewhat satisfied
    - very satisfied
    - extremely satisfied
    - Prefer not to say

22. Are you trying to do any of the following about your weight?

    - I am not trying to do anything about my weight
    - stay the same weight
    - lose weight
    - gain weight
    - Prefer not to say

23. Thinking back ***over the past 30 days***, how many cigarettes (the kind that come in a pack or roll-your-own) did you smoke in a normal week?
    - None
    - 1-5/week
    - 6-15/week
    - About a pack/week
    - More than a pack/week
    - Prefer not to say

24. Thinking back ***over the past 30 days***, how often did you consume marijuana in a normal week?
    - Never
    - Less than 1 day a week
    - 1-2 days/week
    - 3-6 days/week but not every day
    - Every day
    - Prefer not to say

25. Thinking back ***over the past 30 days***, how often did you consume alcohol in a normal week?
    - Never
    - Less than 1 day a week
    - 1-2 days /week
    - 3-6 days/week but not every day
    - Every day
    - Prefer not to say

26. In the ***past year***, have any of these events occurred in your life? Check all that apply.
    - Death of a close family member
    - Death of a close friend
    - Divorce between parents
    - Serious legal problems
    - Major personal injury or illness

- Responsibilities for others such as children/spouse
- Threat to major source of income
- Difficulty with roommate(s)
- Change in health of a family member
- Pregnancy
- Sexual problems
- Serious disagreements with parents
- Change in lifestyle for financial reasons
- Difficulty in identifying a major
- Serious argument with close family member
- Problems with a girlfriend or boyfriend
- Having to repeat a course
- Increased workload at school
- Outstanding personal achievement
- First semester in college
- Change in living conditions
- Serious disagreements with an instructor
- Lower grades than expected
- Change in sleeping habits
- Change in social habits
- Change in eating habits
- Chronic car problems
- Change in number of family get togethers
- Too many missed classes
- Change in plans for a major
- Dropped more than one class
- Minor traffic violations
- Prefer not to say

27. In general, how would you rate your physical health?
    - Excellent
    - Very good
    - Good
    - Fair
    - Poor
    - Prefer not to say

28. On how many of the ***past 7 days*** did you participate in vigorous exercise (i.e. activities that take hard physical effort and make you breathe much harder than normal) for at least 20 minutes or moderate exercise (activities that take moderate physical effort and make you breathe somewhat harder than normal) for at least 30 minutes?
    - Never
    - 1 day/week
    - 2 days/week
    - 3 days/week
    - 4 days/week
    - 5 days/week
    - 6 days/week

- Every day
- More than once a day
- Prefer not to say

29. On how many of the ***past 7 days*** did you get enough sleep so that you felt rested when you woke up in the morning?
    - Never
    - 1 day/week
    - 2 days/week
    - 3 days/week
    - 4 days/week
    - 5 days/week
    - 6 days/week
    - Every day
    - Prefer not to say

30. Do you currently take any medication for mental health issues?
    - Yes
    - No
    - Prefer not to say

Please tell us more about the medication you take for mental health issues:
Name of medication:

Great, part one is done! Now we will move on to the second part of the survey.

The following questions will ask about your diet, food allergies, and more. Please answer every question, failure to do so will lead your responses to be unusable for this study. If you are unsure about the answer, try to give your best estimate.

The questions are about foods you ate and drinks you drank ***during the past month***, that is, the past 30 days. When answering, please include meals and snacks at home, at work or school, in restaurants and anyplace else.

31. During the ***past month***, how often did you eat hot or cold cereals? Check one.
    - Never
    - 1x/month
    - 2-3x/month
    - 1x/week
    - 2x/week
    - 3-4x/week
    - 5-6x/week
    - 1x/day
    - 2 or more times/day

32. During the ***past month***, what kind of cereal did you usually eat?

33. If there was another kind of cereal that you usually ate during the ***past month***, what kind was it?

34. During the ***past month***, how often did you have any dairy milk (either to drink or on cereal)? Include regular milks, chocolate or flavored milks, lactose-free milk, buttermilk. Please do not include small amounts of milk in coffee or tea. Do not soy milk or other non-dairy milks such as almond milk. Check one.

- ○ Never (go to question 6)
- ○ 1x last month
- ○ 2-3 times last month
- ○ 1x/week
- ○ 2x/week
- ○ 3-4x/week
- ○ 5-6x/week
- ○ 1x/day
- ○ 2 or more times/day
- ○ 4-5x/day
- ○ 6 or more times/day

35. During the ***past month***, what kind of diary milk did you usually drink? Mark one.

- ○ Whole or regular milk
- ○ 2% fat or reduced-fat milk
- ○ 1%, 0.5% or low-fat milk
- ○ Fat-free, skim or non-fat milk
- ○ Other kind of milk, please specify:

36. During the ***past month***, how often did you have any non-dairy milk such as soy milk, almond milk, rice milk etc. (either to drink or on cereal)? Please do not include small amounts of milk in coffee or tea. Check one.

- ○ Never
- ○ 1x last month
- ○ 2-3 times last month
- ○ 1x/week
- ○ 2x/week
- ○ 3-4x/week
- ○ 5-6x/week
- ○ 1x/day
- ○ 2 or more times/day
- ○ 4-5x/day
- ○ 6 or more times/day

37. During the ***past month***, how often did you drink regular soda or pop that contains sugar? Do not include diet soda. Check one.

- ○ Never
- ○ 1x last month
- ○ 2-3 times last month
- ○ 1x/week

- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day
- 4-5x/day
- 6 or more times/day

38. During the ***past month***, how often did you drink 100% pure fruit juices such as orange, mango, apple, grape and pineapple juices? Do not include fruit-flavored drinks with added sugar or fruit juice you made at home and added sugar to. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day
- 4-5x/day
- 6 or more times/day

39. During the ***past month***, how often did you drink coffee or tea that had sugar or honey added to it? Include coffee and tea you sweetened yourself and pre-sweetened tea and coffee drinks such as Arizona Iced Tea and Frappuccino. Do not include artificially sweetened coffee or diet tea. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day
- 4-5x/day
- 6 or more times/day

40. During the ***past month***, how often did you drink sweetened fruit drinks, sports or energy drinks, such as Kool-Aid, lemonade, Hi-C, cranberry drink, Gatorade, Red Bull or Vitamin Water? Include fruit juices you made at home and added sugar to. Do not include diet drinks or artificially sweetened drinks. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week

- 5-6x/week
- 1x/day
- 2 or more times/day
- 4-5x/day
- 6 or more times/day

41. During the ***past month***, how often did you eat fruit? Include fresh, frozen or canned fruit. Do not include juices. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

42. During the ***past month***, how often did you eat a green leafy or lettuce salad, with or without other vegetables? Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

43. During the ***past month***, how often did you eat any kind of fried potatoes, including French fries, home fries, or hash brown potatoes? Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

44. During the ***past month***, how often did you eat any other kind of potatoes, such as baked, boiled, mashed potatoes, sweet potatoes, or potato salad? Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week

- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

45. During the ***past month***, how often did you eat cooked dried beans or canned beans and legumes such as baked beans, pinto beans, kidney beans, lima beans, lentils, soybeans, chickpeas, or refried beans? Do not include green beans. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

46. During the ***past month***, how often did you eat brown rice or other cooked whole grains, such as quinoa, barley, bulgur, cracked wheat, or millet? Do not include white rice. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

47. During the ***past month***, not including what you just told us about (green salads, potatoes, cooked dried beans etc.), how often did you eat other vegetables? Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

48. During the past month, how often did you eat nuts and seeds such as peanuts, cashews, walnuts, pecans, sunflower seeds or pumpkin seeds? Check one.

- Never
- 1x last month
- 2-3 times last month

- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

49. During the ***past month***, how often did you eat pizza? Include frozen pizza, fast food pizza, and homemade pizza. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

50. During the ***past month***, how often did you eat tomato sauces such as with spaghetti or noodles or mixed into foods such as lasagna? Do not include tomato sauce on pizza. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

51. During the ***past month***, how often did you eat any kind of cheese? Include cheese as a snack, cheese on burgers, sandwiches, and cheese in foods such as lasagna, quesadillas, or casseroles. Do not include cheese on pizza. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

52. During the ***past month***, how often did you eat yoghurt, Greek yoghurt or other dairy products? Do not include fluid dairy milk or cheese. Check one.

- Never
- 1x last month

- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

53. During the ***past month***, how often did you eat red meat, such as beef, pork, ham, or sausage? Include red meat you had in sandwiches, lasagna, stew, and other mixtures. Red meats may also include veal, lamb, and any lunch meats made with these meats. Do not include chicken, turkey or seafood. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

54. During the ***past month***, how often did you eat any processed meat, such as bacon, lunch meats, or hot dogs? Include processed meats you had in sandwiches, soups, pizza, casseroles, and other mixtures. Processed meats are those preserved by smoking, curing, or salting, or by the addition of preservatives. Examples are: ham, bacon, pastrami, salami, sausages, bratwursts, frankfurters, hot dogs, or spam. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

55. During the ***past month***, how often did you eat poultry such as chicken or turkey? Include poultry you had in sandwiches, lasagna, stew, and other mixtures. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

56. During the ***past month***, how often did you eat fish or seafood? Check one.

- ○ Never
- ○ 1x last month
- ○ 2-3 times last month
- ○ 1x/week
- ○ 2x/week
- ○ 3-4x/week
- ○ 5-6x/week
- ○ 1x/day
- ○ 2 or more times/day

57. During the past month, how often did you eat vegetarian meat alternatives and soy products such as tofu, vegetarian sausage, vegetarian cold cuts etc.? Check one.

- ○ Never
- ○ 1x last month
- ○ 2-3 times last month
- ○ 1x/week
- ○ 2x/week
- ○ 3-4x/week
- ○ 5-6x/week
- ○ 1x/day
- ○ 2 or more times/day

58. During the ***past month***, how often did you eat whole grain bread including toast, rolls and in sandwiches? Whole grain breads include whole wheat, rye, oatmeal and pumpernickel. Do not include white bread or multigrain bread. Check one.

- ○ Never
- ○ 1x last month
- ○ 2-3 times last month
- ○ 1x/week
- ○ 2x/week
- ○ 3-4x/week
- ○ 5-6x/week
- ○ 1x/day
- ○ 2 or more times/day

59. During the ***past month***, how often did you eat chocolate or any other types of candy? Do not include sugar-free candy. Check one.

- ○ Never
- ○ 1x last month
- ○ 2-3 times last month
- ○ 1x/week
- ○ 2x/week
- ○ 3-4x/week
- ○ 5-6x/week
- ○ 1x/day
- ○ 2 or more times/day

60. During the ***past month***, how often did you eat doughnuts, sweet rolls, Danish, muffins, pan dulce, or pop-tarts? Do not include sugar-free items. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

61. During the ***past month***, how often did you eat cookies, cake, pie or brownies? Do not include sugar-free kinds. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

62. During the ***past month***, how often did you eat ice cream or other frozen desserts? Do not include sugar-free kinds. Check one.

- Never
- 1x last month
- 2-3 times last month
- 1x/week
- 2x/week
- 3-4x/week
- 5-6x/week
- 1x/day
- 2 or more times/day

63. During the ***past month***, did you take any of the following supplements? Check all that apply.

- Multivitamin
- Calcium
- Vitamin D
- Vitamin B12
- Vitamin C
- Iron
- Omega – 3
- Other, please specify:
- I did not take any supplements

64. Please specify how often (per week) and much (units/dosage per intake) of [automatic insert of responses above] you took during the past month:

65. Do you identify as one of the following:
- Pescetarian (you eat fish, eggs, dairy, but no meat or poultry)
- Vegetarian (you eat eggs and dairy, but no fish, meat or poultry)
- Vegan (you don't eat any animal products)
- Other, please specify:
- I don't identify as any of the above
- Prefer not to say

66. How old were you when you first identified as [automatic insert of response above]?

67. What is you reason to identify as [automatic insert of response above]? Check the option that is your most important reason.
- Weight loss
- Health reasons
- Ethical reasons (i.e. to reduce the suffering of animals)
- Environmental reasons
- Religious or cultural reasons
- Other, please specify:
- Prefer not to say

68. Do you have any of the following food allergies? Check all that apply.
- Peanuts
- Tree nuts (almonds, brazil nuts, cashews, hazelnuts, macadamia, pecans, pine nuts, pistachios, walnuts)
- Eggs
- Lactose
- Wheat
- Gluten
- Sesame
- Soy
- Mustard
- Fish
- Shellfish (i.e. crustaceans and molluscs)
- Other, please specify:
- I have no food allergies
- Prefer not to say

Awesome, part two is done, too!

In this final and short part of the survey, we will ask you a few questions about yourself. Remember that answering these questions is voluntary. If you choose not to answer a certain question, please check the box "prefer not to say" or leave the text box blank in order to move on to the next question.

69. How old are you (in years)?

70. Which term do you use to describe you gender identity?
    - Woman
    - Man
    - Trans Woman
    - Trans Man
    - Gender queer
    - Other, please specify:
    - Prefer not to say

71. What term best describes your sexual orientation?
    - Asexual
    - Bisexual
    - Gay
    - Lesbian
    - Pansexual
    - Queer
    - Same gender loving
    - Straight/homosexual
    - Other, please specify:
    - Prefer not to say

72. What is your relationship status?
    - Not in a relationship
    - In a relationship but not living together
    - In a relationship and living together
    - I'm not sure
    - Prefer not to say

73. What is your height (please indicate feet and inches or centimeters)?

74. What is your weight (please indicate pounds or kilograms)?

75. How would you describe your ethnic or cultural background?
    - Aboriginal/First Nation
    - Arab
    - Black
    - Chinese
    - Filipino
    - Japanese
    - Korean
    - Latin American
    - South Asian (e.g. Indian, Pakistani, Sri Lankan)
    - Southeast Asian (e.g. Vietnamese, Cambodian, Malaysian)

- West Asian (e.g. Iranian, Afghan)
- White
- Other, please specify:
- Prefer not to say

76. Are you an international student?
    - Yes
    - No
    - Prefer not to say

77. Is English your first language?
    - Yes
    - No
    - Prefer not to say

78. Where do you currently live?
    - Campus residency hall, please specify which one:
    - Fraternity or sorority house
    - Other university housing, please specify:
    - Parent or guardian's home
    - In a house/apartment by myself
    - In a house/apartment with room mates
    - Other off-campus housing, please specify:
    - Prefer not to say

79. What is your current year in school?
    - 1st year undergrad
    - 2nd year undergrad
    - 3rd year undergrad
    - 4th year undergrad
    - Higher than 4th year undergrad
    - Graduate or professional degree
    - Not seeking a degree
    - Other, please specify
    - Prefer not to say

80. What is your field of study?_____

Would you like to enter the draw to win one of several $50 gift cards? You will need to enter your email address, however, this will be stored separately and will not be traceable to the answers you have given above. Thank you so much for your time, we greatly appreciate your help!