

**Barriers and enablers to achievement of
food security and high-quality diets for tertiary
education students in Australia**

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Abstract

Considering the large number of international students enrolled in Australian tertiary education institutions, their barriers to achieving nutritional health require more attention and research. Food insecurity remains a public health concern in tertiary education students in developed countries, and poor diet quality has been commonly reported in young adults. This thesis aimed to explore dietary changes experienced by international students and to assess food security status and diet quality among domestic and international students attending a large Australian university. Evidence-based recommendations are provided to achieve food security and better diet quality in domestic and international tertiary education students.

Chapter One introduces the key concepts in this thesis, including international students, dietary acculturation, food security, and diet quality, and provides an outline of the thesis.

Chapter Two describes the methods that have been used in this thesis, starting with the procedures of a scoping review and a systematic review, followed by the mixed methods research design, including one qualitative study using semi-structured interviews, and two quantitative studies using surveys.

Chapter Three presents a scoping review of dietary acculturation and food insecurity among international tertiary education students. This review synthesised both qualitative and quantitative evidence on dietary changes and food security status of international students. These students often had a hybrid diet in the host country as they were able to adapt to the local food culture while maintaining some of their original dietary habits. International students appeared to have a higher risk of experiencing food insecurity than their domestic peers, but this issue was insufficiently researched in international students.

Chapter Four presents a systematic review of the association between food security status and dietary outcomes in university students. Poorer dietary outcomes appeared to be associated with food insecurity in university students, although only a small number of studies reported statistically significant findings. The overall diet quality of students with different food security status was rarely measured using validated dietary assessment tools.

The next three chapters report three primary studies using a mixed methods research design. Recruitment for these studies was extremely difficult due to the COVID-19 pandemic, especially because international students were not permitted to enter Australia from early 2020 until December 2021 due to the closure of national borders.

Chapter Five presents a qualitative study using semi-structured interviews and interpretative phenomenological analysis to explore dietary experiences of international students after their arrival in Australia. Fourteen international students from a large Australian university were interviewed. These students adapted to the local food environment but experienced challenges in finding their preferred food choices and having a healthy diet in Australia. Living independently for the first time contributed most to their dietary changes because they had not needed to arrange or cook meals when living with parents and on campus in their home country. Time and financial constraints affected their meal regularity and the frequency of cooking and dining out. The inability to enjoy authentic traditional foods in Australia upset some international students.

Chapter Six compares the prevalence of food insecurity and its risk factors and impacts between international and domestic students in a large Australian university during the COVID-19 pandemic. Food security status was assessed through a cross-sectional online

survey based on the 18-item Household Food Security Survey Module. A total of 376 domestic students and 91 international students completed the survey. The prevalence of food insecurity was 13.0% in domestic students and 18.7% in international students in our sample. International students had a higher risk of experiencing food insecurity compared with domestic students (OR = 2.02, 95% CI 1.00–4.07, $p = 0.013$). Domestic students with food insecurity reported lower intakes of fruits and poor academic outcomes than food-secure students. Poorer wellbeing was found in both domestic and international students with food insecurity compared with food-secure students. The risk factors for food insecurity and strategies to cope with food insecurity are also reported in this chapter.

Chapter Seven reports a dietary recall sub-study of the food security survey. To measure the diet quality of domestic and international students from a large Australian university, this study collected 24-hour dietary recalls using the Automated Self-Administered 24-hour Dietary Assessment Tool Australian version (ASA24-Aus) and applied the validated Healthy Eating Index for Australian Adults (HEIFA-2013). A total of 115 domestic students and 26 international students completed one dietary recall, and poor diet quality was found in both student groups. An association between food insecurity and poorer diet quality was indicated among our sample population. Better cooking skills and higher cooking frequency were associated with better diet quality.

The thesis concludes with **Chapter Eight** which summarises the key findings from this thesis and discusses recommendations for future practice to achieve food security and better diet quality among international and domestic tertiary education students. Directions for future research into dietary experiences of tertiary education students are also included in the final chapter.

Declaration

This is to certify that to the best of my knowledge, the content of this thesis is my own work.

This thesis has not been submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Yumeng Shi

26 October 2022

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Note on authorship contribution

I Yumeng Shi (the candidate) hereby declare that no part of this thesis has been submitted for a degree at The University of Sydney or at any other tertiary institution. The research presented in this thesis was conducted by the candidate under the guidance of my supervisor Professor Margaret Allman-Farinelli. Contributions were made by the supervisor as well as co-authors Natalya Lukomskyj, Dr Alyse Davies, Dr Nematullah Hayba, and Dr Amanda Grech. All work presented in this thesis is the original work of the candidate and the aforementioned supervisor and co-authors.

For **Chapters Three to Seven**, contributions are outlined in the author contribution section at the beginning of each chapter. The research questions and design of studies presented in these chapters were developed by myself (the candidate) and my supervisor Professor Margaret Allman-Farinelli. I was the primary researcher involved in conducting these studies and wrote the first draft of the manuscript for publication in **Chapters Three to Seven**.

In **Chapters Three and Four**, I (the candidate) developed the review protocols, conducted the literature search, study selection, and data extraction, and synthesised the findings. In **Chapter Five**, I developed the interview guide, completed the semi-structured interviews, and analysed the qualitative data. In **Chapter Six**, I developed the questionnaire, conducted the survey, and analysed the data. In **Chapter Seven**, I managed the data collection and conducted the data analysis with assistance from Dr Amanda Grech.

Authorship attribution statement

As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statements above are correct.

Margaret Allman-Farinelli

26 October 2022

In addition to the statements above, in cases where I am not the corresponding author of a published item, permission to include the published material has been granted by the corresponding author.

Yumeng Shi

26 October 2022

Ethical approval

Methods and materials of the qualitative study to explore dietary changes of international students in Australia, as detailed in **Chapter Five**, were approved by the Human Research Ethics Committee at The University of Sydney in February 2020 (approval number 2020/006, see Appendix II-1).

Methods and materials of the pilot test of the food security questionnaire among Australian university students, as detailed in **Chapter Two** and **Chapter Six**, were approved by the Human Research Ethics Committee at The University of Sydney in July 2021 (approval number 2021/445, see Appendix II-2).

Methods and materials of the study to assess food security status and diet quality of international and domestic students in Australian universities, as detailed in **Chapter Six** and **Chapter Seven**, were approved by the Human Research Ethics Committee at The University of Sydney in October 2021 (approval number 2021/745, see Appendix II-3).

Publications

The following first-author peer-reviewed publications arose directly from research conducted as part of the PhD candidature:

1. **Shi Y**, Lukomskyj N, Allman-Farinelli M. Food access, dietary acculturation, and food insecurity among international tertiary education students: a scoping review protocol. *JBIEvidence Synthesis*. 2020;18(9):2090-2097.
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3. **Shi Y**, Davies A, Allman-Farinelli M. The association between food insecurity and dietary outcomes in university students: a systematic review. *Journal of the Academy of Nutrition and Dietetics*. 2021;121(12):2475-2500.e1. **(Chapter Four)**
4. **Shi Y**, Hayba N, Allman-Farinelli M. International tertiary education students experienced difficulties in dietary transitions in Australia: a qualitative study. *Health Promotion Journal of Australia*. Published online Apr 7, 2023. doi:10.1002/hpja.728 **(Chapter Five)**
5. **Shi Y**, Allman-Farinelli M. Food insecurity among international and domestic students in an Australian university two years into the global COVID-19 pandemic. Under review in *European Journal of Clinical Nutrition*. **(Chapter Six)**
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9. Hayba N, **Shi Y**, Allman-Farinelli M. Enabling better nutrition for adolescents from Middle Eastern backgrounds: semi-structured interviews with parents. *Nutrients*. 2021;13(11):3918.
10. Davies A, **Shi Y**, Bauman A, Allman-Farinelli M. Validity of new technologies that measure bone-related dietary and physical activity risk factors in adolescents and young adults: a scoping review. *International Journal of Environmental Research and Public Health*. 2021;18(11):5688.
11. Lukomskyj N, **Shi Y**, Allman-Farinelli M, Rangan A. Associations between breakfast consumption from childhood to adulthood and cardiometabolic health: a systematic review. *Nutrition & Dietetics*. 2021;78(1):6-23.
12. Lukomskyj N, Allman-Farinelli M, **Shi Y**, Rangan A. Dietary exposures in childhood and adulthood and cardiometabolic outcomes: a systematic scoping review. *Journal of Human Nutrition and Dietetics*. 2021;34(3):511-523.
13. Sainsbury E, **Shi Y**, Flack J, Colagiuri S. The diagnosis and management of diabetes in Australia: does the “Rule of Halves” apply? *Diabetes Research and Clinical Practice*. 2020;170:108524.

Conference abstracts

Oral presentations

1. **Shi Y**, Allman-Farinelli M. “A comparison of food security status among international and domestic students in Australian universities”. Dietitians Australia 2022 Conference, August 2022, Adelaide, Australia
2. **Shi Y**, Davies A, Allman-Farinelli M. “Food insecurity is associated with poorer dietary outcomes in university students: a systematic review”. 7th Charles Perkins Centre EMCR Symposium 2021, September 2021, Sydney, Australia
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1. **Shi Y**, Lukomskyj N, Davies A, Hayba N, Grech A, Allman-Farinelli M. “Barriers and enablers to achievement of food security and high-quality diets for international and domestic tertiary education students in Australia”. School of Life and Environmental Sciences Higher Degree Research Exit Seminar, August 2022, Sydney, Australia (Exit oral seminar)
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3. Louie S, **Shi Y**, Allman-Farinelli M. “The effects of the COVID-19 pandemic on food security in Australia and implications for program planning: a scoping review”. The Nutrition Society of Australia (NSA) 2021 Virtual Conference ‘Opportunities for Nutrition Science in a New Era’, December 2021, Australia
4. Lukomskyj N, **Shi Y**, Allman-Farinelli M, Rangan A. “The relationship between breakfast consumption from childhood to adulthood and cardiometabolic outcomes: a systematic review”. Dietitians Australia 37th National Conference, August 2020, Melbourne, Australia
5. Lukomskyj N, **Shi Y**, Allman-Farinelli M, Rangan A. “Associations between individual long-term diet from childhood to adulthood and cardiometabolic outcomes: a systematic review”. International Journal of Behavioral Nutrition and Physical Activity (ISBNPA) 2020 Annual Meeting, June 2020, Auckland, New Zealand

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Abbreviations

24HR	24-hour recall
ADG	Australian Dietary Guidelines
AGHE	Australian Guide to Healthy Eating
ASA24	Automated Self-Administered 24-hour Dietary Assessment Tool
ASA24-Aus	Automated Self-Administered 24-hour Dietary Assessment Tool Australian version
AUSNUT	Australian Food, Supplement and Nutrient Database
BMI	Body mass index
BMR	Basal metabolic rate
CI	Confidence interval
EI	Energy intake
FI	Food insecure/insecurity
FS	Food secure/security
FSSM	Food Security Survey Module
HEIFA-2013	Healthy Eating Index for Australian Adults
HFIAS	Household Food Insecurity Access Scale
HFSSM	Household Food Security Survey Module
HREC	Human Research Ethics Committee
JBI	JBI, formerly known as the Joanna Briggs Institute
NSW	New South Wales
OR	Odds ratio
PRISMA	Preferred Reporting Items for Systematic reviews and Meta-Analyses
PRISMA-ScR	Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews

REDCap	Research Electronic Data Capture
SD	Standard deviation
SNAP	Supplemental Nutrition Assistance Program
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture
WHO	World Health Organization

Chapter One. Introduction

1.1 Introduction to chapter^a

This thesis aims to explore the dietary experiences of international and domestic tertiary education students in Australia using a mixed methods research design, and to develop evidence-based recommendations for these two student groups to achieve food security and improve diet quality. The context and key concepts of this thesis are described in **Chapter One**, along with specific aims and an outline of the thesis.

^a Four chapters of this thesis have been published (Chapters Three, Four, Five, and Seven). Chapter Three, Four, and Seven are presented in the journal format. For Chapter Five, a modified version of the publication is presented. For Chapter Six, a modified version of the submitted manuscript (under review) is presented. For Chapter Five and Six, layout, terminology, English language, and referencing style is in accordance with journal requirements. Chapters One, Two, and Eight (unpublished) use Australian English and AMA 11th referencing style.

1.2 International students

1.2.1 Definition of international students

International students are defined as individuals who leave their home country to receive tertiary education (i.e., at a college or university) in a foreign country with a temporary visa.^{1,2} These students do not hold citizenship or permanent residency in the destination country (i.e., host country).

1.2.2 Trends in international tertiary education

The internationalisation of tertiary education has substantially expanded in the past two decades.¹ The most attractive destination countries for international students are the United States (US), the United Kingdom (UK), and Australia.^{1,3} Some other countries, such as the Netherlands, Russia, Canada, China, and Malaysia, have gained an increased share of the market in recent years.³ The major source of international students globally is Asian countries such as China, India, and South Korea.^{3,4}

In Australia, the number of international students enrolled in tertiary education institutions was increasing prior to the COVID-19 pandemic and reached 521,948 in 2019.⁵ The two largest source countries of international tertiary education students in Australia were China and India (totalling 51% of international students in 2019 when this PhD began), which is consistent with the global trend; the next largest source countries were Nepal, Malaysia, and Vietnam.³⁻⁵ The proportion of international students in Australian universities ranged from 2% to 50%.⁶ According to data from the Organisation for Economic Co-operation and Development in 2018, the proportion of international students in the tertiary education sector in Australia (27%) is the second highest in the world, after Luxembourg (48%).^{1,7}

The global COVID-19 pandemic caused a decline in international student enrolments in some popular host countries.^{8,9} In Australia, the US, and Canada, the declines were reported to be approximately 20% or less in 2020 and 2021.^{8,9} This modest reduction was a result of tertiary education institutions responding quickly to transfer to online teaching immediately after the outbreak to overcome international travel restrictions. In Australia, international students from mainland China were not allowed to enter Australia from February 2020, and by March 2020, all offshore international students were unable to enter Australia due to the closure of the national borders.¹⁰ The number of onshore international students decreased during the pandemic because no commencing students could enter the country and existing students completed their studies and left the country after graduation.^{11,12} International students were permitted to enter Australia from December 2021,¹³ but some students remained offshore according to the most recent data in 2022.¹⁴

Before the COVID-19 pandemic, international tertiary education substantially contributed to the economy of host countries through the revenue from tuition fees and living expenses of international students.⁴ In Australia, international education was the third largest export in the 2014–15 financial year and was still the fourth largest in the midst of the COVID-19 pandemic.^{15,16} International students choosing to stay in the host country after graduation contributed to the labour market and the economy in the long run.⁴

1.2.3 Challenges for international students

International students face many challenges, especially during the transition period after their arrival in the host country. Cultural differences and language barriers may cause difficulties in both social and academic life when studying in the tertiary education facilities of the host country. Friendship formation and relationship development with individuals from different

countries are not easy endeavours for international students living in a foreign country.¹⁷ Differences in teaching styles and the relationship between student and faculty/professors mean international students take time to adjust before achieving favourable academic outcomes.^{17,18} Some international students studying in Western countries may have financial support from wealthy families, but financial challenges remain common in the entire international student cohort due to high and rising tuition fees and cost of living with limited job and financial assistance opportunities.^{4,17} International students may find health care services in the host country to be less accessible than in their home country because of their unfamiliarity with the payment systems and health insurance in the host country.¹⁹

Psychological distress from the aforementioned challenges is common in international students.²⁰⁻²² Although domestic students may experience similar levels of stress, international students in Australia were found to be receiving less social support and were less likely to seek help for mental health issues than their domestic peers.^{21,23} Previous research has identified several barriers for international students to access counselling services, such as perceived high costs, lack of time, language difficulties, insufficient knowledge of symptoms of mental health problems and available services, the perception that the severity of symptoms was not enough to seek treatment, and self-stigma (avoiding telling others about mental illness).^{23,24}

1.3 Dietary acculturation

1.3.1 Acculturation

When settling in a foreign cultural environment, people experience acculturation, which involves both assimilation to the host culture and maintenance of the original culture.²⁵ Individuals may have different processes of acculturation, which have been summarised by

Berry into four types: integration, assimilation, separation, and marginalisation (see Figure 1.1).²⁶ Integration refers to individuals who are willing to maintain their cultural identity and interact with the host culture simultaneously; this group tends to have the lowest level of acculturative stress and better performance in adaptation. In contrast, marginalisation is defined as having limited interests in either maintaining their cultural identity or interacting with the host culture, and this is the most stressed group. Assimilation refers to showing more interest in moving towards the host culture and avoiding the original culture, while the opposite is defined as separation.

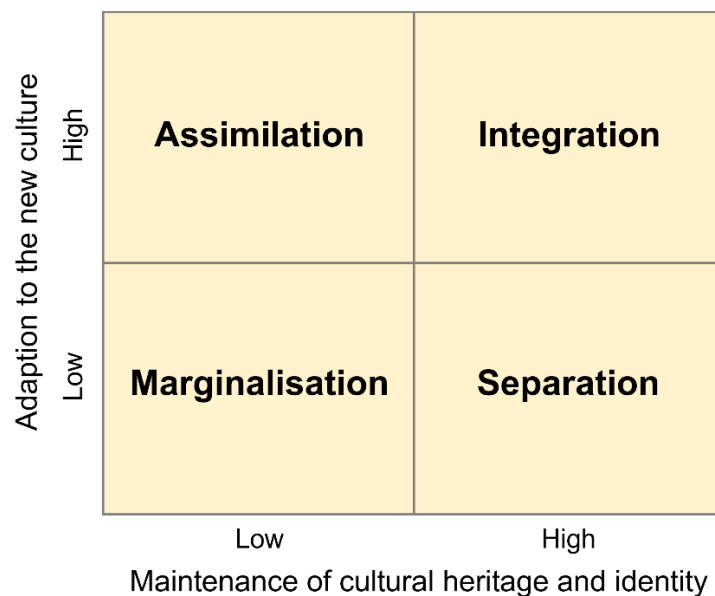


Figure 1.1. Berry’s model of acculturation.²⁶

For international students, the process of acculturation occurs in many aspects of life in the host country, for example, academic learning, communicating with professors and peers from different cultural backgrounds, diet, and other health-related behaviours.^{27,28} This adjustment process can generate both excitement and stress. Acculturative stress may contribute to some negative health outcomes such as poor sleep and appetite, fatigue, blood pressure and

digestive problems, and even depression among international students.²⁹ On the other hand, acculturation may also bring some positive changes for these students, such as perceived discouragement of smoking and encouragement of physical activities for females in the US.^{30,31}

A higher level of acculturative stress and difficulties in adjustment and adaption is correlated with larger perceived cultural distance.^{32,33} For example, in Russian universities, exchange students from Asia reported the greatest perceived cultural distance and the highest level of stress compared with students from the former Soviet Union and Africa.³⁴ Students from East Asia were found to have more difficulties in adjusting to the American culture compared with students from places with more similar cultures, such as Europe and South America.¹⁷

The adjustment to life in the host country is a dynamic journey for international students. A U-curve model has often been used to describe the experience of individuals who move to a foreign country, beginning with excitement and positive feelings, then declining to experience a crisis with disorientation, followed by recovery with better adjustment.³⁵⁻³⁷ However, this model was not supported by data from some studies of international students. Bailey and Dua found Asian students experienced the most stress within their first six months of residence in Australia.³⁸ Brown and Holloway reported that negative feelings (e.g., stress and anxiety) associated with culture shock predominated at the initial stage of the adjustment process and may gradually reduce with time, but feelings of homesickness and loneliness were more unpredictable.³⁹ Chien argued that the U-curve model is no longer applicable to the adjustment and adaption of international students because their experience tends to be more complex with the development of globalisation and technology.⁴⁰

To facilitate adjustment and address acculturative stress for international students, both tertiary institutions and host countries need to provide more tailored and culturally appropriate intervention programs and counselling services.^{27,28} Also, encouraging the utilisation of academic and health counselling, and reducing the stigma around mental illness and seeking help for these students may be necessary to ease their acculturation process.^{27,28}

1.3.2 Dietary acculturation

Food is one of the essential domains of cultural identity, and dietary habits may differ considerably within a country and across nations.^{41,42} Dietary acculturation refers to the adoption of the food choices and eating patterns in the host country by individuals who move to a foreign country.⁴³ Similar to other aspects of acculturation, dietary acculturation is a complex and dynamic process rather than a linear change from the original diet to the host country diet.^{44,45}

Both quantitative and qualitative measures have been used to research dietary acculturation.^{46,47} Quantitative methods have included dietary acculturation scales, dietary assessment (e.g., food frequency questionnaire, 24-hour recall, and food diary), and questionnaires on general eating patterns. The main qualitative approaches have been semi-structured interviews and focus groups exploring dietary changes before and after arriving in the host country, and factors influencing the changes, in addition to health outcomes. Some studies have used a combination of quantitative and qualitative measures (i.e., mixed methods).^{48,49}

Some previous studies have explored dietary acculturation among Asian immigrants in a host country with Western culture, for example, countries in North America, Europe, and

Australasia.⁵⁰⁻⁵⁴ Immigrants are often open to new foods in the host country while they maintain some of their original dietary habits.^{54,55} Breakfast appears to be the first meal acculturated to the host dietary style, while evening meals were more likely to retain traditional styles.^{53,56} Both healthy and unhealthy dietary transitions were observed across studies. Some Asian immigrants reported increased awareness and attempts to consume greater amounts of healthy foods (e.g., fruits, vegetables, and grains) and follow a low-fat diet after their arrival in Canada.^{56,57} Alternatively, many immigrants adopted less healthy dietary behaviours, such as lower consumption of fruits and vegetables, and more frequent consumption of fast and processed foods, which contributed to excessive energy intakes, higher intakes of fat and added sugar, but reduced intake of fibre and micronutrients.⁵⁷⁻⁶⁰ In Australia, Asian immigrants were found to have increased intakes of energy-dense choices and decreased intakes of healthy choices (e.g., soy, green vegetables, and tea).⁵⁴ Changes in meal preparation methods also occurred, with Asian immigrants increasingly using local cooking styles and healthier cooking methods such as grilling and stir-frying.^{53,56,57}

The factors influencing the changes in dietary habits of Asian immigrants living in Western countries are multidimensional. Migration-related factors include language barriers and length of residence in the host country.^{50,55,56} Immigrants' food choices may be restricted by their religion and socioeconomic status.^{50,55} Food-related beliefs, perceptions, and skills also contribute to immigrants' food decisions, for example, attitudes to traditional and local foods, unfamiliarity with food availability and cooking methods in the host country, nutrition knowledge, taste preferences, and cooking skills.^{50,54,61} Psychosocial factors include time constraints and stress.^{53,55} Environmental factors include the availability and cost of, and access to, traditional versus local foods.^{55,61} Traditional foods have become more available in

recent decades with the development of globalisation, but limited availability of proper traditional ingredients is still reported.^{55,61}

Unhealthy transitions during the process of dietary acculturation may contribute to the elevated risk of developing diet-related chronic conditions, such as obesity, diabetes, coronary heart disease, and osteoporosis, after migration to a host country.^{54,55,59} The Western diet has been constantly criticised for its contribution to noncommunicable diseases.^{62,63}

Compared with immigrants, international students may have different experiences in dietary acculturation as they tend to be younger and their residence in the host country is more temporary than for immigrants.⁶⁴ The associated influencing factors and outcomes may also be different considering the differences in sociodemographic characteristics between two groups, such as employment status and income. Experiences of international students in dietary acculturation will be described in **Chapter Three**.

1.3.3 Food environment in Australia

1.3.3.1 Community food environment

In studies that measured food environments in Australia, easy access to unhealthy foods and less support for getting healthy foods have been frequently reported. Unhealthy foods and beverages (i.e., discretionary choices) predominated price promotions and the display of checkout areas in supermarkets.^{65,66} Discretionary choices refer to foods and beverages that are not included in the five food groups (i.e., fruit, vegetables, grain foods, dairy products, and other main sources of protein such as lean meats, poultry, fish, and eggs) and which contain high saturated fat and/or added sugars, salt, or alcohol, and low fibre.⁶⁷

Unhealthy food outlets (e.g., convenience stores, fast food chains) often outweighed healthy food outlets (e.g., supermarkets) in close proximity to their home.⁶⁸⁻⁷⁰ In rural/regional and more disadvantaged areas (e.g., low socioeconomic status areas), people are exposed to a less supportive environment for healthy foods than urban and less disadvantaged areas. For example, Whelan et al. found considerable difficulties in purchasing healthy foods anywhere other than supermarkets in rural Australia,⁷¹ and Cameron observed less shelf spaces for fruits and vegetables in rural supermarkets than in urban ones.⁷² Higher prices of fruits and vegetables in remote areas than in highly accessible areas in New South Wales (NSW) were noted by Chapman et al.⁷³ However, another study conducted in urban Melbourne reported greater access to both supermarkets and fast food outlets in more disadvantaged areas than in less disadvantaged areas.⁷⁴ The use of online food delivery services became more prevalent during the COVID-19 pandemic; however, popular food outlets and menu items available from these services are dominated by discretionary choices.^{75,76}

A higher proportion of healthy food outlets near home may be positively associated with healthier dietary practices, such as better diet quality, and purchasing more fruits and vegetables, based on studies conducted in Australian communities,^{70,77-81} but nonsignificant associations have also been reported.⁸² Some studies found an association between the healthfulness of the food environment and body mass index (BMI), but findings were inconsistent in the direction (i.e., positive or negative) and the significance of the association.^{69,74,82-84}

1.3.3.2 Food environment on campus

Similar to the general physical food environment in Australia, unhealthy food and beverage options are more readily available than healthy choices on Australian campuses. The

dominance of energy-dense and nutritionally poor foods and beverages is very typical in food outlets and vending machines in tertiary education institutions.⁸⁵⁻⁹⁰ Findings regarding the differences between the cost of healthy and unhealthy choices on campus in Australia have been mixed. Whatnall et al. and Shi et al. found healthy foods were significantly more expensive than unhealthy foods; the latter study found the same trend in beverages, while the former study found the opposite in beverages. However, Ng et al. found no significant differences in the cost of healthy and unhealthy choices for both foods and beverages in a regional campus.⁸⁵⁻⁸⁷

Poorer dietary intakes were found in tertiary education students who purchased more food and beverage items on campus, for example, lower consumption of foods from the five food groups but higher consumption of discretionary choices.^{91,92} Specific policies are now available to regulate food availability and promotion in health facilities and schools in some states, but rarely for food environments in tertiary institutions.⁹³⁻⁹⁶ Consumers in universities are aware of the limited availability of healthy food choices on campus, and they urge improvements in the variety of healthy foods and beverages with better prices.^{85,97}

1.4 Food insecurity

1.4.1 Definition of food security

At the first World Food Summit held by the Food and Agriculture Organization of the United Nations (FAO) in 1996, food security was defined as follows: “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”.⁹⁸ It is a human right to have adequate food to maintain nutritional balance.^{99,100} The FAO definition

identifies four dimensions that are commonly used to assess food security: food availability, food access, utilisation, and stability (see Figure 1.2).^{99,101-103}

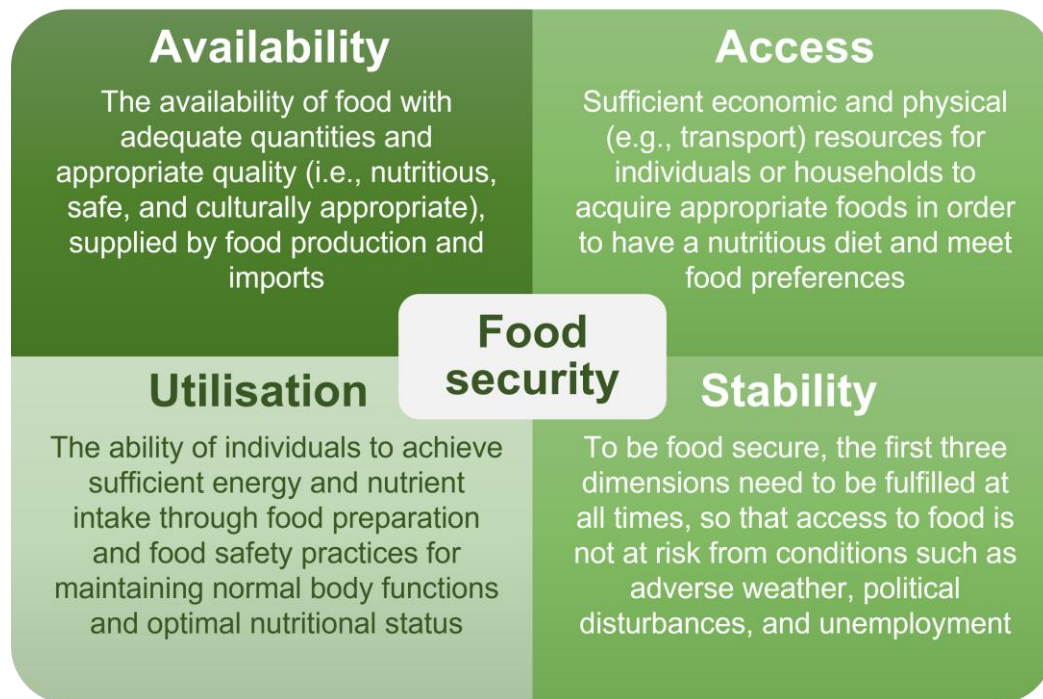


Figure 1.2. Four key dimensions of food security.

1.4.2 Tools for measuring food security status

Various assessment tools have been used to measure food security status in different countries at the individual and household levels. Some review articles have grouped these tools into three categories – experience-based, coping strategy, and dietary diversity indicators – and these will be described below.^{102,104}

The most commonly used tools were those assessing the food insecurity experience of the individual or household.¹⁰⁴⁻¹⁰⁶ In 2006, the US Department of Agriculture (USDA) developed the 18-item Household Food Security Survey Module (FSSM) to measure food security status of households with dependent children,¹⁰⁷ the 10-item Adult FSSM for use with individuals

or households without dependent children,¹⁰⁸ and the 6-item short-form FSSM as a substitute when longer versions cannot be implemented.¹⁰⁹ These USDA tools classify food security status into four categories: high, marginal, low, and very low. The threshold of low food security is two affirmative responses in the 6-item FSSM and three affirmative responses in the two longer versions. The threshold of very low security is five, six, and eight affirmative responses in the 6-item, 10-item, and 18-item tools, respectively.¹⁰⁷⁻¹⁰⁹ Examples of other multiple-item tools include the Radimer/Cornell Food Security Scale,¹¹⁰ the Food Insecurity Experience Scale,¹¹¹ the Household Food Insecurity Access Scale (HFIAS),¹¹² and the Household Hunger Scale.¹¹³ There are also some region- and country-specific tools, for example, the Latin American and Caribbean Household Food Security Scale,¹¹⁴ the Brazilian Household Food Insecurity Measurement Scale,¹¹⁵ and the New Zealand Household Food Security Measurement Tool.¹¹⁶ The Household Food and Nutrition Security Survey has been developed for the Australian population.^{117,118} The classification criteria of food security and insecurity differ between the tools. Most of these assessment tools focus on the ‘access’ dimension of food security, while the other three dimensions are rarely measured.^{101,105}

A single-item measure has also been widely used in Australian studies. The question “In the last 12 months was there any time you have run out of food and not been able to purchase more?” was applied in the Australian National Health Survey to estimate the prevalence of food insecurity.¹¹⁹ Other single-item tools include the single-item Food Insecurity Measure from the 2005 Oregon Pregnancy Risk Assessment Monitoring System,¹²⁰ and a single-item food security indicator from a food literacy behaviour checklist.¹²¹ However, single-item tools often show a lower prevalence of food insecurity than multiple-item tools, indicating that using a single question may underestimate the issue of food insecurity among the population.^{119,122-125}

Tools that measure coping strategies and dietary diversity have been less commonly used for assessing food security.^{102,104} Coping strategies are behavioural responses made by individuals or households when facing food insecurity and can be measured by tools such as the Coping Strategies Index.¹²⁶ Dietary diversity is one of the key components of diet quality and can be measured by tools such as the Household Dietary Diversity Score and Food Consumption Score, but these tools often require a short recall period (e.g., past week), which may not be able to represent the full picture of food insecurity experience.^{127,128}

Different measurement tools often have different ways in coding the levels of food security. For example, HFIAS contains four categories which are food secure, mildly food insecure, moderately food insecure, and severely food insecure,¹¹² while the aforementioned USDA tools used high, marginal, low, and very low food security.¹⁰⁷ Moreover, different ways of coding may be applied when using the same tool. The USDA tools suggested that high and marginal food security can be combined as the food-secure group, while low and very low food security can be combined as the food-insecure group.¹⁰⁷ However, some studies kept marginal food security as a separate category,¹²⁹ and some categorised marginal food security as part of the food-insecure group.¹³⁰ This classification considered the increased anxiety and insufficient capability over making food choices among people with marginal food security.¹³¹

Self-reported food security measurement tools may introduce some response biases. Firstly, respondents may overreport the severity of the hardship in the food availability dimension to receive more food aid, which is called economic desirability bias.¹³² On the other hand, social desirability bias refers to the underreporting of the difficulties in food access so as to hide problems.¹³² Secondly, in household surveys, the respondent might not be representative of

the whole household, as each household member may have different interpretations and experiences of food insecurity.¹³³ Another bias may be caused by the inconsistency of recall periods between respondents. For example, if a survey was active during seasonal transitions, respondents may or may not have experienced the transitional period depending on their time point to complete the survey.¹³³

1.4.3 Prevalence and severity of food insecurity

Compared with less economically developed countries, higher incomes and a more comprehensive social welfare system may contribute to a lower risk of experiencing food insecurity in developed countries; however, food insecurity is still one of the public health priorities to be tackled in rich countries.¹³⁴⁻¹³⁷ The prevalence of food insecurity is remarkably higher in vulnerable groups than in the general population within high-income countries, for example, among homeless people, the elderly, people who are struggling with addictions, and people living with a disability.^{138,139}

In Australia, the national prevalence of household food insecurity (i.e., affirmative response to the question “In the last 12 months was there any time you have run out of food and not been able to purchase more?” in the National Health Survey) was found to be approximately 4% from the 2011–12 survey, and 3.3% in NSW.¹⁴⁰ The severity of food insecurity was not indicated from the answers of this single question, but the follow-up question could provide more insight. Respondents with affirmative response to the previous question were asked if they or their household had gone without food.¹⁴⁰ The results showed that 1.5% of the general population and 1.1% of the NSW population had gone without food.¹⁴⁰ McKechnie et al. argued that the single-item tool used in national surveys potentially underestimated the national prevalence of food insecurity in Australia.¹¹⁹ By using the 8-item Food Insecurity

Experience Scale from FAO and data collected from the Gallup World Poll in 2014, the prevalence of moderate and severe food insecurity in Australia was 10.6%.¹⁴¹ A wide range (from 2% to 90%) in the prevalence and severity of food insecurity has been reported in the general population and specific population groups (e.g., young people) in Australia using different measurement tools.¹⁴²

1.4.4 Factors influencing food security status

The association between sociodemographic factors and food insecurity has been assessed in many Australian and international studies. Higher or lower odds of being food insecure have been found to be associated with different genders, immigration status, highest education level reached, household types, marital status, employment status, and income.¹⁴³⁻¹⁴⁵ Findings between different samples and contexts have been inconsistent. For example, in socioeconomically disadvantaged groups in Australia, being employed and having a higher household income were associated with a lower risk of food insecurity in a Victorian study,¹⁴⁶ but no association was found between sociodemographic factors and food insecurity in another sample in Western Australia.¹⁴⁷ In young adults, a higher risk of food insecurity was detected in adults with younger age, from minority backgrounds (e.g., Black and Indigenous), and with lower socioeconomic status and education.¹⁴⁸⁻¹⁵¹

Food preparation resources and skills have also been found to be associated with food insecurity.^{121,152,153} The adequacy of cooking equipment and storage facilities was inversely associated with the risk of food insecurity in a cross-sectional survey in college students in the US.¹⁵³ Lower self-perceived cooking skills were reported by food-insecure participants in an Australian study,¹²¹ while this association was not found in a Canadian sample.¹⁵⁴

1.4.5 Health outcomes and food insecurity

Food-insecure adults may have worse diets and a higher risk of chronic diseases such as obesity, type 2 diabetes, and cardiovascular diseases than food-secure individuals.^{144,155-159} Similar negative outcomes have been reported in food-insecure young adults.^{148,160} In emerging adulthood, during the transition from adolescence to adulthood,¹⁶¹ poorer diet quality and eating habits, such as lower consumption of vegetables and whole grains, higher consumption of sugary drinks, and skipping breakfast, were found in food-insecure adults compared with food-secure adults.¹⁶² More evidence of the association between food insecurity and dietary outcomes in university students will be described in **Chapter Four**. Many studies have shown an association between food insecurity and increased BMI/waist circumference in women.^{149,151,158,163-166} In contrast, studies from Korea and Iran did not find significant differences in the risk of metabolic syndrome between food-secure and food-insecure adults.^{167,168} A meta-analysis that pooled studies from 14 countries revealed that food insecurity was associated with obesity in adults living in developed countries, but it was associated with being underweight in adults living in the least developed countries.¹⁶⁹

Food insecurity has also been found to be associated with sleep and mental health problems among adults. Worse sleep outcomes include difficulty falling asleep, shorter sleep duration, and poorer sleep quality in food-insecure adults and young adults.¹⁷⁰⁻¹⁷⁴ Moreover, the association between food insecurity and poorer mental health status (e.g., higher odds of depression and psychological distress) has been frequently reported in both high-income and lower-income countries.¹⁷⁵⁻¹⁷⁸ This association may differ by age group, gender, and marital status.¹⁷⁹⁻¹⁸¹ Increased risk of depression and suicidal ideation has also been reported in food-insecure young adults.^{173,182} There is evidence to show that the risk of mental health disorders increases with the severity of food insecurity.^{180,183}

However, the direction of the association between health outcomes and food insecurity is not clear, as most findings were derived from cross-sectional studies. A systematic narrative review of longitudinal studies suggests a bidirectional association between emotional health and food insecurity.¹⁷⁵

1.4.6 Food insecurity during the COVID-19 pandemic

The ongoing COVID-19 pandemic has worsened the issue of food insecurity globally.¹⁸⁴⁻¹⁸⁶ More people are struggling with sourcing adequate food and having a good quality diet, and many have experienced food insecurity for the first time due to the changes that happened during the pandemic.¹⁸⁴⁻¹⁸⁷ In Australia, casual workers and international students became newly food insecure due to the loss of working opportunities and income in the first year of the pandemic.¹⁸⁷

Food affordability and physical food access have been substantially affected by the pandemic since early 2020 in Australia and many other countries.¹⁸⁴⁻¹⁸⁸ Loss of employment and income, with increased food prices, contributed to the reduction in food affordability, and pandemic-related restrictions (e.g., lockdowns) interrupted physical access to food.¹⁸⁴⁻¹⁸⁷ Food shortages occurred due to panic buying, particularly in the initial outbreak.¹⁸⁹ Continuous waves of the pandemic will have a fluctuating impact on food insecurity in future.

To cope with disruptions during the pandemic, sacrifices in the quality and/or quantity of food eaten were prevalent. For example, less fruits and vegetables but more processed foods were consumed by food-insecure emerging adults.^{190,191} Although more meals were prepared at home, the consumption of fast food also increased due to a limited budget for food shopping and limited availability in grocery stores.^{190,191} Moreover, choosing less preferred

food options and reducing the number of meals and portion sizes were reported.^{185,190,191} Negative changes in food choices during lockdowns were also reported by college students in the US.¹⁹² Continuous data collection and interventions will be needed to monitor and improve different dimensions of food security during and after the pandemic, especially for vulnerable groups.

1.4.7 Interventions to address food insecurity

To address household food insecurity in high-income countries, common interventions can be grouped into three types.¹³⁹ First, financial benefits are provided in the US, Canada, and some European countries as national interventions to reduce the number of food-insecure households.¹³⁹ In the US, the Supplemental Nutrition Assistance Program (SNAP) is implemented nationally to offer payments to participants who meet certain eligibility criteria so that they can purchase foods.¹⁹³ In some other rich countries, other financial benefits in health care and housing are available due to the proven association between food insecurity and these living expenses.¹³⁹ However, few policies have been made specifically for young adults or tertiary education students. Second, food banks provide free groceries to individuals, often without checking eligibility. However, the effectiveness of food banks is questionable due to their limited operating hours, the poor nutritional quality of provided foods, and the stigma people feel if they collect free foods.¹⁹⁴⁻¹⁹⁷ Third, programs at the community level include cooking classes, nutrition education, farmers' markets, community kitchens and gardens.¹⁹⁸⁻²⁰² These interventions mainly focus on improving physical food access and skills or knowledge in preparing meals, but their effects on decreasing the prevalence of food insecurity need to be enhanced to ensure sustainability.

A systematic scoping review identified that interventions in Australia have mostly concentrated on the food availability and utilisation dimensions of food security, but were limited in the dimension of economic access.²⁰³ However, during the COVID-19 pandemic, supplement payments from the government were seen to have some positive impacts in alleviating food insecurity.¹⁸⁷ Some people were able to use the payments for better meals, but payments may not have been enough to address food and nutrition insecurity for others due to the high cost of other living expenses.^{204,205}

1.5 Diet quality

1.5.1 Assessment of diet quality

1.5.1.1 Definition of diet quality and theoretical framework of diet quality indices

The definition of diet quality lacks consensus and changes over time.^{206,207} With improved knowledge about the relationship between nutrition and health outcomes, and increased food availability in recent decades, the concept of diet quality has also evolved.^{206,207} It is now an umbrella term often used to describe compliance with dietary recommendations to achieve optimal health and prevent diseases.²⁰⁶ Many determinants can influence diet quality in modern society, such as cultural background, food preferences, personal expectations, enjoyment, and convenience.²⁰⁷

Since development of the first index in 1994, a variety of diet quality indices have been developed and utilised in recent years.^{206,208} Many countries, including the US, Canada, European countries, and Australia, have developed diet quality indices on the basis of their national dietary guidelines to allow in-country comparisons.²⁰⁹⁻²¹³ For cross-country comparisons, some indices were designed based on commonly recommended diets (e.g., Mediterranean diet) and international dietary guidelines such as the healthy diet defined

by the World Health Organization (WHO).^{214,215} The target population and purpose of diet quality indices also vary. Indices may be developed for the general adult population or for specific groups (e.g., children, pregnant women), and focus on overall health or specific diseases (e.g., hypertension).²¹⁶⁻²¹⁸ Some examples of diet quality indices are listed in Table 1.1.

Table 1.1. Examples of existing diet quality indices.

Theoretical basis		Reference (author, year)	Diet quality index
National dietary guidelines	Dietary guidelines for Americans (2015–2020)	Reedy et al., ²⁰⁹ 2018	Healthy Eating Index – 2015
	Australian dietary guidelines (2013)	Collins et al., ²¹⁹ 2015	Australian Recommended Food Score
		Roy et al., ²²⁰ 2016	Healthy Eating Index for Australian Adults – 2013
	New Zealand food and nutrition guidelines for healthy adults	Wong et al., ²²¹ 2017	Healthy Dietary Habits Index
	Dutch dietary guidelines (2015)	Looman et al., ²¹² 2017	Dutch Healthy Diet Index – 2015
	Swedish nutrition recommendations (SNR; 2005) and the Swedish dietary guidelines	Drake et al., ²¹¹ 2011	Diet Quality Index – SNR
	Malaysian dietary guidelines (2010)	Jailani et al., ²²² 2021	New Standardized Malaysian Healthy Eating Index
International recommendations	Mediterranean diet	Stefler et al., ²²³ 2017	Mediterranean Diet Score
		García-Conesa et al., ²²⁴ 2020	Mediterranean Diet Adherence Screener
	WHO nutrition guidelines (2015)	Kanauchi et al., ²¹⁵ 2018	Healthy Diet Indicator – 2015
Specific population groups/diseases	Existing diet-lifestyle recommendations for preschoolers from the Food Guide Pyramid (USDA), Canada’s Food Guide, the American Heart Association, and the American Academy of Pediatrics	Manios et al., ²¹⁶ 2010	Preschoolers Diet-Lifestyle Index
	Traditional Mediterranean diet and on the specific need during pregnancy for iron, calcium, and folic acid	Mariscal-Arcas et al., ²¹⁷ 2009	Mediterranean Diet Score – Pregnancy
	Dietary Approaches to Stop Hypertension (DASH) diet	Warren-Findlow et al., ²²⁵ 2017	DASH – Quality

WHO = World Health Organization; USDA = US Department of Agriculture

1.5.1.2 Dietary assessment methods and dimensions of diet quality indices

In studies applying diet quality indices, different dietary assessment methods have been used, including food records, 24-hour recall, food frequency questionnaires, and diet history.^{213,226}

The Automated Self-Administered 24-Hour Dietary Assessment Tool (ASA24), developed by the US National Cancer Institute, is an online platform for completing 24-hour recalls and food records,²²⁷ and is a valid tool to measure the quality of overall diet in the US adult population.²²⁸ The Australian version of ASA24 will be further introduced in **Chapter Two**.

Existing indices commonly assess four dimensions of diet quality: sufficient intake of foods and nutrients that are beneficial for health; moderate consumption of foods and nutrients that should be limited; the overall balance of macronutrients and micronutrients; and variety/diversity of foods being consumed.²²⁹ Some measurement tools focus solely on dietary diversity, but these tools were found to be more useful for detecting micronutrient adequacy instead of the overall diet quality.²³⁰ Other approaches may include indicators based on nutrient and energy density, the inflammatory potential of diet, and total antioxidant capacity; however, the introduction of these concepts to measure diet quality needs further research to achieve consistent criteria.^{206,231-233}

1.5.1.3 Components and scoring of diet quality indices

The most frequently included components of diet quality indices are healthy and unhealthy food groups, individual foods and beverages, nutrients, and the variety of foods.^{213,214,226,229,234} The common food groups and items included are vegetables, fruits, cereals, sources of protein, and dairy products. The consumption of alcoholic beverages, sweets, and other discretionary foods may also be included. The most commonly included nutrients are total fat, saturated and unsaturated fatty acids, cholesterol, sodium, added sugars,

and fibre. Some indices also incorporate lifestyle behaviours, such as physical activity, screen time, sleep, culinary practices, and breakfast consumption.^{213,214,226}

Different measurement units and cut-off values are applied in each diet quality index to quantify and score each component. The commonly used units included servings, grams, ratio, percentage of energy intake, and consumption frequency.^{229,234} The cut-off values need to be specified for the target population group and adjusted for energy intake, as individuals with higher energy requirements and consumption may meet requirements for food groups and nutrients more easily.^{229,234} A review conducted by Burggraf et al. recommended the application of normative cut-off values for items with available recommendations for dietary intake, such as recommended dietary allowances, tolerable upper intake levels, and acceptable macronutrient distribution ranges.²²⁹ For items without recommendations or those items that cannot be discriminated by normative cut-off values (e.g., when almost the entire sample cannot meet the recommended values), Burggraf et al. suggested using percentile cut-off values, such as median and quartile cut-off values.²²⁹

The scores for individual items in the index are combined into one total diet quality index score. Most existing indices assign the same weight to each component; however, weighted aggregation – considering higher weights for components with greater impacts on health or diseases and lower weights for correlated components – has been recommended.^{229,234} For example, Domínguez et al. adjusted the weightings of components in two Mediterranean diet quality indices by the strength of evidence for the association between each dietary component and the risk of coronary heart diseases.²³⁵ During the development of a diet quality index to assess adherence to the Swedish nutrition recommendations, an analysis of correlation between components was conducted, which showed a strong correlation between

saturated fatty acids and monounsaturated fatty acids (MUFA), and thus MUFA was removed from the index composition.²¹¹

1.5.1.4 Validation of diet quality indices

Before selecting a diet quality index, its applicability, validity and reliability for the target population should be assessed. Trijsburg et al. reviewed the evaluation of existing diet indices and recommended the following assessment in the target population: construct validity (the ability of the index to discriminate based on sociodemographic and other characteristics, and the association between the index and foods/nutrients intake); relative validity (the ability to generate consistent outcomes by using two different dietary assessment methods to collect dietary intakes); reproducibility (whether the index can produce similar results on two different occasions); and reliability (internal consistency).²²⁶ A sensitivity/specificity analysis and an assessment of the association between the index and health outcomes of interest was also suggested.²²⁶

The diet quality indices that have been used in the adult population in Australia and New Zealand were critically appraised in a systematic review by Hlaing-Hlaing et al.²¹³ This review used the recommendations for diet quality indices from Burggraf et al. and Trijsburg et al. to conduct the critical appraisal.^{226,229} The Healthy Eating Index for Australian Adults (HEIFA-2013) was one of the tools with the best performance in the appraisal.^{213,220} More details about HEIFA-2013 will be introduced in **Chapter Two**.

1.5.1.5 Diet quality indices and health outcomes

The association between diet quality and health outcomes (e.g., mortality, risk of chronic diseases, and depression) has been investigated in many studies with inconsistent

findings.^{213,214,234,236,237} Some studies found low to moderate associations between better diet quality and favourable health outcomes, such as reduced mortality, and lower risk of cardiovascular diseases and cancer, while some studies did not find associations.^{213,214,234,236,237} Short follow-up periods of studies may limit their ability to detect long-term health impacts of diet quality.²³⁷ Comparison of results across studies is difficult due to wide variability in the choices of diet quality index, target population groups, study designs, and methods to treat confounding factors.^{234,237}

1.5.2 Diet quality in young adults

Some studies assessing diet quality in young adults derived sub-samples from national or large-scale surveys to report diet quality in young adults,^{238,239} while some recruited only young adults to measure their diet quality specifically.^{51,240} The common tools used in this population group are the same as for the general population as mentioned above, for example, tools based on national dietary guidelines, international recommendations, and the Mediterranean diet.

Existing evidence shows a better diet quality with increasing age in adults, indicating that younger adults consume a less healthy diet compared with adults in older age groups.²⁴¹⁻²⁴⁴ A systematic review by Winpenny et al. reported some evidence of reduced diet quality during transitions in young adulthood, such as the transitional period from high school to university and after completing full-time education.²⁴⁵ In Australia, Grech et al. used data from the National Nutrition and Physical Activity Survey 2011–12 and HEIFA-2013 to assess the diet quality of young adults and found a decrease in diet quality with higher dietary energy density.²⁴⁶ Lower consumption of fruits and vegetables and higher consumption of foods with high saturated fat, added sugar, and sodium contributed to higher energy density and lower

quality in the diet. This dietary pattern was associated with some sociodemographic characteristics including having a lower level of education, being born in Western countries, having a lower income (male), and living in areas with lower socioeconomic status (female).²⁴⁶

1.5.3 Diet quality in tertiary education students

The diet quality of tertiary education students was often rated as relatively poor in previous studies and may further decrease during examination periods.²⁴⁷⁻²⁵⁰ Many factors have been found to be associated with diet quality in this student population, including sociodemographic characteristics (e.g., gender, year of study, socioeconomic status, and living arrangement), lifestyle behaviours (e.g., physical activity, food choices on campus, food preparation), stress, and national and campus food environments.^{92,248,250-254} More nutrition and health knowledge may not be translated into better diet quality,^{255,256} but some intervention studies found positive impacts of nutrition education on dietary behaviours.^{257,258} Unfavourable outcomes in physical and psychological health and academic performance have been reported in tertiary education students with poorer diet quality.²⁵⁹⁻²⁶²

Dietary acculturation observed in international students may cause some positive and/or negative changes in dietary patterns.⁴⁷ However, it is not clear how dietary changes and other challenges (introduced earlier in Section 1.2.3) experienced by international students contribute to their overall diet quality, and whether there are any differences in the diet quality between international and domestic students. **Chapter Seven** will further explore the diet quality of tertiary education students, measuring the diet quality of both international and domestic students in an Australian context and comparing the two student groups.

1.6 Thesis aims

The overarching objective of this research is to understand the dietary changes made by international students after they travel to Australia and to assess food security status and diet quality of both international and domestic students attending an Australian university. This includes the investigation of associated influencing factors and outcomes. The ultimate aim is to develop evidence-based and tailored recommendations for both international and domestic tertiary education students in Australia to achieve food security and better diet quality.

The specific aims of this research are:

- 1) To summarise current evidence on dietary acculturation and food insecurity among international tertiary education students in Australia and other countries (**Chapter Three**)
- 2) To systematically investigate the association between food insecurity and dietary outcomes in university students using the current literature (**Chapter Four**)
- 3) To explore dietary changes experienced by international students after they commenced studies in an Australian university and the rationale behind these changes (**Chapter Five**)
- 4) To measure the prevalence and severity of food insecurity among Australian university students and the associated influencing factors and outcomes, and compare international and domestic students (**Chapter Six**)
- 5) To assess the diet quality of international and domestic students studying in an Australian university (**Chapter Seven**)
- 6) To integrate research findings from this thesis and develop practical recommendations for international and domestic students attending Australian universities to allow them to achieve food security and improve their diet quality (**Chapter Eight**).

1.7 Thesis outline

A brief outline of this thesis is provided in this section with a diagrammatic summary in Figure 1.3. After an introduction to the thesis in **Chapter One**, **Chapter Two** describes the research methods that have been used in this thesis, including a scoping review and a systematic review, the mixed methods research design, qualitative research, a food security survey, and the assessment of diet quality.

Chapter Three summarises the phenomenon of dietary acculturation and the prevalence of food insecurity in international tertiary education students from previous studies, and **Chapter Four** presents a systematic review of the association between food insecurity and nutritional health in university students.

Primary studies in this thesis used a mixed methods design, including a qualitative study (**Chapter Five**) and two quantitative studies (**Chapters Six and Seven**). **Chapter Five** is a qualitative study using semi-structured interviews to explore changes in diets of international students after they started studying in an Australian university, as well as the reasons for and impacts of those changes. Subsequently, an online questionnaire was designed to assess the food security status of university students in Australia and identify differences between international and domestic students in **Chapter Six**. **Chapter Seven** presents the assessment of diet quality using 24-hour recalls and discriminates the diet quality of international and domestic students.

Chapter Eight summarises the key findings of this thesis and provides recommendations for helping Australian university students achieve food security and better diet quality. Suggestions for future practice are included, as well as directions for future research.

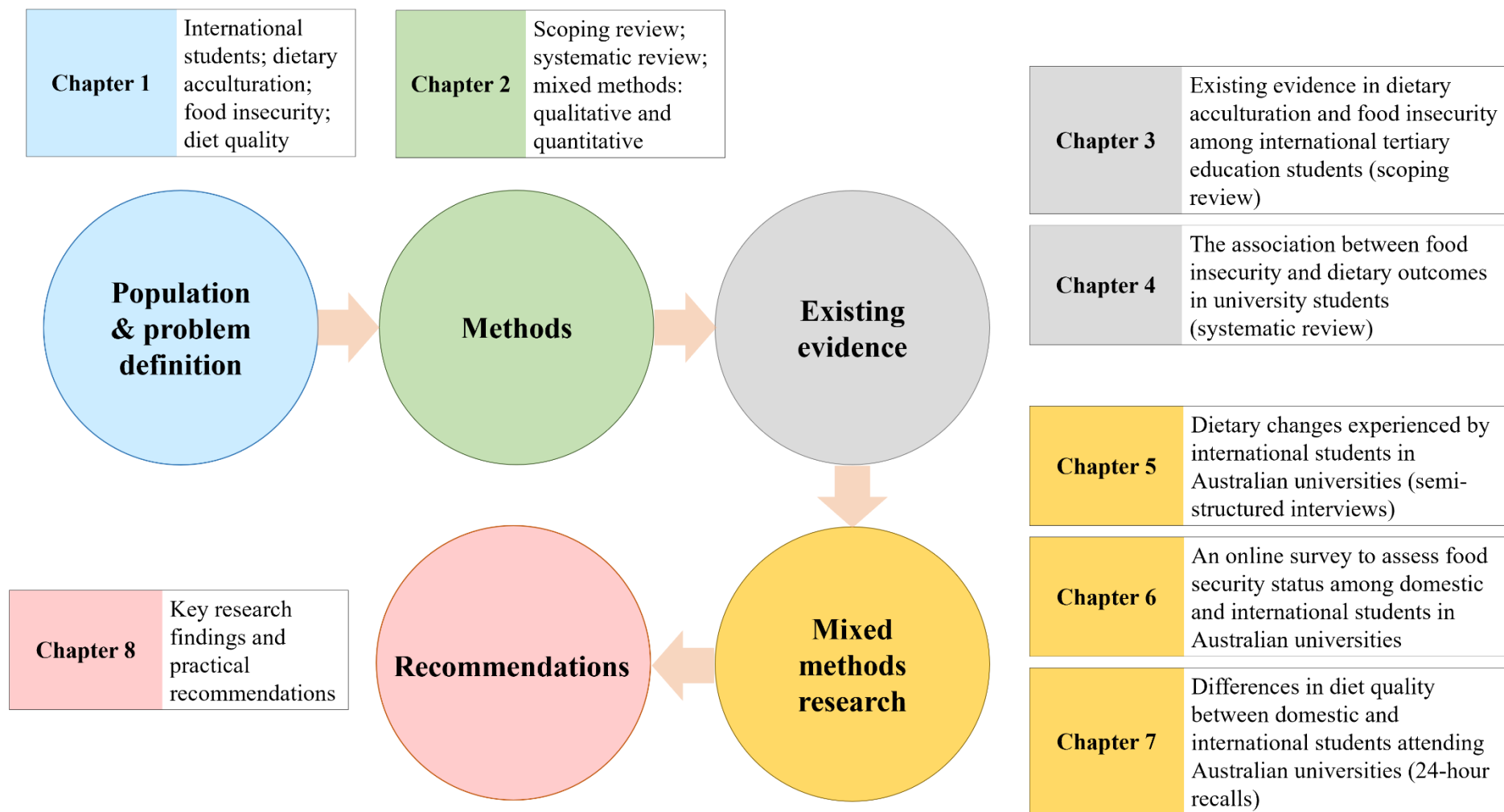


Figure 1.3. A diagrammatic outline of the components presented in each chapter.

1.8 References

1. Organisation for Economic Co-operation and Development (OECD). *Education at a Glance 2020*. OECD; 2020.
2. United Nations Educational Scientific and Cultural Organization (UNESCO) Institute for Statistics. *Global Education Digest 2006 Comparing Education Statistics Across the World*. UNESCO Institute for Statistics; 2006.
3. Nous Group. *International Higher Education Student Flows Final Report*. Nous Group; 2019.
4. Organisation for Economic Co-operation and Development (OECD). *How is International Student Mobility Shaping Up?* OECD; 2013.
5. Department of Education, Skills and Employment, Australian Government. 2019 Student summary tables. Accessed September 17, 2022. <https://www.dese.gov.au/higher-education-statistics/resources/2019-student-summary-tables>
6. Department of Education, Skills and Employment, Australian Government. Onshore higher education international students as a proportion of all students by university, 2019. Accessed September 17, 2021. https://internationaleducation.gov.au/research/research-snapshots/Documents/RS_International%20students%20at%20universities.pdf
7. Organisation for Economic Co-operation and Development (OECD). International student mobility (indicator). Accessed September 17, 2022. <https://data.oecd.org/students/international-student-mobility.htm>
8. Mason L. *International Student Mobility Flows and COVID-19 Realities*. Institute of International Education; 2021.
9. Department of Education, Australian Government. International student data – full year data (based on data finalised in December 2021). Accessed September 17, 2022. <https://www.education.gov.au/international-education-data-and-research/international-student-monthly-summary-and-data-tables#toc-international-student-data-full-year-data-based-on-data-finalised-in-december-2021->
10. Department of Education, Skills and Employment, Australian Government. Understanding the impacts of COVID-19: selected country fact sheets. Accessed September 17, 2022. <https://www.dese.gov.au/international-education/resources/understanding-impacts-covid19-selected-country-fact-sheets>
11. Department of Education, Skills and Employment, Australian Government. International student data monthly summary – June 2021. Accessed September 17, 2022. <https://internationaleducation.gov.au/research/international-student-data/Documents/MONTHLY%20SUMMARIES/2021/Jun%202021%20MonthlyInfo-graphic.pdf>
12. Department of Education, Skills and Employment, Australian Government. End of year summary of international student data 2020. Accessed September 17, 2022. <https://internationaleducation.gov.au/research/international-student-data/Documents/MONTHLY%20SUMMARIES/2020/Full%20year%20summary.pdf>
13. ICEF Monitor. International students cleared to enter Australia beginning 15 December. Accessed September 17, 2022.

<https://monitor.icef.com/2021/12/international-students-cleared-to-enter-australia-beginning-15-december/>

14. Department of Education, Australian Government. Student visa holders in and outside Australia. Accessed September 17, 2022. <https://www.education.gov.au/international-education-data-and-research/student-visa-holders-and-outside-australia>
15. Department of Education and Training, Australian Government. Prepared by Deloitte Access Economics. *The Value of International Education to Australia*. Australian Government; 2016. Accessed September 17, 2022. <https://internationaleducation.gov.au/research/research-papers/Documents/ValueInternationalEd.pdf>
16. Brumby J. Foreign students are our fourth largest export, even with the pandemic. *The Sydney Morning Herald*. February 19, 2021. Accessed September 17, 2022. <https://www.smh.com.au/national/foreign-students-are-our-fourth-largest-export-even-with-the-pandemic-20210218-p573pz.html>
17. Leong P. Coming to America: assessing the patterns of acculturation, friendship formation, and the academic experiences of international students at a US College. *J Int Stud*. 2015;5(4):459-474. doi:10.32674/jis.v5i4.408
18. Sultana Q, Smith R. Evaluation of international students' perceptions of Eastern Kentucky University. Paper presented at: The 40th Annual Conference of the Mid South Educational Research Association; November 2–4, 2011; Oxford, MS. Accessed September 17, 2022. <https://eric.ed.gov/?id=ED532280>
19. Martin S, Dyer J. Health maintenance practices and healthcare experiences among international university students. *J Am Assoc Nurse Pract*. 2017;29(11):651-657. doi:10.1002/2327-6924.12524
20. Fritz MV, Chin D, DeMarinis V. Stressors, anxiety, acculturation and adjustment among international and North American students. *Int J Intercult Relat*. 2008;32(3):244-259. doi:10.1016/j.ijintrel.2008.01.001
21. Khawaja NG, Dempsey J. A comparison of international and domestic tertiary students in Australia. *J Psychol Couns Sch*. 2008;18(1):30-46. doi:10.1375/ajgc.18.1.30
22. Msengi IG. Sources of stress and its impact on health behaviors and academic performance of international students at a comprehensive Midwestern university. *Int J Global Health Health Disparities*. 2007;5(1):55-69.
23. Skromanis S, Cooling N, Rodgers B, et al. Health and well-being of international university students, and comparison with domestic students, in Tasmania, Australia. *Int J Environ Res Public Health*. 2018;15(6):1147. doi:10.3390/ijerph15061147
24. Lu SH, Dear BF, Johnston L, Wootton BM, Titov N. An internet survey of emotional health, treatment seeking and barriers to accessing mental health treatment among Chinese-speaking international students in Australia. *Couns Psychol Q*. 2014;27(1):96-108. doi:10.1080/09515070.2013.824408
25. Sam DL, Berry JW. Acculturation: when individuals and groups of different cultural backgrounds meet. *Perspect Psychol Sci*. 2010;5(4):472-481. doi:10.1177/1745691610373075

26. Berry JW. Acculturation: living successfully in two cultures. *Int J Intercult Relat.* 2005;29(6):697-712. doi:10.1016/j.ijintrel.2005.07.013
27. Smith RA, Khawaja NG. A review of the acculturation experiences of international students. *Int J Intercult Relat.* 2011;35(6):699-713. doi:10.1016/j.ijintrel.2011.08.004
28. Yan Z. Acculturation and well-being among international students: challenges and opportunities. In: Gaulee U, Sharma S, Bista K, eds. *Rethinking Education Across Borders.* Springer Singapore; 2020:303-315.
29. Mori SC. Addressing the mental health concerns of international students. *J Couns Dev.* 2000;78(2):137-144. doi:10.1002/j.1556-6676.2000.tb02571.x
30. Yan Z, Altobaiti HA, FitzPatrick K. Smoking behavior among Saudi Arabian male college students in the US: a case study. *J Behav Health.* 2017;6(2):83. doi:10.5455/jbh.20161222063231
31. Yan Z, Cardinal BJ. Perception of physical activity participation of Chinese female graduate students: a case study. *Res Q Exerc Sport.* 2013;84(3):384-396. doi:10.1080/02701367.2013.813895
32. Demes KA, Geeraert N. Measures matter: scales for adaptation, cultural distance, and acculturation orientation revisited. *J Cross-Cult Psychol.* 2013;45(1):91-109. doi:10.1177/0022022113487590
33. Taušová J, Bender M, Dimitrova R, van de Vijver F. The role of perceived cultural distance, personal growth initiative, language proficiencies, and tridimensional acculturation orientations for psychological adjustment among international students. *Int J Intercult Relat.* 2019;69:11-23. doi:10.1016/j.ijintrel.2018.11.004
34. Galchenko I, van de Vijver FJR. The role of perceived cultural distance in the acculturation of exchange students in Russia. *Int J Intercult Relat.* 2007;31(2):181-197. doi:10.1016/j.ijintrel.2006.03.004
35. Lysgaard S. Adjustment in a foreign society: Norwegian Fulbright grantees visiting the United States. *Int Soc Sci Bull.* 1955;7(1):45-51.
36. Oberg K. Cultural shock: adjustment to new cultural environments. *Pract Anthropol.* 1960;os-7(4):177-182. doi:10.1177/009182966000700405
37. Adler PS. The transitional experience: An alternative view of culture shock. *J Humanistic Psychol.* 1975;15(4):13-23. doi:10.1177/002216787501500403
38. Bailey FJ, Dua J. Individualism—collectivism, coping styles, and stress in international and Anglo-Australian students: a comparative study. *Aust Psychol.* 1999;34(3):177-182. doi:10.1080/00050069908257451
39. Brown L, Holloway I. The adjustment journey of international postgraduate students at an English university: an ethnographic study. *J Res Int Educ.* 2008;7(2):232-249. doi:10.1177/1475240908091306
40. Chien YYG. After six decades: applying the U-curve hypothesis to the adjustment of international postgraduate students. *J Res Int Educ.* 2016;15(1):32-51. doi:10.1177/1475240916639398
41. Bhugra D, Becker MA. Migration, cultural bereavement and cultural identity. *World Psychiatry.* 2005;4(1):18-24.
42. Kittler PG, Sucher KP, Nelms M. *Food and Culture.* Cengage Learning; 2016.

43. Satia-Abouta J, Patterson RE, Neuhouser ML, Elder J. Dietary acculturation: applications to nutrition research and dietetics. *J Am Diet Assoc.* 2002;102(8):1105-1118. doi:10.1016/S0002-8223(02)90247-6
44. Satia-Abouta J. Dietary acculturation: definition, process, assessment, and implications. *Int J Hum Ecol.* 2003;4(1):71-86.
45. Lanham A, Lubari E, Gallegos D, Radcliffe B. Health promotion in emerging collectivist communities: a study of dietary acculturation in the South Sudanese community in Logan City, Australia. *Health Promot J Austr.* 2021;33(1):224-231. doi:10.1002/hpja.491
46. Lee SD, Kellow NJ, Choi TST, Huggins CE. Assessment of dietary acculturation in East Asian populations: a scoping review. *Adv Nutr.* 2021;12(3):865-886. doi:10.1093/advances/nmaa127
47. Shi Y, Lukomskyj N, Allman-Farinelli M. Food access, dietary acculturation, and food insecurity among international tertiary education students: a scoping review. *Nutrition.* 2021;85:111100. doi:10.1016/j.nut.2020.111100
48. Lane G, Nisbet C, Vatanparast H. Dietary habits of newcomer children in Canada. *Public Health Nutr.* 2019;22(17):3151-3162. doi:10.1017/s1368980019001964
49. Wu B, Smith C. Acculturation and environmental factors influencing dietary behaviors and body mass index of Chinese students in the United States. *Appetite.* 2016;103:324-335. doi:10.1016/j.appet.2016.04.029
50. Terragni L, Garnweidner LM, Pettersen KS, Mosdøl A. Migration as a turning point in food habits: the early phase of dietary acculturation among women from South Asian, African, and Middle Eastern countries living in Norway. *Ecol Food Nutr.* 2014;53(3):273-291. doi:10.1080/03670244.2013.817402
51. Kirshner L, Yi SS, Wylie-Rosett J, Matthan NR, Beasley JM. Acculturation and diet among Chinese American immigrants in New York City. *Curr Dev Nutr.* 2020;4(1):nzz124. doi:10.1093/cdn/nzz124
52. Raza Q, Nicolaou M, Snijder MB, Stronks K, Seidell JC. Dietary acculturation among the South-Asian Surinamese population in the Netherlands: the HELIUS study. *Public Health Nutr.* 2017;20(11):1983-1992. doi:10.1017/s1368980016000914
53. Varghese S, Moore-Orr R. Dietary acculturation and health-related issues of Indian immigrant families in Newfoundland. *Can J Diet Pract Res.* 2002;63(2):72-79. doi:10.3148/63.2.2002.72
54. Wahlqvist ML. Asian migration to Australia: food and health consequences. *Asia Pac J Clin Nutr.* 2002;11(suppl 3):S562-S568. doi:10.1046/j.1440-6047.11.supp3.13.x
55. Zou P, Ba D, Luo Y, et al. Dietary characteristics and influencing factors on Chinese immigrants in Canada and the United States: a scoping review. *Nutrients.* 2022;14(10):2166. doi:10.3390/nu14102166
56. Kwok S, Mann L, Wong K, Blum I. Dietary habits and health beliefs of Chinese Canadians. *Can J Diet Pract Res.* 2009;70(2):73-80. doi:10.3148/70.2.2009.73
57. Lesser IA, Gasevic D, Lear SA. The association between acculturation and dietary patterns of South Asian immigrants. *PLoS One.* 2014;9(2):e88495. doi:10.1371/journal.pone.0088495

58. Jiang Y, Nagao-Sato S, Overcash F, Reicks M. Associations between acculturation and diet and health indicators among US Asian adults: NHANES 2011–2016. *J Food Compost Anal.* 2021;102:104061. doi:10.1016/j.jfca.2021.104061
59. Sanou D, O'Reilly E, Ngnie-Teta I, et al. Acculturation and nutritional health of immigrants in Canada: a scoping review. *J Immigr Minor Health.* 2014;16(1):24-34. doi:10.1007/s10903-013-9823-7
60. Park SY, Murphy SP, Sharma S, Kolonel LN. Dietary intakes and health-related behaviours of Korean American women born in the USA and Korea: the Multiethnic Cohort Study. *Public Health Nutr.* 2005;8(7):904-911. doi:10.1079/phn2005740
61. Mahadevan M, Blair D. Changes in food habits of south Indian Hindu Brahmin immigrants in State College, PA. *Ecol Food Nutr.* 2009;48(5):404-432. doi:10.1080/03670240903170533
62. Cordain L, Eaton SB, Sebastian A, et al. Origins and evolution of the Western diet: health implications for the 21st century. *Am J Clin Nutr.* 2005;81(2):341-354. doi:10.1093/ajcn.81.2.341
63. Kopp W. How Western diet and lifestyle drive the pandemic of obesity and civilization diseases. *Diabetes Metab Syndr Obes.* 2019;12:2221-2236. doi:10.2147/DMSO.S216791
64. Brown L. The transformative power of the international sojourn: an ethnographic study of the international student experience. *Ann Tour Res.* 2009;36(3):502-521. doi:10.1016/j.annals.2009.03.002
65. Grigsby-Duffy L, Schultz S, Orellana L, et al. The healthiness of food and beverages on price promotion at promotional displays: a cross-sectional audit of Australian supermarkets. *Int J Environ Res Public Health.* 2020;17(23):9026. doi:10.3390/ijerph17239026
66. Schultz S, Cameron AJ, Grigsby-Duffy L, et al. Availability and placement of healthy and discretionary food in Australian supermarkets by chain and level of socio-economic disadvantage. *Public Health Nutr.* 2021;24(2):203-214. doi:10.1017/s1368980020002505
67. National Health and Medical Research Council (NHMRC). *Australian Guide to Healthy Eating.* NHMRC; 2013. Accessed September 17, 2022. <https://www.eatforhealth.gov.au/>
68. Bivoltis A, Trapp G, Knuiman M, Hooper P, Ambrosini GL. The evolution of local food environments within established neighbourhoods and new developments in Perth, Western Australia. *Health Place.* 2019;57:204-217. doi:10.1016/j.healthplace.2019.04.011
69. Feng X, Astell-Burt T, Badland H, Mavoa S, Giles-Corti B. Modest ratios of fast food outlets to supermarkets and green grocers are associated with higher body mass index: longitudinal analysis of a sample of 15,229 Australians aged 45 years and older in the Australian National Liveability Study. *Health Place.* 2018;49:101-110. doi:10.1016/j.healthplace.2017.10.004
70. Mason KE, Bentley RJ, Kavanagh AM. Fruit and vegetable purchasing and the relative density of healthy and unhealthy food stores: evidence from an Australian multilevel study. *J Epidemiol Community Health.* 2013;67(3):231-236. doi:10.1136/jech-2012-201535

71. Whelan J, Millar L, Bell C, et al. You can't find healthy food in the bush: poor accessibility, availability and adequacy of food in rural Australia. *Int J Environ Res Public Health*. 2018;15(10):2316. doi:10.3390/ijerph15102316
72. Cameron AJ. The shelf space and strategic placement of healthy and discretionary foods in urban, urban-fringe and rural/non-metropolitan Australian supermarkets. *Public Health Nutr*. 2018;21(3):593-600. doi:10.1017/s1368980017003019
73. Chapman K, Kelly B, Bauman A, Innes-Hughes C, Allman-Farinelli M. Trends in the cost of a healthy food basket and fruit and vegetable availability in New South Wales, Australia, between 2006 and 2009. *Nutr Diet*. 2014;71(2):117-126. doi:10.1111/1747-0080.12057
74. Murphy M, Koohsari MJ, Badland H, Giles-Corti B. Supermarket access, transport mode and BMI: the potential for urban design and planning policy across socio-economic areas. *Public Health Nutr*. 2017;20(18):3304-3315. doi:10.1017/s1368980017002336
75. Partridge SR, Gibson AA, Roy R, et al. Junk food on demand: a cross-sectional analysis of the nutritional quality of popular online food delivery outlets in Australia and New Zealand. *Nutrients*. 2020;12(10):3107. doi:10.3390/nu12103107
76. Wang C, Korai A, Jia SS, et al. Hunger for home delivery: cross-sectional analysis of the nutritional quality of complete menus on an online food delivery platform in Australia. *Nutrients*. 2021;13(3):905. doi:10.3390/nu13030905
77. Bivoltsis A, Trapp G, Knuiman M, Hooper P, Ambrosini GL. Do changes in the local food environment within new residential developments influence the diets of residents? Longitudinal results from RESIDE. *Int J Environ Res Public Health*. 2020;17(18):6778. doi:10.3390/ijerph17186778
78. Kemp C, Collins J, Palermo C. Is the type and location of grocery stores a predictor of healthy and unhealthy food availability? A cross-sectional study. *Nutr Diet*. 2019;76(3):277-283. doi:10.1111/1747-0080.12541
79. Moayyed H, Kelly B, Feng X, Flood V. Is living near healthier food stores associated with better food intake in regional Australia? *Int J Environ Res Public Health*. 2017;14(8):884. doi:10.3390/ijerph14080884
80. Trapp GS, Hickling S, Christian HE, et al. Individual, social, and environmental correlates of healthy and unhealthy eating. *Health Educ Behav*. 2015;42(6):759-768. doi:10.1177/1090198115578750
81. Williams LK, Thornton L, Ball K, Crawford D. Is the objective food environment associated with perceptions of the food environment? *Public Health Nutr*. 2012;15(2):291-298. doi:10.1017/s1368980011001947
82. Needham C, Sacks G, Orellana L, Robinson E, Allender S, Strugnell C. A systematic review of the Australian food retail environment: characteristics, variation by geographic area, socioeconomic position and associations with diet and obesity. *Obes Rev*. 2020;21(2):e12941. doi:10.1111/obr.12941
83. Lamb KE, Thornton LE, Olstad DL, Cerin E, Ball K. Associations between major chain fast-food outlet availability and change in body mass index: a longitudinal observational study of women from Victoria, Australia. *BMJ Open*. 2017;7(10):e016594. doi:10.1136/bmjopen-2017-016594

84. Murphy M, Badland H, Jordan H, Koohsari MJ, Giles-Corti B. Local food environments, suburban development, and BMI: a mixed methods study. *Int J Environ Res Public Health*. 2018;15(7):1392. doi:10.3390/ijerph15071392
85. Ng KW, Sangster J, Priestly J. Assessing the availability, price, nutritional value and consumer views about foods and beverages from vending machines across university campuses in regional New South Wales, Australia. *Health Promot J Austr*. 2019;30(1):76-82. doi:10.1002/hpja.34
86. Shi Y, Wang Q, Norman C, Allman-Farinelli M, Colagiuri S. It is time to make policy for healthier food environments in Australian universities. *Nutrients*. 2018;10(12):1909. doi:10.3390/nu10121909
87. Whatnall MC, Ng HS, Liao CY, Patterson AJ, Hutchesson MJ. What is the nutritional value of food and drinks sold in vending machines at an Australian university? A food environment audit study. *Nutr Diet*. 2020;77(5):550-552. doi:10.1111/1747-0080.12615
88. Roy R, Hebden L, Kelly B, et al. Description, measurement and evaluation of tertiary-education food environments. *Br J Nutr*. 2016;115(9):1598-1606. doi:10.1017/s0007114516000568
89. Grech A, Hebden L, Roy R, Allman-Farinelli M. Are products sold in university vending machines nutritionally poor? A food environment audit. *Nutr Diet*. 2017;74(2):185-190. doi:10.1111/1747-0080.12332
90. Shi Y, Grech AL, Allman-Farinelli M. Changes in the nutritional quality of products sold in university vending machines since implementation of the health star rating in 2014; an environmental audit. *BMC Public Health*. 2018;18(1):1255. doi:10.1186/s12889-018-6177-z
91. Roy R, Rangan A, Hebden L, et al. Dietary contribution of foods and beverages sold within a university campus and its effect on diet quality of young adults. *Nutrition*. 2017;34:118-123. doi:10.1016/j.nut.2016.09.013
92. Whatnall MC, Soo ZM, Patterson AJ, Hutchesson MJ. University students purchasing food on campus more frequently consume more energy-dense, nutrient-poor foods: a cross-sectional survey. *Nutrients*. 2021;13(4):1053. doi:10.3390/nu13041053
93. NSW Ministry of Health. Healthy Food and Drink in NSW Health Facilities for Staff and Visitors Framework. Accessed September 17, 2022. <https://www.health.nsw.gov.au/heal/Pages/healthy-food-framework.aspx>
94. Centre for Population Health. NSW Healthy School Canteen Strategy. Accessed September 17, 2022. <https://www.health.nsw.gov.au/heal/Pages/healthy-school-canteens.aspx>
95. Department of Health and Human Services, Victorian Government. Healthy school canteens. Accessed September 17, 2022. <https://www.health.vic.gov.au/publications/healthy-school-canteens>
96. Queensland Government. Smart Choices—Healthy Food and Drink Supply Strategy for Queensland Schools. Updated January, 2020. Accessed September 17, 2022. <https://education.qld.gov.au/student/Documents/smart-choices-strategy.pdf>

97. Murray S, Peterson C, Primo C, et al. Prevalence of food insecurity and satisfaction with on-campus food choices among Australian university students. *Int J Sustain High Educ.* 2021;22(4):731-746. doi:10.1108/IJSHE-09-2020-0348
98. Food and Agriculture Organization of the United Nations (FAO). *Rome Declaration on World Food Security and World Food Summit Plan of Action.* FAO; 1996. Accessed September 17, 2022. <http://www.fao.org/3/w3613e/w3613e00.htm>
99. Gunaratne MS, Radin Firdaus RB, Rathnasooriya SI. Climate change and food security in Sri Lanka: towards food sovereignty. *Humanit Soc Sci Commun.* 2021;8(1):229. doi:10.1057/s41599-021-00917-4
100. Office of the United Nations High Commissioner for Human Rights. *The Right to Adequate Food, Fact Sheet No. 34.* United Nations; 2010. Accessed September 17, 2022. <https://www.ohchr.org/Documents/Publications/FactSheet34en.pdf>
101. Ashby S, Kleve S, McKechnie R, Palermo C. Measurement of the dimensions of food insecurity in developed countries: a systematic literature review. *Public Health Nutr.* 2016;19(16):2887-2896. doi:10.1017/S1368980016001166
102. Leroy JL, Ruel M, Frongillo EA, Harris J, Ballard TJ. Measuring the food access dimension of food security: a critical review and mapping of indicators. *Food Nutr Bull.* 2015;36(2):167-195. doi:10.1177/0379572115587274
103. FAO Agricultural and Development Economics Division. Policy brief: food security. Accessed September 17, 2022. https://www.fao.org/fileadmin/templates/faotaly/documents/pdf/pdf_Food_Security_Cocept_Note.pdf
104. Beacom E, Furey S, Hollywood L, Humphreys P. Investigating food insecurity measurement globally to inform practice locally: a rapid evidence review. *Crit Rev Food Sci Nutr.* 2021;61(20):3319-3339. doi:10.1080/10408398.2020.1798347
105. Carrillo-Alvarez E, Salinas-Roca B, Costa-Tutusaus L, Mila-Villarroel R, Shankar Krishnan N. The measurement of food insecurity in high-income countries: a scoping review. *Int J Environ Res Public Health.* 2021;18(18):9829. doi:10.3390/ijerph18189829
106. Marques ES, Reichenheim ME, de Moraes CL, Antunes MM, Salles-Costa R. Household food insecurity: a systematic review of the measuring instruments used in epidemiological studies. *Public Health Nutr.* 2015;18(5):877-892. doi:10.1017/S1368980014001050
107. Economic Research Service, The United States Department of Agriculture. US Household Food Security Survey Module. Accessed September 17, 2022. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#household>
108. Economic Research Service, The United States Department of Agriculture. US Adult Food Security Survey Module. Accessed September 17, 2022. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#adult>
109. Economic Research Service, The United States Department of Agriculture. Six-Item Short Form of the Food Security Survey Module. Accessed September 17, 2022. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#six>

110. Radimer KL, Olson CM, Greene JC, Campbell CC, Habicht J-P. Understanding hunger and developing indicators to assess it in women and children. *J Nutr Educ.* 1992;24(1)(suppl 1):36S-44S. doi:10.1016/S0022-3182(12)80137-3
111. Cafiero C, Viviani S, Nord M. Food security measurement in a global context: the Food Insecurity Experience Scale. *Measurement.* 2018;116:146-152. doi:10.1016/j.measurement.2017.10.065
112. Coates J, Swindale A, Bilinsky P. *Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide (v. 3)*. Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2007. Accessed September 17, 2022. <https://www.fantaproject.org/monitoring-and-evaluation/household-food-insecurity-access-scale-hfias>
113. Ballard T, Coates J, Swindale A, Deitchler M. *Household Hunger Scale: Indicator Definition and Measurement Guide*. Food and Nutrition Technical Assistance Project, Academy for Educational Development; 2011. Accessed September 17, 2022. <https://www.fantaproject.org/sites/default/files/resources/HHS-Indicator-Guide-Aug2011.pdf>
114. Perez-Escamilla R, Dessalines M, Finnigan M, Hromi-Fiedler A, Pachón H. Validity of the Latin American and Caribbean Household Food Security Scale (ELCSA) in South Haiti. *FASEB J.* 2008;22(suppl 1):871.873. doi:10.1096/fasebj.22.1_supplement.871.3
115. Reichenheim ME, Interlenghi GS, Moraes CL, Segall-Corrêa AM, Pérez-Escamilla R, Salles-Costa R. A model-based approach to identify classes and respective cutoffs of the Brazilian Household Food Insecurity Measurement Scale. *J Nutr.* 2016;146(7):1356-1364. doi:10.3945/jn.116.231845
116. Parnell WR, Gray AR. Development of a food security measurement tool for New Zealand households. *Br J Nutr.* 2014;112(8):1393-1401. doi:10.1017/S0007114514002104
117. Archer C, Gallegos D, McKechnie R. Developing measures of food and nutrition security within an Australian context. *Public Health Nutr.* 2017;20(14):2513-2522. doi:10.1017/s1368980017001288
118. Kleve S, Gallegos D, Ashby S, Palermo C, McKechnie R. Preliminary validation and piloting of a comprehensive measure of household food security in Australia. *Public Health Nutr.* 2018;21(3):526-534. doi:10.1017/S1368980017003007
119. McKechnie R, Turrell G, Giskes K, Gallegos D. Single-item measure of food insecurity used in the National Health Survey may underestimate prevalence in Australia. *Aust N Z J Public Health.* 2018;42(4):389-395. doi:10.1111/1753-6405.12812
120. Yates JT. *Maternal Depression and Food Insecurity During Pregnancy Among Oregon Women*. Master's thesis. Oregon Health and Science University; 2008.
121. Begley A, Paynter E, Butcher LM, Dhaliwal SS. Examining the association between food literacy and food insecurity. *Nutrients.* 2019;11(2):445. doi:10.3390/nu11020445
122. Van den Berg L, Raubenheimer J. Food insecurity among students at the University of the Free State, South Africa. *South Afr J Clin Nutr.* 2015;28(4):160-169. doi:10.1080/16070658.2015.11734556

123. Crawford B, Yamazaki R, Franke E, Amanatidis S, Ravulo J, Torvaldsen S. Is something better than nothing? Food insecurity and eating patterns of young people experiencing homelessness. *Aust N Z J Public Health*. 2015;39(4):350-354. doi:10.1111/1753-6405.12371
124. Hughes R, Serebryanikova I, Donaldson K, Leveritt M. Student food insecurity: the skeleton in the university closet. *Nutr Diet*. 2011;68(1):27-32. doi:10.1111/j.1747-0080.2010.01496.x
125. Nolan M, Rikard-Bell G, Mohsin M, Williams M. Food insecurity in three socially disadvantaged localities in Sydney, Australia. *Health Promot J Austr*. 2006;17(3):247-253. doi:10.1071/HE06247
126. Maxwell D, Caldwell R. *The Coping Strategies Index: Field Methods Manual (Second Edition)*. Cooperative for Assistance and Relief Everywhere (CARE); 2008. Accessed September 17, 2022. https://www.fsnnetwork.org/sites/default/files/coping_strategies_tool.pdf
127. Kennedy G, Berardo A, Papavero C, et al. Proxy measures of household food consumption for food security assessment and surveillance: comparison of the household dietary diversity and food consumption scores. *Public Health Nutr*. 2010;13(12):2010-2018. doi:10.1017/S136898001000145X
128. Vaitla B, Coates J, Glaeser L, Hillbruner C, Biswal P, Maxwell D. The measurement of household food security: correlation and latent variable analysis of alternative indicators in a large multi-country dataset. *Food Policy*. 2017;68:193-205. doi:10.1016/j.foodpol.2017.02.006
129. Soldavini J, Berner M, Da Silva J. Rates of and characteristics associated with food insecurity differ among undergraduate and graduate students at a large public university in the Southeast United States. *Prev Med Rep*. 2019;14:100836. doi:10.1016/j.pmedr.2019.100836
130. Kent K, Visentin D, Peterson C, et al. Severity of food insecurity among Australian university students, professional and academic staff. *Nutrients*. 2022;14(19):3956. doi:10.3390/nu14193956
131. Gamba RJ, Schmeltz MT, Ortiz N, et al. 'Spending all this time stressing and worrying and calculating': marginal food security and student life at a diverse urban university. *Public Health Nutr*. 2021;24(10):2788-2797. doi:10.1017/s1368980021001300
132. Tadesse G, Abate GT, Zewdie T. Biases in self-reported food insecurity measurement: a list experiment approach. *Food Policy*. 2020;92:101862. doi:10.1016/j.foodpol.2020.101862
133. Jones AD, Ngure FM, Pelto G, Young SL. What are we assessing when we measure food security? A compendium and review of current metrics. *Adv Nutr*. 2013;4(5):481-505. doi:10.3945/an.113.004119
134. Frongillo EA, Nguyen HT, Smith MD, Coleman-Jensen A. Food insecurity is more strongly associated with poor subjective well-being in more-developed countries than in less-developed countries. *J Nutr*. 2019;149(2):330-335. doi:10.1093/jn/nxy261
135. Omidvar N, Ahmadi D, Sinclair K, Melgar-Quiñonez H. Food security in selected Middle East and North Africa (MENA) countries: an inter-country comparison. *Food Secur*. 2019;11(3):531-540. doi:10.1007/s12571-019-00935-w

136. Pollard CM, Booth S. Food insecurity and hunger in rich countries—it is time for action against inequality. *Int J Environ Res Public Health*. 2019;16(10):1804. doi:10.3390/ijerph16101804
137. Smith MD, Rabbitt MP, Coleman-Jensen A. Who are the world’s food insecure? New evidence from the Food and Agriculture Organization’s Food Insecurity Experience Scale. *World Dev*. 2017;93:402-412. doi:10.1016/j.worlddev.2017.01.006
138. Bowden M. *Understanding Food Insecurity in Australia. CFCA Paper No 55*. Australian Institute of Family Studies; 2020. Accessed September 17, 2022. <https://aifs.gov.au/cfca/publications/understanding-food-insecurity-australia>
139. Loopstra R. Interventions to address household food insecurity in high-income countries. *Proc Nutr Soc*. 2018;77(3):270-281. doi:10.1017/s002966511800006x
140. Australian Bureau of Statistics. Australian Health Survey: nutrition – state and territory results. Accessed September 17, 2022. <https://www.abs.gov.au/statistics/health/health-conditions-and-risks/australian-health-survey-nutrition-state-and-territory-results/latest-release#key-findings>
141. Food and Agriculture Organization of the United Nations. Methods for estimating comparable prevalence rates of food insecurity experienced by adults throughout the world. Accessed September 17, 2022. <https://www.fao.org/publications/card/en/c/2c22259f-ad59-4399-b740-b967744bb98d>
142. McKay FH, Haines BC, Dunn M. Measuring and understanding food insecurity in Australia: a systematic review. *Int J Environ Res Public Health*. 2019;16(3):476. doi:10.3390/ijerph16030476
143. Jung NM, de Bairros FS, Pattussi MP, Pauli S, Neutzling MB. Gender differences in the prevalence of household food insecurity: a systematic review and meta-analysis. *Public Health Nutr*. 2017;20(5):902-916. doi:10.1017/S1368980016002925
144. Lund TB, Holm L, Tetens I, Smed S, Nielsen AL. Food insecurity in Denmark—socio-demographic determinants and associations with eating- and health-related variables. *Eur J Public Health*. 2018;28(2):283-288. doi:10.1093/eurpub/ckx121
145. Tarasuk V, Fafard St-Germain AA, Mitchell A. Geographic and socio-demographic predictors of household food insecurity in Canada, 2011–12. *BMC Public Health*. 2019;19(1):12. doi:10.1186/s12889-018-6344-2
146. Thornton LE, Pearce JR, Ball K. Sociodemographic factors associated with healthy eating and food security in socio-economically disadvantaged groups in the UK and Victoria, Australia. *Public Health Nutr*. 2014;17(1):20-30. doi:10.1017/S1368980013000347
147. Seivwright AN, Callis Z, Flatau P. Food insecurity and socioeconomic disadvantage in Australia. *Int J Environ Res Public Health*. 2020;17(2):559. doi:10.3390/ijerph17020559
148. Bhawra J, Kirkpatrick SI, Hammond D. Food insecurity among Canadian youth and young adults: insights from the Canada Food Study. *Can J Public Health*. 2021;112(4):663-675. doi:10.17269/s41997-020-00469-1
149. Li Y, Rosenthal SR. Food insecurity and obesity among US young adults: the moderating role of biological sex and the mediating role of diet healthfulness. *Public Health Nutr*. 2021;24(15):5058-5065. doi:10.1017/s1368980020004577

150. Maia I, Monjardino T, Lucas R, Ramos E, Santos AC. Household food insecurity and socio-demographic determinants in young adults: findings from a Portuguese population-based sample. *Int J Public Health*. 2019;64(6):887-895. doi:10.1007/s00038-019-01243-y
151. Vercammen KA, Moran AJ, Carnethon MR, et al. Longitudinal analysis of food insufficiency and cardiovascular disease risk factors in the coronary artery risk development in young adults study. *Am J Prev Med*. 2022;62(1):65-76. doi:10.1016/j.amepre.2021.06.020
152. Butcher LM, O'Sullivan TA, Ryan MM, et al. To dine in or not to dine in: a comparison of food selection and preparation behaviours in those with and without food security. *Health Promot J Austr*. 2021;32(suppl 2):267-282. doi:10.1002/hpja.427
153. Gaines A, Robb CA, Knol LL, Sickler S. Examining the role of financial factors, resources and skills in predicting food security status among college students. *Int J Consum Stud*. 2014;38(4):374-384. doi:10.1111/ijcs.12110
154. Huisken A, Orr SK, Tarasuk V. Adults' food skills and use of gardens are not associated with household food insecurity in Canada. *Can J Public Health*. 2017;107(6):e526-e532. doi:10.17269/cjph.107.5692
155. Abdurahman AA, Chaka EE, Nedjat S, Dorosty AR, Majdzadeh R. The association of household food insecurity with the risk of type 2 diabetes mellitus in adults: a systematic review and meta-analysis. *Eur J Nutr*. 2019;58(4):1341-1350. doi:10.1007/s00394-018-1705-2
156. Farrell P, Thow AM, Abimbola S, Faruqui N, Negin J. How food insecurity could lead to obesity in LMICs: when not enough is too much: a realist review of how food insecurity could lead to obesity in low- and middle-income countries. *Health Promot Int*. 2018;33(5):812-826. doi:10.1093/heapro/dax026
157. Liu Y, Eicher-Miller HA. Food insecurity and cardiovascular disease risk. *Curr Atheroscler Rep*. 2021;23(6):24. doi:10.1007/s11883-021-00923-6
158. Te Vazquez J, Feng SN, Orr CJ, Berkowitz SA. Food insecurity and cardiometabolic conditions: a review of recent research. *Curr Nutr Rep*. 2021;10(4):243-254. doi:10.1007/s13668-021-00364-2
159. Thomas MK, Lammert LJ, Beverly EA. Food insecurity and its impact on body weight, type 2 diabetes, cardiovascular disease, and mental health. *Curr Cardiovasc Risk Rep*. 2021;15(9):15. doi:10.1007/s12170-021-00679-3
160. Nagata JM, Palar K, Gooding HC, Garber AK, Bibbins-Domingo K, Weiser SD. Food insecurity and chronic disease in US young adults: findings from the National Longitudinal Study of Adolescent to Adult Health. *J Gen Intern Med*. 2019;34(12):2756-2762. doi:10.1007/s11606-019-05317-8
161. Arnett JJ. Emerging adulthood: a theory of development from the late teens through the twenties. *Am Psychol*. 2000;55(5):469-480. doi:10.1037/0003-066X.55.5.469
162. Larson N, Laska MN, Neumark-Sztainer D. Food insecurity, diet quality, home food availability, and health risk behaviors among emerging adults: findings from the EAT 2010–2018 Study. *Am J Public Health*. 2020;110(9):1422-1428. doi:10.2105/ajph.2020.305783

163. Ashe KM, Lapane KL. Food insecurity and obesity: exploring the role of social support. *J Womens Health*. 2018;27(5):651-658. doi:10.1089/jwh.2017.6454
164. Franklin B, Jones A, Love D, Puckett S, Macklin J, White-Means S. Exploring mediators of food insecurity and obesity: a review of recent literature. *J Community Health*. 2012;37(1):253-264. doi:10.1007/s10900-011-9420-4
165. Hernandez DC, Reesor LM, Murillo R. Food insecurity and adult overweight/obesity: gender and race/ethnic disparities. *Appetite*. 2017;117:373-378. doi:10.1016/j.appet.2017.07.010
166. Gooding HC, Walls CE, Richmond TK. Food insecurity and increased BMI in young adult women. *Obesity (Silver Spring)*. 2012;20(9):1896-1901. doi:10.1038/oby.2011.233
167. Faramarzi E, Somi M, Ostadrahimi A, et al. Association between food insecurity and metabolic syndrome in North West of Iran: Azar cohort study. *J Cardiovasc Thorac Res*. 2019;11(3):196-202. doi:10.15171/jcvtr.2019.33
168. Lee JW, Shin WK, Kim Y. Food security status is not associated with increased risk of metabolic syndrome in Korean adults. *Metab Syndr Relat Disord*. 2021;19(4):192-199. doi:10.1089/met.2020.0101
169. Moradi S, Mirzababaei A, Dadfarma A, et al. Food insecurity and adult weight abnormality risk: a systematic review and meta-analysis. *Eur J Nutr*. 2019;58(1):45-61. doi:10.1007/s00394-018-1819-6
170. Arenas DJ, Thomas A, Wang J, DeLisser HM. A systematic review and meta-analysis of depression, anxiety, and sleep disorders in US adults with food insecurity. *J Gen Intern Med*. 2019;34(12):2874-2882. doi:10.1007/s11606-019-05202-4
171. Ding M, Keiley MK, Garza KB, Duffy PA, Zizza CA. Food insecurity is associated with poor sleep outcomes among US adults. *J Nutr*. 2015;145(3):615-621. doi:10.3945/jn.114.199919
172. Isaura ER, Chen YC, Su HY, Yang SH. The relationship between food security status and sleep disturbance among adults: a cross-sectional study in an Indonesian population. *Nutrients*. 2020;12(11):3411. doi:10.3390/nu12113411
173. Nagata JM, Palar K, Gooding HC, et al. Food insecurity is associated with poorer mental health and sleep outcomes in young adults. *J Adolesc Health*. 2019;65(6):805-811. doi:10.1016/j.jadohealth.2019.08.010
174. Troxel WM, Haas A, Ghosh-Dastidar B, et al. Food insecurity is associated with objectively measured sleep problems. *Behav Sleep Med*. 2020;18(6):719-729. doi:10.1080/15402002.2019.1669605
175. Bruening M, Dinour LM, Chavez JBR. Food insecurity and emotional health in the USA: a systematic narrative review of longitudinal research. *Public Health Nutr*. 2017;20(17):3200-3208. doi:10.1017/S1368980017002221
176. Jebena MG, Lindstrom D, Belachew T, et al. Food insecurity and common mental disorders among Ethiopian youth: structural equation modeling. *PLoS One*. 2016;11(11):e0165931. doi:10.1371/journal.pone.0165931
177. Perkins JM, Nyakato VN, Kakuhikire B, et al. Food insecurity, social networks and symptoms of depression among men and women in rural Uganda: a cross-sectional,

- population-based study. *Public Health Nutr.* 2018;21(5):838-848. doi:10.1017/s1368980017002154
178. Shafiee M, Vatanparast H, Janzen B, et al. Household food insecurity is associated with depressive symptoms in the Canadian adult population. *J Affect Disord.* 2021;279:563-571. doi:10.1016/j.jad.2020.10.057
 179. Lee JW, Shin WK, Kim Y. Impact of sex and marital status on the prevalence of perceived depression in association with food insecurity. *PLoS One.* 2020;15(6):e0234105. doi:10.1371/journal.pone.0234105
 180. Men F, Elgar FJ, Tarasuk V. Food insecurity is associated with mental health problems among Canadian youth. *J Epidemiol Community Health.* 2021;75(8):741-748. doi:10.1136/jech-2020-216149
 181. Pourmotabbed A, Moradi S, Babaei A, et al. Food insecurity and mental health: a systematic review and meta-analysis. *Public Health Nutr.* 2020;23(10):1778-1790. doi:10.1017/S136898001900435X
 182. Pryor L, Lioret S, van der Waerden J, Fombonne É, Falissard B, Melchior M. Food insecurity and mental health problems among a community sample of young adults. *Soc Psychiatry Psychiatr Epidemiol.* 2016;51(8):1073-1081. doi:10.1007/s00127-016-1249-9
 183. Loh IH, Oddo VM, Otten J. Food insecurity is associated with depression among a vulnerable workforce: early care and education workers. *Int J Environ Res Public Health.* 2020;18(1):170. doi:10.3390/ijerph18010170
 184. Bene C, Bakker D, Chavarro MJ, Even B, Melo J, Sonneveld A. Global assessment of the impacts of COVID-19 on food security. *Glob Food Sec.* 2021;31:100575. doi:10.1016/j.gfs.2021.100575
 185. Jafri A, Mathe N, Aglago EK, et al. Food availability, accessibility and dietary practices during the COVID-19 pandemic: a multi-country survey. *Public Health Nutr.* 2021;24(7):1798-1805. doi:10.1017/s1368980021000987
 186. Picchioni F, Goulao LF, Roberfroid D. The impact of COVID-19 on diet quality, food security and nutrition in low and middle income countries: a systematic review of the evidence. *Clin Nutr.* 2022;41(12):2955-2964. doi:10.1016/j.clnu.2021.08.015
 187. Louie S, Shi Y, Allman-Farinelli M. The effects of the COVID-19 pandemic on food security in Australia: a scoping review. *Nutr Diet.* 2022;79(1):28-47. doi:10.1111/1747-0080.12720
 188. Kent K, Murray S, Penrose B, et al. Food insecure households faced greater challenges putting healthy food on the table during the COVID-19 pandemic in Australia. *Appetite.* 2022;169:105815. doi:10.1016/j.appet.2021.105815
 189. Boyacı-Gündüz CP, Ibrahim SA, Wei OC, Galanakis CM. Transformation of the food sector: security and resilience during the COVID-19 pandemic. *Foods.* 2021;10(3):497. doi:10.3390/foods10030497
 190. Larson N, Alexander T, Slaughter-Acey JC, Berge J, Widome R, Neumark-Sztainer D. Barriers to accessing healthy food and food assistance during the COVID-19 pandemic and racial justice uprisings: a mixed-methods investigation of emerging adults' experiences. *J Acad Nutr Diet.* 2021;121(9):1679-1694. doi:10.1016/j.jand.2021.05.018

191. Larson N, Slaughter-Acey J, Alexander T, Berge J, Harnack L, Neumark-Sztainer D. Emerging adults' intersecting experiences of food insecurity, unsafe neighbourhoods and discrimination during the coronavirus disease 2019 (COVID-19) outbreak. *Public Health Nutr.* 2021;24(3):519-530. doi:10.1017/s136898002000422x
192. Powell PK, Lawler S, Durham J, Cullerton K. The food choices of US university students during COVID-19. *Appetite.* 2021;161:105130. doi:10.1016/j.appet.2021.105130
193. Andreyeva T, Tripp AS, Schwartz MB. Dietary quality of Americans by Supplemental Nutrition Assistance Program participation status: a systematic review. *Am J Prev Med.* 2015;49(4):594-604. doi:10.1016/j.amepre.2015.04.035
194. An R, Wang J, Liu J, Shen J, Loehmer E, McCaffrey J. A systematic review of food pantry-based interventions in the USA. *Public Health Nutr.* 2019;22(9):1704-1716. doi:10.1017/S1368980019000144
195. Bazerghi C, McKay FH, Dunn M. The role of food banks in addressing food insecurity: a systematic review. *J Community Health.* 2016;41(4):732-740. doi:10.1007/s10900-015-0147-5
196. Mook L, Murdock A, Gundersen C. Food banking and food insecurity in high-income countries. *Voluntas.* 2020;31(5):833-840. doi:10.1007/s11266-020-00219-4
197. Simmet A, Depa J, Tinnemann P, Stroebele-Benschop N. The nutritional quality of food provided from food pantries: a systematic review of existing literature. *J Acad Nutr Diet.* 2017;117(4):577-588. doi:10.1016/j.jand.2016.08.015
198. Atoloye AT, Savoie-Roskos MR, Guenther PM, Durward CM. Effectiveness of expanded food and nutrition education program in changing nutrition-related outcomes among adults with low income: a systematic review. *J Nutr Educ Behav.* 2021;53(8):691-705. doi:10.1016/j.jneb.2021.03.006
199. Iacovou M, Pattieson DC, Truby H, Palermo C. Social health and nutrition impacts of community kitchens: a systematic review. *Public Health Nutr.* 2013;16(3):535-543. doi:10.1017/S1368980012002753
200. Malberg Dyg P, Christensen S, Peterson CJ. Community gardens and wellbeing amongst vulnerable populations: a thematic review. *Health Promot Int.* 2020;35(4):790-803. doi:10.1093/heapro/daz067
201. Mortazavi Z, Dorosty AR, Eshraghian MR, Ghaffari M, Ansari-Moghaddam A. Nutritional education and its effects on household food insecurity in Southeastern Iran. *Iran J Public Health.* 2021;50(4):798-805. doi:10.18502/ijph.v50i4.6006
202. Savoie-Roskos M, Durward C, Jeweks M, LeBlanc H. Reducing food insecurity and improving fruit and vegetable intake among Farmers' Market Incentive Program participants. *J Nutr Educ Behav.* 2016;48(1):70-76.e71. doi:10.1016/j.jneb.2015.10.003
203. Yui V, Palermo C, Kleve S. Population-based interventions addressing food insecurity in Australia: a systematic scoping review. *Nutr Diet.* 2020;77(1):6-18. doi:10.1111/1747-0080.12580
204. Callis Z, Seivwright A, Orr C, Flatau P. *The Impact of COVID-19 on Families in Hardship In Western Australia.* The 100 Families WA project (Anglicare, Centrecare, Jacaranda Community Centre, Mercycare, Ruah Community Services, Uniting WA,

- Wanslea, WACOSS, The University of Western Australia (Centre for Social Impact and the School of Population and Global Health)); 2020.
205. Foodbank Australia. *Foodbank hunger report 2020*. Foodbank Australia; 2020.
 206. Alkerwi A. Diet quality concept. *Nutrition*. 2014;30(6):613-618. doi:10.1016/j.nut.2013.10.001
 207. Elmadfa I, Meyer AL. Diet quality, a term subject to change over time. *Int J Vitam Nutr Res*. 2012;82(3):144-147. doi:10.1024/0300-9831/a000104
 208. Patterson RE, Haines PS, Popkin BM. Diet quality index: capturing a multidimensional behavior. *J Am Diet Assoc*. 1994;94(1):57-64. doi:10.1016/0002-8223(94)92042-7
 209. Reedy J, Lerman JL, Krebs-Smith SM, et al. Evaluation of the Healthy Eating Index-2015. *J Acad Nutr Diet*. 2018;118(9):1622-1633. doi:10.1016/j.jand.2018.05.019
 210. Garriguet D. Diet quality in Canada. *Health Rep*. 2009;20(3):41-52.
 211. Drake I, Gullberg B, Ericson U, et al. Development of a diet quality index assessing adherence to the Swedish nutrition recommendations and dietary guidelines in the Malmö Diet and Cancer cohort. *Public Health Nutr*. 2011;14(5):835-845. doi:10.1017/s1368980010003848
 212. Looman M, Feskens EJ, de Rijk M, et al. Development and evaluation of the Dutch Healthy Diet index 2015. *Public Health Nutr*. 2017;20(13):2289-2299. doi:10.1017/s136898001700091x
 213. Hlaing-Hlaing H, Pezdirc K, Tavener M, James EL, Hure A. Diet quality indices used in Australian and New Zealand adults: a systematic review and critical appraisal. *Nutrients*. 2020;12(12):3777. doi:10.3390/nu12123777
 214. Hernández-Ruiz A, García-Villanova B, Guerra Hernández EJ, Amiano P, Azpiri M, Molina-Montes E. Description of indexes based on the adherence to the Mediterranean dietary pattern: a review. *Nutr Hosp*. 2015;32(5):1872-1884. doi:10.3305/nh.2015.32.5.9629
 215. Kanauchi M, Kanauchi K. The World Health Organization's Healthy Diet Indicator and its associated factors: a cross-sectional study in central Kinki, Japan. *Prev Med Rep*. 2018;12:198-202. doi:10.1016/j.pmedr.2018.09.011
 216. Manios Y, Kourlaba G, Grammatikaki E, Androutsos O, Moschonis G, Roma-Giannikou E. Development of a diet-lifestyle quality index for young children and its relation to obesity: the Preschoolers Diet-Lifestyle Index. *Public Health Nutr*. 2010;13(12):2000-2009. doi:10.1017/s1368980010000698
 217. Mariscal-Arcas M, Rivas A, Monteagudo C, Granada A, Cerrillo I, Olea-Serrano F. Proposal of a Mediterranean diet index for pregnant women. *Br J Nutr*. 2009;102(5):744-749. doi:10.1017/s0007114509274769
 218. Schwingshackl L, Bogensberger B, Hoffmann G. Diet quality as assessed by the Healthy Eating Index, Alternate Healthy Eating Index, Dietary Approaches to Stop Hypertension Score, and health outcomes: an updated systematic review and meta-analysis of cohort studies. *J Acad Nutr Diet*. 2018;118(1):74-100.e111. doi:10.1016/j.jand.2017.08.024

219. Collins CE, Burrows TL, Rollo ME, et al. The comparative validity and reproducibility of a diet quality index for adults: the Australian Recommended Food Score. *Nutrients*. 2015;7(2):785-798. doi:10.3390/nu7020785
220. Roy R, Hebden L, Rangan A, Allman-Farinelli M. The development, application, and validation of a Healthy Eating Index for Australian Adults (HEIFA-2013). *Nutrition*. 2016;32(4):432-440. doi:10.1016/j.nut.2015.10.006
221. Wong JE, Haszard JJ, Howe AS, Parnell WR, Skidmore PML. Development of a Healthy Dietary Habits Index for New Zealand adults. *Nutrients*. 2017;9(5):454. doi:10.3390/nu9050454
222. Jailani M, Elias SM, Rajikan R. The new standardized Malaysian Healthy Eating Index. *Nutrients*. 2021;13(10):3474. doi:10.3390/nu13103474
223. Stefler D, Malyutina S, Kubinova R, et al. Mediterranean diet score and total and cardiovascular mortality in Eastern Europe: the HAPIEE study. *Eur J Nutr*. 2017;56(1):421-429. doi:10.1007/s00394-015-1092-x
224. García-Conesa M-T, Philippou E, Pafilas C, et al. Exploring the validity of the 14-item Mediterranean Diet Adherence Screener (MEDAS): a cross-national study in seven European countries around the Mediterranean region. *Nutrients*. 2020;12(10):2960. doi:10.3390/nu12102960
225. Warren-Findlow J, Reeve CL, Racine EF. Psychometric validation of a brief self-report measure of diet quality: the DASH-Q. *J Nutr Educ Behav*. 2017;49(2):92-99.e91. doi:10.1016/j.jneb.2016.09.004
226. Trijsburg L, Talsma EF, de Vries JHM, Kennedy G, Kuijsten A, Brouwer ID. Diet quality indices for research in low- and middle-income countries: a systematic review. *Nutr Rev*. 2019;77(8):515-540. doi:10.1093/nutrit/nuz017
227. National Cancer Institute. Automated Self-Administered 24-Hour (ASA24[®]) Dietary Assessment Tool. Accessed September 17, 2022. <https://epi.grants.cancer.gov/asa24/>
228. Frankenfeld CL, Poudrier JK, Waters NM, Gillevet PM, Xu Y. Dietary intake measured from a self-administered, online 24-hour recall system compared with 4-day diet records in an adult US population. *J Acad Nutr Diet*. 2012;112(10):1642-1647. doi:10.1016/j.jand.2012.06.003
229. Burggraf C, Teuber R, Brosig S, Meier T. Review of a priori dietary quality indices in relation to their construction criteria. *Nutr Rev*. 2018;76(10):747-764. doi:10.1093/nutrit/nuy027
230. Verger EO, Le Port A, Borderon A, et al. Dietary diversity indicators and their associations with dietary adequacy and health outcomes: a systematic scoping review. *Adv Nutr*. 2021;12(5):1659-1672. doi:10.1093/advances/nmab009
231. Sluik D, Streppel MT, van Lee L, Geelen A, Feskens EJ. Evaluation of a nutrient-rich food index score in the Netherlands. *J Nutr Sci*. 2015;4:e14. doi:10.1017/jns.2015.4
232. Cavicchia PP, Steck SE, Hurley TG, et al. A new dietary inflammatory index predicts interval changes in serum high-sensitivity C-reactive protein. *J Nutr*. 2009;139(12):2365-2372. doi:10.3945/jn.109.114025
233. Puchau B, Zulet MÁ, de Echávarri AG, Hermsdorff HHM, Martínez JA. Dietary total antioxidant capacity: a novel indicator of diet quality in healthy young adults. *J Am Coll Nutr*. 2009;28(6):648-656. doi:10.1080/07315724.2009.10719797

234. Waijers PM, Feskens EJ, Ocké MC. A critical review of predefined diet quality scores. *Br J Nutr.* 2007;97(2):219-231. doi:10.1017/s0007114507250421
235. Domínguez LJ, Bes-Rastrollo M, de la Fuente-Arrillaga C, et al. Similar prediction of total mortality, diabetes incidence and cardiovascular events using relative- and absolute-component Mediterranean diet score: the SUN cohort. *Nutr Metab Cardiovasc Dis.* 2013;23(5):451-458. doi:10.1016/j.numecd.2011.10.009
236. Kourlaba G, Panagiotakos DB. Dietary quality indices and human health: a review. *Maturitas.* 2009;62(1):1-8. doi:10.1016/j.maturitas.2008.11.021
237. Wirt A, Collins CE. Diet quality—what is it and does it matter? *Public Health Nutr.* 2009;12(12):2473-2492. doi:10.1017/s136898000900531x
238. Aljadani HM, Patterson A, Sibbritt D, Taylor RM, Collins CE. Frequency and variety of usual intakes of healthy foods, fruit, and vegetables predicts lower 6-year weight gain in young women. *Eur J Clin Nutr.* 2020;74(6):945-952. doi:10.1038/s41430-019-0532-8
239. Yoshida Y, Scribner R, Chen L, Broyles S, Phillippi S, Tseng TS. Diet quality and its relationship with central obesity among Mexican Americans: findings from National Health and Nutrition Examination Survey (NHANES) 1999–2012. *Public Health Nutr.* 2017;20(7):1193-1202. doi:10.1017/s1368980016003190
240. Thorpe MG, Kestin M, Riddell LJ, Keast RS, McNaughton SA. Diet quality in young adults and its association with food-related behaviours. *Public Health Nutr.* 2014;17(8):1767-1775. doi:10.1017/s1368980013001924
241. de Paula Matos Souza J, Magela de Lima M, Martins Horta P. Diet quality among the Brazilian population and associated socioeconomic and demographic factors: analysis from the National Dietary Survey 2008–2009. *J Acad Nutr Diet.* 2019;119(11):1866-1874. doi:10.1016/j.jand.2019.04.014
242. Imamura F, Micha R, Khatibzadeh S, et al. Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment. *Lancet Glob Health.* 2015;3(3):e132-e142. doi:10.1016/s2214-109x(14)70381-x
243. Hiza HA, Casavale KO, Guenther PM, Davis CA. Diet quality of Americans differs by age, sex, race/ethnicity, income, and education level. *J Acad Nutr Diet.* 2013;113(2):297-306. doi:10.1016/j.jand.2012.08.011
244. Grech A, Sui Z, Siu HY, Zheng M, Allman-Farinelli M, Rangan A. Socio-demographic determinants of diet quality in Australian adults using the validated Healthy Eating Index for Australian Adults (HEIFA-2013). *Healthcare.* 2017;5(1):7. doi:10.3390/healthcare5010007
245. Winpenny EM, Smith M, Penney T, et al. Changes in physical activity, diet, and body weight across the education and employment transitions of early adulthood: a systematic review and meta-analysis. *Obes Rev.* 2020;21(4):e12962. doi:10.1111/obr.12962
246. Grech A, Rangan A, Allman-Farinelli M. Social determinants and poor diet quality of energy-dense diets of Australian young adults. *Healthcare.* 2017;5(4):70. doi:10.3390/healthcare5040070

247. Helvacı G, Kartal FT, Ayhan NY. Healthy Eating Index (HEI-2015) of female college students according to obesity and exercise participation. *J Obes Metab Syndr*. 2021;30(3):296-303. doi:10.7570/jomes21018
248. Ramón-Arbués E, Granada-López JM, Martínez-Abadía B, Echániz-Serrano E, Antón-Solanas I, Jerue BA. Factors related to diet quality: a cross-sectional study of 1055 university students. *Nutrients*. 2021;13(10):3512. doi:10.3390/nu13103512
249. Carlos M, Elena B, Teresa IM. Are adherence to the Mediterranean diet, emotional eating, alcohol intake, and anxiety related in university students in Spain? *Nutrients*. 2020;12(8):2224. doi:10.3390/nu12082224
250. Michels N, Man T, Vinck B, Verbeyst L. Dietary changes and its psychosocial moderators during the university examination period. *Eur J Nutr*. 2020;59(1):273-286. doi:10.1007/s00394-019-01906-9
251. Chacón-Cuberos R, Zurita-Ortega F, Olmedo-Moreno EM, Castro-Sánchez M. Relationship between academic stress, physical activity and diet in university students of education. *Behav Sci*. 2019;9(6):59. doi:10.3390/bs9060059
252. Beaudry KM, Ludwa IA, Thomas AM, Ward WE, Falk B, Josse AR. First-year university is associated with greater body weight, body composition and adverse dietary changes in males than females. *PLoS One*. 2019;14(7):e0218554. doi:10.1371/journal.pone.0218554
253. Merhout F, Doyle J. Socioeconomic status and diet quality in college students. *J Nutr Educ Behav*. 2019;51(9):1107-1112. doi:10.1016/j.jneb.2019.06.021
254. Telleria-Aramburu N, Arroyo-Izaga M. Risk factors of overweight/obesity-related lifestyles in university students: results from the EHU12/24 study. *Br J Nutr*. 2022;127(6):914-926. doi:10.1017/s0007114521001483
255. Suliga E, Cieśla E, Michel S, et al. Diet quality compared to the nutritional knowledge of Polish, German, and Slovakian university students—preliminary research. *Int J Environ Res Public Health*. 2020;17(23):9062. doi:10.3390/ijerph17239062
256. Baydemir C, Ozgur EG, Balci S. Evaluation of adherence to Mediterranean diet in medical students at Kocaeli University, Turkey. *J Int Med Res*. 2018;46(4):1585-1594. doi:10.1177/0300060518757158
257. Schroeter C, Corder T, Brookes B, Reller V. An incentive-based health program using MyPlate: a pilot study analyzing college students' dietary intake behavior. *J Am Coll Health*. 2021;69(3):252-259. doi:10.1080/07448481.2019.1661845
258. Yolcuoğlu İ Z, Kızıltan G. Effect of nutrition education on diet quality, sustainable nutrition and eating behaviors among university students. *J Am Coll Nutr*. 2022;41(7):713-719. doi:10.1080/07315724.2021.1955420
259. Jalloun RA, Maneerattanasuporn T. Comparison of diet quality among female students in different majors at Taibah University. *Nutr Health*. 2021;27(2):133-140. doi:10.1177/0260106020967846
260. Quehl R, Haines J, Lewis SP, Buchholz AC. Food and mood: diet quality is inversely associated with depressive symptoms in female university students. *Can J Diet Pract Res*. 2017;78(3):124-128. doi:10.3148/cjdpr-2017-007

261. Whatnall MC, Patterson AJ, Burrows TL, Hutchesson MJ. Higher diet quality in university students is associated with higher academic achievement: a cross-sectional study. *J Hum Nutr Diet*. 2019;32(3):321-328. doi:10.1111/jhn.12632
262. El Hajj JS, Julien SG. Factors associated with adherence to the Mediterranean diet and dietary habits among university students in Lebanon. *J Nutr Metab*. 2021;2021:6688462. doi:10.1155/2021/6688462

1.9 Conclusion to chapter

This chapter introduced the key concepts in this thesis, including international students, dietary acculturation, food insecurity, and diet quality. Dietary changes experienced by individuals moving to a new country, including international students, may lead to differences in their food security status and diet quality compared with the local population. More attention should be focused on the diet-related experience of international and domestic tertiary education students in an Australian context. Methods and materials that have been used in this thesis will be described in **Chapter Two**.

Chapter Two. Materials and methods

2.1 Introduction to chapter

Following from the background information on the key topics of this thesis in **Chapter One**, this chapter will describe the methods used. The procedures of the scoping review and systematic review will be outlined first, followed by the mixed methods research design that included one qualitative study using interviews and two quantitative studies using surveys.

2.2 Scoping review

To map the available evidence on dietary acculturation and food security status among international students attending tertiary education institutions, a scoping review was conducted (**Chapter Three**). A scoping review was selected, rather than a systematic review, based on the different purposes of the two types of review.¹ The aims of scoping reviews include providing an overview of existing evidence in an emerging field, identifying key concepts on a certain topic and gaps in research, and examining the feasibility of conducting a systematic review.¹ In contrast, systematic reviews often aim to address a precise and clinically meaningful research question and to provide guidance for future practice.¹ A scoping review was therefore considered to be more appropriate to look at what research has been done regarding dietary changes and food security in international students.

The scoping review was guided by a five-stage methodological framework from Arksey and O'Malley (see Figure 2.1) and the PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) checklist.^{2,3} An *a priori* scoping review protocol was published in *JBI Evidence Synthesis* (see Appendix I-1). The completed PRISMA-ScR checklist was submitted with the scoping review manuscript to the journal *Nutrition* for peer review.

Stage 1

Identifying the research question

- i) What are the changes in food consumption and dietary behaviours made by international students when attending tertiary education institutions in a foreign country?
- ii) What are the factors influencing the consumption and any changes over time?
- iii) Are they experiencing food insecurity?

Stage 2

Identifying relevant studies

- A three-step strategy: initial limited search → full search (electronic databases including MEDLINE, CINAHL, ERIC, Global Health, CENTRAL and PsycINFO) → screening of reference lists of included studies.

Stage 3

Study selection

- Two independent reviewers screened against inclusion criteria (discussion between two reviewers or consultation with a third expert to address any disagreement): titles and abstracts → full text.

Stage 4

Charting the data

- The first reviewer extracted data from all studies by using a data extraction form and the second reviewer extracted 20% of studies, and the two reviewers compared extracted data to ensure the accuracy and consistency.
- To present extracted data, quotations from qualitative studies and major findings from quantitative studies were charted thematically. Demographics of included studies were summarised in tables. Studies in dietary changes and food security were charted separately.

Stage 5

Collating, summarising and reporting results

- The results of included studies were summarised; implications and recommendations for intervention and future research were identified.

Figure 2.1. Process for scoping review of dietary acculturation and food insecurity among international students, applying the five-stage methodological framework for scoping reviews from Arksey and O'Malley.²

2.3 Systematic review

To investigate the association between food insecurity and dietary outcomes among university students, a systematic review was completed. The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) 2009 statement⁴ was used to conduct this review (the updated 2020 statement was published after the review was completed).⁵ The methods used for this review are summarised in Figure 2.2. An *a priori* systematic review protocol was registered on PROSPERO, an international prospective register of systematic reviews (registration number CRD42020196196; see Appendix I-2). The completed MOOSE (Meta-analyses Of Observational Studies in Epidemiology) checklist⁶ was submitted with the systematic review manuscript as required by the *Journal of the Academy of Nutrition and Dietetics*. Critical appraisal checklists from JBI were used to assess the quality of each included study.^{7,8}

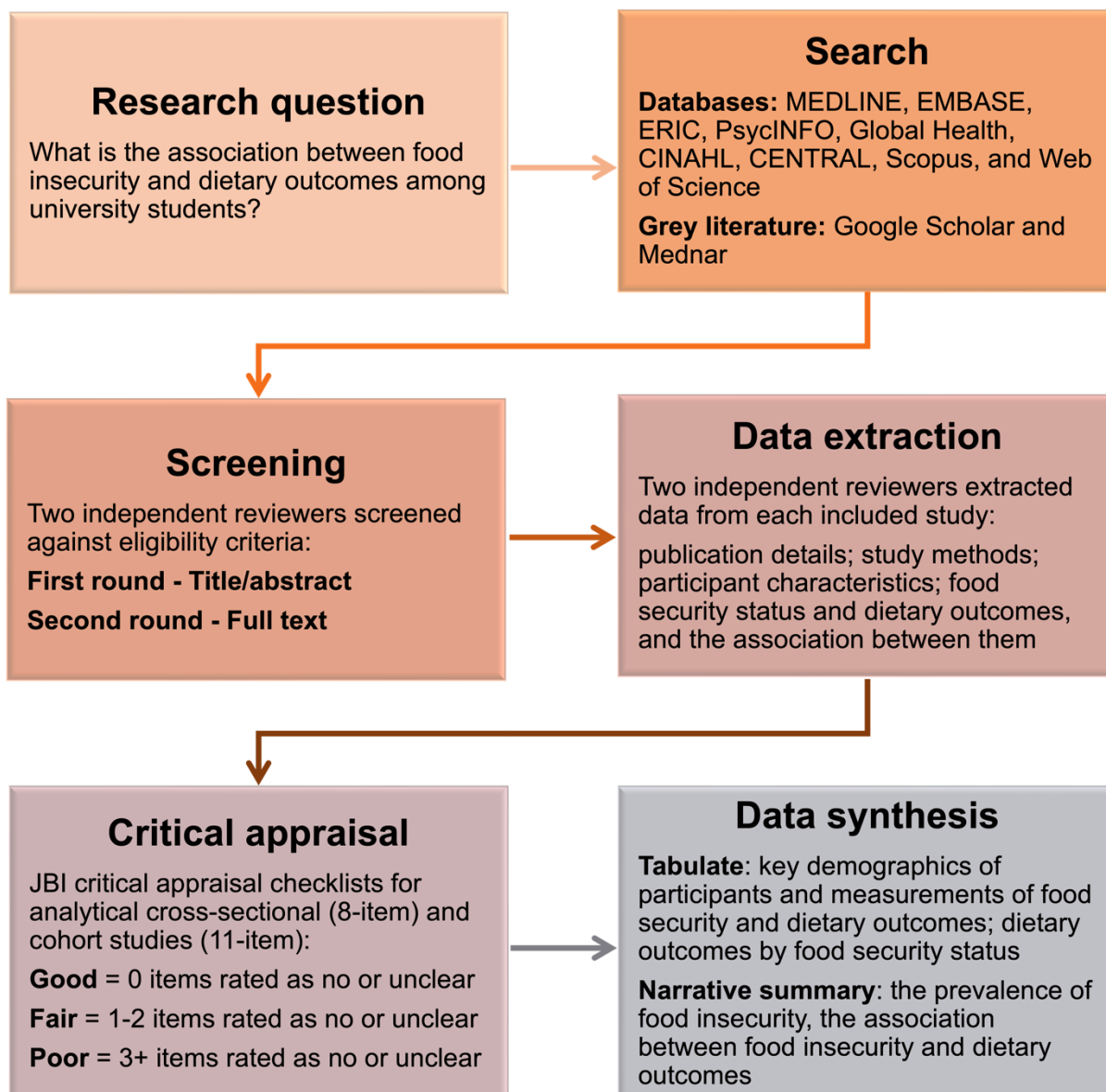


Figure 2.2. Methods for systematic review on the association between food insecurity and dietary outcomes among university students.

2.4 Mixed methods research

“Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.”^{9(p123)}

This definition of mixed methods research was provided by Johnson et al. after analysing the opinions from leaders in this type of research.⁹ The mixed methods research design can be applied in a single study or in a research program with multiple closely related studies⁹; this thesis is a case of the latter. Common designs for mixed methods research can be divided into four types: a) convergent parallel (conduct qualitative and quantitative data collection and analysis at the same stage with equal importance), b) exploratory sequential (qualitative data collection and analysis prior to quantitative data collection and analysis), c) explanatory sequential (quantitative data collection and analysis prior to qualitative data collection and analysis), and d) embedded (one dominant design and the other embedded within the dominant design) (see Figure 2.3).^{10,11} The mixed methods research design helps researchers to address more complex research questions and provide broader and deeper understanding compared with qualitative or quantitative approaches alone.¹¹

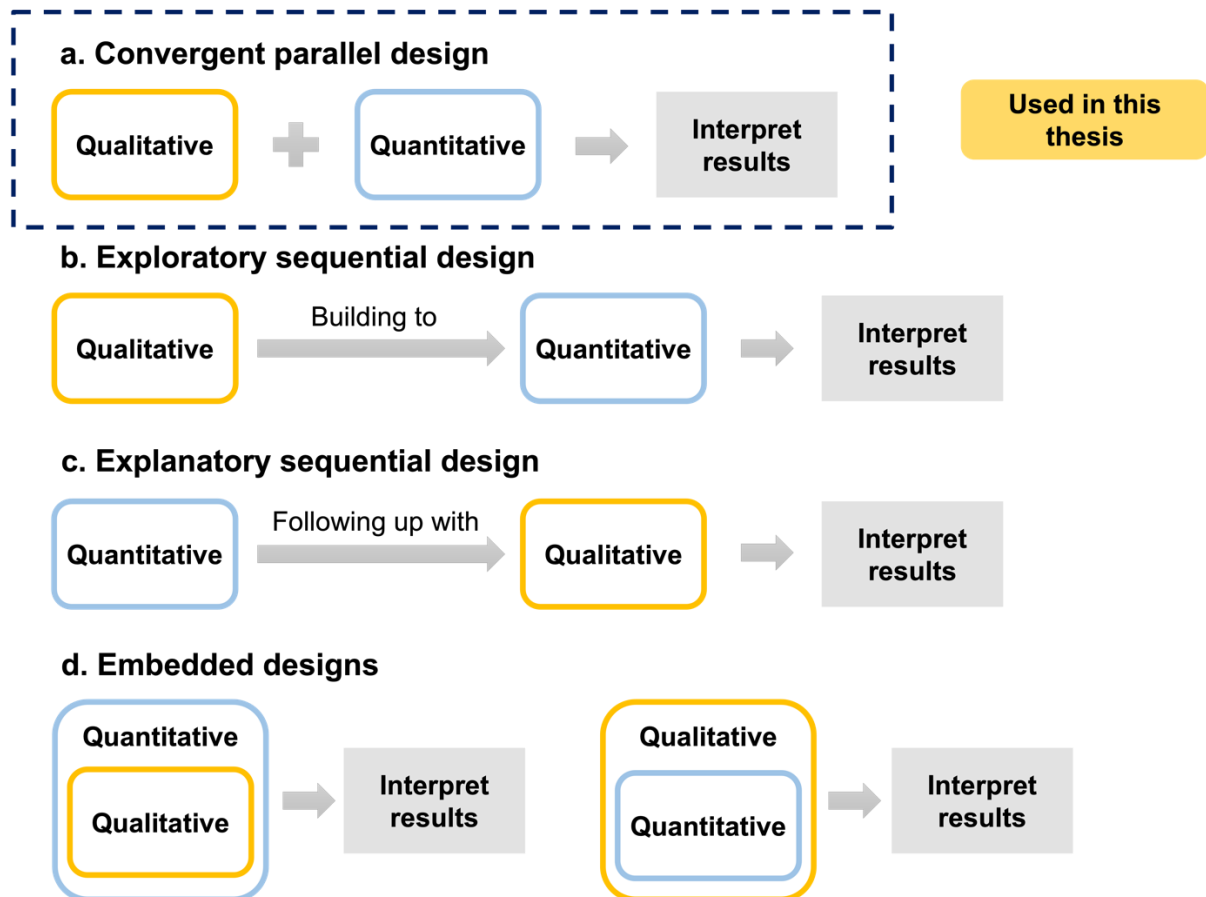


Figure 2.3. Common mixed methods research designs.

In this thesis, the qualitative study aimed to understand changes in dietary behaviours among international students after they commenced tertiary education in Australia through semi-structured interviews. The preliminary findings from the qualitative study were used to facilitate the design of the quantitative studies that followed. The quantitative studies measured the prevalence of food insecurity and diet quality among international and domestic students, and compared the two student groups. All findings from these studies were integrated to develop recommendations for achieving improved food security and better diet quality for Australian university students (**Chapter Eight**). The overall design of this mixed methods research is summarised in Figure 2.4.

Mixed methods design

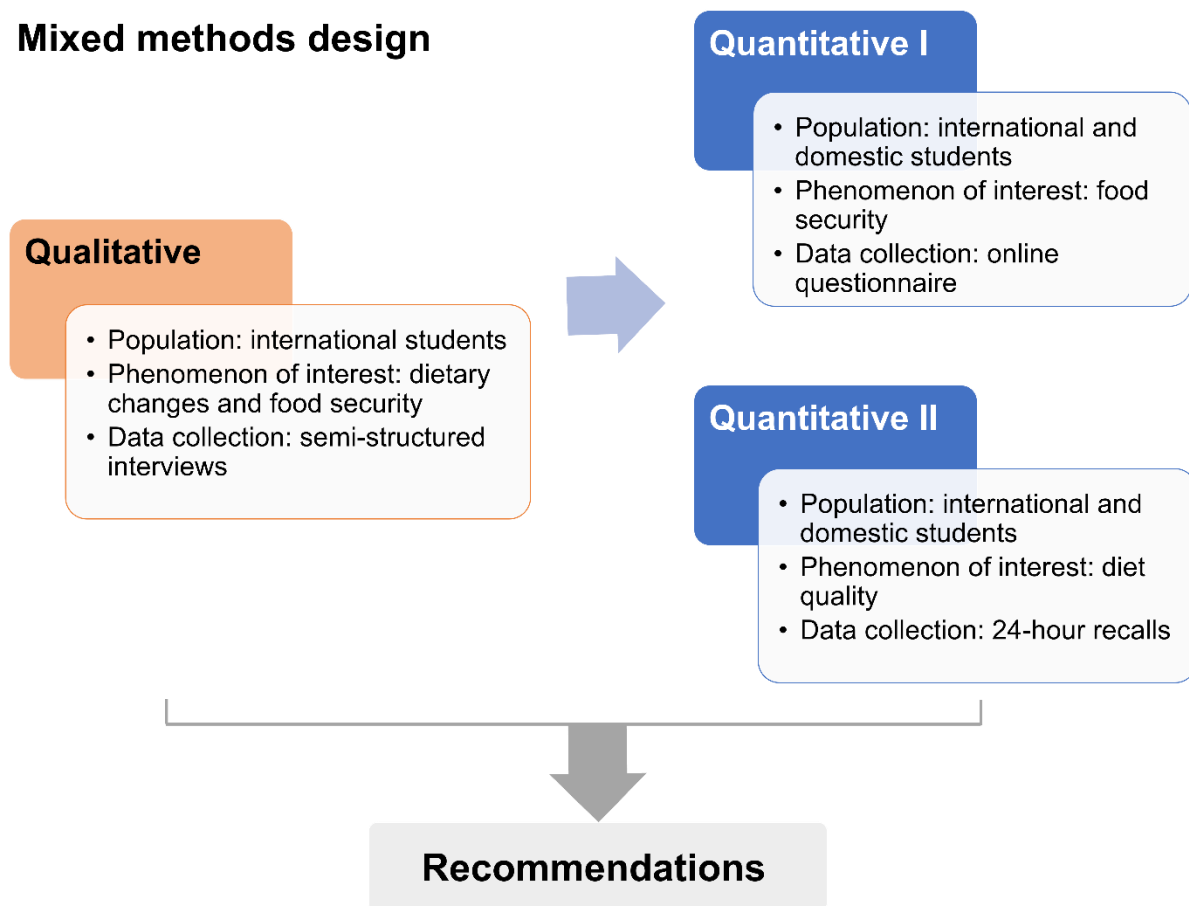


Figure 2.4. The mixed methods design in this thesis.

2.5 Qualitative study

To understand changes in dietary habits of international students after they relocated from their home country to Australia for receiving tertiary education, a qualitative approach was chosen. This study aimed to determine what changes were made by international students and why they made the changes, in addition to the impacts of these changes. Students' experiences of food insecurity were also investigated to assist the design of a food security questionnaire. The phenomenological approach was used as the theoretical framework to guide this research because of its appropriateness for exploring lived experience in a group of people facing significant life transitions,¹² which was the purpose of this study.

Purposive sampling was used to recruit appropriate participants, and they were invited to tell their friends about joining the study (snowball recruitment). Participants checked their eligibility and provided consent via a questionnaire hosted on the Research Electronic Data Capture (REDCap, Vanderbilt University, Nashville, TN, US) secure online platform for survey management. To compensate participants for their time, a \$20 supermarket gift voucher was provided for each participant who completed the interview. In total, 14 international students were interviewed between March 2020 and April 2022. Recruitment of onshore international students in Australia was severely hampered by the national border closure and continuing travel restrictions resulting from the ongoing COVID-19 pandemic. The sample size was guided by the concept of ‘information power’, which indicates that the more relevant information held by the sample, the fewer participants are needed.¹³ The information power was continuously monitored during the process of data collection, and recruitment ceased when the information power was considered adequate for the purpose of this study. This study was approved by the University of Sydney Human Research Ethics Committee (HREC) 2020/006 (see Appendix II-1).

Semi-structured interviews were used to collect data to obtain an in-depth understanding of the phenomena being studied. Individual interviews were used in preference to focus group discussions because they provided greater privacy for participants and made it easier for them to share opinions about sensitive issues (e.g., food insecurity). The interview guide was developed based on literature reviews and piloted with international students and colleagues conducting nutrition research. The guide was then modified to improve the clarity of questions and was further adjusted during the process of data collection. The final interview guide can be seen in **Chapter Five**. Face-to-face interviews were conducted via Zoom (Zoom Video Communications, San Jose, CA, US), a commonly used platform for online conferencing, due

to lockdowns and restrictions during the pandemic. Data coding and analysis were conducted in NVivo (QSR International, Melbourne, VIC, Australia) by two researchers. Data analysis was guided by the approach of interpretative phenomenological analysis, which aims to provide a detailed exploration of lived experiences from participants.¹² The process followed for this qualitative research is shown in Figure 2.5, and further details of each step will be described in **Chapter Five**.

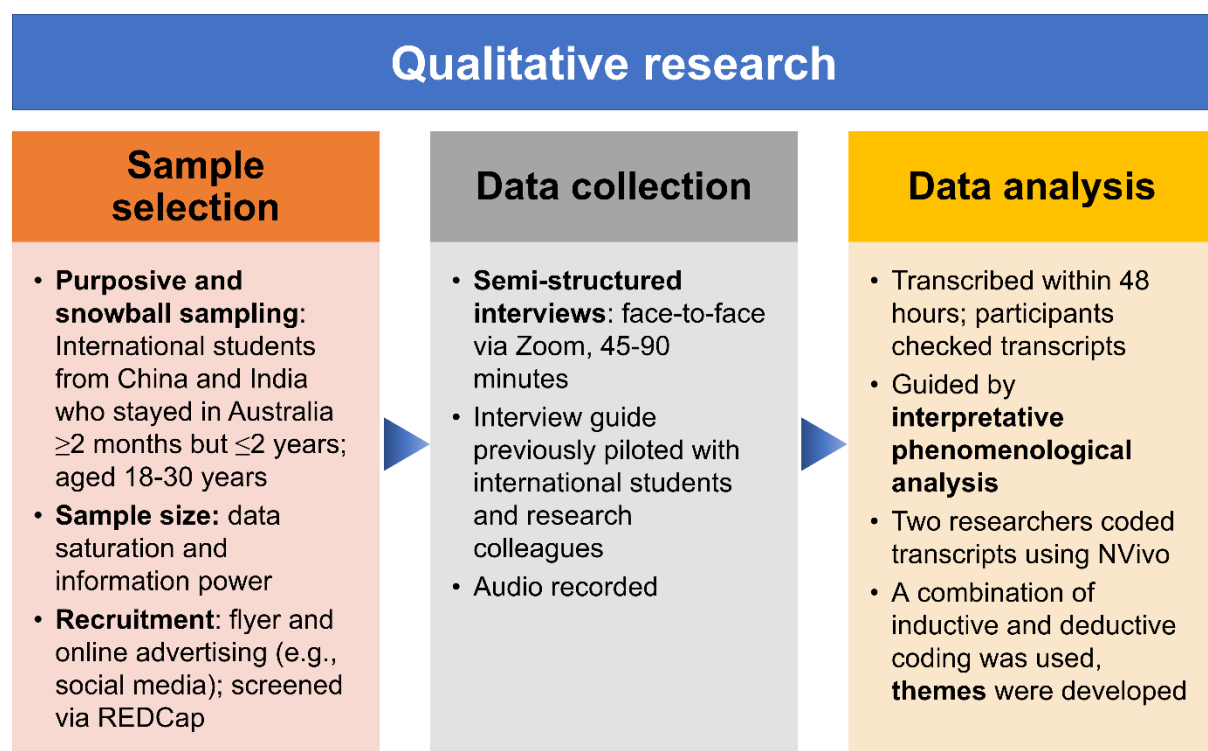


Figure 2.5. Methods of the qualitative study on dietary patterns of international students.

2.6 Food security survey

To assess the food security status of international and domestic tertiary education students in Australia and detect differences between the two student groups in their experience of food insecurity, an online survey was conducted among students from a large Australian university.

2.6.1 Development of questionnaire

A 73-item pilot questionnaire was developed based on literature reviews and preliminary results of a qualitative study (**Chapter Five**) exploring dietary changes and food security status of international students in Australia. During the development process, comment was sought from other specialists in nutrition and dietetics before the final survey was developed. The questionnaire consisted of five modules: demographics (module 1), living, employment, and financial status (module 2), food security status (module 3), diet-related behaviours (module 4), and health and academic outcomes (module 5).

Questions concerning common demographic characteristics of tertiary education students were tailored to the Australian context. For example, Indigenous students were able to state their identification as Aboriginal and Torres Strait Islander. International students were asked to specify their length of residence in Australia and their country of origin. The most common sources of international students in Australia (i.e., top five countries) were listed as options for country of origin, with another option of “other” into which text could be typed for clarification.¹⁴ Questions on living arrangement, employment, and financial status were included in the second module, with further questions on changes in these factors during the COVID-19 pandemic.¹⁵

To measure the food security status of tertiary education students, the 10-item Adult Food Security Survey Module (FSSM) from the US Department of Agriculture (USDA)¹⁶ was used in the pilot questionnaire. This survey tool is commonly used to investigate the prevalence of food insecurity among tertiary education students, but the validity of this tool in tertiary education students requires further research.¹⁷

Questions related to dietary behaviours were grouped into module 4, including questions about weekly food budget, adequacy of cooking facilities, self-perception of culinary skills, and frequency of cooking and eating out. To include questions related to food literacy, a 4-item tool that has been validated in tertiary education students to measure cooking self-efficacy was included.¹⁸⁻²⁰ The questions on the consumption of fruits and vegetables were extracted from the National Nutrition and Physical Activity Survey 2011–12, and have previously been validated.^{21,22} Examples of standard serves from the Australian Guide to Healthy Eating (AGHE) were included in the questionnaire for participants to estimate their intake.²³ The awareness of available food assistance services was assessed, since low awareness was often reported in previous food security research in tertiary education students. Additional programs were organised for this population during the COVID-19 pandemic.²⁴⁻²⁶ Some coping strategies from existing literature were listed to assess whether the students used them, and respondents were allowed to type their additional strategies in an open question.²⁶⁻³²

In the final module, the impacts of food security status on health and academic outcomes were assessed. Self-perceived physical and mental health were included.³³ Self-reported height (cm) and weight (kg) were collected for the calculation of body mass index (BMI). Mental health status was further measured by the WHO-5 Well-Being Index.³⁴ The influence on academic outcomes was assessed from three perspectives: attendance of classes, academic performance, and withdrawal from courses.³⁵ At the end of this module, a list of available support services was attached for participants if they needed to seek help, including food assistance programs, mental health counselling, and international student support services.

2.6.2 Pilot test and modification of questionnaire

The pilot survey was conducted online in July and August 2021 with ethics approval from the University of Sydney HREC 2021/445 (see Appendix II-2). Current non-dietetic undergraduate and postgraduate students aged 18–30 years in Australia were eligible to participate. Participants were able to check their eligibility, provide consent, and complete the self-administered questionnaire via REDCap. Convenience sampling was used to recruit participants for this pilot study. A total of 22 participants completed the pilot questionnaire. One of eight domestic students and one of 14 international students were food insecure.

An open-ended question was added at the end of each module in the pilot questionnaire for comments and suggestions. The questionnaire was then modified based on the responses and suggestions from participants of the survey pilot. The expression of some questions and options were modified for better understanding. For example, in the first module, the option of “Postgraduate” in the question asking about the student’s current degree was further clarified as “Postgraduate (including Higher Degree by Research)” to eliminate confusion for students enrolled in research degrees. The definition of dependent children was added to the last question in the first module: “Do you have any dependent children (under the age of 18 years)?”. The option of “Prefer not to say” was added in the second module for questions related to employment and financial status to encourage participants to complete the survey even if they preferred not to answer those questions. A few coping strategies in module 4 were also further explained to improve understanding; for example, the meaning of “stretched” was not clear to some participants and was modified to “Stretched (i.e., spread out) food to make it last longer”, and examples of sharing food were added as “Sharing food or groceries (e.g., with friends, roommates, or family members)”.

Unlike the 18-item Household FSSM,³⁶ the 10-item Adult FSSM does not contain questions for households with dependent children. After consultation with an expert in food security research, the questionnaire was modified to use the 18-item Household FSSM instead of the 10-item Adult FSSM. The 18-item Household FSSM contained the same set of 10 questions as the 10-item Adult FSSM for households without children and an additional eight questions for households with children. Participants with dependent children were required to answer those additional eight questions for the food security status of children.

A final open-ended question was added at the end of the survey to ask participants to comment on the survey and/or food security. The major components of the final questionnaire are listed in Table 2.1, and the complete questionnaire can be seen in Appendix I-3.

Table 2.1. Major components in the final food security questionnaire.

Module number	Main purpose	Components
Module 1	Demographics	Age, gender, domestic or international student, Aboriginal or Torres Strait Islander status (domestic students only), length of stay in Australia and home country (international students only), enrolment status, current degree, year of study, marital status, whether they have dependent children
Module 2	Living, employment and financial status	Living arrangement (type of accommodation, live alone or with others); employment status (type of employment, weekly working hours); financial status (weekly income, sources of financial support); COVID-19-related changes (in living arrangement, job, income, support payment)
Module 3	Food security status	18-item Household Food Security Survey Module
Module 4	Diet-related behaviours	Whether student's accommodation provided meals, weekly food budget, adequacy of cooking facilities, cooking skills, cooking self-efficacy (4-item checklist), frequency of cooking and eating out, daily servings of fruits and vegetables, awareness of available food relief programs, coping strategies
Module 5	Health and academic outcomes	Self-perceived physical and mental health, height, weight, WHO-5 Well-Being Index (5-item), academic outcomes (class attendance, academic performance, withdrawal from courses)

2.6.3 Survey recruitment and data collection

The final survey was conducted in a large Australian university from October 2021 until May 2022 with ethics approval from the University of Sydney HREC 2021/745 (see Appendix II-3). Current university students aged 18–30 years who were studying in Australia and were not completing or had completed a nutrition course were eligible to participate. Convenience and snowball sampling were used to recruit participants. Online recruitment methods were utilised through, for example, social media, newsletter, and the university's online learning system. As for the pilot survey, REDCap was used to screen participants, obtain consent, and manage the questionnaire.

2.6.4 Data analysis

To determine students' food security status, the criteria in the 18-item Household FSSM were used. Affirmative responses were “yes,” “often,” “sometimes,” “almost every month”, and “some months but not every month”. The sum of affirmative responses was the raw score, and the classification criteria based on the raw score were applied as in Table 2.2. High and marginal food security were considered as food secure, while low and very low food security were considered as food insecure.

Table 2.2. Food security classification criteria.

Food security categories		Without children ^a (raw score)	With children ^b (raw score)
Food secure	High food security	0	0
	Marginal food security	1–2	1–2
Food insecure	Low food security	3–5	3–7
	Very low food security	6–10	8–18

^a Assessed by the 10-item Adult Food Security Survey Module

^b Assessed by the 18-item Household Food Security Survey Module

All statistical analysis was performed using SPSS Statistics for Windows, version 25.0 (IBM Corp, Armonk, NY, US). The Chi-square test and Fisher's exact test were used to compare the differences in categorical variables. The independent sample t-test (for normal data) and the Mann-Whitney U test (for non-normal data) were used to compare differences in continuous variables. Binary logistic regression models were used to determine the association between student characteristics and the risk of experiencing food insecurity in domestic and international students.

To summarise the comments on food security from the final open-ended question, a thematic analysis was performed. Themes were derived and developed from the collected data and presented with representative quotations.

2.7 Diet quality measurement

To assess the diet quality of both international and domestic students, 24-hour dietary recalls were collected from students using the Australian version of the Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24-Aus) between October 2021 and July 2022. The recruitment to this study was performed simultaneously with the food security survey as approved by the University of Sydney HREC 2021/745 (see Appendix II-3). Survey respondents were asked whether they had an interest in completing two dietary recalls, and participants were able to provide their consent on REDCap. The Healthy Eating Index for Australian Adults (HEIFA-2013) was used to calculate the overall diet quality scores from the recall data. The following sub-sections will introduce the data collection tool (ASA24-Aus), diet quality index (HEIFA-2013), and statistical analysis.

2.7.1 Automated Self-Administered 24-hour Dietary Assessment Tool Australian version (ASA24-Aus)

The original ASA24 was developed by the US National Cancer Institute. It allows respondents to complete 24-hour recalls online. In our study, participants were asked to complete two self-administered 24-hour recalls, on two non-consecutive days (one weekday and one weekend day). Participants were required to enter information about all foods and drinks they consumed on the previous day from midnight to midnight. The ASA24 followed a multiple-pass approach to collect information on food and drink items, preparation methods, additional ingredients, portion size, and forgotten items (Figure 2.6). Each recall takes approximately 25 to 30 minutes to complete.

The most recent version of the ASA24-Aus (ASA24-Australia-2016) was selected for use in our study. This version uses the Australian Food, Supplement and Nutrient Database

(AUSNUT) 2011–13;³⁷ however, no food group database was available for this version. The analytic files generated from this version of the ASA24-Aus contain intakes of energy and some, but not all, nutrients that are included in AUSNUT 2011–13 (e.g., protein, total fats, saturated fatty acids, calcium, sodium, and vitamin C), but food group intakes are not provided.

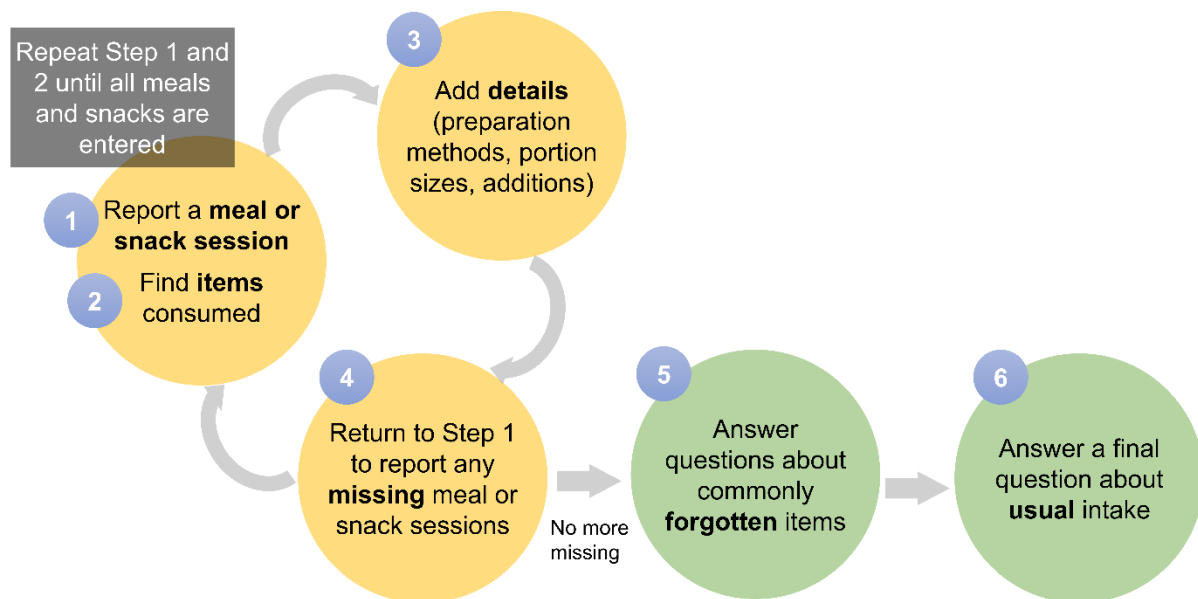


Figure 2.6. Flow of 24-hour recalls in the Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24).

2.7.2 Healthy Eating Index for Australian Adults (HEIFA-2013)

The HEIFA-2013 was developed based on the most recent Australian Dietary Guidelines (ADG) and AGHE published in 2013.^{23,38,39} The HEIFA-2013 is a quantitative measure of diet quality examining adherence to the national guidelines in Australia. This index has been validated in Australian young adults from dietary data collected by food frequency questionnaires, food records, and 24-hour dietary recalls.³⁹⁻⁴¹

The HEIFA-2013 consists of 11 components, including the consumption of five main food groups (vegetables, fruits, grains, dairy products, lean meat and alternatives), discretionary

foods, four nutrients (fat, added sugar, sodium, alcohol), and water.^{39,41} The minimum total score is 0 and the maximum is 100. The intake of alcohol and water are allocated 5 marks for each, and each of the other nine components is allocated 10 marks. The HEIFA-2013 not only considers the adequacy of intake but also dietary variety. The scores of vegetables, fruits, and grains contain two parts – one for total daily intake, and one for variety of vegetables and fruits/consumption of wholegrains – with 5 marks for each part.

Within each component of the index, the scoring criteria were developed based on the difference between the actual intake of an individual and ADG recommendations for adults aged 19–50 years.³⁸ The maximum sub-score can be achieved by meeting the corresponding recommendation for a specific gender. The standard serve sizes were derived from the AGHE, and the detailed scoring criteria are listed in Table 2.3.

Table 2.3. Healthy Eating Index for Australian Adults (HEIFA-2013) scoring criteria.

Components		Indicator (maximum marks)	Scoring criteria	
Five food groups	Vegetables	Serves of total vegetables per day ^a (5 marks)	Male:	Female:
			≥6.0 serves = 5	≥5.0 serves = 5
			4.8–5.9 serves = 4	4.0–4.9 serves = 4
			3.6–4.7 serves = 3	3.0–3.9 serves = 3
			2.4–3.5 serves = 2	2.0–2.9 serves = 2
			1.0–2.3 serves = 1	1.0–1.9 serves = 1
			<1.0 serve = 0	<1.0 serve = 0
		Serves of different varieties per day ^a (5 marks)	≥1.0 serve of green = 1	
			≥1.0 serve of orange = 1	
			≥1.0 serve of cruciferous = 1	
			≥1.0 serve of tuber or bulb = 1	
			≥0.5 serve of legumes = 1	
	Fruits	Serves of total fruits per day ^a (5 marks)	≥2.0 serves = 5	
			1.5–1.9 serves = 3.75	
			1.0–1.4 serves = 2.5	
			0.5–0.9 serve = 1.25	
			<0.5 serve = 0	
		Variety of fruit per day (5 marks)	2 or more varieties = 5	
			<2 varieties = 0	
	Grains	Serves of grains per day ^a (5 marks)	≥6.0 serves = 5	
			5.0–5.9 serves = 4.17	
			4.0–4.9 serves = 3.34	
			3.0–3.9 serves = 2.5	
			2.0–2.9 serves = 1.67	
			1.0–1.9 serves = 0.84	
			<1.0 serve = 0	
		Serves of wholegrains per day ^a (5 marks)	≥3.0 serves = 5	
			2.5–2.9 serves = 4	
			2.0–2.4 serves = 3	
			1.5–1.9 serves = 2	
			1.0–1.4 serves = 1	
			<1.0 serve = 0	
	Dairy products	Serves per day ^a (10 marks)	≥2.5 serves = 10	
			2.0–2.4 serves = 8	
			1.5–1.9 serves = 6	
			1.0–1.4 serves = 4	
			0.5–0.9 serves = 2	
			<0.5 serve = 0	

Components		Indicator (maximum marks)	Scoring criteria	
Meat and alternatives		Serves per day ^a (10 marks)	Male: ≥3.0 serves = 10 2.5–2.9 serves = 8 2.0–2.4 serves = 6 1.5–1.9 serves = 4 1.0–1.4 serves = 2 <1.0 serve = 0	Female: ≥2.5 serves = 10 2.0–2.4 serves = 8 1.5–1.9 serves = 6 1.0–1.4 serves = 4 0.5–0.9 serve = 2 <0.5 serve = 0
Discretionary choices		Serves per day ^a (10 marks)	Male: <3.0 serves = 10 3.0–3.9 serves = 7.5 4.0–4.9 serves = 5 5.0–5.9 serves = 2.5 ≥6.0 serves = 0	Female: <2.5 serves = 10 2.5–3.4 serves = 7.5 3.5–4.4 serves = 5 4.5–5.4 serves = 2.5 ≥5.5 serves = 0
Nutrients	Fat	% Energy intake from total saturated fat per day (5 marks)	≤10% of total energy = 5 >10% – 12% = 2.5 >12% = 0	
		Serves of poly- and monounsaturated fatty acids per day ^a (5 marks)	Male: ≥4.0 serves = 5 3.0–3.9 serves = 3.75 2.0–2.9 serves = 2.5 1.0–1.9 serves = 1.25 <1.0 serve = 0	Female: ≥2.0 serves = 5 1.5–1.9 serves = 3.75 1.0–1.4 serves = 2.5 0.5–0.9 serve = 1.25 <0.5 serve = 0
	Added sugar	% Energy intake from added sugar per day (10 marks)	≤5% of total energy = 10 >5% – 10% = 5 >10% = 0	
	Sodium	Sodium intake per day (10 marks)	≤1610 mg = 10 >1610 – 2300 mg = 5 >2300 mg = 0	
	Alcohol	Number of standard drinks per day ^a (5 marks)	≤2 standard drinks = 5 >2 standard drinks = 0	
Water		Proportion of water consumed in relation to other beverages per day (5 marks)	≥50% = 5 40% – 49% = 4 30% – 39% = 3 20% – 29% = 2 10% – 19% = 1 <10% = 0	

^a Standard serve sizes: vegetables (75g vegetables and legumes, 125g vegetable juice); fruits (150g whole/canned fruit, 125mL fruit juice, 30g dried fruit); grains/wholegrains (500kJ); dairy products (250mL milk, 200mL yoghurt, 550kJ cheese, 200mL custard); lean meat and alternatives (65g red meat/offal, 80g poultry, 100g fish/seafood, 120g eggs, 170g meat alternatives, 30g nuts/seeds); discretionary choices (375mL beverages, 600kJ foods); poly- and monounsaturated fatty acids (250kJ); standard drink (10g alcohol).

2.7.3 *Data analysis*

Mixed dishes reported by participants were disaggregated into ingredients based on the recipe file from AUSNUT 2011–13.³⁷ The combination of ingredients from mixed dishes and individual food or drink items was used for the assessment of food group intakes. Fat and sodium intakes were extracted from the output analysis file from the ASA24-Aus. Intake of added sugar was not included in the ASA24-Aus output and was calculated by merging the file of reported food items from participants with the nutrient file from AUSNUT 2011–13.³⁷ The HEIFA-2013 score for each participant was then calculated from food group and nutrient intakes based on the scoring criteria. These steps were conducted in SAS version 9.4 (SAS Institute Inc, Cary, NC, US) statistical software using programs written by Dr Amanda Grech and modified by the candidate.

Statistical analysis was conducted using SPSS Statistics for Windows, version 25.0 (IBM Corp, Armonk, NY, US). To control for misreporting, the mean HEIFA-2013 scores were adjusted by the ratio of energy intake to estimated basal metabolic rate (EI:BMR) for a more accurate estimation of the diet quality.⁴² The estimated BMR was calculated based on self-reported weight by using the Schofield equation.⁴³ Analysis of covariance was used to calculate the adjusted mean HEIFA-2013 total scores and compare the differences by student characteristics. For comparing the scores of individual components of the HEIFA-2013 by food security status, the Mann-Whitney U test was used due to non-normal distribution.

2.8 References

1. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol*. 2018;18(1):143. doi:10.1186/s12874-018-0611-x
2. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005;8(1):19-32. doi:10.1080/1364557032000119616
3. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169(7):467-473. doi:10.7326/M18-0850
4. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009;339:b2535. doi:10.1136/bmj.b2535
5. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71
6. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. *JAMA*. 2000;283(15):2008-2012. doi:10.1001/jama.283.15.2008
7. Moola S, Munn Z, Tufanaru C, et al. Chapter 7: Systematic reviews of etiology and risk, Appendix 7.5 Critical appraisal checklist for analytical cross-sectional studies. In: Aromataris E, Munn Z, eds. *JBIM Manual for Evidence Synthesis*. Joanna Briggs Institute; 2020.
8. Moola S, Munn Z, Tufanaru C, et al. Chapter 7: Systematic reviews of etiology and risk, Appendix 7.1 Critical appraisal checklist for cohort studies. In: Aromataris E, Munn Z, eds. *JBIM Manual for Evidence Synthesis*. Joanna Briggs Institute; 2020.
9. Johnson RB, Onwuegbuzie AJ, Turner LA. Toward a definition of mixed methods research. *J Mix Methods Res*. 2007;1(2):112-133. doi:10.1177/1558689806298224
10. Creswell JW, Plano Clark VL. *Designing and Conducting Mixed Methods Research*. 2nd ed. SAGE Publications; 2011.
11. Kajamaa A, Mattick K, de la Croix A. How to ... do mixed-methods research. *Clin Teach*. 2020;17(3):267-271. doi:10.1111/tct.13145
12. Smith JA, Larkin MH, Flowers P. *Interpretative Phenomenological Analysis: Theory, Method and Research*. SAGE; 2008.
13. Malterud K, Siersma VD, Guassora AD. Sample size in qualitative interview studies: guided by information power. *Qual Health Res*. 2016;26(13):1753-1760. doi:10.1177/1049732315617444
14. Department of Education, Skills and Employment, Australian Government. International student data monthly summary – June 2021. Accessed September 17, 2022. <https://internationaleducation.gov.au/research/international-student-data/Documents/MONTHLY%20SUMMARIES/2021/Jun%202021%20MonthlyInfoGraphic.pdf>

15. Kent K, Murray S, Penrose B, et al. Prevalence and socio-demographic predictors of food insecurity in Australia during the COVID-19 pandemic. *Nutrients*. 2020;12(9):2682. doi:10.3390/nu12092682
16. Economic Research Service, The United States Department of Agriculture. US Adult Food Security Survey Module. Accessed September 17, 2022. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#adult>
17. Shi Y, Davies A, Allman-Farinelli M. The association between food insecurity and dietary outcomes in university students: a systematic review. *J Acad Nutr Diet*. 2021;121(12):2475-2500.e2471. doi:10.1016/j.jand.2021.07.015
18. Clifford D, Anderson J, Auld G, Champ J. Good Grubbin': impact of a TV cooking show for college students living off campus. *J Nutr Educ Behav*. 2009;41(3):194-200. doi:10.1016/j.jneb.2008.01.006
19. Gaines A, Robb CA, Knol LL, Sickler S. Examining the role of financial factors, resources and skills in predicting food security status among college students. *Int J Consum Stud*. 2014;38(4):374-384. doi:10.1111/ijcs.12110
20. Knol LL, Robb CA, McKinley EM, Wood M. Very low food security status is related to lower cooking self-efficacy and less frequent food preparation behaviors among college students. *J Nutr Educ Behav*. 2019;51(3):357-363. doi:10.1016/j.jneb.2018.10.009
21. Australian Bureau of Statistics. 4363.0.55.001 – National Nutrition and Physical Activity Survey 2011–12: questionnaire. Accessed September 17, 2022. [https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/734DF823586D5AD9CA257B8E0014A387/\\$File/national%20nutrition%20and%20physical%20activity%20survey%202011-12%20questionnaire.pdf](https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/734DF823586D5AD9CA257B8E0014A387/$File/national%20nutrition%20and%20physical%20activity%20survey%202011-12%20questionnaire.pdf)
22. Marks G, Webb K, Rutishauser I, Riley M. *Monitoring Food Habits in the Australian Population Using Short Questions*. Australian Government Department of Health and Aged Care; 2001. *National Food and Nutrition Monitoring and Surveillance Project*. 01/01.
23. National Health and Medical Research Council (NHMRC). *Australian Guide to Healthy Eating*. NHMRC; 2013. Accessed September 17, 2022. <https://www.eatforhealth.gov.au/>
24. Hughes R, Serebryanikova I, Donaldson K, Leveritt M. Student food insecurity: the skeleton in the university closet. *Nutr Diet*. 2011;68(1):27-32. doi:10.1111/j.1747-0080.2010.01496.x
25. Study NSW. COVID-19 Help Hub for international students – food assistance. Accessed September 17, 2022. <https://www.study.sydney/programs/food-assistance>
26. Waity JF, Huelskamp A, Russell J. Collaborating to assess and address food insecurity on a college campus: a case study at a mid-sized, regional university. *Innovative High Educ*. 2020;45:405-417. doi:10.1007/s10755-020-09512-y
27. Bowden M. *Understanding Food Insecurity in Australia*. CFCA Paper No 55. Australian Institute of Family Studies; 2020. Accessed September 17, 2022. <https://aifs.gov.au/cfca/publications/understanding-food-insecurity-australia>

28. Brescia SA, Cuite CL. Understanding coping mechanisms: an investigation into the strategies students use to avoid, manage, or alleviate food insecurity. *J Coll Character*. 2019;20(4):310-326. doi:10.1080/2194587X.2019.1669463
29. Farahbakhsh J, Ball GD, Farmer AP, Maximova K, Hanbazaza M, Willows ND. How do student clients of a university-based food bank cope with food insecurity? *Can J Diet Pract Res*. 2015;76(4):200-203. doi:10.3148/cjdpr-2015-020
30. Frank L. "Hungry for an Education": prevalence and outcomes of food insecurity among students at a primarily undergraduate university in rural Nova Scotia. *Can J High Educ*. 2018;48(2):109-129. doi:10.47678/cjhe.v48i2.188112
31. Hanbazaza M, Ball GDC, Farmer AP, Maximova K, Farahbakhsh J, Willows ND. A comparison of characteristics and food insecurity coping strategies between international and domestic postsecondary students using a food bank located on a university campus. *Can J Diet Pract Res*. 2017;78(4):208-211. doi:10.3148/cjdpr-2017-012
32. Huelskamp A, Waity J, Russell J. Effects of campus food insecurity on obesogenic behaviors in college students. *J Am Coll Health*. 2021;69(5):572-575. doi:10.1080/07448481.2019.1684298
33. Becerra MB, Becerra BJ. Psychological distress among college students: role of food insecurity and other social determinants of mental health. *Int J Environ Res Public Health*. 2020;17(11):4118. doi:10.3390/ijerph17114118
34. Topp CW, Østergaard SD, Søndergaard S, Bech P. The WHO-5 Well-Being Index: a systematic review of the literature. *Psychother Psychosom*. 2015;84(3):167-176. doi:10.1159/000376585
35. Silva MR, Kleinert WL, Sheppard AV, et al. The relationship between food security, housing stability, and school performance among college students in an urban university. *J Coll Stud Retent: Res Theory Pract*. 2017;19(3):284-299. doi:10.1177/1521025115621918
36. Economic Research Service, The United States Department of Agriculture. US Household Food Security Survey Module. Accessed September 17, 2022. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#household>
37. Food Standards Australia New Zealand. AUSNUT 2011–2013. Updated November 13, 2020. Accessed September 17, 2022. <https://www.foodstandards.gov.au/science/monitoringnutrients/ausnut/pages/default.aspx>
38. National Health and Medical Research Council (NHMRC). Australian Dietary Guidelines: summary. NHMRC;2013. Accessed September 17, 2022. https://www.eatforhealth.gov.au/sites/default/files/content/The%20Guidelines/n55a_australian_dietary_guidelines_summary_131014_1.pdf
39. Roy R, Hebden L, Rangan A, Allman-Farinelli M. The development, application, and validation of a Healthy Eating Index for Australian Adults (HEIFA-2013). *Nutrition*. 2016;32(4):432-440. doi:10.1016/j.nut.2015.10.006
40. Grech A, Rangan A, Allman-Farinelli M. Social determinants and poor diet quality of energy-dense diets of Australian young adults. *Healthcare*. 2017;5(4):70. doi:10.3390/healthcare5040070

41. Grech A, Sui Z, Siu HY, Zheng M, Allman-Farinelli M, Rangan A. Socio-demographic determinants of diet quality in Australian adults using the validated Healthy Eating Index for Australian Adults (HEIFA-2013). *Healthcare*. 2017;5(1):7. doi:10.3390/healthcare5010007
42. Black AE. The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying diet reports of poor validity. *Eur J Clin Nutr*. 2000;54(5):395-404. doi:10.1038/sj.ejcn.1600971
43. Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. *Hum Nutr Clin Nutr*. 1985;39(suppl 1):5-41.

2.9 Conclusion to chapter

Chapter Two summarised the methods that have been used in this thesis, including both literature reviews and primary studies using the mixed methods research design. The following chapters will report these reviews and studies one by one starting from a scoping review of dietary acculturation and food insecurity among international students in **Chapter Three**.

Chapter Three. Food access, dietary acculturation, and food insecurity among international tertiary education students: a scoping review

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3.1 Publication details

This chapter presents the manuscript entitled “Food access, dietary acculturation, and food insecurity among international tertiary education students: a scoping review” published in *Nutrition*, 2021, Volume 85, May: 111100, doi:10.1016/j.nut.2020.111100. The manuscript is presented in the journal format. The protocol of this scoping review has been published in *JBIEvidence Synthesis*, 2020, Volume 18, Issue 9: 2090–2097, doi:10.11124/JBISRIR-D-19-00328 (see *Appendix I-1*).

3.2 Author contribution

I Yumeng Shi (the candidate) was the primary researcher involved in developing the research question, search strategy, study selection, data extraction and synthesis. The second author (Natalya Lukomskyj) assisted with screening of articles and extracting the data. Professor Margaret Allman-Farinelli contributed to the design of the study and the synthesis of the results. I summarised the information and wrote the first draft of this manuscript for publication. All authors reviewed and revised the manuscript draft.

3.3 Introduction to chapter

After introducing the background information (**Chapter One**) and research methods (**Chapter Two**) of this thesis, this chapter reports a narrative synthesis of published quantitative and qualitative studies that examined dietary changes and food security status of international students in tertiary education settings. Quality assessment of included studies was not conducted for this scoping review following the suggestion from the JBI. The findings from quantitative studies were summarised in a tabular form with key demographics. A thematic analysis was conducted to synthesise the findings from qualitative studies. A descriptive summary of all included studies on dietary changes and food security status of international students is provided.

3.4 Manuscript

(Appears on next page)



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Review article

Food access, dietary acculturation, and food insecurity among international tertiary education students: A scoping review



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ABSTRACT

The number of international students within tertiary education facilities continues to increase globally, but the challenges for this population in achieving a healthy diet in an unfamiliar environment receives insufficient attention. This scoping review aimed to synthesize current literature that investigated dietary changes and food security status of this student population. We followed a five-stage methodological framework developed by Arksey and O'Malley. Six electronic databases were searched. All types of research methods, including qualitative, quantitative, and mixed methods, were considered for inclusion. This review included 30 articles reporting dietary changes and 12 articles reporting food insecurity in international students. The students were able to explore novel foods in their host country without totally abandoning their original diet, thus developing a hybrid diet. Dietary habits oscillated between the new and traditional dietary cultures with many students consuming foods from their new food environment but less so in the long term. Changes in diet may contribute to weight change and some negative health impacts, but none of the included studies investigated the effects on academic performance. Additionally, international students appeared to be more vulnerable to food insecurity, but the contributing factors and impacts of this issue were insufficiently researched. International students often experienced dietary acculturation and faced more challenges in food security than their domestic peers. More specific support should be provided by tertiary institutions and governments to international students including regular culturally appropriate nutrition education programs.

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Introduction

The internationalization of tertiary education has become a growing trend as a result of the progression of globalization. International students temporarily relocate from their home country to a foreign country to receive postsecondary education in tertiary institutions [1]. Western countries, such as the United States, the United Kingdom, and Australia [2], are the most attractive destinations for international students. In addition to the economic contribution, international education could strengthen the communication between universities and other parts of the world as graduated international students could

build networks in diverse industries in the host country and in their home countries [3,4]. However, international students often receive limited care from a health and nutrition perspective compared with the academic support provided by the tertiary education facilities [5,6].

Acculturation is a process experienced by individuals who move to a different cultural environment [7]. It involves both adaption to the host culture and maintenance of the original culture [8]. At the initial stage, acculturative stress may predominate feelings of excitement [9]. International students may face challenges caused by language differences, academic pressure, financial difficulties, and lack of social support from families and friends [10]. By understanding the needs of international students, tertiary institutions can provide services to facilitate their adjustment in order to improve both academic and living experiences in the host country [11].

With exposure to the host country's food culture, the process of dietary acculturation may involve adoption of new foods and eating habits and finding alternative ways to consume traditional foods [12]. Dietary acculturation may cause both positive and negative changes in dietary habits among immigrants. For example, an increase in using healthier food preparation methods (e.g., grilling and stir-frying) was reported in South Asian immigrants in Canada [13]. On the other hand,

YS conducted the searches, study selection, data extraction and synthesis, and wrote the first draft. NL contributed to the study selection and data extraction. MAF designed the study and contributed to the synthesis of the results. All authors reviewed and revised the manuscript draft. YS is funded by China Scholarship Council Postgraduate Research Scholarship. NL is supported by an Australian Government Research Training Program Scholarship. The conduct of this review was not affected by these funders. MAF has received funding from the National Health and Medical Research Council, NSW Health, Australian Research Council and Cancer Council NSW for other projects but not for this review.

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the association between the acculturation to Western lifestyles (e.g., the adoption of a diet high in fat and sugar), and the increased risk for chronic diseases was found in individuals who migrated to the United States [12]. Nevertheless, dietary acculturation and its effects have not been widely investigated in international students.

Dietary practices also can be influenced by food security status. Having steady access to sufficient and safe food with adequate nutrition is defined as *food security* [14]. From existing surveys, the rates of food insecurity in university students were much higher than the general population in the same region, even in developed countries [15,16]. Few studies focused specifically on food insecurity in international students. This group may be more severely affected than other students due to financial difficulties caused by higher tuition fees and additional living costs, unfamiliarity with the new food environment, and limited information about eligible food assistance programs [17]. To cope with food insecurity, overseas students may develop a range of strategies to modify their original dietary habits (e.g., substituting traditional ingredients with local food products).

Considering the complex challenges and unique needs of international students in the higher education sector, the evidence-base for nutrition-related issues resulting from temporary translocation is of importance to governments and tertiary education facilities for the development of policies for campus food environments and nutrition education programs. Therefore, the aim of this scoping review was to synthesize the current literature that investigated any changes in dietary habits and any experiences of food insecurity among international college students after their arrival in the destination country. Factors affecting nutrition and effects on physical and psychological health as well as academic performance are documented.

Three research questions were used to guide this review:

- 1 What types of changes in food consumption and dietary behaviors are made by international students when attending tertiary education institutions in a foreign country?
- 2 What factors influence international students' food consumption and any changes over time?
- 3 Are international students experiencing food insecurity?

Materials and methods

This scoping review was conducted by following the five-stage methodological framework developed by Arksey and O'Malley [18] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews checklist [19]. The review was registered on the Systematic Review Register organized by Joanna Briggs Institute (JBI), and the review protocol has been published in JBI Evidence Synthesis previously [20].

Search strategy

The three-step strategy recommended by the JBI was employed as the search strategy to locate both published and unpublished original studies [21]. Two electronic databases, MEDLINE and PsycINFO, were used to find relevant articles on the topic in the initial limited search. Based on the identified keywords and index terms from the initial search, a full search strategy was then developed with assistance from a research librarian. The next step was a full search in the selected electronic databases, including MEDLINE, CINAHL, ERIC, Global Health, Cochrane Central Register of Controlled Trials (CENTRAL), and PsycINFO. An example of the search strategy in CINAHL is shown in Appendix A. The major sources of international students in Australia were specified in the search strategy as this review will be used to guide future research in dietary practices of international higher education students in an Australian context. Finally, the reference lists of included articles were screened, and a search of unpublished studies was conducted to identify additional papers. ProQuest Dissertations and Theses, and Open Access Theses and Dissertations were used to search additional studies.

Participants

Studies investigating international students who leave their home country to receive higher education in a foreign country were included in this scoping review. Students who were born in foreign countries but have become immigrants in the host country were not eligible. A full list of inclusion and exclusion criteria is shown in Appendix B.

Concept

Changes in food and dietary patterns were the main phenomenon to be included, either the change before and after first moving to the host country or the change over time since arrival, and the food security status in this population. Associated factors and effects were also considered for inclusion. Factors may include living status, personal skills, and food environment. Effects on physical health (e.g., weight changes), psychological health (e.g., depression), and academic performance (e.g., grade point average) were included.

Context

This review considered participants in tertiary education institutions from any country around the world. All types and settings of tertiary education were eligible, such as postsecondary education, higher education, college, and university. The living status of students was not limited. Students may live alone or with others in private accommodations or residential colleges on campus.

Type of sources

This review considered all types of research methods, including qualitative, quantitative, and mixed methods. Unpublished studies from dissertations and theses of higher-degree research students were also considered for inclusion. The language of publication was limited to English and no restriction was set for the year of publication.

Study selection

All records from the full search were imported into EndNote X9.3 (Clarivate Analytics, PA, USA) [22]. After removal of duplicates, two reviewers screened the titles and abstracts against the inclusion criteria independently. Eligible studies were then retrieved in full-text and screened by the two independent reviewers. For the studies that did not meet the inclusion criteria in the full-text screening, the reasons for exclusion were recorded by both reviewers. Disagreements between the reviewers were addressed through discussion or consultation with the third reviewer.

Data extraction

A data charting form was used to extract data from included studies. Extracted data included author, year of publication, country, study aims, research design, sampling strategy, data collection methods, data analysis, demographic information of participants, primary outcomes (i.e., dietary changes and food security status), secondary outcomes (i.e., associated factors and effects on physical and psychological health, and academic performance), and implications from the full-text articles. The first reviewer completed the data extraction for all included studies, and the second reviewer extracted data from a subsample (~20%) of inclusion independently. Results from two reviewers were compared and discussed to achieve accuracy and consistency. A third reviewer was consulted if there were any disagreements between two reviewers.

Synthesis of results

For quantitative studies, the findings extracted by the data charting form were summarized in a tabular form with key demographics. For the qualitative research from the included studies, thematic analysis was conducted, which incorporated both inductive and deductive methods. The main themes (i.e., dietary changes, factors, and impacts) were decided deductively based on the research questions of this review and extracted data. The first author read the included studies repeatedly and identified the categories from the results and discussion of these studies inductively. These categories were then grouped into subthemes under each main theme. The categories and themes were verified by the second author. Discrepancies were discussed between the reviewers to achieve agreements. Quotations from the qualitative studies were selected by the first review author to represent common themes. A descriptive summary of all included studies was synthesized in dietary changes and food security status of international students from the included studies.

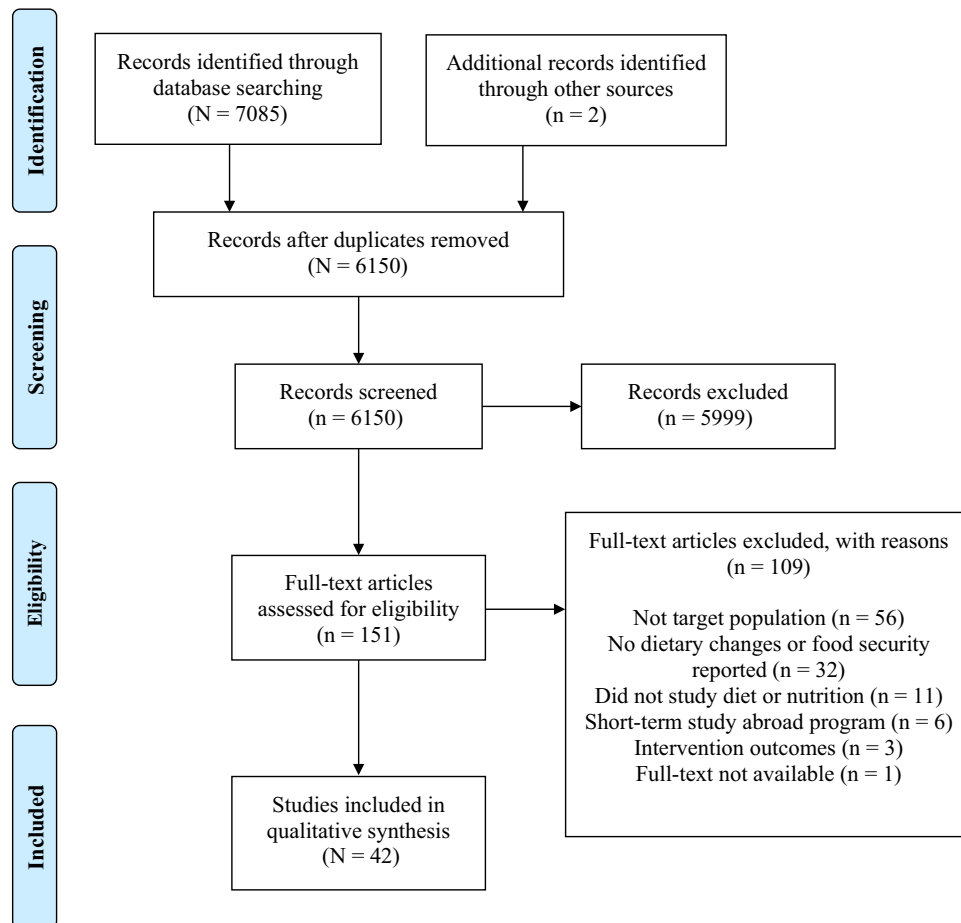


Fig. 1. PRISMA flow diagram of record identification and study selection.

Results

The full search identified 7085 citations and two articles were identified through the reference lists of included studies (Fig. 1). After removal of duplicates, titles and abstracts of 6150 citations were screened. After the exclusion from the first screening, 151 articles were screened in full text. Finally, 42 studies were eligible for inclusion. The excluded articles from full text screening are listed with reasons in Appendix C.

Study populations

Among the studies that investigated dietary changes, the majority were from the United Kingdom ($n = 13$) and the United States ($n = 8$), and 2 studies were from Australia. The demographic characteristics of qualitative and quantitative studies are shown in Table 1 [9,11,23–33] and Table 2 [33–50], respectively. The age range of international students varied, mostly between 18 and 40 y. Within 20 articles that reported the level of education of their participants, 2 and 10 studies focused on undergraduates and postgraduates, respectively, and 8 recruited both groups. From the studies that reported living situations ($n = 13$), most international students lived at home with families in their home country and lived in a dormitory or rental accommodation alone or with friends/roommates in the host country. The length of residence in the host country

of participants ranged widely across studies, from a few months to several years.

Of 12 food security studies, 7 were conducted in Canada [16,51–56]. Only one study reported the demographic characteristics of international students as a distinct group [54] while the remaining studies were inclusive of all college students.

Types of research

Of the studies reporting dietary changes, 12 and 17 studies used qualitative and quantitative approaches, respectively, and another [33] employed mixed methods. Five of these studies were longitudinal design, collecting data from participants at more than one time point [26,32,34,40,48]. All food security studies used a cross-sectional design and one [55] combined this with a qualitative method.

Data collection methods

Qualitative approach

The most common qualitative method was the semistructured interview ($n = 7$), followed by focus groups ($n = 3$), photovoice ($n = 2$) and survey with open-ended questions ($n = 1$) (Table 1). Photovoice is an innovative method that requires participants to take photographs for capturing typical meals or dietary habits followed by a focus group or a workshop to discuss the selected photographs.

Table 1
Demographic characteristics of participants in the included studies that used a qualitative approach to investigate the dietary changes of international higher education students

Author (year of publication) [reference number]	Country	Study design & methods of data collection	Sample size	Area of origin	Age (y)	Sex (% female)	Education	Length of stay
Alakaam et al. (2015) [23]	United States	Qualitative, focus group	32	Asia, Middle East, Latin America	19–38	38	25% UG, 75% G	6 m–2 y: 28%, 2–4 y: 72%
Alloh, Tait, and Talyor (2018) [24]	United Kingdom	Qualitative, semistructured interview	9	Nigeria	22–35	56	Master	6–10.5 m
Amos and Lordly (2014) [25]	Canada	Qualitative, photovoice	15	China, Saudi Arabia	25–30	87	67% UG, 33% G	Not stated
Brown, Edwards, and Hartwell (2010) [9]	United Kingdom	Qualitative, semistructured interview	10	Turkey, Italy, Malaysia, Grenada, Thailand, China, Taiwan, South Korea, Spain, France	21–41	70	Master	Not stated
Cappellini and Yen (2013) [26]	United Kingdom	Longitudinal, qualitative, focus group (4 time points)	12	China	21–22	75	Attending 1-y business program in UK	≤1 y
Corcoran (2018) [11]	United Kingdom	Qualitative, photovoice	18	7 different African and Asian countries	22–41	61	PG	≥6 m
Hartwell, Edwards, and Brown (2011) [27]	United Kingdom	Qualitative, semistructured interview	10	Asia, Europe	21–35	60	Master	1–36 m, mean 6.4 m
Leu and Banwell (2016) [28]	Australia	Qualitative, semistructured interview	31	Southeast Asia	≥18	58	UG	≥1 y
O'Sullivan and Amirabdollahian (2016) [29]	United Kingdom	Qualitative, semistructured interview	10	Sri Lanka, Lebanon, Malta, South Korea, Netherlands, Mauritania, Romania, Ghana, Bangladesh, Ireland	20–45 (90% 20–29)	80	Not stated	<1 y
Saccone and Obeng (2015) [30]	United States	Qualitative, online survey with open-ended questions	25	13 different countries in Africa, Asia, South America, Europe, North America	17–39 (64% 17–29)	60	8% UG, 92% G	<1 y: 24%, 1–2 y: 32%, 2–3 y: 16%, 4–5 y: 4%, >5 y: 24% <5 y
Yan and FitzPatrick (2016) [31]	United States	Qualitative, semistructured interview	18	5 different countries (77% from China and Saudi Arabia)	Mean 19.2	33	UG	5 m–7 y
Yen et al. (2018) [32]	United Kingdom	Longitudinal, qualitative, semistructured interview (3 times)	21	China	22–26	62	Attending 1-y study course in UK	5 m–7 y
Wu and Smith (2016) [33]	United States	Mixed methods (focus group, survey, 24-h recall, anthropometric measurement)	43	China	19–31	63	53% UG, 47% G	≥6 m, mean 20.3 m, ranged 6–104 m

G, graduate; UG, undergraduate; PG, postgraduate; UK, United Kingdom.

Table 2
Summary of included studies that reported the dietary changes of international higher education students by using quantitative methods

Author (year) [reference number] Country	Study design/ Data collection methods	Aims/ Objectives	Sample size	Participant characteristics	Primary outcomes Dietary acculturation	Food consumption patterns	Meal patterns	Secondary outcomes Factors	Impacts
Almohanna et al. (2015) [34] United States	Longitudinal, surveys	To determine the effects of dietary acculturation on health status of newly arrived INT	35	Area of origin: China, India, other countries; Age (y): 18–36; Education: 86% G, 14% UG; Length of stay: Newly arrived (V1), 6 wk (V2), 12 wk (V3)	54% (V1) and 66% (V3) of students thought they were shifting to American diet; cooking native diet ↓ from 78% (V1) to 60% (V3)	Burgers frequency ↑ from V1 to V3 (S); mean calorie intake ↑ in total sample from V1 to V3 (NS)	↑ skipped meals (37–49%) and replaced with snacks (60–71%) from V1 to V3; ↑ eat in fast food restaurants from V1 to V3, 42% ≥3 d/wk at V3	N/A	71% (n = 25) gained wt, mostly occurred in the first 6 wk; mean FBG of total sample ↓ (S); NS change in BP
Atanasova et al. (2014) [35] Bulgaria	Cross-sectional, survey	To evaluate BMI and food frequency consumption in foreign medical students before and after arrival	51	Area of origin: Greece, Turkey, other; Age (y): mean 21.6; Education: Medical students; Length of stay: Not stated	N/A	NS changes in food consumption frequencies before and after moving to Bulgaria; fresh FV intake was low at high frequencies	N/A	N/A	Current BMI only: 76.7% normal wt and 16.7% overweight in men; 85.7% normal wt and 9.5% underweight in women
Brittin and Obeidat (2011) [36] United States	Cross-sectional, survey	To investigate food practices, changes in food practices, food preferences and acculturation of some Arab students in US universities	45	Area of origin: Arab; Age (y): mean 29; Education: mean 19.2 y; Length of stay: mean 3.2 y	Most (n = 37) changed eating habits; outside food changed from Arabic to American, Chinese and Mexican; food consumption frequency ↑ in 15 U.S. foods, ↓ in 24 Arabic foods	Some (n = 23) reported their US diet was less healthy than their home country diet, due to more fat and less FV; Food consumption frequency ↓ in 19 common foods and total vegetable, meat, milk, fats, and sweets	Number of meals significantly ↓ (from 2.8 to 2.4 meals/d); BF was the most skipped meal in both home country (n = 27) and the U.S. (n = 25); main meal changed from lunch to dinner	Unavailability and higher cost of Arabic foods, lower cost of some foods in the U.S., convenience and lack of time to prepare traditional foods; acculturation; length of U.S. residence	Most (n = 28) reported wt gain, 21 gained 5–15 lb
Chai et al. (2019) [37] United States	Cross-sectional, survey	To investigate dietary nutrient intake of Asian INT and their psychological health as associated with their level of acculturation to U.S. culture	172	Area of origin: Asia; Age (y): mean 26.3; Education: 46% master, 54% PhD; Length of stay: mean 29.2 m	Small ↑ in U.S. food adoption and ↑ (S) in traditional food consumption with longer residence in the U.S.	↓ added sugar consumption with longer residence; ↑ added sugar and whole grains consumption with ↑ acculturation to U.S. culture, and ↓ consumption with the ↑ maintenance of original culture	N/A	Length of residence in the U.S., acculturation level to U.S. culture and original culture, nationalities	55.2% reported wt gain with a median of 10 lb, the median rate was 0.4 lb/m; students with food expenses of \$200–\$299 and \$300–\$399 were 20% and 60% less likely to have NSPD than \$100–\$199
Danquah et al. (2010) [38] Ghana	Cross-sectional, survey	To find out the dietary practices of foreign students in the university and to compare the circumstances in Ghana with their native country	150	Ethnicity: African, Caucasian, other; Age (y): 64.6% 21–30; Education: Not stated; Length of stay: At least 1 semester	N/A	Biscuit consumption ↑ 26.5% in Ghana compared with home; most students consumed fruit (139/147) and fried foods (144/147)	39/13/12 students skipped BF/lunch/supper in Ghana (more than at home); the popular food was egg sandwich for BF, rice for lunch/dinner; snacking: 35% at home, 39.7% in Ghana	Availability, affordability and convenience influenced food choices; reasons for meal skipping: no time, not hungry, wt control; most students considered fruits intake and less fried foods as very important	N/A
Dzatse et al. (2017) [39] South Korea	Cross-sectional, survey	To investigate the current dietary intake of Ghanaian students living in SK and to compare their meal skipping habits before and after migrating to SK	81	Area of origin: Ghana; Age (y): mean 29.4; Education: Not stated; Length of stay: mean 19.7 m	N/A	Mean daily food group intake: cereal 373.9 g, vegetables 226.7 g, fruits 96.0 g, nuts and seeds 0.5 g, dairy 105.5 g; mean daily energy intake: 2289.6 kcal	Meal skipping frequency (BF, lunch, and dinner) ↑ (S) after coming to Korea among students who skipped meals ≥7 times/wk	Inadequate time was the main reason for skipping meals	None of the participants met the recommendation for calcium; students who skipped meals ≥7 times/wk had ↓ NAR for vitamins B ₁ and B ₂ compared with those who skipped <7 times/wk (S)

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Table 2 (Continued)

Author (year [reference number] Country)	Study design/Data collection methods	Aims/ Objectives	Sample size	Participant characteristics	Primary outcomes Dietary acculturation	Food consumption patterns	Meal patterns	Secondary outcomes Factors	Impacts
Edwards, Hartwell, and Brown (2010) [40] United Kingdom	Longitudinal, surveys	To evaluate the extent of food neophobia in INT (PG), how this might vary by demographics, and how acculturation might manifest itself in students' dietary behavior	226	Area of origin: 36 countries; Age (y): mean 25.3; Education: Master; Length of stay: Mean 9.7 m (range 1 wk–84 m)	Food neophobia scores ↑ from the first 3 m to 4–12 m, and fell back after 12 m (but still higher than the initial value); students reported small but NS changes in eating habits, the extent of changes ↓ with longer stay	NS changes were reported in students' perceived healthiness of their diets (between less healthy and about the same); ↑ bread and cereal, milk and dairy consumption in Asian students, fewer changes in European students; overall ↑ in alcohol intake	BF frequency ↓ (S) in Asian students; the number of main meals ↓ (S) in both Asian and European students	N/A	N/A
Lee, Gao, and Kim (2015) [41] South Korea	Cross-sectional, survey	To explore how sex and acculturation level change the dietary practices or wt/BMI before and after migration among Chinese INT in SK	142	Area of origin: China; Age (y): mean 25.4 y; Education: 23.2% UG, 49.3% G; Length of stay: Mean 35.5 m	N/A	↓ frequent in FV intake; ↑ frequent bread or instant noodle (instead of rice), and fast-food consumption (all S)	↓ frequency in eating BF, ↓ in number of meals/d, ↓ meal regularity, ↑ frequent late-night snack (all S)	Eating out frequency was ↑ in students who always/often participated in meeting with Koreans; highly acculturated group consumed ↑ frequently bread and instant noodles	↑ (S) in body wt and BMI in men; overweight and obese students were more likely to be men and higher acculturation group
Lockie and Dickerson (1991) [42] United Kingdom	Cross-sectional, survey	Not stated	51	Area of origin: Nigeria; Age (y): 90% 20–29; Education: Not stated; Length of stay: 63% <1 y	Few changes to eating habits were made during their stay in the UK; brought traditional foods from home, or obtained from friends, or received food parcels	Less fruit consumption at lunch and dinner in UK, similar at break or bedtime; sweet and chocolate intake was very low during the survey week in the UK; low alcohol consumption	BF: similar items in both countries; lunch and dinner: most students consumed soups or stews (traditional foods)	Difficulties in obtaining traditional food in UK; length of stay had little effect in food choice and nutrients intake	Total folate intake below recommend-ation; ↓ (S) thiamin in long-stay students (>1 y); the mean % of energy supplied by CHO, fat and SF was in line with UK recommend-ations
Loomes and Croft (2013) [43] Australia	Cross-sectional, survey	To elicit a snapshot of the eating behavior of more than 300 INT studying across 4 campuses of an AUS university	316	Area of origin: 31 countries; Age (y): 53.5% 18–26; Education: Studying diplomas, UG, PG; Length of stay: 4.9% <3 m, others 3 m–4 y	N/A	Of students reported snacking (44.3%), they were more likely to consume fast foods; water and milk were the most popular drinks for main meals, considerable juice and soft drink intake across meals; >95% of participants were not regular drinkers	26.3%/12.7%/7.6% skipped BF/lunch/dinner in AUS; 18.2% always prepared own meals, 34.2% did most days, around half didn't prepare own meals very often or at all in AUS, compared to 36% of men and 26% of women had not cooked in home country	91.9% not aware of FV recommendation; preferred cooking styles aligned with nationalities; reasons for not cooking: could not cook, no access to cooking facilities, did not know where to shop, too expensive; 17.4% rated their cooking skills as poor or very poor	N/A
Ogah (2001) [44] United States	Cross-sectional, survey	To describe health behaviors of INT and determine if there were any changes after coming to the U.S.	81	Area of origin: different countries; Age (y): 85% >21; Education: 54% G; Length of stay: Not stated	N/A	↓ (S) in the FV consumption; ↑ (S) in fast food and foods in high fat and sugar	↓ (S) in the frequency of BF	N/A	N/A
Pan et al. (1999) [45] United States	Cross-sectional, survey	To collect information on changes in dietary patterns among Asian students before and after immigration to the U.S.	63	Area of origin: Asia; Age (y): 21–35; Education: Not stated; Length of stay: Mean 25 m (range 6 m–10 y)	59% had changed eating habits (85% in students who stayed in US >3 y); 57% chose U.S. style when ate out; 71% had ethnic foods for traditional festival, 24% had U.S. foods for western holidays	↑ sweet and salty snacks in US, ↑ (S) in the consumption frequency of fats, sweets, dairy, and fruits; ↓ (S) in meat and vegetables	Number of meals ↓ (S) from 3.1 to 2.8 meals/d; the most commonly skipped meals was BF; the frequency of eating out ↓ (S) from 2.9 to 1.9 times/w; more M prepared food in U.S. (↑ from 5% to 24%)	No time to prepare traditional foods, unavailability and poor quality of ethnic foods, not knowing how to cook, ethnic foods being more expensive; convenience and availability of U.S. foods when ate out	62% reported wt change—a gain of ~5 lb

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Table 2 (Continued)

Author (year) [reference number] Country	Study design/ Data collection methods	Aims/ Objectives	Sample size	Participant characteristics	Primary outcomes Dietary acculturation	Food consumption patterns	Meal patterns	Secondary outcomes Factors	Impacts
Papadaki and Scott (2002) [46] United Kingdom	Cross-sectional, survey	To determine whether the temporary translocation of Greek students to Glasgow has caused undesirable changes to dietary habits in line with the Scottish eating pattern	80	Area of origin: Greece; Age (y): mean 25.5; Education: PG; Length of stay: <1 y	85% reported eating habits changed for worse; 17% replaced olive oil with other fats in cooking, 11% started using spread on bread	↓ (S) in frequency of FV, meat, poultry, fish, yogurt, beans, pulses; ↑ (S) in savoury snacks, soft and alcoholic drinks, mayonnaise, dips and other sauces, biscuits; estimated FV intake: mean 363/124 g in Greece/Glasgow (40/5% met target)	22% home cooked meals on daily basis in the UK, 20% take-away/fast food at least 3–4 d/wk, 35% microwave/frozen meals at least 3–4 d/wk	64% had problems finding Greek foods; most respondents agreed food is ↓ tasty and ↑ expensive in Glasgow; not easy to find fresh fish; ↑ availability of convenience foods; food shopping and cooking were mostly done by family members prior to translocation	35% reported wt gain, 29% wt loss
Perez-Cueto et al. (2009) [47] Belgium	Cross-sectional, survey	To assess nutrition knowledge, perceived changes in dietary habits and barriers to healthy eating, and determinants of dietary changes in INT since their arrival in Belgium	235	Area of origin: Africa, America, Asia, Europe; Age (y): mean 27.5; Education: Master; Length of stay: mean 10.8 m (range 1–42 m)	85% reported dietary changes	35%/29%/37% reported ↑ FV/dairy products/fibre rich foods; 34%/20%/28% reported ↓ soft drinks/processed foods/red meat; 33% reported eating ↓ fried foods, sugar and confectionary	N/A	Barriers to healthy eating: lack of information (65%), price (56%), peer pressure (45%), lack of will power (47%), unavailability (45%), perception of healthy foods as boring (33%); 65% of students did not perceive having received healthy eating education	N/A
Reeves and Henry (2000) [48] United Kingdom	Longitudinal, surveys	To investigate the ability of Malaysian students to modulate food intake when they moved from a country with low ED to higher ED	109	Area of origin: Malaysia; Age (y): mean 22; Education: Not stated; Length of stay: Newly arrived, after 3 and 6 m (time 1, 2, and 3)	Both Malaysian and UK food habits were employed; some direct exchanges were made e. g. fish fingers instead of fresh fish, sausages instead of pork or beef	↓ frequent in red/white meat and fish consumption, ↑ sausages and burgers, ↓ FV, ↑ breakfast cereal, no change in alcohol intake	BF was the most likely meal to have changed, the students were more likely to have toast or cereal or to skip breakfast; lunch showed less change; dinner showed the least change	Availability of certain foods in UK supermarkets (reason for direct exchange)	↓ (S) BMR in men between time 1 and 3; small ↑ in body wt and body fat but NS over 6 m; ↑ (S) in ED and ↓ (S) in protein intake
Santos et al. (2015) [49] United Kingdom	Cross-sectional, survey	To assess the changes in eating habits and food choice motives of Portuguese university students after migration to London, according to sex	55	Area of origin: Portugal; Age (y): mean 22.5/24 for men/women; Education: 9% attending nutritional/ food science course; Length of stay: Median 23.5/8 m for men/women	N/A	↓ (S) in the intake of red meat, fish, pastries and vegetable soup, and ↑ (S) in the intake of hamburger and tea with milk in both men and women; consumption frequency of fresh fruit in men and vegetables in women ↓ (S)	N/A	Importance of food choice motives: availability in shops nearby, easy and quick preparation and price ↑ (S) after migration in both sexes; nutritional information for women and wt control for men ↑ (S)	N/A
Vilela et al. (2014) [50] United Kingdom	Cross-sectional, survey	To investigate differences in eating habits before and after migration to London among Portuguese student and the differences between English and Portuguese students	55	Area of origin: Portugal; Age (y): mean 23.3/25.4 y for ST/LT; Education: 9% attending nutritional/ food science course; Length of stay: Median 3/44 m for ST (<1 y)/LT (>1 y)	↓ (S) consumption of Portuguese typical food in both ST and LT groups; LT students reported ↑ consumption of items in English diet	In ST and LT groups: ↓ (S) weekly intake of FV, white fish, cod fish, shellfish, fatty meat, potato and ice cream, ↑ (S) fast and take-away food; ST group ↓ olive oil and ↑ tea with milk; LT group ↓ dairies and ↑ bacon, tea and porridge	N/A	ST group had ↑ (S) inadequate kitchen utensils and cooking skills than LT group; both groups reported (in UK): inadequate time to prepare food; problems in finding traditional food, good quality meat and fresh fish; ↑ availability of fast and take-away food	N/A

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Table 2 (Continued)

Author (year [reference number]) Country	Study design/ Data collection methods	Aims/Objectives	Sample size	Participant characteristics	Primary outcomes Dietary acculturation	Food consumption patterns	Meal patterns	Secondary outcomes Factors	Impacts
Wu and Smith (2016) [33] United States	Cross-sectional, mixed methods	To learn how Chinese students living in the U.S. experience acculturation and how it influences dietary behaviors and health status	43	Area of origin: China; Age (y): 19–31; Education: 53% UG, 47% G; Length of stay: Mean 20.3 m (range 6–104 m)	Moderate adoption of American foods	Inadequate dairy, FV consumption	BF was the first adopted meal for men, lunch for women	Grocery shopping: men did more frequent in the US than China; women tended to shop weekly instead of daily; most U.S. foods were more likely to gain wt	69% of men and 85% of women gained wt after 6 m or longer in the U.S.; students who ate more U.S. foods were more likely to gain wt

↑, increase/more; ↓, decrease/less; AUS, Australia; BF, breakfast; BMI, body mass index; BMR, basal metabolic rate; BP, blood pressure; CHO, carbohydrates; ED, energy density; FBG, fasting blood glucose; FV, fruits and vegetables; G, graduates; INT, international students; LT, long-term; N/A, not applicable; NAR, nutrient adequacy ratio; NS, not significant; PG, postgraduates; S, significant; SF, saturated fat; SK, South Korea; NSPD: nonspecific psychological distress; ST, short-term; UG, undergraduates; UK, United Kingdom; wt, weight.

Quantitative approach

All quantitative studies used a self- or interviewer-administered questionnaire to collect data. Of the studies measuring dietary changes quantitatively, the most prevalent variable was food consumption frequency (n = 12). Other assessment methods included questionnaires in general eating habits and meal patterns, 24-h recall, and food diary.

Food security was commonly assessed by the 10-item Adult Food Security Survey Module [57]. Most studies (n = 9) asked participants to respond based on their experience during the past 12 mo, and one study [54] assessed the previous 30 d. Two studies reported the percentages of food-insecure students by using different measurement tools or applying different classification criteria [51,58].

To measure the health effects of dietary changes, anthropometric assessment was the most common method. Nine studies measured or included self-reported weight-related data [33–37,41,45,46,48], and one [48] also measured waist and hip circumference and used skinfold measurements to assess total body fat. Blood pressure and fasting blood glucose concentrations were measured in one longitudinal study [34], and basal metabolic rate was measured in another [48]. Regarding psychological health, only one study used Kessler 6 which is a standardized survey tool to measure nonspecific psychological distress [37]. None of the included studies measured the academic performance of international students in a quantitative manner.

Dietary changes

The main findings through quantitative methods are listed in Table 2. The categories and themes synthesized from the studies that used the qualitative approach are listed in Table 3 [9,11,23–33], including three main themes (i.e., dietary changes, factors that contributed to the changes, and effects of the changes) and seven subthemes (i.e., dietary acculturation, food consumption patterns, dietary patterns, individual factors, environmental factors, effect on weight, and effect on health). Representative quotations from the included qualitative studies for all categories under each subtheme are listed in Appendix D.

There was always a negotiation between traditional and host food for international students. They explored new foods in the host country while maintaining their original diet.

... despite a reluctance to abandon home food, students were keen to describe themselves as open to new food cultures; they had access to a diverse range of cuisines offered by their peers, as well as local food. ... Nevertheless, the foods that were most favoured were students' own national dishes. ... What this study points to is an intermittent embrace of new food and a simultaneous retention of origin culture habits that indicated the presence of two selves [9].

Traditional dishes were often preferred by these students due to familiar and better taste, which may help them to alleviate homesickness and maintain cultural identity [9,25,26,32]. Moreover, most international students considered their home diet to be healthier and more varied than the local diet [9,11,23,25,29,33]. Students from the United Kingdom often criticized British foods as being unappetizing with a bland taste; whereas students in the United States commented on the high fat and sugar in the American diet [9,23,29,32]. However, traditional foods and ingredients with authentic taste and reasonable prices were not readily

Table 3

Themes to show the dietary changes, contributing factors, and effects of the changes among international higher education students from studies that used a qualitative approach

Themes*	Alakaam (2015) [23]	Alloh (2018) [24]	Amos (2014) [25]	Brown (2010) [9]	Cappellini (2013) [26]	Corcoran (2018) [11]	Hartwell (2011) [27]	Leu (2016) [28]	O'Sullivan (2016) [29]	Saccone (2015) [30]	Yan (2016) [31]	Yen (2018) [32]	Wu (2016) [33]
Dietary changes													
Dietary acculturation													
Adapt to host food culture (n = 13)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Maintain original diet (n = 13)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ship food supply from home (n = 4)	✓			✓			✓		✓				
Substitute traditional ingredients with local supply (n = 4)			✓			✓		✓				✓	
Dynamic changes (n = 5)	✓				✓					✓	✓		✓
Self-perception of healthfulness of the changes (n = 6)	✓		✓	✓				✓	✓				✓
Food consumption patterns													
Food groups consumption (n = 6)	✓					✓		✓	✓	✓			✓
Convenience and fast food consumption (n = 12)	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Alcohol/Beverages (n = 7)	✓	✓	✓							✓	✓	✓	✓
Weekday/weekend variation (n = 6)						✓	✓		✓		✓	✓	✓
Meal patterns													
Meal skipping and meal regularity (n = 5)	✓					✓	✓		✓				✓
Meal contents (n = 9)	✓	✓	✓		✓	✓	✓		✓			✓	✓
Portion size (n = 4)	✓		✓						✓				✓
Home cooked meals (n = 11)	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Eating out and takeaway (n = 9)	✓		✓		✓	✓	✓	✓			✓	✓	✓
Factors													
Individual factors													
Personal preferences (n = 9)	✓		✓	✓		✓	✓	✓	✓			✓	✓
Meaning of food (n = 5)			✓	✓	✓		✓					✓	
Taste (n = 11)	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Religious factor (n = 6)	✓		✓				✓	✓	✓		✓		✓
Health concern (n = 10)	✓		✓	✓		✓	✓	✓	✓		✓		✓
Time and study (n = 9)	✓	✓				✓	✓	✓	✓	✓	✓		✓
Living status and family influences (n = 7)	✓				✓			✓	✓		✓	✓	✓
Nutrition, food, and culinary knowledge (n = 8)	✓				✓	✓		✓	✓		✓	✓	✓
Cooking skills (n = 9)	✓			✓	✓	✓		✓	✓		✓	✓	✓
Cooking facilities (n = 4)						✓		✓	✓				✓
Social interactions (n = 12)	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓

(continued on next page)

Table 3 (Continued)

Themes*	Alakaam (2015) [23]	Alloh (2018) [24]	Amos (2014) [25]	Brown (2010) [9]	Cappellini (2013) [26]	Corcoran (2018) [11]	Hartwell (2011) [27]	Leu (2016) [28]	O'Sullivan (2016) [29]	Saccone (2015) [30]	Yan (2016) [31]	Yen (2018) [32]	Wu (2016) [33]
Stress and emotions (n = 7)		✓		✓	✓		✓	✓	✓				✓
Environmental factors													
Campus food environment (n = 6)	✓				✓						✓		
Food availability (n = 10)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Food access (n = 10)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Food cost (n = 10)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Food quality (n = 9)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ethnic restaurants (n = 5)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Effects													
Weight													
Weight gain (n = 7)	✓	✓	✓	✓					✓	✓	✓	✓	✓
Weight loss (n = 3)									✓	✓	✓	✓	✓
Health													
Physical health (n = 9)	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
Psychological health (n = 3)	✓		✓	✓	✓				✓	✓			✓

*n = number of studies finding this theme.

available in grocery stores and restaurants compared with foods of the host country. This forced international students to modify traditional recipes to local style by substituting authentic ingredients with common ones found in the host country [11,25,28,32,48]. The temporary nature of living abroad helped the students tackle the difficulties in eating traditional foods because they would be able to eat them when they returned home [9,29].

The three main meals showed different degrees of change. Breakfast appeared to be the most acculturated meal with diverse styles and incorporation of typical foods in the host country [11,26,33,48].

For example Cecilia now opts for a British breakfast. Assimilated through her British flatmates, she follows the British convention of having toast with butter and jam in the morning [26].

At lunch, some international students were willing to take extra efforts to cook their own traditional meals and others may choose convenient options instead of eating on campus due to dissatisfaction with campus food services [25,26,32,48]. Unfavorable taste and high cost of available options and limited choices in healthy and traditional meals were the common impressions of foods in the universities [11,23,32,33]. Conversely, fast-food outlets with global brands near the campus provided standardized food services and a familiar environment with lower cost for international students [32]. These global fast-food chains (e.g., McDonald's, KFC, and Pizza Hut) also stopped students from trying the host diet after arrival. Finally, dinner illustrated the least acculturation and mostly consisted of dishes with familiar ingredients [33,42,48].

After the initial dietary changes within a few months after arrival, eating habits of international students may experience further alteration over time in the host country. After noticing the negative health effects of consuming excessive fast foods, some learned to find healthier options and started to cook or reverted to their home diet when they became more familiar with the host environment [23,26,29–31,33]. A British longitudinal study observed a lower extent of change in students with a longer stay in the host country [40].

I think after come to the US, [school name] always provides the free pizza, free hamburger and I gained 10 pounds. It's very scary. Then I tried to change back to eating at Chinese restaurants. But it was too oily and I still could not lose weight. And then I figured out that maybe I should cook for myself. And then I lose like five pounds [Female, graduate, stayed in the US for 24 months] [33].

Weight change was the most common health outcome reported after living in the host country (n = 14). Increased consumption of convenience and fast food contributed to weight gain in a relatively short period (i.e., within 1 y) after arrival [24,25,29,33,34,36]. A sedentary lifestyle and less physical activity due to intensive academic schedules were also reported as part of the reasons for weight gain [23,24]. Weight gain among freshmen students is also common in college students in general [59]. On the contrary, some students lost weight due to the loss of appetite under stress in an unfamiliar living and academic environment [29]. Students who were not fond of the local diet and lacked cooking skills also experienced weight loss initially [31]. Local foods in the Western host country were considered to have other negative effects on health by some international students, such as high blood glucose concentrations, high cholesterol concentrations, and

Table 4

Summary of studies that reported food security status of international higher education students.

Author (year) [reference number]	Country	Study design/ Methodology	Sample size (number or % of international students)	Level of education	Food security measurement	Main findings
Food security status Blundell et al. (2019) [51]	Canada	Cross-sectional survey	971 (140)	77.4% UG	10-item Statistics Canada's Household FSSM	Health Canada's Classification: Food insecurity in INT 75/140 (54%; OR, 3.04; 95% CI, 1.89–4.88; $P < 0.001$) vs in-province students; PROOF's classification: Food insecurity in INT 93/140 (66%; OR, 2.02; 95% CI, 1.29–3.15; $P = 0.002$) vs in-province students.
El Zein et al. (2018) [60]	United States	Cross-sectional survey	899 (101)	65.6% UG	10-item USDA-Adult FSSM	Food insecurity in INT vs in-state students vs out-of-state students: 37.6% vs 30.7% vs 29.3%
Frank (2018) [52]	Canada	Cross-sectional survey	1030 (8.1%)	95.8% UG	10-item adult Household FSSM from the CCHS	Moderately and severely food insecurity in INT vs DOM: 26.5% and 18.1% vs 23.8% and 13.9% ($P = 0.412$).
Gallegos, Ramsey, and Ong (2014) [15]	Australia	Cross-sectional survey	810 (8.3%)	Not stated	18-item USDA-FSSM	INT in food insecure vs in food secure students: 8.7% vs 8.1% ($P = 0.80$).
Hughes et al. (2011) [58]	Australia	Cross-sectional survey	399 (116)	79.1% UG	Multi-item from USDA Community Food Security Assessment Toolkit; single-item from ANNS	Single-item: food insecurity in INT vs DOM—10.3% vs 13.6% ($P = 0.243$); Multi-item: food insecurity without and with hunger in INT vs DOM - 54.8% and 21.7% vs 43.2% and 26.9%
Martinez et al. (2018) [62]	United States	Cross-sectional survey	8705 (9%)	66% UG	6-item short form USDA-FSSM	INT in food insecure vs in food secure students: 8% vs 9%
Olauson et al. (2018) [16]	Canada	Cross-sectional survey	1282 (137)	83.7% UG	10-item USDA-Household FSSM (adult), used in CCHS	Food insecurity in INT vs DOM: 58% vs 37% ($P < 0.001$; OR, 2.01; 95% CI, 1.11–3.82; $P = 0.022$) vs DOM
Silverthorn (2016) [56]	Canada	Cross-sectional survey	4013 (172)	60.4% UG	Selected questions from the Household FSSM found in the CCHS	Food insecurity (moderately, severely) in INT vs DOM: 46.2% (34.7%, 11.6%) vs 38.3% (30.3%, 8%).
Soldavini, Berner, and Da Silva (2019) [61]	United States	Cross-sectional survey	4819 (266)	59.8% UG	10-item USDA-Adult FSSM	Marginal food security and food insecurity (i.e. low or very low food security) in INT: UG: 25/107 (23.4%) and 36/107 (33.6%; OR, 1.92; 95% CI, 1.14–3.23; $P < 0.05$) vs DOM (food insecurity); G: 40/159 (25.2%) and 29/159 (18.2%; OR, 1.69; 95% CI, 1.01–2.80; $P < 0.05$) vs DOM (marginal food security) (Food security status of INT was not reported specifically.)
Maynard et al. (2018) [55]	Canada	Mixed methods	14 (3)	100% UG	10 adult-referenced items from Household FSSM	Some participants indicated that food insecurity was common among INT. Quote from a participant*: "some [may have] difficult times for food ... that's really the norm of INT."
Food bank clients and usage El Zein et al. (2018) [60]	United States	Cross-sectional survey	899 (101)	65.6% UG	10-item USDA-Adult FSSM	Food pantry use in INT: OR, 7.16; 95% CI, 3.13–16.35, $P < 0.001$) vs DOM
Hanbazaza et al. (2016) [53]	Canada	Cross-sectional	568 (33%) CFB clients	66.1% UG	Not used	INT in CFB clients vs in total university students: 33% vs 13.7% ($P < 0.05$)
Hanbazaza et al. (2017) [54]	Canada	Cross-sectional survey	58 (27) CFB clients	UG, G	10-item Adult FSSM (past 30 days)	Food insecurity in INT vs DOM clients: 96.2% vs 100%.

ANNS, Australian National Nutrition Survey; CCHS: Canadian Community Health Survey; CFB, campus food bank; DOM, domestic students; FSSM, Food Security Survey Module; G, graduates; INT, international students; UG, undergraduates; USDA: United States Department of Agriculture.

*Demographic characteristics of the quoted participant were not reported.

digestive problems [9,23–25,27]. Regarding psychological health, eating familiar foods may help reduce homesickness, but it may worsen the situation for some students [9]. Eating junk foods and the inability to follow religious dietary requirements may increase feelings of guilt [23]. Academic outcomes of dietary changes were absent from detected studies.

Food insecurity

The prevalence and/or odds ratios of food insecurity in international students from quantitative studies and quotations from the study employing mixed methods are listed in Table 4 [15,16,51–56,58,60–62]. Of seven studies that presented the prevalence of food insecurity in both international and domestic students, six [16,51,52,56,60,61] reported higher percentages of food insecurity among international students, with an Australian survey [58] reporting mixed findings. The Australian study found international students experienced a higher percentage of food insecurity without hunger when using the multi-item assessment tool, but a lower prevalence in food insecurity using the single-item instrument. International students were two to three times more likely to be food insecure than their counterparts in the studies demonstrating significant differences [16,51,61]. Furthermore, international students were more likely to use food banks, but the low awareness of available resources and stigma of using food assistance were generally found in college students whether international or domestic [53,60].

Discussion

Dietary acculturation was prevalent in international students after they arrived in the host country, with the co-existence of the adaption to the host food culture and the maintenance of their home culture. Negative changes in dietary habits were often recognized when the students first arrived, but the process of transition was dynamic and depended on various factors, such as personal preferences, health concerns, family influences, time availability, and food environment. Both weight gain and weight loss may occur after changes in dietary habits. Additionally, it was not uncommon for international students to experience food insecurity, and some studies found a higher prevalence in these students compared with domestic students. The factors that contributed to food insecurity and its effects on health and academic performance were investigated in college students in general but were not clear in this special student group.

For many international students, it was their first time leaving home and taking their own responsibility for meal planning and food preparation. Before arriving in the host country, regular and nutritious meals were often readily prepared by parents or other relatives at home [28,29,33]. Some students enjoyed taking charge of their own diet in their new environment, but also realized negative changes due to a lack of regulations from parents, such as skipping breakfast and omitting fruit consumption [29,33]. The competence of cooking skills was varied in the samples across studies. Some students learned basic techniques, such as boiling water and cutting vegetables, before leaving home, and some used online recipes or consulted parents and friends when they cooked for themselves [9,26,28,29,33]. Students who regularly prepared their own meals may experience improvement in their cooking skills over time [11,28]. Nevertheless, those with limited skills

often chose to eat outside home or have convenience foods [11,23,29,33]. Insufficient access to cooking facilities was another barrier to food preparation, such as lack of a kitchen with privacy and limited fridge spaces [28,29,33]. In terms of nutritional and cooking knowledge, most students did not receive any systematic education previously but some were exposed to educational programs on campus in the host country (e.g., during orientation) [23,31,47]. According to the existing literature, these students had some simple knowledge of healthy eating but not always precise [11,38,43,47].

Accessing healthy foods or cooking meals similar to those eaten at home was seen as difficult with respect to the cost and food availability in the host country, and there was little time for eating this way with academic time demands. Compared with the home countries of many international students, convenience and fast foods were often reported as cheaper and more accessible than fresh and healthier options in the host countries [23,24,28–30,47]. Greek students reported difficulties in purchasing traditional food and higher availability of convenience food in Glasgow, which contributed to a lower adherence to the Mediterranean diet [46]. Although preparing one's own meals was considered healthier than eating out, students who cooked for themselves were not always making healthy meals due to limited food budget and time for food shopping and preparation [28]. A healthy diet was less prioritized under the pressure of academic success [29,30]. Furthermore, the taste of food was important to many students, but some other students considered having enough food as more critical [28,31]. However, this does not mean that they would completely disregard the food quality. Some students were willing to pay slightly more for better taste or nutritional quality and take extra efforts to find ideal traditional ingredients [28].

The social role of food was emphasized by many international students. Eating together was a normal way of consuming meals in their home countries with collectivist culture, and eating alone in a foreign country may exacerbate homesickness for some students [9,27,32]. Many qualitative studies also found some participants cooked with friends to prepare traditional dishes [9,25,26,28,32]. Sharing meals and cooking with others became an important means of building friendships while studying abroad. Friendship was an essential part of life in the United States from Chinese students' experience [63]. Although some students preferred to eat with people from the same country, others were able to share meals and eat out with students from the host and other countries, particularly on special occasions such as celebratory meals, 'bring a plate' activities, and Western holidays [9,26,29,32,45]. More interactions with local contacts seemed to increase the exposure to novel foods in the new environment [26,27,33,41]. Additionally, a role modeling effect was observed as some international students learned how to achieve healthy lifestyles in the host country from their domestic peers [31].

Food services on campus may play an important role in the adjustment period for international students [64]. Students from different universities and cultural backgrounds could have various requirements and expectations to the campus food availability [65]. Additionally, food outlets and grocery stores near the universities and accommodations might be the main food sources for most international students since they might not be able to afford a car and may lack time to travel a longer distance for foods [28].

International students seemed to be more vulnerable to food insecurity than their domestic peers. Different classification criteria and assessment methods made it difficult to synthesize the prevalence of food insecurity across studies. Marginal food security was the variation in the classifications as it represented people with concerns in access to healthy meals compared with actual insufficient food access [51].

The factors that contributed to food insecurity and its effects were mostly analyzed for the total community of college students rather than solely international students, but additional challenges for students from foreign countries were discussed in a small number of studies. In contrast to local students, they paid higher tuition fees and had less access to study loans and other financial assistance provided by governments and universities [55,60]. Limited social support to overcome the loneliness and cultural barriers during the adjustment period, as well as insufficient access to cultural foods, may also increase the risk for this minority group being food insecure [51,56]. A Canadian study found similar coping strategies in domestic and international students, but the latter were less likely to ask for food from others, or to report self-perceived poor or only fair mental health [54]. Further detrimental effects on health and academic success have not been reported in international students specifically.

To facilitate decision making for healthy food choices among international students, nutritional education programs were frequently recommended by existing literature [23,25,33,36,39]. These programs should be culturally appropriate for students from different cultural groups, and they need to be conducted at orientation and repeated during the semester. Nutritional advice from local dietary guidelines should be translated to include their familiar ingredients to meet their cultural needs [24]. Information on the locations of stores selling both local and traditional food as well as ethnic restaurants need to be provided [33,43]. Information about available food assistance programs could also be more widely disseminated [53,60]. These could also be incorporated into brochures and web-based information delivered to commencing students before their departure for their precedent preparation [11,43]. A cooking class is a popular way to promote nutrition knowledge and demonstrate healthy recipes at a low cost. For example, a series of community cooking workshops that were implemented for international students in a Canadian university elicited positive changes from participants [66]. International students developed a better understanding of healthy eating and a balanced diet to guide their future dietary practices. With the food shopping and cooking skills they learned, participants were able to prepare their own nutritious meals after the program. By meeting new people during the workshops, an extra benefit was the improvement of social skills which helped them to be more connected with peers in their cohort. Another U.S. peer education program between international and domestic students found significant intervention effects in dietary practices and using nutrition labels for groups [67].

Universities should take action to improve their food services to provide more culturally diverse and healthy options with favorable prices for international students [9,25,31]. A survey conducted at an Australian university showed that high

cost was a more prevalent reason for not choosing healthy options on campus among international students compared with domestic students [68]. Cooperation with local markets and traditional food grocery stores could be beneficial [11,23]. Moreover, cooking facilities should be easily accessible in residential colleges and other accommodations on campus, such as a kitchen, cooking utensils, microwave, fridge, and freezer [41]. Apart from academic success, governments and tertiary institutions should prioritize the nutritional needs and food security of international students and make specific policies for this group [23,24]. Future research could be done with larger sample sizes, and longitudinal studies may help with observing long-term changes and effects. To further identify the barriers to food security of international students, more qualitative data might be required. Among higher education students in general, academic performances have been found to be positively associated with consuming regular meals and sufficient fruit intake, and negatively associated with food insecurity [62,69]. The relationship between changes in nutritional practices and health and academic outcomes need further investigation in students from diverse cultural backgrounds.

Strengths and limitations

This scoping review synthesized both qualitative and quantitative findings in dietary acculturation and food insecurity of international students, which provided a comprehensive understanding of the phenomena with the contributing factors and their effects. One of the limitations might be the restriction on the language of the publication, and thus most of the studies were from Western countries. However, as these countries are the most popular destinations of international college students the large body of studies should have been captured.

Conclusions

International students often embraced the local food culture when they first arrived in the host country. Both individual factors and the differences in food environments between the host and home country affected the changes in their eating habits. These changes contributed to weight change and some negative effects on physical health leading to some reverting more closely to their traditional diets. Further research on mental health and academic success associated with the changes in eating habits need more investigation. International students faced additional challenges in healthy eating and food security in the host country compared with their domestic peers. Their needs in nutritional health should be specifically targeted and addressed by tertiary institutions and governments. More evidence-based support in culturally appropriate nutrition education should be provided for international students, and improvements in campus food environments are necessary to facilitate their healthy food choices.

Acknowledgments

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Appendix A. Search strategy in CINAHL (EBSCO), searched in September 2019

Group	Search	Query	Results	
International students	S1	(MH "Students+")	119,555	
	S2	TX international or foreign* or overseas or abroad or asia* or china or chinese or malaysia* or nepal* or india or indian or ethnic*	688,883	
	S3	S1 AND S2	17,264	
	S4	(MM "Students, Foreign")	536	
	S5	TX Student* N3 (international or foreign* or overseas or abroad or asia* or china or chinese or malaysia* or nepal* or india or indian or ethnic*)	5,681	
	S6	TX Study N3 (abroad or foreign* or overseas)	897	
	S7	TX Education N3 (international or abroad or foreign* or overseas)	6,347	
	S8	S3 OR S4 OR S5 OR S6 OR S7	25,727	
	S9	(MH "Colleges and Universities+")	40,886	
	S10	TX tertiary N3 (education or institution* or learning)	1,791	
	S11	TX education N2 (technical or post-secondary or postsecondary or higher or further or continu*)	161,638	
Tertiary education	S12	TX TAFE or polytechnic* or college* or campus* or universit*	199,369	
	S13	S9 OR S10 OR S11 OR S12	365,991	
	S14	S3 AND S13	7,770	
	S15	S8 OR S14	25,727	
	(Population) Dietary changes	S16	(MH "Diet+")	102,544
		S17	(MM "Nutritional Status")	6,997
		S18	(MH "Nutrition")	23,364
		S19	(MH "Eating Behavior+")	34,861
		S20	TX Diet* N3 (habit* or pattern* or chang* or quality or intake* or behavio?r* or acculturation)	30,925
		S21	TX Eat* N3 (habit* or pattern* or behavio?r*)	5,974
		S22	TX Food* N3 (habit* or quality or choice* or acculturation)	17,620
S23		TX Nutrition* N3 (chang* or intake* or quality or status or maintain* or maintenance or poor)	23,155	
S24		TX Intake* N3 (energy or nutrient*)	22,342	
S25		TX Meal* N3 (skip* or miss* or pattern*)	755	
S26		S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25	167,617	
Food types	S27	(MH "Food and Beverages+")	166,479	
	S28	TX Food* N3 (fresh or fast or out or outdoor or outside or home or tradition* or cultural or western or ethnic* or local)	6,495	
	S29	TX (Consum* or intake*) N3 (food* or fruit* or vegetable* or meat* or snack* or dairy)	33,621	
	S30	TX snack* or take away	7,668	
	S31	TX out* N (dine or dining or eat*)	29	
	S32	S27 OR S28 OR S29 OR S30 OR S31	187,338	
	Factors	S33	(MM "Food Security")	1,576
		S34	(MH "Meal Preparation+")	15,784
		S35	(MM "Hunger")	855
		S36	TX food* N3 (prepar* or environment* or access* or availab* or suppl* secur* or secur* or cost*)	10,362
		S37	TX knowledge N3 (nutrition* or diet* or food*)	2,784
S38		TX cook* N3 (skill* or knowledge or practice* or facilit*)	411	
S39		TX hunger* or hungry	5,045	
S40		S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39	33,090	
(Concepts)		S41	S26 OR S32 OR S40	292,202
Final		S42	S15 AND S41	1,386

Appendix B. Inclusion and exclusion criteria

	Inclusion criteria	Exclusion criteria
Participants	International students who leave their home country for the sole purpose of receiving higher education in a foreign country.	Students who born in foreign countries and have migrated to the host country.
Concept		
Primary outcomes	Changes in food and dietary patterns, as well as food security status in the host country.	Studies that investigated living and cultural experience but did not focus on dietary changes or food security.
Secondary outcomes (optional)	Factors and impacts that are associated with the primary outcomes. Factors may include living status, personal skills and food environment. Impacts on physical health (e.g. weight changes), psychological health (e.g. depression) and academic performance (e.g. grade point average) were included.	Not applicable.
Context	Tertiary education institutions from any country in the world. All types and settings of tertiary education were eligible, such as post-secondary education, higher education, college and university.	Primary and secondary education settings.
Type of sources	All types of research methods were eligible, including qualitative, quantitative and mixed methods. The language of publication was limited to English and no restriction for the year of publication.	Non-English studies.

Appendix C. Excluded studies from the full-text screening

No.	References	Reason for exclusion
1	Al-Domi H. Addressing the levels of knowledge and awareness on human rights and the right to food in a group of students at the University of Jordan. <i>Pak J Nutr.</i> 2011;10(7):609-617.	Not target population
2	Al-Gelban KS. Dietary habits and exercise practices among the students of a Saudi Teachers' Training College. <i>Saudi Med J.</i> 2008;29(5):754-759.	Not target population
3	Al-Nakeeb Y, Lyons M, Dodd LJ, Al-Nuaim A. An investigation into the lifestyle, health habits and risk factors of young adults. <i>Int J Environ Res Public Health.</i> 2015;12(4):4380-4394.	Not target population
4	Al-Shehri HM, Al-Qahtani AM, Shaikh IA, et al. Assessment of lifestyle and eating habits among undergraduate students in Najran University, Najran, Saudi Arabia. <i>Int J Med Sci Public Health.</i> 2017;6(3):638-646.	Not target population
5	Ali A, Guo X, Sherwani M, Ali A. Factors affecting Halal meat purchase intention. <i>Br Food J.</i> 2017;119(3):527-541.	No dietary changes or food security reported
6	AlJaber MI, Alwehaib AI, Algaeed HA, Arafah AM, Binsebayel OA. Effect of academic stressors on eating habits among medical students in Riyadh, Saudi Arabia. <i>J Fam Med Prim Care.</i> 2019;8(2):390-400.	Not target population
7	An R, Chiang S-Y. International Students' Culture Learning and Cultural Adaptation in China. <i>J Multiling Multicult Dev.</i> 2015;36(7):661-676.	No dietary changes or food security reported
8	Ashrafal K, Shahgahan M, Asrafal I. Factors influencing eating behavior and dietary intake among resident students in a public university in Bangladesh: a qualitative study. <i>PLoS One.</i> 2018;13(6):e0198801.	Not target population
9	Bakar WAMA, Ismail S, Sidek S, Rahman RA. Prevalence and factors affecting food insecurity among university students in Pahang, Malaysia. <i>Malays J Nutr.</i> 2019;25(1):59-67.	Not target population
10	Barzegari A, Ebrahimi M, Azizi M, Ranjbar K. A study of nutrition knowledge, attitudes and food habits of college students. <i>World Appl Sci J.</i> 2011;15(7):1012-1017.	Not target population
11	Bek H. An Analysis of Cultural and Psycho-Social Problems Experienced by Students of Afghanistan Citizenship Studying in Turkey. <i>Univers J Educ Res.</i> 2018;6(5):928-935.	No dietary changes or food security reported
12	Bobo M, Procopie R, Bucur M. Exploring the role of individual food security in the assessment of population's food safety. <i>Amfiteatru Econ.</i> 2019;21(51):347-360.	Not target population
13	Bruening M, van Woerden I, Todd M, Laska MN. Hungry to learn: the prevalence and effects of food insecurity on health behaviors and outcomes over time among a diverse sample of university freshmen. <i>Int J Behav Nutr Phys Act.</i> 2018;15:9.	Not target population
14	Choi J, Hwang J, Yi J. Acculturation, Body Perception, and Weight Status Among Vietnamese American Students. <i>J Immigr Minor Health.</i> 2011;13(6):1116-1124.	No dietary changes or food security reported
15	Claudat K, White EK, Warren CS. Acculturative stress, self-esteem, and eating pathology in Latina and Asian American female college students. Empirical Study; Quantitative Study. <i>J Clin Psychol.</i> 2016;72(1):88-100.	Not target population
16	Conn BM, Ejessi K, Foster DW. Acculturative stress as a moderator of the effect of drinking motives on alcohol use and problems among young adults. <i>Addict Behav.</i> 2017;75:85-94.	Not target population
17	de Oliveira MCF, Anderson J, Auld G, Kendall P. Validation of a tool to measure processes of change for fruit and vegetable consumption among male college students. <i>J Nutr Educ Behav.</i> 2005;37(1):2-11.	No dietary changes or food security reported
18	Dominguez-Whitehead Y. Students' Food Acquisition Struggles in the Context of South Africa: The Fundamentals of Student Development. <i>J Coll Stud Dev.</i> 2015;56(3):292-308.	Not target population
19	Doostan F, Mohseni-Takaloo S, Nosrati M. Assessment of the dietary pattern of dormitory students in Kerman, Iran. <i>J Pak Med Assoc.</i> 2016;66(9):1054-1059.	Not target population
20	Eche D, Hernandez Herrera M. Studying food security among students: a comparative case study between public and private universities in Quito-Ecuador. <i>Nutr Hosp.</i> 2018;35(6):1372-1378.	Not target population
21	El-Ansari W, Suominen S, Samara A. Eating habits and dietary intake: is adherence to dietary guidelines associated with importance of healthy eating among undergraduate university students in Finland? <i>Central Eur J Public Health.</i> 2015;23(4):306-313.	Not target population
22	El-Hakeem BA, Sraa A-M, Nanees G, Alsheri M. Association between dietary habits and body mass index to female students college sciences and arts campus 1 at Khamis Mushayt King Khalid University. <i>Food Nutr Sci.</i> 2015;6(14):1316-1323.	Not target population
23	Farahbakhsh J, Ball GD, Farmer AP, Maximova K, Hanbazaza M, Willows ND. How do Student Clients of a University-based Food Bank Cope with Food Insecurity? <i>Can J Diet Pract Res.</i> 2015;76(4):200-203.	Not target population
24	Farheen, Zoya N, Tanveer F. A study on dietary habits on college students and to create awareness on dietary pattern among adolescents. <i>Int J Res Appl Sci Eng Technol.</i> 2018;6(3):1482-1489.	Not target population
25	Furukawa T. Weight changes and eating attitudes of Japanese adolescents under acculturative stresses: A prospective study. <i>Int J Eat Disord.</i> 1994;15(1):71-79.	Not target population
26	Garden-Robinson J, Eighmy MA, Lyonga AN. Use of electronic group method in assessing food safety training needs and delivery methods among international college students in the U.S. <i>Appetite.</i> 2010;55(3):746-749.	No dietary changes or food security reported
27	Gazibara T, Tepavcevic DBK, Popovic A, Pekmezovic T. Eating habits and body-weights of students of the University of Belgrade, Serbia: a cross-sectional study. <i>J Health Popul Nutr.</i> 2013;31(3):330-333.	Not target population
28	Gram M, Blichfeldt BS. When bad food happens to good intentions: Female students' food dilemmas. <i>J Youth Stud.</i> 2014;17(8):982-997.	No dietary changes or food security reported
29	Gram M, Hogg M, Blichfeldt BS, MacLaran P. Intergenerational relationships and food consumption: The stories of young adults leaving home. <i>Young Consum.</i> 2015;16(1):71-84.	Not target population
30	Greenberg L, Cwikel J, Mirsky J. Cultural correlates of eating attitudes: a comparison between native-born and immigrant university students in Israel. <i>Int J Eat Disord.</i> 2007;40(1):51-58.	Not target population
31	Hanna BE. Eating a Home: Food, Imaginary Selves and Study Abroad Testimonials. <i>High Educ Res Dev.</i> 2016;35(6):1196-1209.	Short-term study abroad program
32	Hendershot CS, Dillworth TM, Neighbors C, George WH. Differential effects of acculturation on drinking behavior in Chinese- and Korean-American college students. <i>J Stud Alcohol Drugs.</i> 2008;69(1):121-128.	Not target population
33	Herbold N, Geagan K. Study abroad: foodways and nutrition in the traditional Mediterranean diet. <i>J Nutr Educ Behav.</i> 2002;34(4):231-232.	Short-term study abroad program
34	Holt SHA, Cobiac L, Beaumont-Smith NE, Easton K, Best DJ. Dietary habits and the perception and liking of sweetness among Australian and Malaysian students: a cross-cultural study. <i>Food Qual Prefer.</i> 2000;11(4):299-312.	No dietary changes or food security reported

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35	Howard PA. Asian American and Asian International college females: Eating behaviors, relationships, and culture. <i>PhD diss., The University at Buffalo, State University of New York</i> . 2012.	No dietary changes or food security reported
36	Hu JQ, Duval Y. Qualitative analysis and implications of Chinese expatriates' food consumption behavior. <i>J Food Prod Mark</i> . 2003;9(1):31-47.	Not target population
37	Huang H, Shih H, Thiruvadi S, Song Y. A Preliminary Research on the Lifestyle of International Students. <i>US China Educ Rev A</i> . 2011;3:401-411.	No dietary changes or food security reported
38	Izwan Syafiq R, Asma A, Nurzalinda Z, Rahijan Abdul W, Siti Nur AJ. Food insecurity among university students at two selected public universities in Malaysia. <i>Malays Appl Biol</i> . 2019;48(1):101-110.	Not target population
39	Jensen J, Jensen J. Cross cultural encounters: The newly arrived Asian student. <i>Coll Stud J</i> . 1983;17(4):371-377.	Did not study diet or nutrition
40	Joshi G, James D, Haider Z. Lifestyle and Health Information Seeking Behaviors of Asian Indian College Students Residing in the United States. <i>Health Educ Monogr Ser</i> . 2014;31(1):42-47.	No dietary changes or food security reported
41	Kang DS. How international students build a positive relationship with a hosting country: Examination of strategic public, message and channel of national public relations. <i>Int J Intercult Relat</i> . 2014;43:201-214.	Did not study diet or nutrition
42	Khairil A, Norazlan Shah H, Farah Syaifeera I, Nazrul Hadi I, Muhammad Ghazali M. Pilot study on the prevalence of food insecurity among sub-urban university students during holy Ramadan. <i>Pak J Nutr</i> . 2015;14(8):457-460.	Not target population
43	Khalaf A, Westergren A, Berggren V, Ekblom O, Al-Hazzaa HM. Prevalence and association of female weight status and dietary habits with sociodemographic factors: a cross-sectional study in Saudi Arabia. <i>Public Health Nutr</i> . 2015;18(5):784-796.	Not target population
44	Khan M, Oyewole PO. African Americans' image attributes and preferences for ethnic or international restaurants. <i>J Foodserv Bus Res</i> . 2014;17(3):161-178.	Not target population
45	Kramer A, Pruffer-Kramer L, Stock C, Tshiananga JT. Differences in Health Determinants between International and Domestic Students at a German. <i>J Am Coll Health</i> . 2004;53(3):127-32.	No dietary changes or food security reported
46	Kuo Y-H. Understanding international graduate students' experiences at auburn university (alabama). <i>PhD diss., Auburn University</i> . 2004.	Did not study diet or nutrition
47	Lake AJ, Staiger PK, Glowinski H. Effect of Western culture on women's attitudes to eating and perceptions of body shape. <i>Int J Eat Disord</i> . 2000;27(1):83-89.	No dietary changes or food security reported
48	Leong P. Coming to America: Assessing the Patterns of Acculturation, Friendship Formation, and the Academic Experiences of International Students at a U.S. College. <i>J Int Stud</i> . 2015;5(4):459-474.	Did not study diet or nutrition
49	Lim RBT, Tham DKT, Muller-Riemenschneider F, Wong ML. Are University Students in Singapore Meeting the International and National Recommended Daily Servings of Fruits and Vegetables? <i>Asia Pac J Public Health</i> . 2017;29(3):199-210.	Not target population
50	Lu H. Burgers or tofu? Eating between two worlds: risk information seeking and processing during dietary acculturation. <i>Health Commun</i> . 2015;30(8):758-771.	No dietary changes or food security reported
51	Luongo G, Tucker R, Hutchinson C, Dhaliwal R. The Outcomes of the Community Cooking Workshops for International Students at Simon Fraser University. <i>J Int Stud</i> . 2018;8(4):1549-1568.	Intervention outcomes
52	Mann L, Blotnick K. University Students' Eating Behaviors: An Exploration of Influencers. <i>Coll Stud J</i> . 2016;50(4):489-500.	Not target population
53	Martin S, Dyer J. Health maintenance practices and healthcare experiences among international university students. <i>J Am Assoc Nurs Pract</i> . 2017;29(11):651-657.	Did not study diet or nutrition
54	Martinez-Ruiz MP, Tirelli C, Izquierdo-Yusta A, Gomez-Ladron-de-Guevara R. Exploring the adjustment of international university students in relation to dietary practices. <i>Br Food J</i> . 2015;117(12):2947-2974.	No dietary changes or food security reported
55	Matthews J, Quattrochi C. International Students on an American Campus: An Undergraduate Research Study. <i>J Home Econ</i> . 1981;73(1):37-39.	Did not study diet or nutrition
56	McArthur LH, Greathouse KR, Smith ER, Holbert D. A quantitative assessment of the cultural knowledge, attitudes, and experiences of junior and senior dietetics students. <i>J Nutr Educ Behav</i> . 2011;43(6):464-472.	No dietary changes or food security reported
57	McArthur LH, Grivetti LE, Schutz HG. Health food store shopping practices and rationale of international students and students from the United States. <i>Ecol Food Nutr</i> . 1989;23(3):211-224.	No dietary changes or food security reported
58	McArthur LH, Grivetti LE, Schutz HG. Practices, beliefs and knowledge of international and U.S. students regarding food supplements and health foods. <i>Ecol Food Nutrition</i> . 1990;24(4):233-249.	No dietary changes or food security reported
59	Miles R, McBeath B, Brockett S, Sorenson P. Prevalence and Predictors of Social Work Student Food Insecurity. <i>J Soc Work Educ</i> . 2017;53(4):651-663.	Not target population
60	Mohanty BB, Karmajeet R, Jena SK, Nayak GR, Patra SK, Niranjana S. Dietary habit of medical students - a study among the students of a health university in Eastern India. <i>J Evol Med Dent Sci</i> . 2018;7(22):2698-2701.	Not target population
61	Moy FM, Johari S, Ismail Y, Mahad R, Tie FH, Wan Ismail WMA. Breakfast skipping and its associated factors among undergraduates in a public university in Kuala Lumpur. <i>Malays J Nutr</i> . 2009;15(2):165-174.	Not target population
62	Msengi IG. Sources of stress and its impact on health behaviors and academic performance of international students at a comprehensive Midwestern university. <i>Int J Glob Health Health Disparities</i> . 2007;5(1):55-69.	Did not study diet or nutrition
63	Munro N, Quayle M, Simpson H, Barnsley S. Hunger for Knowledge: Food Insecurity among Students at the University of KwaZulu-Natal. <i>Perspect Educ</i> . 2013;31(4):168-179.	Not target population
64	Musaiger AO, Awadhalla MS, Al-Mannai M, AlSawad M, Asokan GV. Dietary habits and sedentary behaviors among health science university students in Bahrain. <i>Int J Adolesc Med Health</i> . 2017;29(2):20150038.	Not target population
65	Nederkorn C, Guerrieri R, Havermans RC, Roefs A, Jansen A. The interactive effect of hunger and impulsivity on food intake and purchase in a virtual supermarket. <i>Int J Obes</i> . 2009;33(8):905-912.	Not target population
66	Ngale Lyonga AN. Culture and food safety awareness: A study of international college students' need for food safety training in the U.S. <i>PhD diss., North Dakota State University</i> . 2010.	Full-text not available
67	O'Palka J, Mitchell J, Martin R. Introducing international students to the American food supply. <i>J Am Diet Assoc</i> . 1983;82(5):531-533.	Intervention outcomes
68	Oraman Y, Yilmaz E, Unakitan G, Basaran B. Analytic study of university students' nutritional habits and attitudes as a part of society in Turkey. <i>9th Baltic Conference on Food Science and Technology "Food for Consumer Well Being" FOODBALT, Jelgava</i> . 2014:339-343.	Not target population
69	Ozdogan Y, Ozcelik AO, Surucuoglu MS. The breakfast habits of female university students. <i>Pak J Nutr</i> . 2010;9(9):882-886.	Not target population
70	Ozturgut O. Chinese Students' Perceptions of Life in the U.S. <i>J Coll Teach Learn</i> . 2012;9(1):1-12.	Did not study diet or nutrition

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71	Payne-Sturges DC, Tjaden A, Caldeira KM, Vincent KB, Arria AM. Student hunger on campus: food insecurity among college students and implications for academic institutions. <i>Am J Health Promot.</i> 2018;32(2):349-354.	Not target population
72	Pedersen ER, Cruz RA, LaBrie JW, Hummer JF. Examining the relationships between acculturation orientations, perceived and actual norms, and drinking behaviors of short-term American sojourners in foreign environments. <i>Prev Sci.</i> 2011;12(4):401-410.	Short-term study abroad program
73	Penman C, Omar M. Figuring Home: The Role of Commodities in the Transnational Experience. <i>Lang Intercult Commun.</i> 2011;11(4):338-350.	No dietary changes or food security reported
74	Petroka K, Dinu M, Hoover C, Casini A, Sofi F. Short-term exposure to a Mediterranean environment influences attitudes and dietary profile in U.S. college students: the Mediterranean diet in Americans (A-MED-AME) pilot study. <i>J Am Coll Nutr.</i> 2016;35(7):621-626.	Short-term study abroad program
75	Phillips E, McDaniel A, Croft A. Food Insecurity and Academic Disruption among College Students. <i>J Stud Aff Res Pract.</i> 2018;55(4):353-372.	Not target population
76	Priyadarshani WMD, Jayasekera JMTK, Gunasekara MA, Ariyathilaka SKL, Kosgahakumbura KNMHH, Thalagama TAKL. Access to healthy foods and indications of food insecurity among private university students in a Colombo suburb, Sri Lanka. <i>Malays J Nutr.</i> 2017;23(1):43-52.	Not target population
77	Ruetzler T. Food, beverage, and service quality: does culture impact satisfaction with university food services? <i>J Culin Sci Technol.</i> 2008;6(4):308-324.	No dietary changes or food security reported
78	Ruetzler T, Hertzman J, Taylor J. A comparative analysis of the impact of culture on university foodservice satisfaction: a pilot study. <i>J Foodserv.</i> 2009;20(4):200-208.	No dietary changes or food security reported
79	Ruetzler T, Taylor J, Hertzman J. Adaptation and international students' perceptions of on-campus foodservice. <i>Br Food J.</i> 2012;114(11):1599-1612.	No dietary changes or food security reported
80	Saeki S, Nihei Y. A longitudinal investigation of cultural adjustment and mood changes in two university students studying abroad. <i>Tohoku Psychologica Folia.</i> 2009;68:25-37.	Did not study diet or nutrition
81	Samples EY. Barriers to Fruit and Vegetable Intake among College Students. <i>Phd diss., Northcentral University.</i> 2017.	Not target population
82	Sasson L, Black J, Dalton S. Lessons learned about food-related attitudes and behaviors from an Italian Study Abroad Program. <i>Top Clin Nutr.</i> 2007;22(4):357-366.	Short-term study abroad program
83	Sayed SA. A cross-sectional study on eating habits and food related beliefs and knowledge in university students of Karachi, Pakistan. <i>Pak J Public Health.</i> 2012;2(2):36-42.	Not target population
84	Seshadri S, Harrill I. Nutrient intake of college students from India in the United States. <i>Nutr Rep Int.</i> 1971;3(3):159-164.	Not target population
85	Sharif BA. Discussing the needs of a neglected population: adjustment problems and health issues on international students. <i>J Health Educ.</i> 1994;25(5):260-265.	No dietary changes or food security reported
86	Shaw A, Capetola T, Lawson JT, Henderson-Wilson C, Murphy B. The Cost of Sustainability in Higher Education: Staff and Student Views of a Campus Food Culture. <i>Int J Sustain High Educ.</i> 2018;19(2):376-392.	No dietary changes or food security reported
87	Shereen MS, Nassr A-M, Noura A-H, Reham A-S, Jaber TA. Preference of food intake among dental students in relation to exercise and body mass index: a cross-sectional study. <i>Int Food Res J.</i> 2014;21(2):685-691.	No dietary changes or food security reported
88	Snelling AM, Schaeffer M, Lehrhoff S. Dieting and nutrition patterns of college females: implications for college health educators. <i>Am J Health Educ.</i> 2002;33(6):357-361.	Not target population
89	Strawson C, Bell RC, Farmer A, Downs SM, Olstad DL, Willows ND. Changing dietary habits of Alberta nutrition students enrolled in a travel study program in Italy. <i>Can J Diet Pract Res.</i> 2015;76(2):93-96.	Short-term study abroad program
90	Sultana Q, Smith R. Evaluation of International Students' Perceptions of Eastern Kentucky University. <i>40th Annual Meeting of the Mid South Educational Research Association, Oxford, MS, Nov 2-4, 2011.</i>	Did not study diet or nutrition
91	Sun WY, Sangweni B, Chen J, Cheung S. Effects of a community-based nutrition education program on the dietary behavior of Chinese-American college students. <i>Health Promot Int.</i> 1999;14(3):241-249.	Not target population
92	Sweni S, Muthusundari A, Meenakshisundaram R, Uma A, Thirumalaikolundusubramanian P. Attitude and practice of medical students studying in Hungary and India toward health during overseas and domestic travel. <i>Travel Med Infect Dis.</i> 2010;8(1):51-55.	Did not study diet or nutrition
93	Tanaka M, Mizuno K, Fukuda S, Shigihara Y, Watanabe Y. Relationships between dietary habits and the prevalence of fatigue in medical students. <i>Nutrition.</i> 2008;24(10):985-989.	Not target population
94	Tirelli C, Martinez-ruiz MP. Influences of product attributes on sojourners' food purchase decisions. <i>Br Food J.</i> 2014;116(2):251-271.	No dietary changes or food security reported
95	Tsai CY, Hoerr SL, Song WO. Dieting behavior of Asian college women attending a US university. <i>J Am Coll Health.</i> 1998;46(4):163-168.	No dietary changes or food security reported
96	Tuta-Sas I, Vlaicu B, Doroftei S, et al. Dietary patterns in young adults from Timis County. <i>Rev Med Chir Soc Med Nat Iasi.</i> 2012;116(4):1150-1156.	Not target population
97	Ul Haq I, Mariyam Z, Li M, et al. A Comparative Study of Nutritional Status, Knowledge Attitude and Practices (KAP) and Dietary Intake between International and Chinese Students in Nanjing, China. <i>Int J Environ Res Public Health.</i> 2018;15:1910.	No dietary changes or food security reported
98	Veena V, Chandra MRS, Shruthi MN, Khan SI. Junk food eating habits and obesity among medical college students in Bangalore: a cross-sectional study. <i>Natl J Community Med.</i> 2018;9(2):100-105.	Not target population
99	Wiecha JM, Fink AK, Wiecha J, Hebert J. Differences in dietary patterns of Vietnamese, white, African-American, and Hispanic adolescents in Worcester, Mass. <i>J Am Diet Assoc.</i> 2001;101(2):248-251.	Not target population
100	Wood JL, Harris F, III. Experiences with "Acute" Food Insecurity among College Students. <i>Educ Res.</i> 2018;47(2):142-145.	Not target population
101	Yan Z, Finn K, Cardinal BJ, Bent L. Promoting Health Behaviors Using Peer Education: A Demonstration Project between International and American College Students. <i>Am J Health Educ.</i> 2014;45(5):288-296.	Intervention outcomes
102	Yardimci H, Ozdogan Y, Ozelik AO, Surucuoglu MS. Fast-food consumption habits of university students: the sample of Ankara. <i>Pak J Nutr.</i> 2012;11(3):265-269.	Not target population
103	Yardmc M, Yildiz K, Sartas N, Coskun B. Health promoting behaviours of Turkish and foreigner university students. <i>Ovidius Univ Ann Phy Educ Sport/Sci Mov Health Ser.</i> 2012;12(1):95-100.	No dietary changes or food security reported
104	Yildiz EA, Demirduzen S, Dogan VB, Duman S, Turkmen N, Yildiz AN. Evaluation of the dietary habits, body images and BMI of Turkish University students who live in dormitory. <i>Pak J Med Sci.</i> 2011;27(1):85-89.	Not target population
105	Yilmaz E, Oraman Y, Unakitan G, Basaran B. Current eating patterns and life style on the health of Namik Kemal University students. <i>9th Baltic Conference on Food Science and Technology "Food for Consumer Well Being" FOODBALT, Jelgava.</i> 2014.	Not target population
106	Yu YH, Farmer A, Mager D, Willows N. Dietary sodium intakes and food sources of sodium in Canadian-born and Asian-born individuals of Chinese ethnicity at a Canadian university campus. <i>J Am Coll Health.</i> 2014;62(4):278-84.	No dietary changes or food security reported

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107	Zamboanga BL, Raffaelli M, Horton NJ. Acculturation status and heavy alcohol use among Mexican American college students: investigating the moderating role of gender. <i>Addict Behav.</i> 2006;31(12):2188-2198.	Not target population
108	Zarei F, Taib MNM, Zarei M. Nutrition and weight management knowledge, dietary intake and body weight status in Iranian postgraduate students in University Putra Malaysia. <i>Pak J Nutr.</i> 2014;13(6):351-358.	No dietary changes or food security reported
109	Zarei M, Mohd Taib MN, Zarei F, Abu Saad H. Factors associated with body weight status of Iranian postgraduate students in university of Putra Malaysia. <i>Nurs Midwifery Stud.</i> 2013;2(4):97-102.	No dietary changes or food security reported

Appendix D. Selected quotations to represent the dietary changes, contributing factors and the impacts of the changes among international higher education students from studies that used a qualitative approach

Themes	Supporting evidence (selective)
<i>Dietary changes: Dietary acculturation</i>	
Adapt to host food culture	The exploration and use of Canadian foods indicate international students' ability to move from their home culture preferences [25]. Some acknowledged changes in diet especially in the aspect of incorporating British meals to their diet plan [24]. Nevertheless, many students have adapted their diets to Australian conditions. They bought more salads, cereals and ingredients to make western foods that they enjoy as they are more easily available and easily prepared [28].
Maintain original diet	Students with strong ethnic ties consume Chinese food for maintaining their ethnic identity and resisting host food culture [26]. The high frequency of traditional foods in the participants' photographs and comparison between Canadian and traditional foods throughout discussion indicated international students had a strong connection to traditional foods... [25] Others however, still preferred to get some items from Asian grocery stores and these choices reflect how strongly participants adhere to their cultural identity and cultural foods [28].
Ship food supply from home	Some participants looked for traditional food in England or brought traditional spices from home to help them provide a familiar taste in England [29]. The unavailability of traditional food made some students ask parents to ship the traditional ingredients from the home country every couple of months [23].
Substitute traditional ingredients with local supply	Acquiring Canadian contacts for traditional ingredients or foods did help participants find an acceptable Canadian version of a familiar food [25]. Some of the dishes were made with the same ingredients that would be used in the participant's home countries but others used the task to show how they made a traditional dish with a substitute ingredient (i.e., instant potato mash or potato croquettes instead of yam) [11]. For example, whilst Chinese lamian noodles are not always accessible, spaghetti is employed together with pickled vegetables and pork into the creation of stir-fried "chao-mien" [32].
Dynamic changes	"When I first arrived I was eating ready meals and frozen pizzas all the time. They are very convenient food. It was fun, but when time pass by I started missing my food! Now I have changed! I wonder how my British flatmates eat this kind of stuff daily. I would not eat this food again! I cook my own food. I cannot eat this food anymore" [Male, lived in student flat on campus with British and other international students in the UK] [26]. "When I just came here I did not know where to find healthy food, so I ate a lot of fast food, and gained a lot of weight. Later, I noticed other college students they lived pretty healthy life style... Now I am an expert about finding American healthy food..." [Muli] [31]. "I think after come to the US, [school name] always provides the free pizza, free hamburger and I gained 10 pounds. It's very scary. Then I tried to change back to eating at Chinese restaurants. But it was too oily and I still could not lose weight. And then I figured out that maybe I should cook for myself. And then I lose like five pounds" [Female, graduate, stayed in the US for 24 months] [33].
Self-perception of the healthfulness of the changes	Only 8 (26%) of participants indicated that they ate fewer vegetables and fruits and increased their meat and carbohydrate intake. Other participants (11; 35.5%) said they made minimal or no changes in their diets and others thought that their diets were healthier (12, 38.7%), meaning that they had increased their fruit and vegetable intake and consumed less meat and carbohydrates. Women's diets were usually healthier while males tended to have similar or less healthy diets compared to their home diets [28]. Eating habits in England was considered less nourishing than at home for most of the participants [29].
<i>Dietary changes: Food consumption patterns</i>	
Food groups consumption	Students who moved to the United States indicated a higher consumption of fried food, meats, sugar, salt, convenience food (frozen, cans, and ready to eat food), cereals, bread, dairy products, soda beverages, snacks, desserts, and less fruits and vegetable [23]. When participants were asked about the biggest difference in their eating habits since moving to England, half of them immediately referred to "less fruits and vegetables" [29]. Snack foods consumed were also mostly western with students eating "potato chips," "cookies," "brownies," "chocolate bars," and "whole grain biscuits [crackers]", in addition to globally consumed foods like dried fruits and nuts [33].
Convenience and fast food consumption	Canadian convenience meant an increased intake of fat and sugar and consumption of larger portion sizes in comparison with their home eating practices; these resulted from higher consumption of snacks, fast food, and beverages [25]. Some participants admit consuming regularly food offered at global brand outlets such as Starbucks, Costa Coffee, Cafe Nero, McDonald's, KFC, Burger King, Subway and Dominos [32]. Many of the participants interviewed reported changes in diet, mainly foods with high fatty content, dense calories, refined and processed meals and sugary meals [24].
Alcohol/ beverages	Four participants take alcohol; however, they reported high reduction in the level of alcohol intake since coming to the United Kingdom [24]. Among the 18 participants, four considered themselves regular drinkers before they came to the US (i.e. drinking 2–3 times a week). Of the four, two drank less after they came to the US and the other two stayed the same. Of the remaining 14 international students, two became regular drinkers after they arrived in the US [31].
Weekday- weekend variation	For example, one participant showed a university day of cheese burger, microwave lasagna, fried chips and sausage, but a day of no classes showed home cooked spaghetti and fried chicken, plantain and kale vegetable soup and special chicken (Participant G ³) [11]. "Rice I eat at weekends – because I have time to prepare the food at weekends" [Female student from China] [27].

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<i>Dietary changes: Meal patterns</i>	
Meal skipping and meal regularity	When asked about meals most of the students said meal patterns were unstructured, the students were consuming more meals in the United States (four meals) at different times according to free time and what was available [23]. Almost all participants admitted that they had more regular eating patterns at home. This changed after living in England, characterized by the increased frequency of skipping meals [29]. The timing of meals was also mentioned particularly by European students who felt that eating “early” interrupted their normal rhythm and impinged on their feelings of “wellness” [27].
Meal contents	Customarily they have rice with every meal and many reported that not having the time to cook rice for breakfast, made them feel unfulfilled and still hungry. Breakfast cereals are not considered an appropriate alternative but they are resigned to consuming these, or forgoing breakfast completely [27]. Breakfast was listed as the first meal to change over to western foods for males. . . Lunch was mixed, female students tended to eat American foods while male students ate Chinese foods, and dinners and restaurant choices were almost always Chinese with the exception of a couple of students [33].
Portion size	The portions provided at meals were larger (in the US) [23]. Canadian convenience meant an increased intake of fat and sugar and consumption of larger portion sizes in comparison with their home eating practices. . . [25]
Home cooked meals	<i>“At 12 o'clock we rush home to prepare our lunch. Wendy does the washing, Sherry does the chopping, I do the cooking. Together we can make a Chinese meal to enjoy together [. . .] we cook two meat dishes, some rice, one vegetable dish, and a soup”</i> [Female, lived in private house with another two Chinese students in the UK] [26]. When asked about meals, most of the students (80%) said that meals are home cooked, occur mostly at homes on a daily basis (home country). . . Some of the students tried to cook but the majority of them were eating convenience foods or in the fast food restaurants (host country). . . [23]
Eating out and takeaway	Although students declare a desire to try new cuisines, their experiences of local restaurants is limited. However, all of them have a good knowledge of the local Chinese restaurants and takeaways, which some consume on a weekly basis [26]. Despite the different types of days' participants presented, takeaway food was commonly represented and nine of 18 participants showed at least one take-away meal. . . and five others showed a meal that they had eaten in a restaurant [11]. It was interesting to note that European students were quite happy and comfortable with take-outs (takeaways) such as pizza while the Asian students liked to go to restaurants with friends [27].
<i>Factors: Individual factors</i>	
Personal preferences	Regarding daily food consumption, participants affirm eating their 'home' food remains their favourite option. . . [32] Food preferences were commonly discussed in the groups. In particular, most identified that Chinese liked cooked food, whereas Americans preferred raw food; Chinese preferred room temperature, warm, or hot food, whereas Americans consumed lots of cold foods and beverages; and Chinese preferred less sweet foods, whereas Americans consumed lots of sweet foods [33].
Meaning of food	However, cooking and eating familiar Chinese food remains part of a coping strategy of navigating the uncertainties and anxieties of being in a new environment and maintaining the cultural identity in the new cultural environment [32]. Deviance from a correlation between home food and emotional comfort was found in interviews with Kang and Jiang, for whom avoidance of home food minimised homesickness. . . [9]
Taste	In the present study, however, all interviewees, regardless of cultural origin made reference to the blandness of locally available food: in the words of Panu, it is, 'not spicy, it has no flavour' [Male, age 33, Thai, living at home with parents, in shared accommodation in the UK, Buddhist] [9]. Participants said they were sometimes in 'survival mode' when they ate food for sustenance and to relieve hunger rather than worrying about its taste. Consequently, the taste of food was important but less so than other factors [28].
Religious factor	<i>“I eat less chicken because of my religion. I can't find Halal meat here. I haven't seen any Halal food in the stores. Even in the big stores like Giant or Wal-Mart there are no Halal foods”</i> [a Muslim participant from Northeastern University] [23]. Religious factors could also influence eating habit in term of food selection, where the international students would avoid certain types of meat [29].
Health concern	All international students felt their home country food was healthier than Canadian food [25]. Indeed, many students perceived their culture's food to be medicinal and this was set in contrast with locally bought food which could be deleterious for health. . . [9] Conversely, the European students felt that ingredient quality and the British reliance on convenience food compromised their health for which there was concern [27].
Time and study	Most of the students claimed that busy schedules were one of the factors that made them consume more convenient and ready to eat food [23]. One of the challenges in eating traditional food is the time necessary for preparation particularly for Asian students [27]. However, preparing everyday meals often conflicts with other practices, including attending classes and studying in the libraries [32].
Living status and family influences	None of them used to cook before coming to the UK, most of them used to eat at university canteen and at home with their parents [26]. Distance from their parents also influenced students' food intake. One student mentioned, <i>“when I was in China, my parents always forced me to eat fruit, but when I got here I always forget to eat fruit”</i> [Male, Graduate, stayed in the US for 6 months] [33].
Nutrition, food and culinary knowledge	After staying in the UK for more than 3 months, participants demonstrate not simply a wider knowledge of British food but also a deeper understanding of local food conventions [26]. Another factor that influenced international students to eat healthier was the health education they received after they came to the US. Although there were no mandatory health related courses they were required to take, international students received useful information related to healthy eating [31].
Cooking skills	Lack of cooking skills caused some participants to provide only simple dishes, or opt for convenience foods such as frozen food and junk food. In some cases it even caused participants to skip meals [29]. <i>“I never cooked before I came here, but my mum, she taught me to cook. Something simple, so I survive. Lucky me, that I found myself as a good chef, that's a surprise and new territory for me”</i> [Male, age 33, Thai, living at home with parents, in shared accommodation in the UK, Buddhist] [9].
Cooking facilities	<i>“I have one freezer drawer and one little shelf in the fridge. So I suppose my choices are dictated by what I have room for”</i> [Irish student, female, age 23, single] [29]. Additionally, students living in the dorms lacked access to kitchen equipment, and thus could not cook for themselves [33].

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Social interactions	<p>This study found that the joint preparation, cooking and eating of food was an important leisure activity; for those with access to compatriots, eating was a social and physical act; for others, food allowed them to communicate an important aspect of their origin culture [9].</p> <p>International students tended to find students from their home country and have traditional food together, especially on weekends or holidays. . . Initiated by the university, they would sometimes organize a 'bring-a-dish' party – a chance to gather with fellow international students and taste traditional dishes from other countries [29].</p> <p>One important factor was role modeling. By observing other students eating healthily and being physically active, they developed expectations regarding the benefits of those behaviors, such as looking fit and energetic. In addition, they provided social pressure to be consistent with others in terms of those behaviors [31].</p>
Stress and emotions	<p>"Like I worried a lot even with school and stuffs like that. . . Am stressing out so much and I just wanted to just drown myself in food" [Female, age 26, 10 months in the UK] [24].</p> <p>On the other hand, mood as well as stressful conditions could affect the appetite for some participants [29].</p>
Factors: Environmental factors Campus food environment	<p>Because participants describe food on campus as "very plain", "not acceptable" and "not filling", they do not consider such a food as a daily lunch option [26].</p> <p>The majority of international students (i.e. 15 of 18) revealed that they did not like the food provided in the cafeteria, mainly because the food was very different from their "home food" and the food was very rich (i.e. high in fat and calories) [31].</p>
Food availability	<p>Participants commented on the vast array and availability of products in Canada, including cheeses, milk, yogurt, and eggs [25]. It was not of comfort to students that such spices and food ingredients could be bought in England, as they were either too expensive or they did not taste the same; alternatively, they were unavailable locally [9].</p> <p>For instance, there are now aisles in mainstream Australian supermarkets devoted to condiments, ingredients, and prepacked or instant meals from overseas. Along with an influx of Asian grocery stores, this has allowed students to find ingredients to make their own cultural foods [28].</p>
Food access	<p>The participants mentioned that the traditional stores were located in big cities while convenience food stores and fast food restaurants are within walking distance. Public transportation to the traditional stores is limited, especially in the Northeast universities [23].</p> <p>Canberra is renowned as a car-dependent city but most students cannot afford their own cars. It has a comparatively poor public bus service (to other major Australian cities) which students are forced to use to get to grocery stores in the city centre or elsewhere. Some students also walk about 20 minutes from the University to the city centre whilst others ride their bikes [28].</p>
Food cost	<p>"... because back home healthy meals like fruits and vegetables are cheaper and you will find them even on the sides of the road..." [Female, age 24, 10 months in the UK] [24].</p> <p>The participants agreed that fast and convenience food is cheaper and this makes them consume more of these items; furthermore, the traditional food items are more expensive and poor in quality [23].</p> <p>All participants reported a negative effect of finance on health experience in the United Kingdom as they all agreed living in the United Kingdom is very expensive and even more expensive to adopt and maintain healthy behaviour and lifestyle [24]. Price could have a double-sided effect in determining health aspect in participants' eating habits. Those who considered eating out expensive chose to prepare food themselves. . . On the other hand, some participants considered fresh groceries more costly than convenient or frozen food. Hence, they would prefer the later [29].</p>
Food quality	<p>Students found access to traditional foods; however, the quality and taste were poorer than similar products in the home country [25].</p> <p>A further negative reflection on the food supply in the UK is indicated in recurrent complaints among students that the fresh food on sale in supermarkets was not of the same quality as at Home [9].</p> <p>Nevertheless, some participants would weigh up the benefits of paying a little more for items that taste better or have more nutritional value [28].</p>
Ethnic restaurants	<p>Participants became very animated when discussing eating out. It was a form of social activity and fulfilled the need to consume traditional cuisine. However, many participants were disappointed by the inauthenticity of the ethnic foods [25].</p> <p>Many reasonably priced Asian restaurants are located close to the Australian National University to cater for the large number of Asian students [28].</p> <p>Regardless of being in rural or urban areas, consuming daily Chinese meals involves cooking, since the local Chinese take-away and restaurants are considered too expensive, poor quality, or lacking in authenticity for being regarded as a routinised option [32].</p>
Impacts: Weight Weight gain	<p>Many placed emphasis on the amount of weight gained within the short period of their stay in the United Kingdom as compared to Nigeria [24].</p> <p>Several of the students reported gaining weight after coming to America. Students discussed reasons for weight change and blamed lack of exercise, stress, and poor eating habits since arriving in America [33].</p>
Weight loss	<p>"[My weight] decreased by two or three kilos, because I didn't eat properly, I didn't eat when I [wanted] to eat, I [did not] like the food, I was completely stressed" [Romanian student, female, age 21, single] [29].</p> <p>"I lost a lot of weight when I first got here because I do not like American food and I do not know how to cook. But whenever I went home, my weight will go up, and when I came back (to the US) my weight will go down again. I am exercising hard now to be more fit" [Hendi*] [31].</p>
Impacts: Health Physical health	<p>Some students felt the negative physical health effects of eating Canadian foods. Describing the physical toll on her body, one student* commented: "My digestion is not as good as in my country. Yeah, I also find in my stomach, when I . . . it's changed to when I speak to some people, like the smell in my mouth is not good" [25].</p> <p>"I'm getting worried about my health – because there is too much fat – my level of cholesterol must be very high." [Male, age 35, Spanish, living alone in Spain but with a host family in the UK, Christian] [9].</p>
Psychological health	<p>Participants (n=22, 88%) stated that some aspects of their health were impacted (both positively and negatively) by diet [30].</p> <p>Several participants reported feelings of guilt in the United States due to eating more meals and consuming unhealthy food. Additionally, Muslim students felt mentally ill because of not consuming Halal food [23].</p> <p>Many experienced weight gain or a fear of weight gain associated with an increased consumption of convenience foods [25].</p>

*Demographic characteristics of the quoted participant were not reported.

References

- [1] United Nations Educational, Scientific and Cultural Organization Institute for Statistics. Global Education Digest 2006 Comparing Education Statistics Across the World. Available at: http://uis.unesco.org/sites/default/files/documents/global-education-digest-2006-comparing-education-statistics-across-the-world-en_0.pdf. Published 2006. Accessed May 1, 2020.
- [2] Organisation for Economic Co-operation and Development. Education at a Glance 2019. OECD Indicators; 2019. <https://doi.org/10.1787/f8d7880d-en>. Available at: Published/Accessed May 1, 2020.
- [3] Ramchandran NT. Enhancing international students' experiences: an imperative agenda for universities in the UK. *J Res Int Educ* 2011;10:201–20.
- [4] Australian Government Department of Education and Training. Prepared by Deloitte Access Economics. The value of international education to Australia. Available at: <https://internationaleducation.gov.au/research/research-papers/Documents/ValueInternationalEd.pdf>. Published 2016. Accessed October 15, 2020.
- [5] Martirosyan NM, Bustamantea RM, Saxon DP. Academic and social support services for international students. *J Int Students* 2019;9:172–91.
- [6] Yan Z, Cardinal BJ. Promoting physical activity among international students in higher education: a peer-education approach. *J Phys Educ Recreat Dance* 2013;84(1):35–40.
- [7] Berry JW. Acculturation: Living successfully in two cultures. *Int J Intercult Relat* 2005;29:697–712.
- [8] Sam DL, Berry JW. Acculturation: when individuals and groups of different cultural backgrounds meet. *Perspect Psychol Sci* 2010;5:472–81.
- [9] Brown L, Edwards J, Hartwell H. A taste of the unfamiliar. Understanding the meanings attached to food by international postgraduate students in England. *Appetite* 2010;54:202–7.
- [10] Smith RA, Khawaja NG. A review of the acculturation experiences of international students. *Int J Intercult Relat* 2011;35:699–713.
- [11] Corcoran N. Exploring international students' food choices using photovoice techniques. *J Int Students* 2018;8:175–93.
- [12] Satia-Abouta J, Patterson RE, Neuhouser ML, Elder J. Dietary acculturation: applications to nutrition research and dietetics. *J Am Diet Assoc* 2002;102:1105–18.
- [13] Lesser IA, Gasevic D, Lear SA. The association between acculturation and dietary patterns of South Asian immigrants. *PLoS One* 2014;9:e88495.
- [14] Food and Agriculture Organization of the United Nations. Rome Declaration on World Food Security and World Food Summit Plan of Action. Available at: <http://www.fao.org/3/w3613e/w3613e00.htm>. Published 1996. Accessed May 1, 2020.
- [15] Gallegos D, Ramsey R, Ong KW. Food insecurity: is it an issue among tertiary students? *High Educ* 2014;67:497–510.
- [16] Olason C, Engler-Stringer R, Vatanparast H, Hanoski R. Student food insecurity: examining barriers to higher education at the University of Saskatchewan. *J Hunger Environ Nutr* 2018;13:19–27.
- [17] Calder MJ, Richter S, Mao Y, Kovacs Burns K, Mogale RS, Danko M. International students attending Canadian universities: their experiences with housing, finances, and other issues. *Can J High Educ* 2016;46:92–110.
- [18] Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005;8:19–32.
- [19] Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews: Checklist and explanation. *Ann Intern Med* 2018;169:467–73.
- [20] Shi Y, Lukomskyj N, Allman-Farinelli M. Food access, dietary acculturation, and food insecurity among international tertiary education students: a scoping review protocol. *JBI Evid Synth* 2020;18:2090–7.
- [21] Peters MDJ GC, McInerney P, Baldini Soares C, Khalil H, Parker D. Scoping reviews. In: Aromataris E, Munn Z, editors. *Joanna Briggs Institute Reviewer's Manual*. Adelaide, Australia: The Joanna Briggs Institute; 2020.
- [22] EndNote. Version X9.3. Philadelphia, PA: Clarivate Analytics; 2020.
- [23] Alakaam AA, Castellanos DC, Bodzio J, Harrison L. The factors that influence dietary habits among international students in the United States. *J Int Students* 2015;5:104–20.
- [24] Alloh FT, Tait D, Taylor C. Away from home: a qualitative exploration of health experiences of Nigerian students in a U.K. university. *J Int Students* 2018;8:1–20.
- [25] Amos S, Lordly D. Picture this: a photovoice study of international students' food experience in Canada. *Can J Diet Pract Res* 2014;75:59–63.
- [26] Cappellini B, Yen DA-w. Little emperors in the UK: acculturation and food over time. *J Bus Res* 2013;66:968–74.
- [27] Hartwell HJ, Edwards JSA, Brown L. Acculturation and food habits: lessons to be learned. *Br Food J* 2011;113:1393–405.
- [28] Leu JH, Banwell C. Looking for a taste of home: a qualitative study of the health implications of the diets of Australian-based Southeast Asian students. *Glob J Health Sci* 2016;8:101–12.
- [29] O'Sullivan N, Amirabdollahian F. Loyal tongue, liberal mind: international students' experiences on dietary acculturation in England. *J Int Students* 2016;6:107–27.
- [30] Saccone BH, Obeng CS. Food choices and eating patterns of international students in the United States: a phenomenological study. *Int Public Health J* 2015;7:357–61.
- [31] Yan Z, FitzPatrick K. Acculturation and health behaviors among international students: a qualitative approach. *Nurs Health Sci* 2016;18:58–63.
- [32] Yen DA, Cappellini B, Wang CL, Nguyen B. Food consumption when travelling abroad: young Chinese sojourners' food consumption in the UK. *Appetite* 2018;121:198–206.
- [33] Wu B, Smith C. Acculturation and environmental factors influencing dietary behaviors and body mass index of Chinese students in the United States. *Appetite* 2016;103:324–35.
- [34] Almohanna A, Conforti F, Eigel W, Barbeau W. Impact of dietary acculturation on the food habits, weight, blood pressure, and fasting blood glucose levels of international college students. *J Am Coll Health* 2015;63:307–14.
- [35] Atanasova V, Gatsseva P, Bivolarska A, Fronas G. Body mass index and food frequency intake of foreign medical students. *Trakia J Sci* 2014;12:367–70.
- [36] Brittain HC, Obeidat BA. Food practices, changes, preferences and acculturation of Arab students in US universities. *Int J Consum Stud* 2011;35:552–9.
- [37] Chai SC, Jiang H, Pappas MA, Fang CS, Setiloane KT. Acculturation, diet, and psychological health among Asian students. *J Am Coll Health* 2019;67:433–40.
- [38] Danquah AO, Odjoi Y, Graham-Acquaah S, Steiner-Asiedu M. A pilot study of the dietary and physical activity behaviours of international students: implications for health promotion. *Afr J Food Sci* 2010;4:86–92.
- [39] Dzatse ME, Kim E, Kim H, Kim H, Aswathy V, Chang N. Meal skipping habits and nutritional status among Ghanaian students living in Korea. *J Nutr Health* 2017;50:376–82.
- [40] Edwards JS, Hartwell HL, Brown L. Changes in food neophobia and dietary habits of international students. *J Hum Nutr Diet* 2010;23:301–11.
- [41] Lee J, Gao RR, Kim JH. Acculturation and changes in dietary behavior and anthropometric measures among Chinese international students in South Korea. *Nutr Res Pract* 2015;9:304–12.
- [42] Lockie GM, Dickerson JWT. Food-choice and nutrient-intakes of male Nigerian students in Aberdeen. *J Hum Nutr Diet* 1991;4:263–72.
- [43] Loomes S, Croft A. An investigation into the eating behaviour of international students studying at an Australian university: should we be concerned? *J High Educ Policy Manag* 2013;35:483–94.
- [44] Ogah J. Comparison of nutrition and dental practices of international students at the University of Northern Iowa before and after coming to the United States. *Int J Glob Health* 2001;1:10–5.
- [45] Pan Y-L, Dixon Z, Himburg S, Huffman F. Asian students change their eating patterns after living in the United States. *J Am Diet Assoc* 1999;99:54–7.
- [46] Papadaki A, Scott JA. The impact on eating habits of temporary translocation from a Mediterranean to a northern European environment. *Eur J Clin Nutr* 2002;56:455–61.
- [47] Perez-Cueto F, Verbeke W, Lachat C, Remaut-De Winter AM. Changes in dietary habits following temporal migration. The case of international students in Belgium. *Appetite* 2009;52:83–8.
- [48] Reeves SL, Henry CJ. Dietary change, energy balance and body weight regulation among migrating students. *Int J Food Sci Nutr* 2000;51:429–38.
- [49] Santos S, Vilela S, Padrao P, Caraher M. Sex-related dietary changes of Portuguese university students after migration to London. *UK Nutr Diet* 2015;72:340–6.
- [50] Vilela S, Santos S, Padrao P, Caraher M. Length of migration and eating habits of Portuguese university students living in London, United Kingdom. *Ecol Food Nutr* 2014;53:419–35.
- [51] Blundell L, Mathews M, Bowley C, Roebotham B. Determining student food insecurity at Memorial University of Newfoundland. *Can J Diet Pract Res* 2019;80:14–21.
- [52] Frank L. "Hungry for an education": prevalence and outcomes of food insecurity among students at a primarily undergraduate university in rural Nova Scotia. *Can J High Educ* 2018;48:109–29.
- [53] Hanbazaza M, Ball GDC, Farmer A, Maximova K, Willows ND. Filling a need: sociodemographic and educational characteristics among student clients of a university-based campus food bank. *J Hunger Environ Nutr* 2016;11:569–77.
- [54] Hanbazaza M, Ball GDC, Farmer AP, Maximova K, Farahbakhsh J, Willows ND. A comparison of characteristics and food insecurity coping strategies between international and domestic postsecondary students using a food bank located on a university campus. *Can J Diet Pract Res* 2017;78:208–11.
- [55] Maynard M, Meyer SB, Perlman CM, Kirkpatrick SI. Experiences of food insecurity among undergraduate students: "you can't starve yourself through school". *Can J High Educ* 2018;48:130–48.
- [56] Silverthorn D. Hungry for knowledge: assessing the prevalence of student food insecurity on five Canadian campuses. Toronto, Canada: Meal Exchange; 2016.
- [57] United States Department of Agriculture. U.S. Adult Household Food Security Survey Module: Three-Stage Design, with Screeners. Available at: <https://www.ers.usda.gov/media/8279/ad2012.pdf>. Published 2012. Accessed May 21, 2020.
- [58] Hughes R, Serebryanikova I, Donaldson K, Leveritt M. Student food insecurity: the skeleton in the university closet. *Nutr Diet* 2011;68:27–32.
- [59] Fedewa MV, Das BM, Evans EM, Dishman RK. Change in weight and adiposity in college students: a systematic review and meta-analysis. *Am J Prev Med* 2014;47:641–52.
- [60] El Zein A, Mathews AE, House L, Shelnett KP. Why are hungry college students not seeking help? Predictors of and barriers to using an on-campus food pantry. *Nutrients* 2018;10:1163.
- [61] Soldavini J, Berner M, Da Silva J. Rates of and characteristics associated with food insecurity differ among undergraduate and graduate students at a large public university in the Southeast United States. *Prev Med Rep* 2019;14:100836.
- [62] Martinez SM, Webb K, Frongillo EA, Ritchie LD. Food insecurity in California's public university system: what are the risk factors? *J Hunger Environ Nutr* 2018;13:1–18.

- [63] Ozturgut O. Chinese students' perceptions of life in the U.S. *J Coll Teach Learn* 2012;9:1–12.
- [64] Ruetzler T, Taylor J, Hertzman J. Adaptation and international students' perceptions of on-campus foodservice. *Br Food J* 2012;114:1599–612.
- [65] Ruetzler T. Food, beverage, and service quality: does culture impact satisfaction with university food services? *J Culin Sci Technol* 2008;6:308–24.
- [66] Luongo G, Tucker R, Hutchinson C, Dhaliwal R. The outcomes of the community cooking workshops for international students at Simon Fraser University. *J Int Students* 2018;8:1549–68.
- [67] Yan Z, Finn K, Cardinal BJ, Bent L. Promoting health behaviors using peer education: a demonstration project between international and American college students. *Am J Health Educ* 2014;45:288–96.
- [68] Shaw A, Capetola T, Lawson JT, Henderson-Wilson C, Murphy B. The cost of sustainability in higher education: staff and student views of a campus food culture. *Int J Sustain High Educ* 2018;19:376–92.
- [69] Burrows TL, Whatnall MC, Patterson AJ, Hutchesson MJ. Associations between dietary intake and academic achievement in college students: a systematic review. *Healthcare* 2017;5:60.

3.5 Conclusion to chapter

This chapter has mapped the existing qualitative and quantitative evidence on dietary changes and food security status of international students after they started studying in tertiary education institutions in a foreign country. Dietary experience of international students lacks solid interpretation in an Australian context. Limited evidence on food security status and diet quality of international students was available. These research gaps will be resolved in **Chapters Five, Six, and Seven**. The findings from this scoping review also facilitated the design of the qualitative study (**Chapter Five**) and food security questionnaire (**Chapter Six**) in this thesis. The next chapter (**Chapter Four**) will be a summary of current evidence on the association between food insecurity and dietary outcomes in tertiary education students.

3.6 Scoping review update

To ensure the inclusion of the most recent evidence, an updated search was conducted in MEDLINE in September 2022 using the same search strategy to capture studies published since September 2019 until September 2022. The study selection was conducted based on the same eligibility criteria to include studies exploring dietary changes and food security status among international students in any country.

The search identified 357 new citations with one additional article from the screening of the reference lists of included studies. After screening titles and abstracts, 332 records were excluded as they did not meet the eligibility criteria, and 26 studies were screened in full text. Finally, seven articles about dietary changes¹⁻⁷ and four articles on food security status⁸⁻¹¹ were included. Reasons for exclusion from the second screening are shown in the PRISMA flow diagram¹² (see Figure 2).

Of seven articles investigating dietary changes among international students, three used qualitative or mixed methods research design,^{1,5,6} and another four were cross-sectional surveys.^{2-4,7} Five studies were conducted in tertiary education institutions in European (the UK^{2,5} and Ukraine⁷) and North American (Canada⁶ and the US¹) countries, and two studies in India.^{3,4} More detailed characteristics of the studies and their participants are shown in Table 5. Key findings from included studies were summarised into three primary outcomes (dietary acculturation, food consumption patterns, and meal patterns) and two secondary outcomes (factors and impacts) in Table 5. The results from these seven studies were consistent with the findings from the original review. None of the studies reported the impact of the COVID-19 pandemic on the dietary changes of international students.

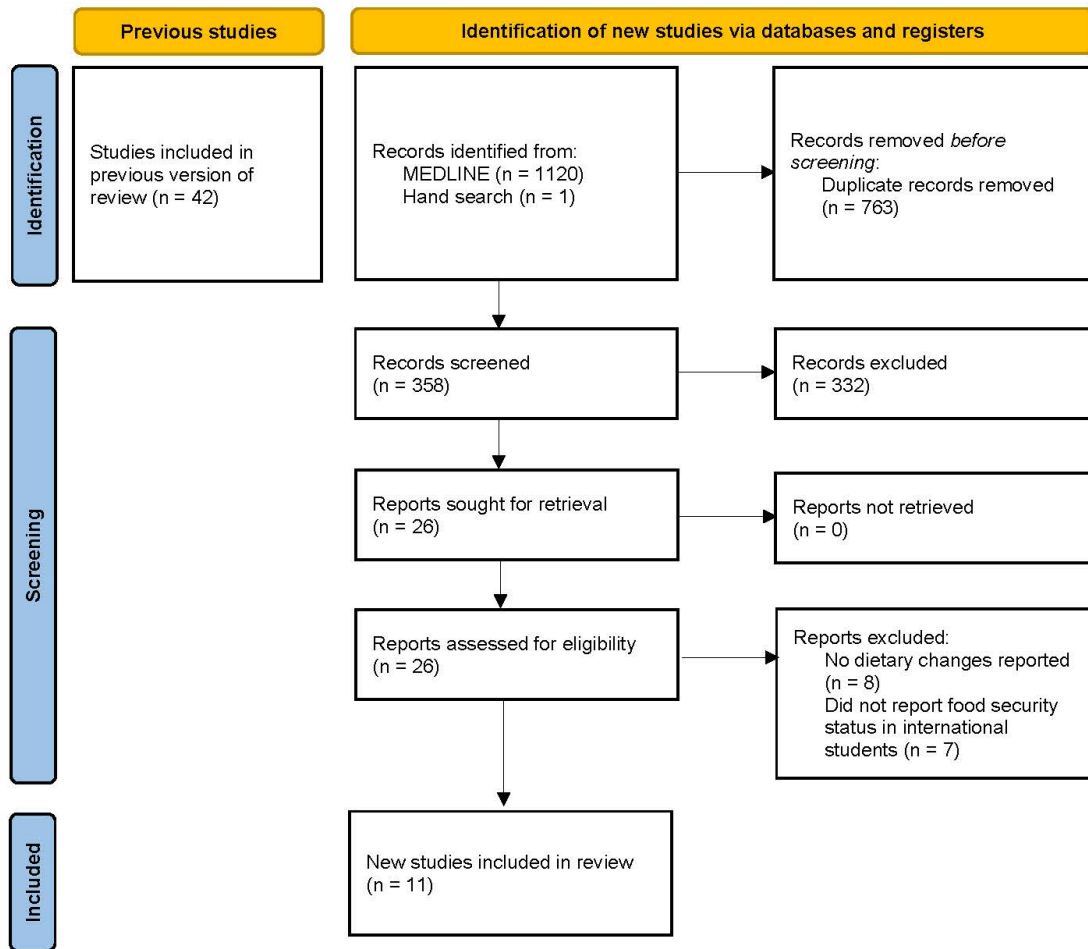


Figure 2. PRISMA flow diagram of record identification and study selection in the updated search for the scoping review of dietary acculturation and food insecurity among international tertiary education students.

Table 5. Summary of included studies that reported the dietary changes of international higher education students from the updated search.

First author (year) Country	Study design/data collection methods	Aims/ objectives	Sample size	Participant characteristics	Primary outcomes			Secondary outcomes	
					Dietary acculturation	Food consumption patterns	Meal patterns	Factors	Impacts
Alakaam ¹ (2020) US	Qualitative, focus groups	To gain an in-depth understanding of the factors related to dietary acculturation among INT in US universities	44	Area of origin: 46% Asia; Age: mean 23.7 y; Gender: 45% F; Education: 77% UG; Length of stay: 45.5% 6 m to 2 y, 54.5% 2 to 5 y	Students who stayed longer in the US and who preferred fast food and convenience were better able to adapt to the American diet and reported more changes to their original eating habits.	Home country: consumed fresh ingredients, rice, noodles, beans, or meat; tea, milk, and water. US: consumed foods high in preservatives, sugars, and fats; adaptation to American foods (e.g., pizza, fries, and sandwiches); soda.	Meals were structured in the home country, but were typically unstructured with larger portion sizes and started including late night meals in the US New experience to eat buffet-style at the dining centre on campus.	Food access, personal food preferences, religion and culture, time constraints, campus environment, healthcare access	Weight gain from adopting an American diet, unstructured mealtimes, and stress. Weight loss from resisting an American diet. Acid reflux, ulcers, acne, and increased fatigue.
Alzain ² (2022) UK	Cross-sectional, survey	To explore the health-related behaviours of Saudi UG students in the UK and how their move to the UK has affected these behaviours	212	Area of origin: Saudi Arabia; Age: did not report; Gender: 33% F; Education: 100% UG; Length of stay: did not report	N/A	S ↓ frequently meat and fish, and rice, but S ↑ frequently fast food in the UK	45.4% reported healthier eating habits in the UK, 14.6% remained the same, 40.1% less healthy.	Reasons for less healthy eating habits: ate more junk food due to a lack of cooking skills and having no time to cook. Reasons for healthier eating habits: independence from their families, healthy foods were more available to them in the UK	N/A

First author (year) Country	Study design/data collection methods	Aims/ objectives	Sample size	Participant characteristics	Primary outcomes			Secondary outcomes	
					Dietary acculturation	Food consumption patterns	Meal patterns	Factors	Impacts
Kivuyo ³ (2020) India	Cross-sectional, survey	To study the factors affecting the dietary acculturation of African emigrant students in India	120	Area of origin: Africa; Age: 48% 23–27 y; Gender: 53% F; Education: 76% UG; Length of stay: did not report	Students prepared for dietary acculturation after landing in India.	Students consumed fresh animal-based foods in the home country, but relied on frozen animal-based foods in India. Different vegetables and grains between African countries and India.	N/A	Awareness about local food options, food affordability, food suitability and hygiene, lack of familiarity with local food markets and local foods, lack of proximity to food access points, lack of mobility	N/A
Mahmoodi ⁴ (2022) India	Cross-sectional, survey	To study dietary acculturation of INT in Pune, India	100	Area of origin: Iran, Africa, South Korea; Age: 53% 23–26 y; Gender: did not report; Education: did not report; Length of stay: 64% < 2 y	N/A	The intake of non-vegetarian food ↓ drastically (↓ beef intake in Iranian and African students, ↓ intake of fish and fish products in Korean students); ↑ intake of biscuits and cake	Considerable variation was detected in the daily number of meals consumed, skipping meals, portion size changes between Iranian, African, and South Korean students.	N/A	↓ intake of protein and micronutrients; African students ↑ 3.33 kg weight

First author (year) Country	Study design/data collection methods	Aims/ objectives	Sample size	Participant characteristics	Primary outcomes			Secondary outcomes	
					Dietary acculturation	Food consumption patterns	Meal patterns	Factors	Impacts
Mensah ⁵ (2022) UK	Mixed methods, survey and semi- structured interviews	To examine the extent of dietary acculturation and dietary enculturation on the influence of student's food choices	60 (18 INT)	Did not report specific demographic information for INT	Acculturative dietary practices were observed; some students mentioned the practice of both enculturation and acculturation	N/A	N/A	Social and physical environment, individual factors (e.g., finances, mood), university life (academic activities, residency type), enculturation (e.g., food preference, comfort), acculturation (e.g., accessibility to particular foods, time and convenience, limited cooking skills)	N/A
Pilli ⁶ (2021) Canada	Mixed methods, food records and focus groups	To investigate the Canadian food experiences and dietary patterns of INT who recently moved to Canada	30	Area of origin: Asia, South America, Western Africa; Age: 87% 18– 25 y; Gender: 67% F; Education: did not report; Length of stay: 73% < 4 m to 2 y	Many participants want to maintain original dietary habits, yet their new independent living status and novel food environments led to changes in dietary habits	Did not meet the recommended intake levels for vegetables and fruit, grain products, and milk and alternatives; convenience foods were prioritized	Some found the structure of weekday schedules facilitated regular meals compared with weekends	Time management, increased food responsibility, limited food skills, food quality and taste, cost, limited access to culturally familiar foods, foods on campus with limited variety and flavour, fast-food environments, socialisation	N/A

First author (year) Country	Study design/data collection methods	Aims/ objectives	Sample size	Participant characteristics	Primary outcomes			Secondary outcomes	
					Dietary acculturation	Food consumption patterns	Meal patterns	Factors	Impacts
Yurochko ⁷ (2021) Ukraine	Cross- sectional, survey	To investigate the eating behaviour of INT in Ukraine	193	Area of origin: mostly from Nigeria, Ghana, Pakistan; Age: mean 23.5 y; Gender: 49% F; Education: UG and PG; Length of stay: mean 43 m	94.8% agreed that they have made dietary changes	↑ intake of refined and fast foods; ↓ intake of soft/fizzy drinks, fried foods, low-fat milk and milk products, and sugar and confectionaries.	N/A	N/A	N/A

↑: increase/more; ↓ decrease/less; F: female(s); INT: international students; m: month(s); N/A: not applicable; PG: postgraduates; S: significant; UG: undergraduates; UK: United Kingdom; US: United States; y: year(s).

Of four articles reporting food security status among international students, one of them used the mixed methods research design¹¹ and three were cross-sectional surveys.⁸⁻¹⁰ All included studies were conducted in the US. They used either the 6-item short form FSSM or the 10-item Adult FSSM to assess food security status.^{13,14} Key findings from included studies are summarised in Table 6. Two studies reported a higher risk of being food insecure among international students compared with domestic students,^{8,9} and one of them conducted the survey during the COVID-19 pandemic.⁸ Soldavini and Berner compared the food security status between before and during the pandemic, and indicated that international students were more likely to experience worsened food security status during the pandemic than domestic students.¹⁰ Wright et al. found all international students in their sample experienced cultural food insecurity referring to problems in the availability, access, utilisation, and stability of familiar foods from their culture.¹¹

More studies investigated dietary changes among international students and found international students were more vulnerable to food insecurity. However, the evidence in diet-related experiences of international students studying in Australia remains limited, and further research would be required. Primary studies in **Chapters Five, Six, and Seven**, will contribute to the evidence body in this field.

Table 6. Summary of studies that reported food security status of international higher education students from the updated search.

First author (year)	Country	Study design/ methodology	Sample size (number or % of international students)	Level of education	Food security measurement	Main findings
Davitt ⁸ (2021)	United States	Cross-sectional survey	1434 (9.1%)	82.1% UG	6-item short form USDA FSSM	INT in food secure vs in food insecure students: 7.8% vs 14.8% (p = 0.001)
Soldavini ⁹ (2020a)	United States	Cross-sectional survey	4829 (270)	59.6% UG	10-item USDA Adult FSSM	INT were more likely to experience marginal (OR = 1.55, CI 1.10–2.19, p < 0.05) and very low food security (OR = 2.51, CI 1.31–4.80, p < 0.01).
Soldavini ¹⁰ (2020b)	United States	Cross-sectional survey	2039 (113)	57% UG	10-item USDA Adult FSSM	Among INT vs DOM: 7.1% vs 12.0% improved food security status, 61.1% vs 68.6% stayed the same, 31.9% vs 19.4% worsened (p = 0.003). INT were more likely to experience worsened food security status during the COVID-19 pandemic (OR = 1.82, CI 1.04–3.20, p < 0.05).
Wright ¹¹ (2021)	United States	Mixed methods, survey and semi-structured interviews	31 (15)	6.7% UG in INT	6-item short form USDA FSSM	Second-generation American students vs. INT: 56.3% vs 100% experienced cultural food insecurity in the last three years; 56.3% vs 33.3% had low or very low food security scores

CI: 95% confidence interval; DOM: domestic students; FSSM: Food Security Survey Module; INT: international students; OR: Odds ratio; UG: undergraduates; USDA: United States Department of Agriculture; vs.: versus.

3.7 Scoping review update references

1. Alakaam A, Willyard A. Eating habits and dietary acculturation effects among international college students in the United States. *AIMS public health*. 2020;7(2):228-240. doi:10.3934/publichealth.2020020
2. Alzain HM, Leavey C, Mitchell G, Gee I, Hall J, Al-Subaie AS. Exploration of changes in health-related behaviours among Saudi Arabian undergraduates in the UK. *Health Promot Int*. 2022;37(1):17. doi:10.1093/heapro/daab055
3. Kivuyo NG, Sharma S. Dietary acculturation among African emigrant students in India: determinants and problems. *Public Health Nutr*. 2020;23(13):2402-2409. doi:10.1017/S1368980019005226
4. Mahmoodi M, George RM, Gokhale D. Dietary acculturation of international students in Pune, India: a cross-sectional study. *Nutr Health*. 2022;28(2):271-276. doi:10.1177/02601060211019678
5. Mensah FZ, Lane KE, Richardson LD. Determinants of eating behaviour in Black, Asian and Minority Ethnic (BAME) university students when living at and away from home: with a focus on the influence of food enculturation and food acculturation. *Appetite*. 2022;171:105932. doi:10.1016/j.appet.2022.105932
6. Pilli BM, Slater J PhD RD. Food experiences and dietary patterns of international students at a Canadian university. *Can J Diet Pract Res*. 2021;82(3):100-106. doi:10.3148/cjdpr-2021-006
7. Yurochko TP, Shevchenko MV, Wenom AHJ. Eating behaviour of international students in Ukraine. *Wiad Lek*. 2021;74(3 cz 2):708-712.
8. Davitt ED, Heer MM, Winham DM, Knoblauch ST, Shelley MC. Effects of COVID-19 on university student food security. *Nutrients*. 2021;13(6):1932. doi:10.3390/nu13061932
9. Soldavini J, Berner M. The importance of precision: differences in characteristics associated with levels of food security among college students. *Public Health Nutr*. 2020;23(9):1473-1483. doi:10.1017/S1368980019004026
10. Soldavini J, Andrew H, Berner M. Characteristics associated with changes in food security status among college students during the COVID-19 pandemic. *Translat Behav Med*. 2020;11(2):295-304. doi:10.1093/tbm/ibaa110
11. Wright KE, Lucero JE, Ferguson JK, et al. The influence of cultural food security on cultural identity and well-being: a qualitative comparison between second-generation American and international students in the United States. *Ecol food nutr*. 2021;60(6):636-662. doi:10.1080/03670244.2021.1875455
12. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71
13. Economic Research Service, The United States Department of Agriculture. Six-Item Short Form of the Food Security Survey Module. Accessed October 4, 2022. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#six>

14. Economic Research Service, The United States Department of Agriculture. US Adult Food Security Survey Module. Accessed October 4, 2022.
<https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#adult>

Chapter Four. The association between food insecurity and dietary outcomes in university students: a systematic review

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4.1 Publication details

This chapter presents the manuscript entitled “The association between food insecurity and dietary outcomes in university students: a systematic review” published in *Journal of the Academy of Nutrition and Dietetics*, 2021, Volume 121, Issue 12: 2475–2500, doi:10.1016/j.jand.2021.07.015. The manuscript is presented in the journal format.

4.2 Author contribution

I Yumeng Shi (the candidate) was the primary researcher involved in the design of the study, developing the research question, search strategy, study selection, data extraction, quality assessment, and data synthesis. The second author (Alyse Davies) contributed to study selection, data extraction, and quality assessment. Professor Margaret Allman-Farinelli contributed to the design of the study and the synthesis of the results. I summarised the evidence and wrote the first draft of this manuscript for publication. All authors reviewed and revised the manuscript draft.

4.3 Introduction to chapter

The last chapter (**Chapter Three**) focused on dietary changes and food security status of international students. Prior to the presentation of primary research projects in this thesis, this chapter presents a systematic review to investigate whether food insecurity is associated with dietary outcomes in the entire university student population.

4.4 Manuscript

(Appears on next page)



The Association Between Food Insecurity and Dietary Outcomes in University Students: A Systematic Review



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*MND = master of nutrition and dietetics (certified in Australia).

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ABSTRACT

Background University students may experience a high prevalence of food insecurity. The impacts of food insecurity on dietary intake and meal patterns of students have not been fully researched.

Objective This systematic review aimed to examine the association between food insecurity and dietary outcomes among university students.

Methods Nine electronic databases and gray literature were searched from their inception to July 2020. Studies that reported dietary outcomes in both food-secure and -insecure students or the association between food insecurity and dietary outcomes among current students in tertiary education settings in any country were included. All study designs were eligible for inclusion, except qualitative studies. Two reviewers completed the screening, data extraction, and quality assessment independently. Study quality was assessed using the Joanna Briggs Institute appraisal tools.

Results Sixteen studies were included in the final qualitative synthesis of this review. Most studies were cross-sectional designs and of fair quality. The prevalence of food insecurity among university students ranged from 21% to 82% across studies. Lower intakes of healthy foods (eg, fruits, vegetables, and whole grains) and higher intakes of unhealthy foods (eg, fast foods, added sugars, and sugar-sweetened beverages) were observed in food-insecure students, and studies with the most representative samples of the student body found these trends. Some food-insecure students consumed breakfast and evening meals less frequently than food-secure students but the evidence was limited. Validated food security and dietary assessment tools were inconsistently used to assess diet quality among students with differing food security status. The heterogeneity of student sampling and data collection may contribute to inconsistent findings.

Conclusion Poorer dietary outcomes were found in university students with food insecurity compared with food-secure students, but statistical significance was only observed in a small number of studies. Future longitudinal studies using food security and dietary assessment tools validated in this population are recommended to confirm the observed associations between food insecurity and diet quality among university students.

J Acad Nutr Diet. 2021;121(12):2475-2500.

FOOD INSECURITY IS A CRITICAL PUBLIC HEALTH ISSUE that is of considerable concern in both developing and developed countries.^{1,2} Food security refers to people having consistent access to nutritious food to enjoy a healthy diet that accommodates their food preferences.³ Food security can be measured using 4 dimensions, including food availability, access, utilization, and stability.^{4,5} Food availability refers to the adequacy of food supply; food access includes both economic and physical access; food utilization relates to food and nutrient intake; and food stability means the consistency of achieving the first 3 dimensions over time.^{4,5}

Sociodemographic factors have been frequently examined in studies investigating food insecurity among university

students, and several associations have been reported. For example, students from ethnic minority groups and undergraduate students were more likely to experience food insecurity than White and graduate students, respectively, while studying in universities.⁶⁻⁹ Students who were financially independent from parents and recipients of financial assistance (eg, scholarships and student loans) were also at higher risk of experiencing food insecurity.^{6,8,10} Additionally, higher prevalence of food insecurity was reported in non-students of similar ages compared with university students.¹¹

Adverse academic and health outcomes have been associated with food insecurity in university students. Compromised academic performances, such as lower grade point average and poor concentration, were found in food-insecure

students.^{7,12,13} Of serious concern was the finding that these students may have to withdraw from their courses or suspend their studies.^{7,14,15} Lower self-reported health and poorer mental health status (eg, depression and anxiety) were also identified in students with food security issues.^{8,16}

A significant proportion of students transition to make their own food choices independently from the control of parents after starting studies in universities.¹⁷ There are also some older students who tend to be more financially independent and are more likely to have children and work full-time while studying in community colleges compared with traditional students.¹⁸⁻²⁰ Community colleges offer opportunities for a wide range of students, including socially and financially disadvantaged groups, to have access to tertiary education.²¹ Unhealthy dietary habits are common in university students (eg, insufficient fruit and vegetable consumption and excessive intake of discretionary foods).^{22,23} Discretionary foods are high in added salt, added sugar, and added saturated fat and low in fiber.²⁴ Living status and campus food environment may affect the diet quality of university students. Living away from the parental home and experiencing a food environment with predominantly unhealthy options may be a barrier for students to make healthy choices and in turn contribute to poor diet quality.^{17,22,25}

Food insecurity can compromise academic outcomes, and university students with certain sociodemographic factors are at higher risk of experiencing food insecurity.^{6-10,12-15} It is important to understand the dietary intake of university students as a result of experiencing food insecurity and how experiencing food insecurity affects their diet quality. This systematic review aims to examine the association between food insecurity and dietary outcomes in university students.

MATERIALS AND METHODS

The conduct of this systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.²⁶ The protocol has been developed and registered with PROSPERO International prospective register of systematic reviews (CRD42020196196).

Eligibility Criteria

Studies that investigated the food security status and dietary outcomes among current students in tertiary education settings in any country were included. All types of tertiary education were eligible for inclusion (eg, college, university, technical and further education, vocational education, and continuing education). Only studies that measured both food security status and dietary outcomes were eligible. Dietary outcomes included frequency of food and meal consumption, actual food intakes, energy and nutrients intakes, meal patterns, and overall diet quality obtained from dietary assessment tools (eg, food frequency questionnaire, food intake diary, 24-hour recall, short questions on food and meal intakes). Studies that solely reported the overall diet quality through a single self-rated question or alcohol consumption were excluded. Eligible studies needed to report either dietary outcomes in both food-secure and -insecure students or the association between food insecurity and dietary outcomes (eg, odds ratio). All primary study designs were eligible for inclusion, except qualitative studies. Conference abstracts were not eligible. The language of publication was

RESEARCH SNAPSHOT

Research Question: What does the literature reveal about the association between food insecurity and dietary outcomes in university students.

Key Findings: Food-insecure university students appear to consume less nutrient-dense food options and more unhealthy foods and drinks than their food-secure peers. A lower frequency of eating breakfast and evening meals is observed in food-insecure students. Findings are inconsistent across the included studies. The heterogeneity in sampling strategies and measurement tools may contribute to this inconsistency. Most included studies are rated as only fair quality using the Joanna Briggs Institute critical appraisal tools. The validity of food security and dietary measurement tools in university students requires further research.

restricted to English, and all articles located in the databases until the final search in July 2020 were included.

Search Strategy

Search terms related to tertiary education students and food security were identified after the pilot search in MEDLINE and Global Health. When conducting the pilot search, we included search terms related to dietary outcomes. The final search strategies did not include these terms because it was found that important articles including food security and dietary outcomes were absent from the search likely because dietary outcomes were not key words or in the abstract. The full search was conducted in 9 electronic databases in July 2020, including MEDLINE, EMBASE, ERIC, PsycINFO, Global Health, CINAHL, CENTRAL, Scopus, and Web of Science. The search terms for MEDLINE are shown in [Table 1](#) (available at www.jandonline.org). Studies investigating food insecurity and university students during the COVID-19 pandemic were not included in this review given the conduct of the search in July 2020.

Additionally, Google Scholar and Mednar were used for searching gray literature. In Google Scholar, site searches were conducted by using the second-level domain names for academic institutions and governments. Forty countries with the highest number of tertiary education students based on the enrollment data in 2017 from World Bank Education Statistics were selected to search.²⁷ Search terms and a list of selected countries are shown in [Figure 1](#) (available at www.jandonline.org). Reference lists of included studies were screened to identify any further studies.

Selection Process

The identified records from searches were imported to EndNote X9.2 (Clarivate Analytics) for screening. Decisions in each step were recorded in EndNote. Titles and abstracts were screened against the inclusion criteria by 2 reviewers (Y.S. and A.D.) independently. For the studies with the potential to be included but for which a decision could not be made, full-text articles were retrieved. Two reviewers screened them against the inclusion and exclusion criteria independently. Reasons for exclusion at this stage were recorded and reported in the PRISMA diagram.

Disagreements between 2 reviewers were solved through discussion between each other or consultation with the third reviewer (M.A.-F.).

Data Extraction

A data extraction form based on an existing tool was piloted and then refined for extracting data from included studies.²⁸ For each included study, author, year of publication, country of the study, research aims, study design, measures of exposures and outcomes, data analysis, demographics of participants, description of the setting, food security status, dietary outcomes, the association between food insecurity and dietary outcomes, and implications of the study were extracted. The representativeness of the samples and more demographic factors were added into the data extraction form after the pilot extraction. Data extraction was completed by 2 reviewers independently (Y.S. and A.D.). Disagreements were discussed between 2 reviewers or addressed by consulting a third expert (M.A.-F.).

Quality Assessment

The 8-item critical appraisal checklist for analytical cross-sectional studies from the Joanna Briggs Institute (JBI) was applied to assess the quality of included cross-sectional studies.²⁹ The checklist assessed 8 factors of the study, including the definition of the inclusion criteria of the sample; the description of the subjects and setting; the measurement of exposures, conditions, and outcomes; the identification and strategies to address confounding factors; and the appropriateness of the method of statistical analysis. For the longitudinal study in this review,³⁰ the 11-item critical appraisal checklist for cohort studies from JBI was used to assess its quality.³¹ The additional items included in this checklist are about the assessment of the changes over time, the sufficiency of the length of the follow up period, the loss to follow-up, and the appropriateness of the strategies to address the loss to follow-up. For each item, the study was coded as yes, no, unclear, or not applicable. To rate the quality of the evidence as good, fair, or poor for each study, we used the following criteria: good (only yes or not applicable ratings), fair (1 to 2 no or unclear ratings), and poor (3 or more no or unclear ratings).

Data Synthesis

The demographic characteristics of participants and the measurement of food security and dietary outcomes in each included study were summarized in a tabular form. Dietary outcomes were grouped into the intake of food groups and nutrients, meal patterns, and overall dietary quality and listed by food security status. The statistical significance of the differences in dietary outcomes between food-secure and -insecure students was also summarized. The prevalence of food insecurity and the association between food insecurity and dietary outcomes were synthesized into a narrative summary.

RESULTS

The searches from electronic databases identified 5396 references and additional 4455 records were identified from the gray literature sources. No additional studies were identified from the review of reference lists of included articles. After

the removal of duplicates, the titles and abstracts of 7437 references were screened, and then 139 articles were read in full text. Sixteen studies were included in the final qualitative synthesis, and 3 of them were from the gray literature.³²⁻³⁴ The PRISMA diagram is shown in Figure 2.

Study Populations

The majority of the included studies were from the United States ($n = 13$),^{14,30,32-42} and 1 study from each of Australia,⁴³ Canada,⁴⁴ and Greece⁴⁵ (see Table 2). All studies were in university students, and no studies in 2-year community college students were identified. The mean age range of the participants was mainly between 18 and 25 years, which was similar to student characteristics in 4-year institutions data reported by the National Center for Education Statistics,²⁰ with the exception of a study of campus food bank clients with a mean age of 30 years.⁴⁴ All studies recruited more female subjects, ranging from 52% to 75% of participants.^{14,30,32-45} Similar to 4-year institutions reported in the National Center for Education Statistics,²⁰ the included studies reported findings from students of diverse backgrounds (ie, the inclusion of students from different ethnic groups or international students) ($n = 15$),^{14,30,32-44} apart from 1 study that did not report the ethnic backgrounds of the sample.⁴⁵ Four articles investigated undergraduates exclusively,^{30,34,36,40} and 11 studies also included graduates,^{14,32,33,35,37-39,41,42,44,45} and 1 did not specify the academic level of students.⁴³ Five studies reported the marital status of their participants, and in these studies, the percentage of married people ranged from 3% to 40%.^{14,32,34,35,43} Four studies reported whether their participants had children and in these studies, the percentage with children ranged from 1% to 31%.^{32,34,35,43} Two studies only surveyed students living in on-campus housing,^{30,36} and 9 studies included both on-campus and off-campus housing.^{14,32-35,40,41,43,45} Twelve articles indicated the financial resources of their participants; 3 of them^{30,36,42} only reported the percentage of students receiving a Pell Grant, which is a federal financial aid program supporting undergraduate students in the United States,⁴⁶ and the remaining included other sources of financial assistance and incomes, eg, study loans and working.^{14,33-35,37-40,43} Ten studies reported the employment status, with about 20% to 70% of students having a full-time or part-time job while studying.^{14,33-35,37,39,40,42,43,45}

Study Designs and Sampling Strategies

A cross-sectional survey study design was used by 13 of 16 studies,^{14,32,34-41,43-45} and 1 used a longitudinal design that collected data at 4 time points over 9 months,³⁰ and 2 employed cross-sectional mixed methods^{33,42} (Table 3). Fifteen studies were conducted at single universities,^{14,30,32-44} and 1 study from Greece recruited participants from multiple universities.⁴⁵ Ten studies used convenience or purposive sampling. Of these studies, 2 studies only recruited the clients of the campus food bank and may not be representative for the general student population since they were likely to have an elevated risk of food insecurity,^{42,44} and 8 studies recruited from all students ($n = 3$),^{33,35,37} first-year students ($n = 3$),^{30,36,40} students from selected faculties ($n = 1$),⁴³ and students attending lectures ($n = 1$).⁴⁵ Three studies recruited a

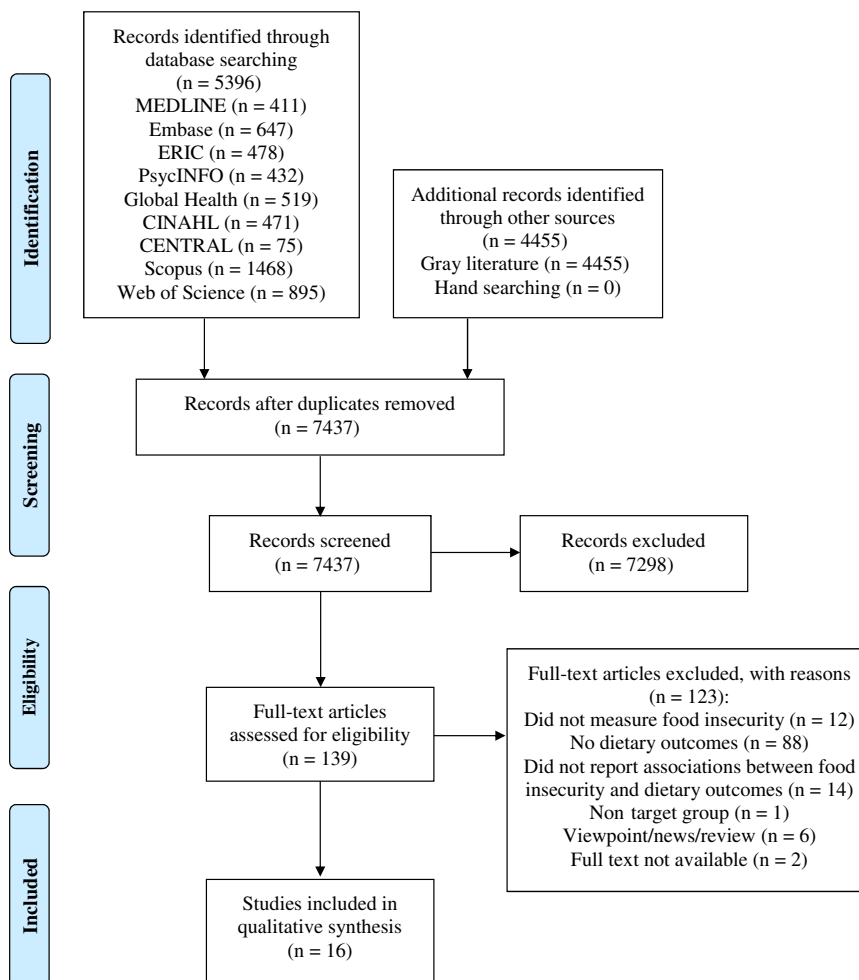


Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of record identification and study selection for a systematic review of the association between food insecurity and dietary outcomes in university students.

random sample of students attending the university (with response rates from 18% to 43%),^{14,38,39} and another 3 recruited from a random sample of students with specific requirements, such as second-year students (with a response rate of 12%),³⁴ non-first-year students (with a response rate of 99%),³² and aged 18 and older (with a response rate of 7%).⁴¹

Quality Assessment

The results of quality assessment are shown in Figure 3. The longitudinal study was rated as good quality.³⁰ Among the studies that used cross-sectional designs, 4 studies^{36,43-45} and 9 studies^{14,32,34,35,38-42} were assessed as good and fair quality, respectively. Two cross-sectional studies were rated as poor quality on the basis that the inclusion criteria of the sample were not clearly defined,^{33,37} confounding factors were not identified,^{33,37} the validity and reliability of the outcomes measures were unclear,³⁷ and the statistical analyses were either unclear or poor^{33,37} (see Figure 3). These 2 studies are omitted from the summary measure in Figure 4.

The representativeness of the sample was checked against the student characteristics in the whole institution by 6 studies that used random sampling,^{14,32,34,38,39,41} and 4 of

them applied sampling weights to make their results representative.^{14,38,39,41} Five studies that used nonrandom sampling also assessed their sample representativeness.^{33,37,40,43,44} The overrepresentation of female students,^{34,40,43} White students,⁴⁰ students of minority race or ethnicity backgrounds,³⁸ first-generation university students,³⁸ students of younger age,⁴³ domestic students,⁴³ full-time students,⁴³ graduate and international students was noted.⁴⁴

The validity and reliability of self-developed questions for food and meal consumption were often not clarified by the authors.^{14,32,34,37,39} Confounding factors were not always identified and included in the analysis of the association between food insecurity and dietary outcomes.^{33-35,37,40,42} No funding bias was reported as they were funded by either universities or other research institutes,^{14,30,33,35-41,44,45} and 4 studies did not report their sources of financial support.^{32,34,42,43}

Measurement of Food Insecurity

To measure the food security status of university students, most studies (n = 14) used the food security survey tools

Table 2. Demographic characteristics of study populations in the included studies (n = 16) of food insecurity and dietary outcomes in university students

First author, year; country	Age (y)	Sex (% female)	Race/ethnicity	Level of study	Marital status	Dependent children	Living status	Financial support	Employment status
Abu, 2019 ³⁵ ; US ^a	Mean 24.4	69.9	57.8% non- Hispanic white	UG ^b and G ^c	20.8% married or living with partner	13.3%	20.8% living alone, 63.6% with a roommate, 1.7% with own parents, 11.6% with other family, 2.3% other living arrangements; 21.4% on campus, 78.6% off campus	61.3% scholarship, 37% loans, 16.8% others	59.0% working
Bruening, 2016 ³⁶ ; US	Mean 18.8	62	46% non- Hispanic white	100% UG	N/R ^d	N/R	100% residence halls	35% Pell Grant ^e	N/R
Bruening, 2018 ³⁰ ; US	N/R	65	51% White	100% UG	N/R	N/R	100% residence halls	33% Pell Grant	N/R
Chaparro, 2007 ³² ; US	Mean 26	57	26% White	62% UG	14% married	10%	12% on campus, 88% off- campus (30% living with parents; 17% with roommates; 19% with spouse; 10% alone; 12% unknown)	N/R	N/R
Farahbakhsh, 2017 ⁴⁴ ; Canada	Mean 30.0	60.3	46.6% international ^f	50.0% UG	N/R	N/R	N/R	N/R	N/R
Gallegos, 2014 ⁴³ ; Australia	74.4% 17-24	75.3	8.3% international, 0.4% Indigenous ^g	N/R	39.5% couple with/without children	30.5%	39.9% living at home, 24.3% renting, 26.5% boarding/ renting room, 9.3% homeowner	11.0% scholarship, 9.5% family assistance, 21.9% income support/other pension	5.8% full-time work, 64.7% casual/part- time work
Hall, 2019 ³³ ; US	N/R	63	72% White/ Caucasian	80.6% UG	N/R	N/R	35% on campus, 65% off campus (51% living with roommates, 7% with spouse/ partner/dependents, 6% alone, 1% with parents/ guardians	35% scholarship, 38% student loan, 17% parent loan, 14% university assistantship/ stipend	4% full-time work, 37% part-time work
Hege, 2020 ³⁷ ; US	N/R	70	78% White	81% UG	N/R	N/R	N/R	96% received financial support	51% working
Leung, 2019 ³⁸ ; US	Mean 22.4	52.3	60.6% White	73.3% UG	N/R	N/R	N/R	83.2% financial aid	N/R
Lunan, 2020 ³⁴ ; US	Mean 19.6	59	67.1% non- Hispanic white	100% UG	2.7% married	0.9%	41.1% on campus, 37.4% off campus	47.7% financial aid recipient	43.2% employed

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Table 2. Demographic characteristics of study populations in the included studies (n = 16) of food insecurity and dietary outcomes in university students (*continued*)

First author, year; country	Age (y)	Sex (% female)	Race/ethnicity	Level of study	Marital status	Dependent children	Living status	Financial support	Employment status
Martinez, 2018 ¹⁴ ; US	Mean 23	67	34% non- Hispanic white	66% UG	13% married or living with a partner	N/R	58% off-campus housing, 33% campus housing, 5% parent/ guardian's home, 2% other housing, 1% fraternity/ sorority house	65% received financial aid, need-based scholarship, grant, loan	52% working
Martinez, 2019 ³⁹ ; US	Mean 23	67	34% non- Hispanic white	66% UG	N/R	N/R	N/R	65% received financial aid, need-based scholarship, grant, loan	47% working
McArthur, 2018 ⁴⁰ ; US	Mean 18.5	72.7	82.5% White	100% UG	N/R	N/R	96.3% on campus, 3.7% off campus	68.2% receiving financial aid	21.4% working
Mirabatur, 2016 ⁴¹ ; US	18 and older	72.2	65.6% White	60.3% UG	N/R	N/R	32.7% housing with food provision, 67.3% housing without food provision	N/R	N/R
Paola, 2018 ⁴² ; US	N/R	66.5	32.4% White	86.9% UG	N/R	N/R	N/R	30.3% Pell Grant eligible	5.3% full-time work, 47.6% part-time work
Theodoridis, 2018 ⁴⁵ ; Greece	Mean 21.7	65.7	N/R	94.1% UG	N/R	N/R	42.4% living alone, 16.1% with others, 3.0% at residence halls, 38.6% with relatives	N/R	28.0% working

^aUS = United States.^bUG = undergraduate.^cG = graduate.^dN/R = not reported.^ePell Grant: federal financial aid supporting undergraduate students in the United States.^fInternational: nondomestic students.^gIndigenous: Aboriginal and/or Torres Strait Islander.

Table 3. Methods of sampling and data collection, and the prevalence of food insecurity among university students in the included studies (n = 16)

First author, year; country	Study design	Sample size	Sampling	Exposure		Primary Outcomes		Funding
				Food insecurity measurement tool	Food insecurity prevalence	Dietary measurement tool	Dietary variables assessed	
Abu, 2019 ³⁵ ; US ^a	Cross-sectional survey	173	Purposive and snowball	9-item Household FI ^b Access Scale; past 4 wk	Mildly FI 24.9%, moderately FI 17.9%, severely FI 16.7%	Dietary diversity scale; past 24 h	Dietary diversity; eating out frequency	Funded by the university
Bruening, 2016 ³⁶ ; US	Cross-sectional survey	209	Convenience (freshmen in 2 residence halls)	Adapted from USDA ^c 18-item Household FSSM ^d and a validated 2-item screener; past month and past 3 mo	Past month: FI 32%; Past 3 mo: FI 37%	Adapted from survey items used in national surveillance systems or other large-scale research efforts in the US; past week (past 2 wk for binge drinking)	FV ^e intake; consumption of breakfast, fast food, and home-cooked meals; binge drinking habits	Supported by National Institutes of Health Common Fund
Bruening, 2018 ³⁰ ; US	Longitudinal surveys	1138; 555; 428; 400 (time 1-4)	Convenience (freshmen in 6 residence halls)	USDA 6-item short form FSSM; past month	Time 1: FI 28%; time 2: FI 35%; time 3: FI 32%; time 4: FI 36%	26-item Dietary Screening Questionnaire; past week	Consumption of major food groups, breakfast, evening meals and fast food; drinking behaviors	Supported by National Institutes of Health Common Fund
Chaparro, 2007 ³² ; US	Cross-sectional survey	408	Random (nonfreshmen)	USDA 18-item Household FSSM; past 12 mo	High FS ^f 54%, marginally FS 24%, low FS 15%, very low FS 6%	Self-developed dietary intake questionnaire; the previous day	Intakes of FV, grains, meats and beans, dairy, fat, sweets, desserts, soy milk, ramen soup, alcohol	N/R ^g
Farahbakhsh, 2017 ⁴⁴ ; Canada	Cross-sectional survey	58	Convenience (campus food bank clients)	USDA 10-item Adult FSSM; past 30 d; Health Canada scoring method to determine FS status	Moderately FI 44.8%; severely FI 44.8%	26-item Dietary Screening Questionnaire; past 30 d	Intakes of fiber, calcium, added sugar, whole grains, dairy, and FV and legumes	Funded by the University Vitamin Fund
Gallegos, 2014 ⁴³ ; Australia	Cross-sectional survey	810	Convenience (business and health faculties)	USDA 18-item Household FSSM; past 12 mo	Low FS 17.7%, very low FS 5.6%, very low FS among children 2.3%	Questions modified from National Health Survey and 1995 National Nutrition Survey	FV intake, takeaway consumption	N/R
Hall, 2019 ³³ ; US	Cross-sectional, mixed methods	3030	Convenience	USDA 10-item Adult FSSM (removed the weight loss question ^h); past 12 mo	Undergraduates: low FS 15%, very low FS 14%; graduates: low FS 21%, very low FS 14%	Food and Agriculture Organization's instrument to measure diet diversity using a 24-h recall method	Dietary diversity score; consumption of 16 food groups	Outreach and International Affairs and College of Science in the University

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Table 3. Methods of sampling and data collection, and the prevalence of food insecurity among university students in the included studies (n = 16) (continued)

First author, year; country	Study design	Sample size	Sampling	Exposure		Primary Outcomes		Funding
				Food insecurity measurement tool	Food insecurity prevalence	Dietary measurement tool	Dietary variables assessed	
Hege, 2020 ³⁷ ; US	Cross-sectional survey	1632	Convenience	USDA 6-item short form FSSM; past 12 mo	Low FS 24%, very low FS 19%	Self-reported food sources	Food sources: obtaining food from fast-food outlet	The Food Connection at the university
Leung, 2019 ³⁸ ; US	Cross-sectional survey	754	Random	USDA 10-item Adult FSSM; past 12 mo	High FS 52.3%, marginal FS 16.6%, low FS 15.8%, very low FS 15.3%	26-item Dietary Screening Questionnaire; past month	Intakes of FV, dairy, whole grains, added sugars, calcium, and fiber	Supported by a grant from Poverty Solutions at the university
Lunan, 2020 ³⁴ ; US	Cross-sectional survey	222	Random (sophomores)	USDA 10-item Adult FSSM; past 12 mo	Low/very low FS: 46.3%	Self-developed questions to assess usual dietary pattern	Consumption of FV/ juices, grains/cereals, meat/seafood/ poultry, other protein foods, dairy and sweets	N/R
Martinez, 2018 ¹⁴ ; US	Cross-sectional survey	8705	Random	USDA 6-item short form FSSM; past 12 mo	Low/very low FS: unweighted 40%, weighted 42%	Self-developed questions regarding sources of groceries and prepared foods	Frequency of choosing fast-food restaurant	Funded by the University Office of the President's Global Food Initiative
Martinez, 2019 ³⁹ ; US	Cross-sectional survey	8705	Random	USDA 6-item short form FSSM; past 12 mo	Low/very low FS: 40%	A question developed for National College Health Assessment II regarding FV daily intake	Daily servings of FV	Funded by the University Office of the President's Global Food Initiative
McArthur, 2018 ⁴⁰ ; US	Cross-sectional survey	456	Purposive (freshmen)	USDA 10-item Adult FSSM; past 12 mo	Low/very low FS 21.5% during the first year of college; 7.1% experienced FI at home during the year before starting college	Meal skipping scale and food consumption questions, developed by authors	Frequency of meal skipping; consumption of FV/ juice, fast foods, and sweets	Not funded

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Table 3. Methods of sampling and data collection, and the prevalence of food insecurity among university students in the included studies (n = 16) (continued)

First author, year; country	Study design	Sample size	Sampling	Exposure		Primary Outcomes		Funding
				Food insecurity measurement tool	Food insecurity prevalence	Dietary measurement tool	Dietary variables assessed	
Mirabitur, 2016 ⁴¹ ; US	Cross-sectional survey	514	Random (exclude age <18 y)	USDA 6-item short form FSSM; past 12 mo	High FS 46%, marginal FS 12%, low FS 25%, very low FS 16%	2-item measure to report daily FV servings, previously validated	Consumption of FV, beans/chicken/fish, snacks, dessert, sodas or sweet teas, fast food	No funding was used to support this research
Paola, 2018 ⁴² ; US	Cross-sectional, mixed methods	221	Convenience (food pantry users)	USDA 6-item short form FSSM; past 30 d	100% FI: without hunger 11.8%; with hunger 88.2%	Adapted from 8-item Starting the Conversation tool to measure diet quality; past 30 d	Consumption of FV, beans/chicken/fish, snacks, dessert, sodas or sweet teas, fast food	N/R (no conflicts of interest to declare)
Theodoridis, 2018 ⁴⁵ ; Greece	Cross-sectional survey	236	Convenience (students attended lectures)	9-item Household FI Access Scale; past 4 wk	Mild FI 14.8%, moderate FI 22.0%, severely FI 45.3%	MEDAS ¹ questionnaire	MEDAS index	Did not receive any specific grant

^aUS = the United States.^bFI = food insecurity/insecure.^cUSDA = US Department of Agriculture.^dFSSM = Food Security Survey Module.^eFV = fruits and vegetables.^fFS = food security/secure.^gN/R = not reported.^hQuestion "In the last 12 months, did you lose weight because there wasn't enough money for food?" was removed.¹MEDAS = Mediterranean Diet Adherence Screen.

First author, year	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11	Overall ^c
Cross-sectional studies												
Abu, 2019 ³⁵	No	Yes	Yes	N/A ^d	No	N/A	Yes	Yes	N/A	N/A	N/A	Fair
Bruening, 2016 ³⁶	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Good
Chaparro, 2007 ³²	Yes	Yes	Yes	N/A	Yes	Yes	Unclear	Yes	N/A	N/A	N/A	Fair
Farahbakhsh, 2017 ⁴⁴	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Good
Gallegos, 2014 ⁴³	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Good
Leung, 2019 ³⁸	No	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Fair
Lunan, 2020 ³⁴	Yes	Yes	Yes	N/A	No	N/A	Unclear	Yes	N/A	N/A	N/A	Fair
Martinez, 2018 ¹⁴	No	Yes	Yes	N/A	Yes	Yes	Unclear	Yes	N/A	N/A	N/A	Fair
Martinez, 2019 ³⁹	No	Yes	Yes	N/A	Yes	Yes	Unclear	Yes	N/A	N/A	N/A	Fair
McArthur, 2018 ⁴⁰	Yes	Yes	Yes	N/A	No	N/A	Yes	Yes	N/A	N/A	N/A	Fair
Mirabitur, 2016 ⁴¹	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Unclear ^e	N/A	N/A	N/A	Fair
Paola, 2018 ⁴²	Yes	Yes	Yes	N/A	No	N/A	Yes	Yes	N/A	N/A	N/A	Fair
Theodoridis, 2018 ⁴⁵	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Good
Hall, 2019 ³³	No	Yes	Yes	N/A	No	N/A	Yes	No	N/A	N/A	N/A	Poor
Hege, 2020 ³⁷	No	Yes	Yes	N/A	No	N/A	Unclear	Unclear	N/A	N/A	N/A	Poor
Longitudinal study												
Bruening, 2018 ³⁰	N/A	N/A	Yes	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Good
<p>^aThe following 8 questions were used for cross-sectional studies (all but not Bruening³⁰). Question 1: Were the criteria for inclusion in the sample clearly defined? Question 2: Were the study subjects and the setting described in detail? Question 3: Was the exposure measured in a valid and reliable way? Question 4: Were objective, standard criteria used for measurement of the condition? (Question 4 was not applicable for the cross-sectional studies in this review.) Question 5: Were confounding factors identified? Question 6: Were strategies to deal with confounding factors stated? Question 7: Were the outcomes measured in a valid and reliable way? (Answers to question 7 were yes if the measure has been validated in the appropriate population; unclear if there is no description in the validity and reliability of the measure.) Question 8: Was appropriate statistical analysis used?</p> <p>^bThe following 11 questions were used for the longitudinal study (Bruening³⁰). Question 1: Were the 2 groups similar and recruited from the same population? Question 2: Were the exposures measured similarly to assign people to both exposed and unexposed groups? Question 3: Was the exposure measured in a valid and reliable way? Question 4: Were confounding factors identified? Question 5: Were strategies to deal with confounding factors stated? Question 6: Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)? Question 7: Were the outcomes measured in a valid and reliable way? Question 8: Was the follow-up time reported and sufficient to be long enough for outcomes to occur? Question 9: Was follow-up complete, and if not, were the reasons to loss to follow-up described and explored? Question 10: Were strategies to address incomplete follow-up utilized? Question 11: Was appropriate statistical analysis used?</p> <p>^cOverall appraisal: To rate the quality of the evidence as good, fair, or poor for each study, we used the following criteria: good (only yes or not applicable), fair (1 to 2 no or unclear), and poor (3 or more no or unclear answers).</p> <p>^dN/A = not applicable.</p> <p>^eUnclear due to inconsistent percentages of each food security category between the text and the table.</p>												

Figure 3. Quality assessment of eligible studies (n = 16) in a systematic review of food insecurity and dietary outcomes in university students by using the Joanna Briggs Institute Critical Appraisal Tools for analytical cross-sectional^a and cohort^b studies.^{29,31}

developed by the United States Department of Agriculture (USDA) (Table 3). Six of them used the 6-item short form of the Food Security Survey Module (FSSM),^{14,30,37,39,41,42} 5 used the 10-item Adult FSSM,^{33,34,38,40,44} and 3 used the 18-item Household FSSM.^{32,36,43} The validity and reliability of the USDA FSSMs have not been supported in university students.⁴⁷⁻⁴⁹ Another 2 articles applied the Household Food Insecurity Access Scale (HFIAS), which contained 9 questions.^{35,45} The reference period of food security questions was either the past 12 months ($n = 10$)^{14,32-34,37-41,43} or the past month ($n = 6$),^{30,35,36,42,44,45} and 1 study asked both the past month and the past 3 months.³⁶

Measurement of Dietary Outcomes

Seven studies utilized the existing dietary survey tools, including the Dietary Screener Questionnaire developed by the US National Cancer Institute ($n = 3$),^{30,38,44} the Starting the Conversation tool ($n = 1$),⁴² the Dietary Diversity scale ($n = 2$),^{33,35} and the Mediterranean Diet Adherence Screen questionnaire ($n = 1$)⁴⁵ (Table 3). Three studies adapted the questions regarding food consumption (eg, fruit and vegetable intake) and meal patterns (eg, breakfast consumption) from previous large-scale surveys.^{36,41,43} These tools were previously validated in adult populations or clinical settings that included participants aged 18 to 30 years but not specifically in university students.⁵⁰⁻⁵⁵ Another 6 studies developed their own questionnaire to measure dietary outcomes,^{14,32,34,37,39,40} but only 1 of them provided the description of both content validity and pilot testing.⁴⁰

Prevalence of Food Insecurity

The prevalence of food insecurity varied in general university students (Table 3). Twelve studies reported a range between 21% and 46%,^{14,30,32-34,36-41,43} and 2 studies reported a higher percentage of food insecurity among university students (60% and 82%, respectively).^{35,45} The latter 2 studies classified food insecurity into mildly, moderately, and severely food insecure after using HFIAS.^{35,45} Mildly food insecure referred to households that worried about the adequacy of food; however, sometimes they were unable to eat their preferred food or a diversity of foods but they still have sufficient quantity of food to avoid hunger or missing meals.⁵⁶ Moderately food insecure households further compromised their quality of diet and started to have less quantity in meals, and severely food insecure households may experience the most severe conditions such as hunger and running out of food.⁵⁶ On the other hand, 12 studies with lower prevalence reported food security status by either 2 categories (ie, food secure and insecure)^{14,30,34,36,37,39,40,43} or 4 categories as high, marginal, low, and very low food security^{32,33,38,41} after using different USDA survey modules. Marginal food security referred to households/individuals who sometimes had problems or worried about the adequacy of food access, but the quality and quantity of food intake were not substantially affected.⁵⁷ Marginal food security was considered to be food secure in 4 studies,^{33,34,38,40} and another 2 treated it as an independent category.^{32,41} Low and very low food security were considered to be food insecurity in 7 studies.^{14,34,37-40,43} The weighted mean prevalence of food insecurity was 39%, 30%, and 27% by using the 6-item,^{14,30,37,39,41,42} 10-item,^{33,34,38,40,44} and 18-item^{32,36,43} FSSM, respectively. In addition, the

prevalence was significantly higher at the end of each semester in an academic year compared with the start of the year from longitudinal surveys.³⁰

Compared with the general university student population, a higher prevalence of food insecurity was found among students using campus food banks, up to 90% (moderately and severely food insecure) in a Canadian university⁴⁴ and 100% (food insecurity with and without hunger) in a US university.⁴²

Food Groups and Nutrient Intake

Dietary outcomes in food-secure and -insecure university students are listed in Table 4. A visual display of the relationship between food insecurity and each dietary outcome is shown in Figure 4, which includes 14 studies.^{14,30,32,34-36,38-45} because 2 studies are omitted in this summary measure due to poor quality.^{33,37}

Significantly lower intakes of total fruits and vegetables among food-insecure students was observed in 5 out of 6 studies.^{30,33,39,41,44} Significantly lower intake of fruits was observed in 4 out of 6 studies.^{32,34,38,43} Significantly lower intake of vegetables was observed in 4 out of 7 studies.^{33,38,42,43} Significantly lower intake of grains or whole grains was observed in 3 out of 6 studies.^{32,34,38} Significantly lower intake of dairy products was observed in 2 out of 6 studies.^{32,33} Significantly lower intake of dietary calcium was observed in 1 out of 3 studies.³⁸ Significantly lower intake of meat or other protein foods was observed in 1 out of 4 studies.³³

Significantly higher intake of sweets or added sugars among food-insecure students was observed in 1 out of 7 studies.³⁸ Significantly higher intake of added sugars from sugar-sweetened beverages was observed in 1 out of 3 studies.³⁸

No significant differences were reported in the consumption of fat ($n = 2$),^{32,42} discretionary choices such as snack chips and instant noodles ($n = 2$),^{32,42} alcohol ($n = 3$),^{30,32,36} and fiber ($n = 3$).^{30,38,44}

Meal Patterns and Overall Dietary Quality

Two studies measured the frequency of breakfast consumption, and they both reported significantly less frequent breakfast among food-insecure students.^{30,36} One study measured the frequency of evening meal consumption and reported significantly fewer evening meals in food-insecure students.³⁰ Another study measured the frequency of skipping each main meal, which was not individually assessed by the food security measurement tools.⁴⁰ It found that significantly fewer meals were skipped by food-insecure students compared with food-secure students, but no significant differences were reported in further details between 2 groups.⁴⁰ The consumption of home-cooked meals was observed to be significantly lower among food-insecure students in 1 of 2 studies,³⁶ and the consumption of fast foods was significantly higher in 2 of 6 studies.^{14,36} No significant differences were reported in the frequency of consuming takeaway foods and eating out ($n = 2$).^{35,43}

Five studies compared overall dietary patterns between food-secure and -insecure students,^{32,33,35,42,45} with 2 finding differences.^{32,45} The study from Greece reported significantly lower adherence to the Mediterranean diet in severely food-

insecure students compared with food-secure students.⁴⁵ Another study reported a significantly higher proportion of food-insecure students consumed an amount of food more or less than usual on the day prior to the survey.³²

DISCUSSION

Food insecurity appeared to be associated with lower consumption of healthy foods among university students, such as fruits, vegetables, and whole grains. High intakes of unhealthy foods (eg, added sugars, sugar-sweetened beverages, and fast foods) were observed in food-insecure students but only a small number of studies found significant differences compared with their food-secure peers. Food insecurity may lead to less frequent consumption of breakfast and evening meals, but limited evidence was shown for university students. The overall diet quality of food-secure and -insecure students was not measured using validated dietary assessment tools in most studies. Further validation studies are required for the tools measuring food security in university students. Current tools for measuring food security were validated in the general population. The majority of included studies used cross-sectional designs and were rated as fair quality using the JBI critical appraisal tools.^{29,31}

A similar association between food insecurity and less favorable dietary outcomes has been observed in other adult populations. Among emerging adults in the United States, which included both postsecondary students and other young adults at a mean age of 22 years, food insecurity was correlated with less consumption of whole grains and total fruits and vegetables, but increased consumption of added sugars and sugar-sweetened beverages.⁵⁸ Moreover, food-insecure emerging adults consumed less home-prepared meals and fast foods more frequently and were more likely to skip breakfast compared with the food-secure group. Previous studies suggested lower intakes of main food groups (eg, fruits, vegetables, grains, meat, and dairy) among food-insecure women compared with food-secure women.⁵⁹ Food-insecure adults in general have a lower diet quality and are more likely to choose energy-dense but nutritionally poor foods.^{60,61} The association between poorer diet quality and food insecurity was also observed in adults with lower incomes.⁶²

The generally poor quality of diet among most university students may explain why the nutritional outcomes of food-secure and -insecure students were not significantly different.³⁰ For many university students, they leave the family home and must learn financial management and food preparation for the first time in addition to living and studying in an unfamiliar environment.³⁸ These challenges often prevented students from consuming a balanced diet.²² Students attending 2-year (community) colleges, who were more likely to be older, have dependent children, financially disadvantaged, and work longer hours, tended to have a less healthy diet than students at 4-year institutions.⁶³ Although the current review did not find data on community college students, it would be prudent to include them in future research as the strategies they use to address food security may differ from those used by the university students and potentially have greater deleterious impacts on diet quality.

The dietary measurement tools used in the included studies may not be able to distinguish eating habits between

food-secure and -insecure students.³⁰ Further, the validity of the existing dietary assessment tools used was unclear for the young adult population in universities. Some of the significant differences in the consumption of main food groups (eg, fruits, grains and dairy) and fast food reported in this review were based on studies that assessed diet using unvalidated measurement tools,^{14,32,34,39} which may weaken the observed association between food insecurity and negative dietary outcomes in university students. Furthermore, the recall periods of measuring food security (ranging from 1 month to 1 year) and nutritional outcomes (ranging from 1 day to 1 month) were rarely matched; only 2 studies conducted among food bank clients measured both variables during the same period, which was in the past 30 days.^{42,44} This inconsistency may contribute to the difficulties in detecting associations.

The heterogeneity of the included studies on a number of factors might explain the inconsistent findings of the relationship between food insecurity and dietary quality. This includes differences in population sampling, measurement tools, and timing of measuring food insecurity and dietary outcomes. The majority of the included studies were cross-sectional design, and thus no causal relationship can be drawn and limited longitudinal evidence was available. Limited generalizability and self-report bias were common across the studies. Those studies that used random sampling and were most representative of the student body demonstrated significantly lower intakes of fruits, vegetables, grains, and dietary calcium plus significantly higher intakes of sweets, added sugars from sugar-sweetened beverages, and fast food in food-insecure students.^{14,38,39,41} Studies that ranked as having a higher quality according to the JBI tools also showed significantly lower intakes of fruits and vegetables, higher intakes of fast food,^{30,36,43,44} and less frequent consumption of breakfast, evening meals, and home-cooked meals in food-insecure students.^{30,36}

In measuring the overall dietary patterns, only 2 studies reported significant differences between food-secure and -insecure students.^{32,45} One study of good quality reported adherence to the Mediterranean diet,⁴⁵ and another study that did not describe the validity of the dietary measurement tool compared the overall amount of the food consumed on the day before the survey with usual intake of participants.³² No significant differences were found in the dietary diversity or the overall diet quality in another 2 studies rated as fair quality.^{35,42} Therefore, the association between food insecurity and the overall diet quality remains unclear among university students from the studies included in this review. Since food insecurity has been shown to be inversely associated with diet quality and poor diet quality can increase chronic disease risk in other population groups,⁶² it is important that this is addressed in food-insecure university students, and validated measurement of the overall diet quality in this population group is required.

The choice of food security measurement tool may affect the estimated prevalence of food insecurity.⁶⁴ The tools with a single question tended to provide a lower estimate of prevalence compared with multi-item tools.⁶⁵⁻⁶⁷ In the included studies of this review, using FSSM from the USDA provided lower estimates than using HFIAS tool.^{35,45} Among the included studies using different FSSM, lower estimates of prevalence were reported by the tools with more items,

Table 4. Dietary outcomes by food security status among university students

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
Total fruits and vegetables (n = 12,007)	Bruening, 2016 ³⁶	209	Mean ± SD daily servings	3.78 ± 2.52	3.28 ± 2.23	.14 ^c	N/R ^d
	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	5+ servings/d	35%	24%	.14 ^e	OR ^f = 0.58 (0.30-1.13) ^g
			≥4 servings/d (time 1-4)	43%, 40%, 45%, 45%	34%, 29%, 44%, 35%	≤.01 at time 1 ^e	OR = 1.08 (0.72-1.62); OR = 0.86 (0.58-1.25) ^h
			>2 cups/d (time 1-4)	58%, 52%, 58%, 48%	56%, 42%, 51%, 41%	NS ^{ei}	OR = 1.11 (0.73-1.67); OR = 0.76 (0.52-1.12) ^h
	Farahbakhsh, 2017 ⁴⁴	58	Mean ± SD daily intake (cup)	Nonseverely FI: 2.97 ± 1.21	Severely FI: 2.12 ± 1.04	.009 ^c	N/R
	Hall, 2019 ³³	3030	Consumption of vitamin A rich fruits and vegetables	High/marginal FS 48.1%	Low/very low FS 34.4%	<.001 ^k	N/R
			Consumption of other fruits and vegetables	High/marginal FS 76.2%	Low/very low FS 61.4%	<.001 ^k	N/R
	Martinez, 2019 ³⁹	8705	Mean (SD) daily servings	2.50 (1.41)	2.00 (1.28)	<.001 ^c	β = .16 ^{***l}
	Mirabitur, 2016 ⁴¹	514	Mean (95% CI) daily servings	High FS 4.9 (4.6-5.2), marginal 4.0 (3.6-4.5)	Low 4.5 (4.1-4.9), very low 4.3 (3.6-5.0)	.01 ^e	N/R
			Mean (95% CI) daily servings in housing with food provision	High FS 5.0 (4.6-5.5), marginal 4.5 (3.7-5.3)	Low 5.1 (4.6-5.6), very low 5.5 (4.1-6.9)	.56 ^e	β = -.35 (-1.18 to 0.48); β = .19 (-0.50 to 0.88); β = .61 (-0.78 to 2.01) ^m
Mean (95% CI) daily servings in housing without food provision			High FS 4.8 (4.5-5.2), marginal 3.7 (3.1-4.3)	Low 4.1 (3.4-4.7), very low 3.9 (3.1-4.7)	.002 ^e	β = -1.09 (-1.72 to -0.46) ^{**} ; β = -.74 (-1.44 to -0.03) [*] ; β = -.62 (-1.56 to 0.32) ^m	
Fruits (n = 2,858)	Chaparro, 2007 ³²	395	Mean (SE) daily intake (cup)	High FS 1.3 (0.08), marginal 1.2 (0.13)	Low 0.8 (0.11), very low 1.0 (0.21)	.038 ⁿ	N/R
			Meet/exceed recommendation ^o	High FS 31%, marginal 27%	Low 9%, very low 13%	.003 ^e	N/R
	Gallegos, 2014 ⁴³ Leung, 2019 ³⁸	810 754	Mean (SE) daily intake (cup)	High FS 0.94 (0.02), marginal 0.94 (0.04)	Low 0.77 (0.03), very low 0.86 (0.04)	<.01 ^e N/R	OR = 0.65 (0.45-0.95) ^p RD ^q = 1.03 (0.94-1.11); RD = 0.83 (0.76-0.90) [*] ; RD = 0.91 (0.83-0.99) ^r

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Table 4. Dietary outcomes by food security status among university students (*continued*)

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
Vegetables (n = 2,858)	Lunan, 2020 ³⁴	222	3+ times/d, 0-2 times/d	33.6%, 63.9%	17.5%, 76.7%	.009 ^e	N/R
	McArthur, 2018 ⁴⁰	456	Mean intake (d/wk)	4.7	4.8	NS ^c	N/R
	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ⁵	FI without hunger: 1.82 ± 0.751	FI with hunger: 2.24 ± 0.687	.058 ^c	N/R
	Chaparro, 2007 ³²	395	Mean (SE) daily intake (cup)	High FS 1.6 (0.07), marginal 1.5 (0.10)	Low 1.3 (0.12), very low 1.3 (0.22)	NS ⁿ	N/R
			Meet/exceed recommendation ^o	High FS 14%, marginal 8%	Low 7%, very low 4%	NS ^e	N/R
	Gallegos, 2014 ⁴³	810	≥4 servings/d	46.6%	28.0%	<.01 ^e	OR = 0.45 (0.33-0.61) ^p
	Hall, 2019 ³³	3030	Consumption of dark green leafy vegetables	High/marginal FS 41.7%	Low/very low FS 27.8%	<.001 ^k	N/R
Grains (n = 3,950)	Leung, 2019 ³⁸	754	Mean (SE) daily intake (cup)	High FS 1.43 (0.02), marginal 0.94 (0.04)	Low 1.34 (0.03), very low 1.41 (0.03)	N/R	RD = 1.03 (0.99-1.08); RD = 0.95 (0.91-1.00)*; RD = 0.99 (0.94-1.03) ^f
	Lunan, 2020 ³⁴	222	3+ times/d, 0-2 times/d	26.9%, 70.6%	19.4%, 74.8%	NS ^e	N/R
	McArthur, 2018 ⁴⁰	456	Mean intake (d/wk)	4.8	4.9	NS ^c	N/R
	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ⁵	FI without hunger: 1.45 ± 1.036	FI with hunger: 2.03 ± 0.713	.017 ^c	N/R
	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	Whole grains > 0.65 oz/d (time 1-4)	54%, 46%, 48%, 44%	46%, 40%, 47%, 50%	NS ^e	OR = 1.00 (0.68-1.46); OR = 1.07 (0.74-1.53) ⁿ
	Chaparro, 2007 ³²	395	Mean (SE) daily intake (oz)	High FS 3.2 (0.12), marginal 3.1 (0.22)	Low 2.3 (0.18), very low 3.0 (0.40)	.003 ⁿ	N/R
			Meet/exceed recommendation ^o	High FS 6%, marginal 10%	Low 7%, very low 4%	.0003 ^e	N/R
	Farahbakhsh, 2017 ⁴⁴	58	Mean ± SD daily intake (oz)—whole grains	Nonseverely FI: 1.48 ± 1.54	Severely FI: 2.42 ± 2.94	.158 ^c	N/R
	Hall, 2019 ³³	3030	Consumption of starches	High/marginal FS 93.3%	Low/very low FS 89.8%	N/R	N/R
Leung, 2019 ³⁸	754	Mean (SE) daily intake (oz)—whole grains	High FS 0.77 (0.02), marginal 0.80 (0.04)	Low 0.78 (0.05), very low 0.70 (0.03)	N/R	RD = 1.08 (0.99-1.19); RD = 1.02 (0.93-1.12); RD = 0.91 (0.83-1.00)* ^f	
Lunan, 2020 ³⁴	222	3+ times/d, 0-2 times/d	45.5%, 52.1%	31.1%, 63.1%	.045 ^e	N/R	

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Table 4. Dietary outcomes by food security status among university students (*continued*)

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
Meat/other protein foods (n = 838)	Chaparro, 2007 ³²	395	Mean (SE) daily intake (oz)	High FS 2.5 (0.13), marginal 2.5 (0.24)	Low 2.2 (0.21), very low 1.7 (0.37)	NS ⁿ	N/R
			Meet/exceed recommendation ^o	High FS 5%, marginal 6%	Low 4%, very low 4%	NS ^e	N/R
	Hall, 2019 ³³	3030	Consumption of meat and fish	High/marginal FS 76.1%	Low/very low FS 61.7%	<.001 ^k	N/R
			Consumption of organ meat	High/marginal FS 1.4%	Low/very low FS 1.1%	N/R	N/R
			Consumption of eggs	High/marginal FS 43.1%	Low/very low FS 34.4%	N/R	N/R
			Consumption of legumes, nuts, and seeds	High/marginal FS 44.4%	Low/very low FS 36.1%	N/R	N/R
	Lunan, 2020 ³⁴	222	3+ times/d, 0-2 times/d—meat, seafood, poultry	26.9%, 69.7%	29.1%, 65.0%	NS ^e	N/R
			3+ times/d, 0-2 times/d—other protein	29.4%, 67.2%	33.0%, 61.2%	NS ^e	N/R
	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ⁵	FI without hunger: 1.64 ± 0.674	FI with hunger: 1.69 ± 0.776	.840 ^c	N/R
	Dairy (n = 3,950)	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	>1.5 cups/d (time 1-4)	60%, 52%, 40%, 45%	59%, 47%, 43%, 42%	NS ^e
Chaparro, 2007 ³²		395	Mean (SE) daily intake (cup)—dairy	High FS 1.5 (0.07), marginal 1.3 (0.13)	Low 1.0 (0.13), very low 1.1 (0.28)	.064 ⁿ	N/R
			Mean (SE) daily intake (cup)—soy milk	High FS 0.2 (0.03), marginal 0.3 (0.06)	Low 0.1 (0.08), very low 0.1 (0.07)	NS ⁿ	N/R
Hall, 2019 ³³		3030	Meet/exceed recommendation ^o	High FS 18%, marginal 16%	Low 8%, very low 17%	.009 ^e	N/R
			Consumption of milk and milk products	High/marginal FS 83.0%	Low/very low FS 70.4%	<.001 ^k	N/R
Farahbakhsh, 2017 ⁴⁴		58	Mean ± SD daily intake (cup)	Nonseverely FI: 1.72 ± 0.70	Severely FI: 1.32 ± 0.81	.054 ^c	N/R
Leung, 2019 ³⁸	754	Mean (SE) daily intake (cup)	High FS 1.64 (0.03), marginal 1.62 (0.05)	Low 1.52 (0.05), very low 1.68 (0.07)	N/R	RD = 1.02 (0.96-1.08); RD = 0.94 (0.89-1.00); RD = 1.00 (0.94-1.06) ^f	

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Table 4. Dietary outcomes by food security status among university students (*continued*)

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
Fat (n = 616)	Lunan, 2020 ³⁴	222	3+ times/d, 0-2 times/d	29.4%, 67.2%	24.3%, 69.9%	NS ^e	N/R
	Chaparro, 2007 ³²	395	Mean (SE) daily intake (tsp)	High FS 1.6 (0.11), marginal 1.4 (0.14)	Low 1.5 (0.36), very low 1.8 (0.40)	NS ⁿ	N/R
	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ^s —butter or margarine seasoning	FI without hunger: 1.82 ± 0.603	FI with hunger: 1.49 ± 0.833	.201 ^c	N/R
Discretionary foods ^t (n = 616)	Chaparro, 2007 ³²	395	Mean (SE) daily intake (package)—saimin soup ^u	High FS 0.2 (0.03), marginal 0.2 (0.05)	Low 0.2 (0.07), very low 0.2 (0.14)	NS ⁿ	N/R
	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ^s —snack chips or crackers	FI without hunger: 0.91 ± 0.539	FI with hunger: 0.78 ± 0.784	.599 ^c	N/R
Sweets (n = 4,627)	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	Added sugars > 16 tsp/d (time 1-4)	52%, 44%, 35%, 40%	51%, 46%, 39%, 35%	NS ^e	OR = 1.10 (0.73-1.67); OR = 0.91 (0.61-1.34) ^h
	Chaparro, 2007 ³²	395	Mean (SE) daily portion—sweets	High FS 1.1 (0.08), marginal 1.3 (0.15)	Low 1.3 (0.22), very low 1.3 (0.32)	NS ⁿ	N/R
			Mean (SE) daily portion—desserts	High FS 0.9 (0.06), marginal 1.1 (0.12)	Low 1.1 (0.21), very low 0.5 (0.13)	NS ⁿ	N/R
	Farahbakhsh, 2017 ⁴⁴	58	Mean ± SD daily intake (tsp)—added sugar	Nonseverely FI ⁱ : 15.24 ± 8.58	Severely FI: 13.45 ± 7.81	.422 ^c	N/R
	Leung, 2019 ³⁸	754	Mean (SE) daily intake (tsp)—added sugar	High FS 14.8 (0.24), marginal 15.1 (0.34)	Low 14.6 (0.50), very low 16.1 (0.46)	N/R	RD = 1.05 (1.00-1.11); RD = 1.00 (0.95-1.05); RD = 1.08 (1.02-1.14) ^{*f}
	Lunan, 2020 ³⁴	222	3+ times/d, 0-2 times/d	21.8%, 74.8%	28.2%, 66.0%	NS ^e	N/R
	McArthur, 2018 ⁴⁰	456	Mean intake (d/wk)	4.2	3.9	NS ^c	N/R

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Table 4. Dietary outcomes by food security status among university students (*continued*)

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
SSBs ^v (n = 3,496)	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ⁵	FI without hunger: 0.73 ± 0.467	FI with hunger: 0.77 ± 0.763	.851 ^c	N/R
	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	Added sugar from SSBs > 6 tsp/d (time 1-4)	61%, 58%, 47%, 54%	63%, 59%, 50%, 54%	NS ^e	OR = 0.95 (0.63-1.45); OR = 0.90 (0.60-1.34) ^h
	Leung, 2019 ³⁸	754	Mean (SE) daily intake (tsp)—added sugar from SSBs	High FS 5.9 (0.16), marginal 6.0 (0.20)	Low 5.9 (0.32), very low 7.2 (0.33)	N/R	RD = 1.10 (1.02-1.18); RD = 1.02 (0.95-1.10); RD = 1.21 (1.12-1.30) ^{*f}
Alcohol (n = 3,125)	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ⁵ —sodas or sweet teas	FI without hunger: 0.55 ± 0.688	FI with hunger: 0.70 ± 0.867	.581 ^c	N/R
	Bruening, 2016 ³⁶	209	Binge drinking in past 2 wk	38%	37%	>.99 ^e	OR = 0.93 (0.49-1.79) ^g
	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	Drink alcohol ever (time 1-4) Binge drinking (time 1-4)	71%, 62%, 57%, 57% 37%, 38%, 39%, 38%	74%, 72%, 65%, 62% 41%, 50%, 43%, 40%	NS ^e NS ^e	OR = 1.09 (0.66-1.83); OR = 1.27 (0.78-2.08) ^h OR = 0.94 (0.57-1.56); OR = 1.33 (0.83-2.13) ^h
Fiber (n = 3,333)	Chaparro, 2007 ³²	395	Mean (SE) daily portion—alcohol	High FS 0.4 (0.07), marginal 0.7 (0.15)	Low 0.5 (0.16), very low 0.2 (0.11)	NS ⁿ	N/R
	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	>15 g/d (time 1-4)	52%, 44%, 42%, 40%	53%, 33%, 45%, 36%	NS ^e	OR = 1.05 (0.68-1.63); OR = 0.88 (0.58-1.34) ^h
	Farahbakhsh, 2017 ⁴⁴	58	Mean ± SD daily intake (g)	Nonseverely FI: 18.72 ± 7.43	Severely FI: 16.11 ± 6.82	.197 ^c	N/R
	Leung, 2019 ³⁸	754	Mean (SE) daily intake (g)	High FS 16.6 (0.18), marginal 16.6 (0.27)	Low 16.1 (0.30), very low 16.2 (0.29)	N/R	RD = 1.02 (0.99-1.06); RD = 0.98 (0.95-1.02); RD = 0.97 (0.93-1.00) ^f

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Table 4. Dietary outcomes by food security status among university students (*continued*)

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
Calcium (from diet alone) (n = 3,333)	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	>900 mg/d (time 1-4)	65%, 52%, 44%, 44%	59%, 51%, 49%, 47%	NS ^e	OR = 1.21 (0.77-1.90); OR = 0.98 (0.64-1.49) ^h
	Farahbakhsh, 2017 ⁴⁴	58	Mean ± SD daily intake (mg)	Nonseverely FI: 958.89 ± 316.31	Severely FI: 790.61 ± 359.57	.076 ^c	N/R
	Leung, 2019 ³⁸	754	Mean (SE) daily intake (mg)	High FS 1007 (10.6), marginal 996 (20.1)	Low 954 (18.1), very low 1023 (23.2)	N/R	RD = 1.02 (0.99-1.05); RD = 0.96 (0.93-0.99)*; RD = 0.99 (0.96-1.03) ^f
Breakfast (n = 2,730)	Bruening, 2016 ³⁶	209	Mean ± SD consumption (d/wk)	3.94 ± 2.58	2.96 ± 2.35	.01 ^c	
	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	4+ d/wk ≥ 4 times/wk (time 1-4)	50% 63%, 55%, 64%, 53%	31% 46%, 36%, 51%, 35%	.01 ^e ≤.01 at time 1, 2, 4 ^e	OR = 0.41 (0.22-0.77)** ^g OR = 1.03 (0.68-1.54); OR = 0.67 (0.46-0.99)* ^h
Evening meal (n = 2521)	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	7 times/wk (time 1-4)	88%, 84%, 88%, 85%	74%, 71%, 78%, 66%	≤.01 at time 1-4 ^e	OR = 0.93 (0.58-1.49); OR = 0.55 (0.36-0.86)* ^h
Skipping meals (n = 456)	McArthur, 2018 ⁴⁰	456	Skip breakfast Mean Meal Skipping Scale scores ^w	52.4% 6.3 ± 1.41, range 3-9	62.3% 5.8 ± 1.60, range 3-10	N/R <.01 ^c	N/R N/R
	Bruening, 2016 ³⁶	209	Mean ± SD consumption (d/wk)	1.95 ± 2.15	1.17 ± 1.78	.01 ^c	N/R
Home-cooked meal (n = 431)	Lunan, 2020 ³⁴	222	2+ d/wk 2+ times/d, ≤ 1 time/d—food preparation for self	43% 38.7%, 57.1%	22% 33.0%, 61.2%	<.01 ^e .429 ^e	OR = 0.34 (0.16-0.72)** ^g N/R
			2+ times/d, ≤ 1 time/d—food preparation for others	5.9%, 89.9%	5.8%, 88.3%	.989 ^e	N/R

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Table 4. Dietary outcomes by food security status among university students (*continued*)

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
Fast food (n = 12,112)	Bruening, 2016 ³⁶	209	Mean ± SD consumption (d/wk)	1.32 ± 1.44	1.81 ± 1.77	.04 ^c	N/R
	Bruening, 2018 ³⁰	1138, 555, 428, 400 (time 1-4)	2+ d/wk ≥2 times/wk (time 1-4)	32% 26%, 16%, 23%, 22%	45% 31%, 23%, 30%, 30%	.09 ^e NS ^e	OR = 1.63 (0.87-3.06) ^g OR = 1.06 (0.68-1.65); OR = 1.25 (0.83-1.88) ^h
	Hege, 2020 ³⁷	1632	Food sources: fast food	31%	Low FS 32%, very low FS 42%	N/R	N/R
	Martinez, 2018 ¹⁴	8705	Food sources: fast-food restaurant (often/very often)	9%	20%	<.001 ^e	N/R
	McArthur, 2018 ⁴⁰	456	Mean consumption (d/wk)	4.1	3.9	NS ^c	N/R
	Paola, 2018 ⁴²	221	Mean ± SD dietary quality scores ⁵	FI without hunger: 1.27 ± 0.647	FI with hunger: 1.26 ± 0.951	.958 ^c	N/R
Takeaway/eating out (n = 983)	Abu, 2019 ³⁵	173	Mean ± SD frequency of eating out (times/wk)	2.1 ± 2.5	1.9 ± 2.1	.662 ⁿ	N/R
			Median (IQR ^x) frequency of eating out (times/wk)	1.0 (0.0-3.0)	1.0 (1.0-3.0)	.662 ⁿ	N/R
	Gallegos, 2014 ⁴³	810	Never, 1-2 times/wk, 3+ times/wk—takeaway consumption	40.6%, 21.5%, 37.5%	44.9%, 19.3%, 35.7%	.53 ^e	N/R
Overall dietary pattern (n = 1,025)	Abu, 2019 ³⁵	173	Dietary diversity (<5 food groups)	20.0%	15.5%	.540 ^e	N/R
	Chaparro, 2007 ³²	395	Amount of food eaten the day before the survey (less than usual, usual, more than usual)	High FS 14%, 79%, 7%; marginal 21%, 69%, 10%	Low 11%, 66%, 23%; very low 30%, 60%, 10%	.007 ^e	OR = 2.95 (1.42-6.16) ^{**y}

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Table 4. Dietary outcomes by food security status among university students (*continued*)

Dietary outcomes	First author, year	Sample size	Variable	FS ^a	FI ^b	P value	Regression models
	Hall, 2019 ³³	3030	Diet Diversity Score (low, moderate, high)	High/marginal FS 51%, 70%, 83%	Low 21%, 17%, 10%; very low 27%, 13%, 6%	N/R	N/R
	Paola, 2018 ⁴²	221	Mean ± SD dietary quality overall scores ⁵	Single visitor: 10.79 ± 3.013	Recurrent visitor: 11.36 ± 3.369	.206 ^c	N/R
	Theodoridis, 2018 ⁴⁵	236	Mean (95% CI) Mediterranean Diet Adherence Screen index	6.67 (6.13-7.20)	Mildly FI—6.80 (6.20-7.40); moderate FI—6.87 (6.37-7.36); severe FI—5.87 (5.50-6.24)	N/R	$\beta = .07$ (−0.75 to 0.89); $\beta = .15$ (−0.60 to 0.89); $\beta = −.74$ (−1.40 to −0.09) ^{*z}

^aFS = food secure.

^bFI = food insecure.

^cDifference assessed by *t* test.

^dN/R = not reported.

^eDifference assessed by χ^2 test.

^fOR = odds ratio

^gModel controlled for sex, age, race/ethnicity, meal plan, Pell Grant status, highest parental education, and clustering within residence hall.

^hOR (99% CI) from structural equation models with prediction of reported outcomes from previous and concurrent FI; adjusted for gender, race/ethnicity, Pell grant status, and residence hall group.

NS = not significant.

ⁱNonseverely FI = a combination of FS and moderately FI.

^jDid not report the method of statistical analysis.

^k β coefficient; controlling for race/ethnicity, sex, being a financial aid recipient, number of hours worked for pay, and an being undergraduate student, and campus affiliation.

^l β coefficient (95% CI), compared the percentage difference between each group (ie, marginal, low and very low FS, respectively) and the reference group (ie, high FS); controlling for gender, race/ethnicity, degree, and car access.

^mDifference assessed by analysis of variance.

ⁿRecommendations in MyPyramid, a food guidance released by the US Department of Agriculture in 2005.

^oOR (95% CI); fruit intakes—adjusted for equivalised household income, housing tenure, suspended/compromised studies, perceived general health and vegetable intakes; vegetable intakes—adjusted for equivalised household income, perceived general health, fruit intakes.

^pRD = relative difference.

^qRD (95% CI), compared the percentage difference between each group (ie, marginal, low and very low FS, respectively) and the reference group (ie, high FS); adjusted for age, sex, race/ethnicity, degree type, first-generation college student, and financial aid.

^rLower sum scores reflected a healthier diet and higher scores reflected poor diet quality; food quality scores for individual food intakes—compared the difference between FI with and without hunger; overall diet quality score—compared the difference between single and recurrent visitors of the campus food pantry.

^sDiscretionary foods: foods that are high in added salt, added sugar, and added saturated fat and low in fiber and do not form one of the daily recommended food groups.²⁴

^tSaimin soup = dried, fried noodle product.

^uSSB = sugar-sweetened beverage.

^vMeal Skipping Scale scores out of a possible 12 points.

^wIQR = interquartile range.

^xOR (95% CI); unadjusted.

^y β coefficient (95% CI), compared the difference between each group (ie, mildly, moderate and severe FI, respectively) and the reference group (ie, FS); adjusted for gender, age, and educational level.

**P* < 0.05.

***P* < 0.01.

****P* < 0.001.

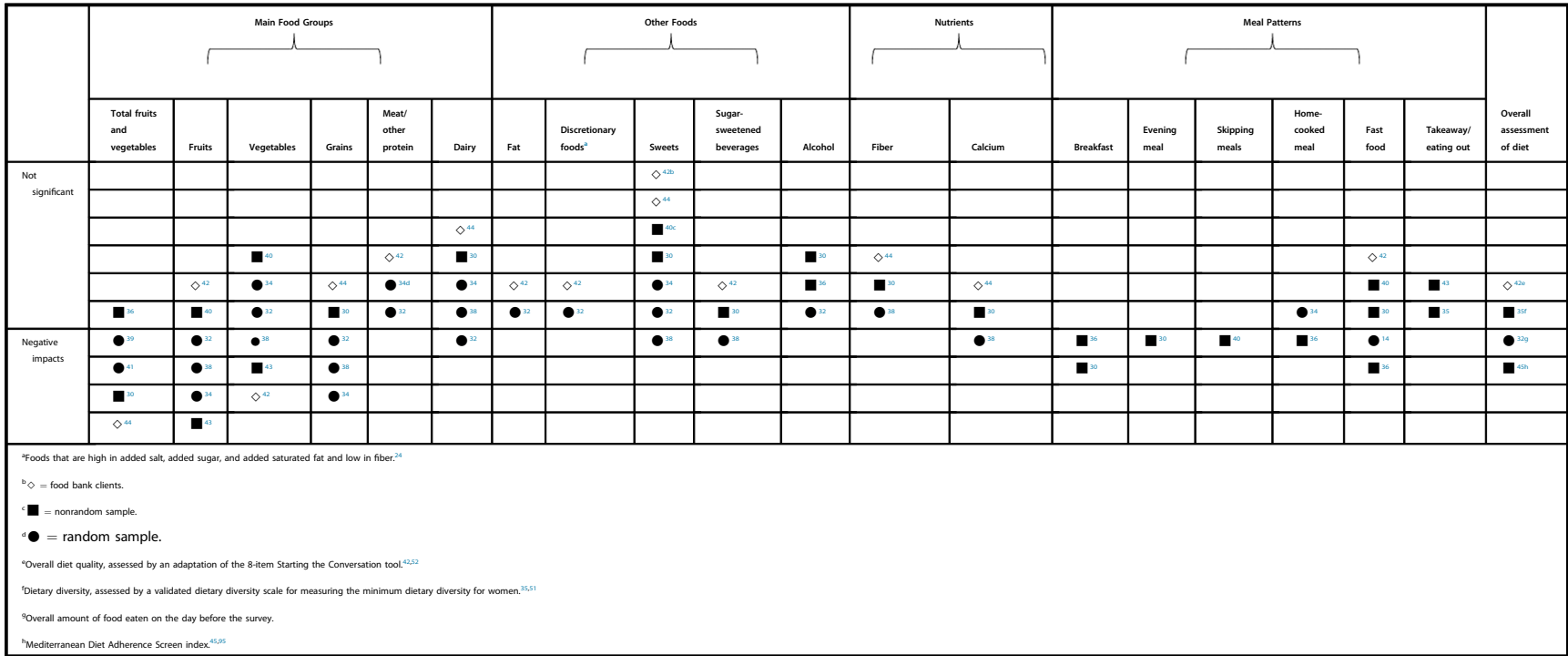


Figure 4. The relationship between food insecurity and dietary outcomes among university students from a systematic review (n = 14). Findings in this figure include 14 studies; 2 studies^{33,37} were excluded due to poor quality after quality assessment by the Joanna Briggs Institute critical appraisal tool.

which was consistent with a previous systematic review in the US university students.⁶⁸ Also, different thresholds were applied to classify food insecurity in the various instruments and studies. For example, the USDA coding scheme classified food insecure by using a threshold of 2 affirmative responses to the 6-item FSSM and 3 affirmative responses to the 10-item and 18-item tools, while the Health Canada scoring system used a threshold of 2 affirmative responses to the 10-item FSSM.^{69,70} Previous research found university students interpreted food security questions differently with the theoretical dimensions of the survey module.⁴⁸ Therefore, misclassification bias might be introduced when measuring food insecurity in university students by using the tools for the general population, which may in turn compromise the estimation of the association between food insecurity and dietary outcomes in this population. Further validation and modification of food security survey items for university students is indicated.⁴⁷⁻⁴⁹

From the included studies that listed dietary outcomes in university students with high, marginal, low, and very low food security, the most food-insecure group (ie, very low food security) might not always experience the poorest outcomes, and poor dietary outcomes were shown in several food insecure categories. For example, Mirabitur et al found the marginally food-secure students consumed the least fruits and vegetables compared with other groups.⁴¹ Students experiencing very low food security ate the highest amount of added sugars but not the least amount of healthy foods such as grains and dairy products.^{32,38} Another qualitative study found students with low food security were more likely to opt for fast foods or skip meals when they were short of money and time, whereas very low food-secure students may not eat anything for the whole day.⁷¹ Responses to different levels of food insecurity might be varied in different student samples. In the United States, differences in the prevalence of food and housing insecurity were found by institution types, that is, 2-year (community) college students were more likely to be food and housing insecure than students at 4-year institutions.^{72,73} Prior research showed the differences in the prevalence and associated characteristics of food insecurity between undergraduates and graduates.⁹ University students with different characteristics might react differently to food insecurity and contribute to varied outcomes in their diet, but the current evidence does not allow this differentiation.

Students with food insecurity may tend to purchase discounted or cheaper foods and drinks with better value for money but poor nutritional quality due to financial difficulties.^{14,43,45} The cost of tuition fees, housing, and other utilities often leaves a limited budget for foods, especially among students living off campus and away from parents.³⁵ In many high-income countries, the costs of fresh produce and healthy food choices (eg, salads) are comparatively higher than fast foods and convenience options per calorie, and food prices are continuously increasing.^{74,75} Adhering to the Mediterranean diet was also connected with higher food costs.⁴⁵ Moreover, young adults have more concerns about the prices of fruits and vegetables compared with the older generation.⁷⁶ Consequently, food-insecure students were more likely to sacrifice food quality to save money and often chose less-healthy options.¹⁴

The provision of foods in their accommodations may have protective effects on the diet quality of food-insecure

students. Lower intakes of fruits and vegetables were reported in students with marginal and low food security who live in accommodations that provided no foods compared with highly food-secure students, but this difference was not observed in students living in housing that provided foods.⁴¹ Less concern in the cost of each meal and more convenient access to fruits and vegetables may contribute to healthier food consumption among students with low food security. Nevertheless, on-campus meal plans (include a fixed number of prepaid meals in dining halls per week) may not be associated with a lower risk of food insecurity.^{34,36,77} In a US university, food insecurity was still reported by 26% of the students who purchased an unlimited meal plan on campus but the reasons remained unclear.⁷⁸

Lower self-efficacy in cooking and pessimistic attitudes to food preparation were observed in food-insecure students.³⁸ Limited access to the kitchen and storage facilities also inhibited the opportunities for them to prepare their own foods.¹⁴ In addition to the time for study, a significant proportion of students with food insecurity had to take full-time or part-time jobs to support themselves,^{35,40,42} and thus they may not have enough time for grocery shopping and cooking. However, food preparation in young adults has been found to be associated with healthier dietary quality in some studies.⁷⁹⁻⁸¹

Food assistance programs are available for vulnerable groups among the general population in several countries. Participants of the Supplemental Nutrition Assistance Program (SNAP), the largest federal food relief program in the United States, were able to achieve sufficient energy intake although no improvements in their diet quality were observed.⁸² The largest food bank network in Israel that offered more perishable and nutrient-dense food items reported healthier diets among their users.⁸³ The Special Supplemental Nutrition Program for Women, Infants, and Children in the United States also found positive long-term impacts on the diet quality of recipient families after they provided more fruits, vegetables, and whole grains but fewer items with high saturated fat.⁸⁴ In other countries included in this review (Australia, Canada, and Greece), there is no national food assistance program run by governments. However, the Canadian government announced an Emergency Food Security Fund to support food banks and food rescue organizations in the country during the COVID-19 pandemic.⁸⁵

University students have little access to some of these food assistance programs. For example, the eligibility of university students for the SNAP program is restricted in the United States and the need for expansion has been revealed.⁸⁶ University students aged 18 to 49 years enrolled in more than 50% of the full-time student load were ineligible for SNAP unless they met 1 of the exemptions (eg, work at least 20 hours per week, take care of a dependent child aged less than 6 years) and all other general eligibility requirements (eg, limits on incomes and household types).^{86,87} A temporary expansion of exemptions due to the COVID-19 pandemic has been enacted in 2021, and some state-level policies related to SNAP eligibility have also been progressed.^{88,89} To help students who are experiencing food insecurity, many universities in the United States and Canada have implemented food pantries on campus. However, the awareness of available food assistance services remained

low and social stigma may prevent students from accessing free products from food banks.^{90,91} Culturally appropriate foods should be incorporated to fill the needs of students from different countries and backgrounds.⁹⁰ The provision of food pantries often had limited availability of fresh food options and were not nutritionally adequate.^{92,93} The effectiveness of food assistance on campus still requires more research to assess if the programs are beneficial for the health and nutritional status of food-insecure students and to discern what improvements to campus food banks are indicated.

Strengths and Limitations

A strength of this review is that it included the search of both academic databases and gray literature by using comprehensive search strategies with the assistance of an academic librarian. Another strength is that the quality of the included studies was assessed and rated by 2 reviewers independently. However, this review has some limitations. Studies in other languages were excluded. A quantitative synthesis of the associations between food insecurity and dietary outcomes was not able to be performed due to the large variations in the methods of included studies. The majority of included studies were cross-sectional designs, and thus the direction of the association between the exposure and dietary outcomes cannot be determined.

Implications

The findings from included studies varied, possibly due to the use of different dietary and food security measurement tools across studies, and it was therefore not possible to reach a consensus. University students can be vulnerable to food insecurity and appeared to consume a less healthy diet as a coping mechanism. Fruits, vegetables, and whole grains were often omitted when experiencing food insecurity. The association between food insecurity and dietary quality among university students deserves further exploration through measurement tools that are tailored more closely to this population. Researchers in this field need to achieve a consensus on the appropriate and validated tools that can be used in university students to assess their diet quality and food security status more accurately. More studies will be needed to investigate how food insecurity and coping strategies affect the dietary patterns by differentiating the characteristics of university students and the severity level of food insecurity. Current estimates of food insecurity may be increasing due to the COVID-19 pandemic,⁹⁴ but the long-term impact of the pandemic once the world recovers is uncertain. More longitudinal studies would be required to determine the long-term impacts of food insecurity on the nutritional health of university students.

CONCLUSIONS

Lower diet quality has been found in food-insecure university students, including less consumption of fruits and vegetables, less frequent breakfast and evening meals, and more consumption of fast foods and added sugars compared with food-secure students, but these findings were not consistently significant across studies. Further evidence from more

rigorous methods of dietary assessment for this population and using better study designs would be needed to confirm the association between food insecurity and diet quality among university students. In the meantime, current study findings suggest that universities should continue to prioritize programs and policies that address the nutritional needs of food-insecure students.

References

- Farrell P, Thow AM, Abimbola S, Faruqi N, Negin J. How food insecurity could lead to obesity in LMICs: When not enough is too much: A realist review of how food insecurity could lead to obesity in low- and middle-income countries. *Health Promot Int.* 2018;33(5):812-826.
- Pollard CM, Booth S. Food insecurity and hunger in rich countries-it is time for action against inequality. *Int J Environ Res Public Health.* 2019;16(10):1804.
- Food and Agriculture Organization of the United Nations (FAO). *Rome Declaration on World Food Security and World Food Summit Plan of Action.* FAO; 1996. Accessed January 9, 2021, <http://www.fao.org/3/w3613e/w3613e00.htm>.
- Ashby S, Kleve S, McKechnie R, Palermo C. Measurement of the dimensions of food insecurity in developed countries: A systematic literature review. *Public Health Nutr.* 2016;19(16):2887-2896.
- Leroy JL, Ruel M, Frongillo EA, Harris J, Ballard TJ. Measuring the food access dimension of food security: A critical review and mapping of indicators. *Food Nutr Bull.* 2015;36(2):167-195.
- Bruening M, Argo K, Payne-Sturges D, Laska MN. The struggle is real: A systematic review of food insecurity on postsecondary education campuses. *J Acad Nutr Diet.* 2017;117(11):1767-1791.
- Phillips E, McDaniel A, Croft A. Food insecurity and academic disruption among college students. *J Stud Aff Res Pract.* 2018;55(4):353-372.
- Regan EP. Food insecurity among college students. *Sociology Compass.* 2020;14(6). 2020;e12790.
- Soldavini J, Berner M, Da Silva J. Rates of and characteristics associated with food insecurity differ among undergraduate and graduate students at a large public university in the Southeast United States. *Prev Med Rep.* 2019;14:100836.
- Gaines A, Robb CA, Knol LL, Sickler S. Examining the role of financial factors, resources and skills in predicting food security status among college students. *Int J Consum Stud.* 2014;38(4):374-384.
- Gundersen C. Are college students more likely to be food insecure than nonstudents of similar ages? *Appl Econ Perspect Policy.* Accessed August 20, 2021. <https://doi.org/10.1002/aep.13110>.
- Munro N, Quayle M, Simpson H, Barnsley S. Hunger for knowledge: Food insecurity among students at the University of KwaZulu-Natal. *Perspect Educ.* 2013;31(4):168-179.
- van Woerden I, Hruschka D, Bruening M. Food insecurity negatively impacts academic performance. *J Public Aff.* 2019;19(3). 2019;e1864.
- Martinez SM, Webb K, Frongillo EA, Ritchie LD. Food insecurity in California's public university system: What are the risk factors? *J Hunger Environ Nutr.* 2018;13(1):1-18.
- Olauson C, Engler-Stringer R, Vatanparast H, Hanoski R. Student food insecurity: Examining barriers to higher education at the University of Saskatchewan. *J Hunger Environ Nutr.* 2018;13(1):19-27.
- Patton-Lopez MM, Lopez-Cevallos DF, Cancel-Tirado DI, Vazquez L. Prevalence and correlates of food insecurity among students attending a midsize rural university in Oregon. *J Nutr Educ Behav.* 2014;46(3):209-214.
- El Ansari W, Stock C, Mikolajczyk RT. Relationships between food consumption and living arrangements among university students in four European countries—a cross-sectional study. *Nutr J.* 2012;11(1):28.
- Radford AW, Cominole M, Skomsvold P. *Demographic and Enrollment Characteristics of Nontraditional Undergraduates: 2011-12.* National Center for Education Statistics, The United States Department of Education. Published 2015. Accessed April 2, 2021, <https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2015025>.
- Brock T. Young adults and higher education: Barriers and breakthroughs to success. *Future Child.* 2010;20(1):109-132.

20. National Center for Education Statistics (NCES). *Characteristics of Postsecondary Students*. NCES, The United States Department of Education. Published 2020. Accessed April 2, 2021, https://nces.ed.gov/programs/coe/indicator_csb.asp.
21. Goldrick-Rab S. Challenges and opportunities for improving community college student success. *Rev Educ Res*. 2010;80(3):437-469.
22. Papadaki A, Hondros G, Scott JA, Kapsokefalou M. Eating habits of university students living at, or away from home in Greece. *Appetite*. 2007;49(1):169-176.
23. Sprake EF, Russell JM, Cecil JE, et al. Dietary patterns of university students in the UK: A cross-sectional study. *Nutr J*. 2018;17(1):90.
24. National Health and Medical Research Council. *Australian Guide to Healthy Eating*. Published 2013. Accessed April 16, 2021, <https://www.eatforhealth.gov.au/>.
25. Sogari G, Velez-Argumedo C, Gomez MI, Mora C. College students and eating habits: A study using an ecological model for healthy behavior. *Nutrients*. 2018;10(12):1823.
26. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ*. 2009;339:b2535.
27. The World Bank Group. Enrolment in tertiary education, all programmes, both sexes (number). Accessed December 22, 2020, https://databank.worldbank.org/indicator/SE.TER.ENR?locations=SD&report_name=EdStats_Indicators_Report&populartype=series.
28. Aromataris E, Munn Z, eds. *JB I Manual for Evidence Synthesis*. Joanna Briggs Institute. Published 2020. Accessed January 9, 2021. <https://synthesismanual.jbi.global>
29. Moola S, Munn Z, Tufanaru C, et al. Chapter 7: Systematic reviews of etiology and risk, Appendix 7.5 Critical appraisal checklist for analytical cross-sectional studies. In: Aromataris E, Munn Z, eds. *JB I Manual for Evidence Synthesis*. Joanna Briggs Institute. Published 2020. Accessed April 2, 2021, <https://wiki.jbi.global/display/MANUAL/Appendix+7.5+Critical+appraisal+checklist+for+analytical+cross-sectional+studies>.
30. Bruening M, van Woerden I, Todd M, Laska MN. Hungry to learn: The prevalence and effects of food insecurity on health behaviors and outcomes over time among a diverse sample of university freshmen. *Int J Behav Nutr Phys Act*. 2018;15(1):9.
31. Moola S, Munn Z, Tufanaru C, et al. Chapter 7: Systematic reviews of etiology and risk, Appendix 7.1 Critical appraisal checklist for cohort studies. In: Aromataris E, Munn Z, eds. *JB I Manual for Evidence Synthesis*. Joanna Briggs Institute; 2020. Accessed April 2, 2021, <https://wiki.jbi.global/display/MANUAL/Appendix+7.1++Critical+appraisal+checklist+for+cohort+studies>.
32. Chaparro MP. *Food Security Status Among College Students at The University of Hawai'i at Manoa*. Master's thesis. University of Hawai'i; 2007.
33. Hall RP, Ranganathan S, Agnew J, et al. *Virginia Tech Food Access and Security Study*. Virginia Tech; 2019.
34. Lunan RL. *Comparisons of Nutrition and Food Budgeting Knowledge of Food Secure and Food Insecure Sophomores at Appalachian State University*. Master's thesis. Appalachian State University; 2020.
35. Abu B, Oldewage-Theron W. Food insecurity among college students in West Texas. *Br Food J*. 2019;121(3):738-754.
36. Bruening M, Brennhofner S, van Woerden I, Todd M, Laska M. Factors related to the high rates of food insecurity among diverse, urban college freshmen. *J Acad Nutr Diet*. 2016;116(9):1450-1457.
37. Hege A, Stephenson T, Pennell M, et al. College food insecurity: Implications on student success and applications for future practice. *J Stud Aff Res Pract*. 2021;58(1):44-61.
38. Leung CW, Wolfson JA, Lahne J, Barry MR, Kasper N, Cohen AJ. Associations between food security status and diet-related outcomes among students at a large, public midwestern university. *J Acad Nutr Diet*. 2019;119(10):1623-1631.
39. Martinez SM, Grandner MA, Nazmi A, Canedo ER, Ritchie LD. Pathways from food insecurity to health outcomes among California university students. *Nutrients*. 2019;11(6):24.
40. McArthur LH, Fasczewski KS, Wartinger E, Miller J. Freshmen at a university in Appalachia experience a higher rate of campus than family food insecurity. *J Community Health*. 2018;43(5):969-976.
41. Mirabitur E, Peterson KE, Rathz C, Matlen S, Kasper N. Predictors of college-student food security and fruit and vegetable intake differ by housing type. *J Am Coll Health*. 2016;64(7):555-564.
42. Paola J, DeBate R. Employing evaluation research to inform campus food pantry policy. *Health Behav Policy Rev*. 2018;5(4):83-94.
43. Gallegos D, Ramsey R, Ong KW. Food insecurity: Is it an issue among tertiary students? *High Educ*. 2014;67(5):497-510.
44. Farahbakhsh J, Hanbazaza M, Ball GDC, Farmer AP, Maximova K, Willows ND. Food insecure student clients of a university-based food bank have compromised health, dietary intake and academic quality. *Nutr Diet*. 2017;74(1):67-73.
45. Theodoridis X, Grammatikopoulou MG, Gkiouras K, et al. Food insecurity and Mediterranean diet adherence among Greek university students. *Nutr Metab Cardiovasc Dis*. 2018;28(5):477-485.
46. Dortch C. *Federal Pell Grant Program of the Higher Education Act: Primer*. Congressional Research Service; 2018.
47. Ames AJ, Barnett TM. Psychometric validation of the 10-Item USDA Food Security Scale for use with college students. *J Appl Meas*. 2019;20(3):228-242.
48. Nikolaus CJ, Ellison B, Nickols-Richardson SM. College students' interpretations of food security questions: Results from cognitive interviews. *BMC Public Health*. 2019;19(1):1282.
49. Ellison B, Bruening M, Hruschka DJ, et al. Viewpoint: Food insecurity among college students: A case for consistent and comparable measurement. *Food Policy*. 2021;101:102031.
50. Bamia C, Martimianaki G, Kritikou M, Trichopoulou A. Indexes for assessing adherence to a Mediterranean diet from data measured through brief questionnaires: Issues raised from the analysis of a Greek population study. *Curr Dev Nutr*. 2014;1(3). 2014;e000075.
51. Women's Dietary Diversity Project Study Group. Development of a dichotomous indicator for population-level assessment of dietary diversity in women of reproductive age. *Curr Dev Nutr*. 2017;1(12). cdn.117.001701.
52. Paxton AE, Strycker LA, Toobert DJ, Ammerman AS, Glasgow RE. Starting the conversation performance of a brief dietary assessment and intervention tool for health professionals. *Am J Prev Med*. 2011;40(1):67-71.
53. Resnicow K, Odom E, Wang T, et al. Validation of three food frequency questionnaires and 24-hour recalls with serum carotenoid levels in a sample of African-American Adults. *Am J Epidemiol*. 2000;152(11):1072-1080.
54. Australian Bureau of Statistics. *National Health Survey: Summary of Results, 2004-05*. Published 2006. Accessed April 2, 2021, <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.02004-05>.
55. Thompson FE, Midthune D, Kahle L, Dodd KW. Development and evaluation of the National Cancer Institute's dietary screener questionnaire scoring algorithms. *J Nutr*. 2017;147(6):1226-1233.
56. Coates J, Swindale A, Bilinsky P. *Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide (v. 3)*. Food and Nutrition Technical Assistance Project, Academy for Educational Development. Published 2007. Accessed April 2, 2021, <https://www.fantaproject.org/monitoring-and-evaluation/household-food-insecurity-access-scale-hfias>.
57. Economic Research Service. US Department of Agriculture. How are food security and insecurity measured? Measurement, Food Security in the U.S. Accessed April 2, 2021, <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/measurement.aspx#measurement>.
58. Larson N, Laska MN, Neumark-Sztainer D. Food insecurity, diet quality, home food availability, and health risk behaviors among emerging adults: Findings from the EAT 2010-2018 study. *Am J Public Health*. 2020;110(9):1422-1428.
59. Johnson CM, Sharkey JR, Lackey MJ, et al. Relationship of food insecurity to women's dietary outcomes: A systematic review. *Nutr Rev*. 2018;76(12):910-928.
60. Hanson KL, Connor LM. Food insecurity and dietary quality in US adults and children: A systematic review. *Am J Clin Nutr*. 2014;100(2):684-692.
61. Walker RE, Kawachi I. Use of concept mapping to explore the influence of food security on food buying practices. *J Acad Nutr Diet*. 2012;112(5):711-717.
62. Leung CW, Epel ES, Ritchie LD, Crawford PB, Laraia BA. Food insecurity is inversely associated with diet quality of lower-income adults. *J Acad Nutr Diet*. 2014;114(12):1943-1953.e2.

63. Laska MN, Pasch KE, Lust K, Story M, Ehlinger E. The differential prevalence of obesity and related behaviors in two- vs. four-year colleges. *Obesity (Silver Spring)*. 2011;19(2):453-456.
64. Nikolaus CJ, Ellison B, Nickols-Richardson SM. Are estimates of food insecurity among college students accurate? Comparison of assessment protocols. *PLoS One*. 2019;14(4). 2019;e0215161.
65. Van den Berg L, Raubenheimer J. Food insecurity among students at the University of the Free State, South Africa. *South Afr J Clin Nutr*. 2015;28(4):160-169.
66. Hughes R, Serebryanikova I, Donaldson K, Leveritt M. Student food insecurity: The skeleton in the university closet. *Nutr Diet*. 2011;68(1):27-32.
67. McKay FH, Haines BC, Dunn M. Measuring and understanding food insecurity in Australia: A systematic review. *Int J Environ Res Public Health*. 2019;16(3):476.
68. Nazmi A, Martinez S, Byrd A, et al. A systematic review of food insecurity among US students in higher education. *J Hunger Environ Nutr*. 2018;14(5):725-740.
69. Economic Research Service. US Department of Agriculture. Survey Tools. Food Security in the U.S. Accessed April 2, 2021, <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/survey-tools/>.
70. Health Canada. *Canadian Community Health Survey, Cycle 2.2, Nutrition (2004): Income-related household food security in Canada*. Health Canada; 2007. Accessed April 2, 2021, <https://www.canada.ca/en/health-canada/services/food-nutrition/food-nutrition-surveillance/health-nutrition-surveys/canadian-community-health-survey-cchs/canadian-community-health-survey-cycle-2-2-nutrition-2004-income-related-household-food-security-canada-health-canada-2007.html>.
71. Fernandez C, Webster J, Cornett A. *Studying on Empty: A Qualitative Study of Low Food Security Among College Students*. Trellis Company; 2019. Accessed April 2, 2021, <https://ssrn.com/abstract=3467730>.
72. Blagg K, Whitmore-Schanzenbach D, Gundersen C, Ziliak JP. *Assessing Food Insecurity on Campus*. Urban Institute; 2017. Accessed April 2, 2021, <https://www.urban.org/research/publication/assessing-food-insecurity-campus>.
73. Dubick J, Mathews B, Cady C. *Hunger on Campus: The Challenge of Food Insecurity for College Students*. College and University Food Bank Alliance; National Student Campaign Against Hunger and Homelessness; Student Government Resource Center; Student Public Interest Research Groups; 2016. Accessed April 2, 2021, <https://safesupportivelearning.ed.gov/resources/hunger-campus-challenge-food-insecurity-college-students>.
74. Darmon N, Drewnowski A. Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: A systematic review and analysis. *Nutr Rev*. 2015;73(10):643-660.
75. Wellard L, Havill M, Hughes C, Watson WL, Chapman K. Energy-dense fast food products cost less: An observational study of the energy density and energy cost of Australian fast foods. *Aust N Z J Public Health*. 2015;39(6):544-545.
76. Chapman K, Goldsbury D, Watson W, et al. Exploring perceptions and beliefs about the cost of fruit and vegetables and whether they are barriers to higher consumption. *Appetite*. 2017;113:310-319.
77. College Counselor Services. Do college students have to purchase meal plans?. Accessed April 2, 2021, <http://www.collegecounselorservices.com/faq/do-college-students-have-to-purchase-meal-plans/>.
78. van Woerden I, Hruschka D, Vega-Lomicronpez S, Schaefer DR, Adams M, Bruening M. Food insecure college students and objective measurements of their usual meal plans. *Nutrients*. 2019;11(4):904.
79. Larson NI, Perry CL, Story M, Neumark-Sztainer D. Food preparation by young adults is associated with better diet quality. *J Am Diet Assoc*. 2006;106(12):2001-2007.
80. Laska MN, Larson NI, Neumark-Sztainer D, Story M. Does involvement in food preparation track from adolescence to young adulthood and is it associated with better dietary quality? Findings from a 10-year longitudinal study. *Public Health Nutr*. 2012;15(7):1150-1158.
81. Smith KJ, McNaughton SA, Gall SL, Blizzard L, Dwyer T, Venn AJ. Involvement of young Australian adults in meal preparation: Cross-sectional associations with sociodemographic factors and diet quality. *J Am Diet Assoc*. 2010;110(9):1363-1367.
82. Andreyeva T, Tripp AS, Schwartz MB. Dietary quality of Americans by Supplemental Nutrition Assistance Program participation status: A systematic review. *Am J Prev Med*. 2015;49(4):594-604.
83. Efrati Philip D, Baransi G, Shahar DR, Troen AM. Food-Aid quality correlates positively with diet quality of food pantry users in the Leket Israel Food Bank Collaborative. *Front Nutr*. 2018;5:123.
84. Kong A, Odums-Young AM, Schiffer LA, et al. The 18-month impact of special supplemental nutrition program for women, infants, and children food package revisions on diets of recipient families. *Am J Prev Med*. 2014;46(6):543-551.
85. Government of Canada. Emergency food security fund. Accessed April 2, 2021, <https://www.agr.gc.ca/eng/agricultural-programs-and-services/emergency-food-security-fund/?id=1585855025072>.
86. Freudenberg N, Goldrick-Rab S, Poppendieck J. College students and SNAP: The new face of food insecurity in the United States. *Am J Public Health*. 2019;109(12):1652-1658.
87. Food and Nutrition Service. US Department of Agriculture. SNAP eligibility. Accessed April 2, 2021, <https://www.fns.usda.gov/snap/recipient/eligibility>.
88. US Department of Education. Education Department amplifies USDA expansion of SNAP benefits to help students pursuing postsecondary education during pandemic. Accessed April 2, 2021, <https://www.ed.gov/news/press-releases/education-department-amplifies-usda-expansion-snap-benefits-help-students-pursuing-postsecondary-education-during-pandemic>.
89. Laska MN, Fleischhacker S, Petsoulis C, Bruening M, Stebleton MJ. Addressing college food insecurity: An assessment of federal legislation before and during coronavirus disease-2019. *J Nutr Educ Behav*. 2020;52(10):982-987.
90. Buch K, Langley S, Johnson T, Coleman N. A university-community partnership to combat food insecurity among college students. *Partnerships: A Journal of Service-Learning and Civic Engagement*. 2016;7:16-26.
91. Hanbazaza M, Ball GDC, Farmer A, Maximova K, Willows ND. Filling a need: Sociodemographic and educational characteristics among student clients of a university-based campus food bank. *J Hunger Environ Nutr*. 2016;11(4):569-577.
92. Jessri M, Abedi A, Wong A, Eslamian G. Nutritional quality and price of food hampers distributed by a campus food bank: A Canadian experience. *J Health Popul Nutr*. 2014;32(2):287-300.
93. Willows ND, Au V. Nutritional quality and price of university food bank hampers. *Can J Diet Pract Res*. 2006;67(2):104-107.
94. Soldavini J, Andrew H, Berner M. Characteristics associated with changes in food security status among college students during the COVID-19 pandemic. *Transl Behav Med*. 2021;11(2):295-304.
95. Schröder H, Fitó M, Estruch R, et al. A short screener is valid for assessing Mediterranean diet adherence among older Spanish men and women. *J Nutr*. 2011;141(6):1140-1145.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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AUTHOR CONTRIBUTIONS

Y. Shi conducted the searches, study selection, data extraction and synthesis, and wrote the first manuscript draft. A. Davies contributed to the study selection and data extraction. M. Allman-Farinelli contributed to the study selection and synthesis of the results. M. Allman-Farinelli and Y. Shi contributed to the study design. All authors reviewed and revised the manuscript draft.

Table 1. Search strategy in MEDLINE (Ovid) for a systematic review of the association between food insecurity and dietary outcomes in university students, searched in July 2020

Group	Search	Query	Results
Tertiary education	1	Universities/	40,838
	2	(education adj2 (technical or higher or further or continu*).tw.	40,355
	3	(TAFE or polytechnic* or college* or universit* or campus*).tw.	464,653
	4	(tertiary or post secondary or postsecondary or postgraduate* or undergraduate* or graduate* or higher degree or PhD or doctor* or diploma* or master* or hono?r* or UG or PG).tw.	540,288
	5	or/1-4	989,514
Students	6	exp Students/	128,022
	7	student*.tw.	278,225
	8	6 or 7	312,431
Population	9	5 and 8	122,874
Food security	10	exp Food Supply/	12,827
	11	Food Assistance/	1061
	12	Hunger/	5373
	13	(food adj2 (secur* or insecur* or sufficien* or insufficien* or access* or availab* or supply or supplies or use* or usage or utilisation or utilization or stability or adequa* or resource* or price* or cost* or quantity)).tw.	35,837
	14	(food adj2 (bank* or pantr* or relief* or hamper* or stamp* or assistance or provision*).tw.	1919
	15	(food adj15 poverty).tw.	1131
	16	(hunger* or hungry).tw.	11,070
	17	or/10-16	56,713
Final	18	9 and 17	411

Countries ^a	China	Argentina	Peru	South Africa
	India	Korea, Rep.	Italy	Morocco
	United States	Germany	Australia	Netherlands
	Brazil	Egypt, Arab Republic	Saudi Arabia	Greece
	Indonesia	Bangladesh	Ukraine	Kazakhstan
	Turkey	France	Canada	Kenya
	Mexico	Colombia	Poland	Dominican Republic
	Iran, Islamic Republic	United Kingdom	Algeria	Romania
	Japan	Spain	Malaysia	Belgium
	Philippines	Pakistan	Chile	Ghana
Search terms ^b	("food security" OR "food insecurity" OR "food access") AND ("diet quality" OR "dietary intake") AND (student) AND (college OR university)			
^a Forty countries with the highest number of tertiary education students based on the enrolment data in 2017 from World Bank Education Statistics ²⁷ ; used for site search in Google Scholar.				
^b Used in Google Scholar and Mednar.				

Figure 1. Gray literature search plan for a systematic review of the association between food insecurity and dietary outcomes in university students.

4.5 Conclusion to chapter

There was an association between food insecurity and poorer dietary outcomes among university students in some existing studies. However, the association between the overall diet quality and food security status was rarely investigated in university students, especially lacking comparisons between domestic and international students. This will be examined in a quantitative study (**Chapter Seven**) and this area may require more research. Primary research projects in this thesis will be presented in the following three chapters, starting with the qualitative study (**Chapter Five**).

4.6 Systematic review update

To capture the most recent studies in the association between food insecurity and dietary outcomes among tertiary education students, an updated search was conducted in MEDLINE using the same search strategy to identify studies published since July 2020 until September 2022. The same eligibility criteria were used for the study selection to include studies differentiating dietary outcomes by food security status among tertiary education students.

The search identified 213 new records and no additional article was found from the hand search of the reference lists of included studies. The first screening of titles and abstracts was conducted based on the eligibility criteria, and 189 records were excluded. The second screening of full text was then conducted for 24 studies, and 17 studies were excluded with reasons shown in Figure 5. Finally, seven articles were included in this update.¹⁻⁷

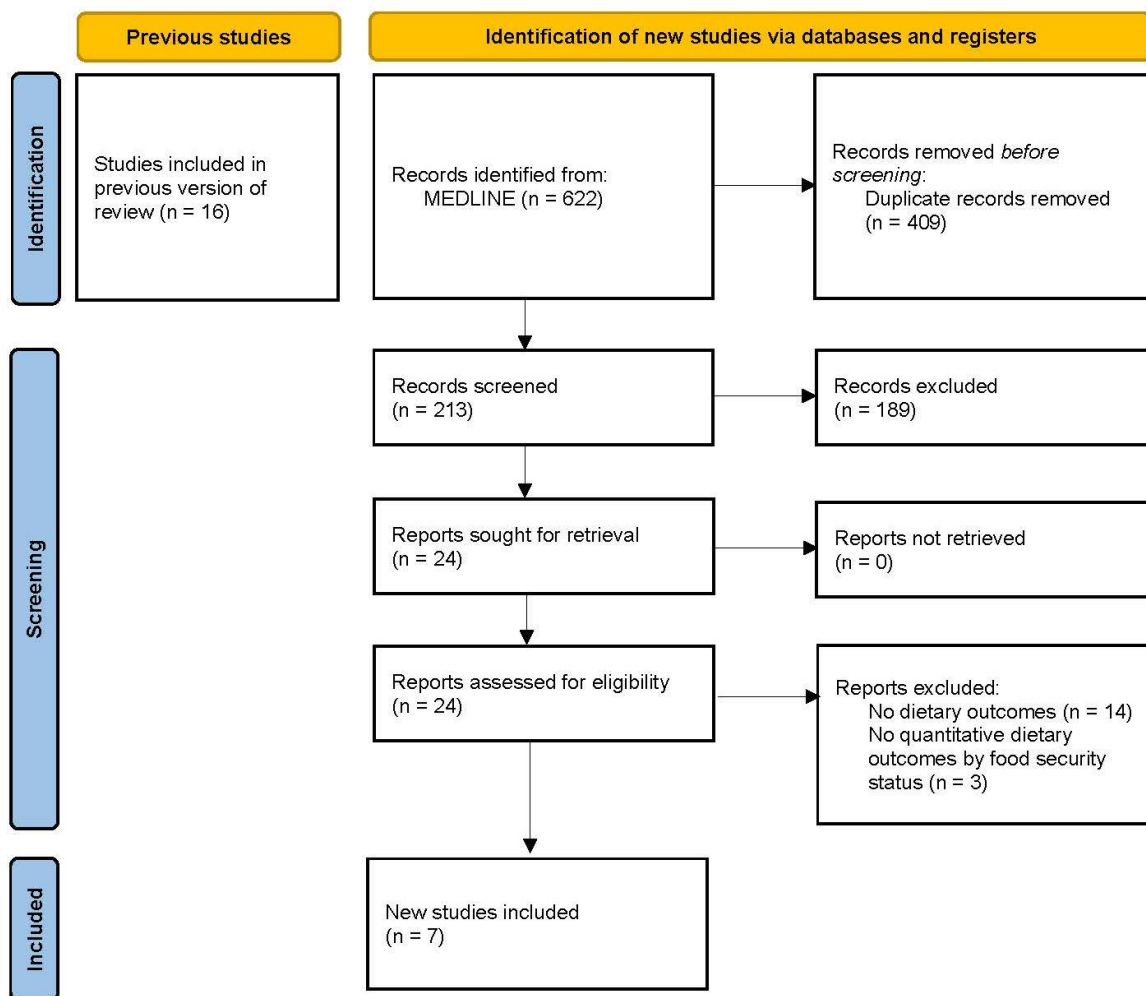


Figure 5. PRISMA flow diagram of record identification and study selection in the updated search for the systematic review of the association between food insecurity and dietary outcomes in university students.

Of seven included studies, six^{1-4,6,7} were from the US with another one from Brazil.⁵ Six studies were conducted among university students,^{1-3,5-7} which was consistent with all included studies in the original review. One study was conducted among students attending two- and four-year colleges and universities in the US.⁴ Key demographic characteristics of participants in the included studies are shown in Table 5. Participants were predominantly female and undergraduate students.

Most included studies were cross-sectional surveys,^{1-3,5-7} and two studies were collected during the COVID-19 pandemic.^{2,5} To assess food security status, five studies from the US used either the six-item short form FSSM (n=3)^{2,6,7} or 10-item Adult FSSM (n=2)^{1,3} from the USDA, and another one used a validated two-item screener.⁴ The Brazilian study used a validated 14-item Brazilian food insecurity scale.⁵ Most studies²⁻⁷ used validated dietary assessment tools and one study¹ used self-developed questions but the content validity was examined and the questions were pilot tested. More details of the methods used by the included studies and the prevalence of food insecurity among tertiary education students in each study can be seen in Table 6.

Table 5. Demographic characteristics of study populations in the included studies (n=7) of food insecurity and dietary outcomes in university students, from the updated search.

First author, year; country	Age (years)	Gender (% female)	Race/Ethnicity	Level of study	Marital status	Living status	Financial support	Employment status
Boone, ¹ 2021; US ^a	Mean 19.5	65	76.1% non-Hispanic White	100% UG ^b	N/R ^c	42.5% on campus	49.1% received financial aid	42.3% employed
Davitt, ² 2021; US	Mean 21.4	61	82% non-Hispanic White	82% UG	17% married or cohabitating	53% living at home with parents/guardians, 47% living on their own (alone or with roommates or a partner)	67% received financial aid	53% employed, 21% lost job in past 4 weeks
El Zein, ³ 2020; US	64.4% 20–21	69.6	47.8% non-Hispanic White	100% UG	40.8% in a relationship	47.6% on campus	60.1% received Pell Grant ^d	63.0% employed
Laska, ⁴ 2021; US	71% 18–24	66	77% non-Hispanic White	84% UG	16% married	40% rent, 27% residence hall, 16% parent’s home, 14% own a house	N/R	N/R
Maciel, ⁵ 2022; Brazil	Median 22.0	66.6	61.0% White	100% UG	N/R	N/R	48.0% reported less income with the pandemic	N/R
Mei, ⁶ 2021; US	Mean 18.5	48.0	55.2% non-Hispanic White	100% UG	N/R	N/R	23.1% received Pell Grant	N/R
Ryan, ⁷ 2022; US	Mean 20.1	81	28% non-Hispanic White	100% UG	N/R	N/R	N/R	N/R

^a US = the United States; ^b UG= undergraduates; ^c N/R = not reported; ^d Pell Grant: federal financial aid supporting undergraduate students in the United States.

Table 6. Methods of sampling and data collection, and the prevalence of food insecurity among university students in the included studies (n=7), from the updated search.

First author, year; country	Study design	Sample size	Sampling	Exposure		Primary Outcomes		Funding
				Food insecurity measurement tool	Food insecurity prevalence	Dietary measurement tool	Dietary variables assessed	
Boone, ¹ 2021; US ^a	Cross-sectional, survey	226	Random (second-year students)	10-item USDA ^b Adult FSSM ^c	Low/very low FS ^d : 46%	Self-developed questions regarding the frequencies of food group consumption	Consumption of FV ^e /juices, grains/ cereals, meat/seafood /poultry, other protein foods, dairy and sweets	N/R ^f
Davitt, ² 2021; US	Cross-sectional, survey	1,434	Convenience	6-item USDA short form FSSM	Low/very low FS: 17%	A validated 10-item food frequency screener for fruits, vegetables, and fibre	Daily FV and fibre servings	No external funding
El Zein, ³ 2020; US	Cross-sectional, survey	683	Convenience (second-year students)	10-item USDA Adult FSSM	25.4% (low FS 14.3%, very low FS 11.1%)	26-item validated Dietary Screener Questionnaire from the NCI ^g	Daily estimates of FV, added sugars from SSBs ^h , total added sugars, fibre, whole grains, dairy products, and calcium.	Data collected under a USDA-funded research project called Get Fruved (NCT02941497)
Laska, ⁴ 2021; US	Analyses of pooled annual data (2015–2018 CSHS ⁱ)	13,720	Random	2-item validated screener often used for clinical settings	23.6%	Youth Risk Behaviour Surveillance System items and self-developed questions	FV and SSBs intake, breakfast and fast food frequency	University Grand Challenges Initiative
Maciel, ⁵ 2022; Brazil	Cross-sectional, survey	4,775	Convenience	14-item validated Brazilian FI scale	38.6% (mild FI 26.4%, moderate FI 7.7%, severe FI 4.5%)	The validated diet quality scale (ESQUADA)	ESQUADA scores categorised into 5 levels (very poor, poor, good, very good, excellent)	CNPq ^k (grant number 431053/2016-2) and CAPES ^l - Finance Code 001

First author, year; country	Study design	Sample size	Sampling	Exposure		Primary Outcomes		Funding
				Food insecurity measurement tool	Food insecurity prevalence	Dietary measurement tool	Dietary variables assessed	
Mei, ⁶ 2021; US	Cross-sectional, survey	1,033	Convenience	6-item USDA short form FSSM	Low/very low FS: 14%	26-item validated Dietary Screener Questionnaire from the NCI; modified Beverage Intake Questionnaire-15	Daily intakes of FV, whole grains, dairy, added sugars from SSBs, total SSBs, total added sugars, calcium, and fibre.	A grant from Poverty Solutions and the McNerney Award at the University
Ryan, ⁷ 2022; US	Cross-sectional, survey	257	Convenience	6-item USDA short form FSSM	Low/very low FS: 41%	The validated all-day FV intake screener; Beverage Intake Questionnaire-15	Daily intake of FV, SSBs, and alcohol.	Supported by the University Institute of Human Development and Social Change's interdisciplinary working group program

^a US = the United States; ^b USDA = United States Department of Agriculture; ^c FSSM = Food Security Survey Module; ^d FS = food security/secure; ^e FV = fruits and vegetables; ^f N/R = not reported; ^g NCI = National Cancer Institute; ^h SSBs = sugar-sweetened beverages; ⁱ CSHS = the Minnesota College Student Health Survey (included 2- and 4-year colleges and universities); ^j FI = food insecurity/insecure; ^k CNPq = National Council for Scientific and Technological Development; ^l CAPES = Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil.

The quality of each study was assessed using the same critical appraisal tool from the JBI and the same rating criteria by the candidate. All seven studies were rated as good quality. Four studies collected the data from a single institution and the representativeness of their sample was checked by comparing with the characteristics in the total enrolment of the institution,^{1,2,6,7} while three studies collected the data from multiple institutions in the country.³⁻⁵ Two^{1,4} out of seven studies used random sampling and the remaining studies^{2,3,5-7} used convenience sampling.

Dietary outcomes from new studies are listed by food security status in Table 7. These studies provided additional significant results in the association between food insecurity and poorer dietary outcomes. Four studies^{3,4,6,7} reported significantly higher intake of sugar-sweetened beverages and two studies^{3,6} reported significantly higher intake of total added sugars in food-insecure students than food-secure students. Two studies observed significantly lower intake of fruits and vegetables.^{3,6} Negative impacts of food insecurity on the consumption of dairy products,⁶ fibre intake,⁶ calcium intake,⁶ the frequency of having breakfast,⁴ the frequency of consuming fast food,⁴ and the overall diet quality⁵ were also observed, but significant results for each of these outcomes were only reported by one study.

These new studies reinforce the findings from the original systematic review as they added more evidence for the association between food insecurity and poorer dietary outcomes in tertiary education students, especially for sugar-sweetened beverages. The impact of food insecurity on the overall diet quality in tertiary education students requires further investigation.

Table 7. Dietary outcomes by food security status among university students, from the updated search.

Dietary outcomes	First author, year	Sample size	Variable	Food secure (FS)	Food insecure (FI)	P value	Regression models
Total fruits and vegetables (n=16,061^a)	Davitt, ² 2021	1,434	5+ serves/d ^b	13.7%	12.8%	0.711 ^c	N/R ^d
	El Zein, ³ 2020	683	Mean daily intake (cup eq ^e)	2.2 ± 0.03	1.6 ± 0.05	0.001 ^f	N/R
	Laska, ⁴ 2021	13,720	5+ times/d	16%	15%	0.52 ^g	N/R
	Ryan, ⁷ 2022	224	< 5 servings/d	90%	90%	0.93 ^c	AOR = 0.84 (0.35–2.03), p > 0.05 ^h
Fruits (n=1,259)	Boone ¹ , 2021	226	3+ times/d	34.4%	22.1%	N/R	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake (cup eq) (SE)	1.09 (0.02)	0.97 (0.04)	0.003 ⁱ	RD = 0.91 (0.84–0.99), p = 0.02 ^j
Vegetables (n=1,259)	Boone, ¹ 2021	226	3+ times/d	25.4%	20.2%	N/R	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake (cup eq) (SE ^k)	1.56 (0.02)	1.37 (0.03)	< 0.001 ⁱ	RD = 0.91 (0.87–0.96), p = 0.0003 ^j
Grains (n=1,942)	Boone, ¹ 2021	226	3+ times/d	42.6%	43.3%	N/R	N/R
	El Zein, ³ 2020	683	Mean daily intake of whole grains (oz)	0.6 ± 0.03	0.7 ± 1.0	0.105 ^f	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake of whole grains (oz eq) (SE)	0.78 (0.01)	0.78 (0.03)	0.79 ⁱ	RD = 1.00 (0.93–1.09), p = 0.90 ^j
Meat/other protein foods (n=226)	Boone, ¹ 2021	226	Meat, seafood, and poultry (3+ times/d)	33.6%	33.7%	N/R	N/R
			Other protein foods (3+ times/d)	41.8%	34.6%	N/R	N/R
Dairy (n=1,942)	Boone, ¹ 2021	226	3+ times/d	32.0%	38.5%	N/R	N/R
	El Zein, ³ 2020	683	Mean daily intake (cup eq)	1.3 ± 0.03	1.3 ± 0.06	0.921 ^f	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake (cup eq) (SE)	1.93 (0.03)	2.01 (0.07)	0.25 ⁱ	RD = 1.10 (1.04–1.17), p = 0.002 ^j
Sweets (n=1,942)	Boone, ¹ 2021	226	3+ times/d	21.3%	23.1%	N/R	N/R
	El Zein, ³ 2020	683	Mean daily intake of added sugars (tsp ^l)	11.5 ± 0.2	14.0 ± 0.1	0.001 ^f	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake of added sugars (tsp eq) (SE)	16.66 (0.18)	17.48 (0.56)	0.07 ⁱ	RD = 1.06 (1.01–1.12), p = 0.01 ^j

Dietary outcomes	First author, year	Sample size	Variable	Food secure (FS)	Food insecure (FI)	P value	Regression models
Sugar-sweetened beverages (SSBs) (n=15,693)	El Zein, ³ 2020	683	Mean daily intake of added sugars from SSBs (tsp)	4.5 ± 0.2	6.4 ± 0.5	< 0.001 ^f	N/R
	Laska, ⁴ 2021	13,720	1+ /d	29%	35%	< 0.0001 ^g	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake of total SSBs (oz eq) (SE)	9.16 (0.46)	14.56 (2.27)	0.05 ^m	RD = 1.56 (1.18–2.06), p = 0.002 ^j
			Mean daily intake of added sugars from SSBs (tsp eq) (SE)	5.87 (0.11)	6.46 (0.37)	0.02 ⁱ	RD = 1.10 (1.02–1.18), p = 0.01 ^j
Ryan, ⁷ 2022	257	≥ 100 kilocalories/d	28%	44%	0.007 ^c	AOR = 1.97 (1.14–3.41), p < 0.05 ^h	
Alcohol (n=255)	Ryan, ⁷ 2022	255	≥ 1 drink/w ⁿ	41%	49%	0.21 ^c	AOR = 1.56 (0.93–2.73), p > 0.05 ^h
Fibre (n=3,150)	Davitt, ² 2021	1,434	20+ g/d	34.3%	28.8%	0.094 ^c	N/R
	El Zein, ³ 2020	683	Mean daily intake (g)	13.3 ± 0.2	12.9 ± 0.2	0.262 ^f	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake (g) (SE)	17.89 (0.13)	16.65 (0.25)	< 0.0001 ⁱ	RD = 0.96 (0.93–0.99), p = 0.01 ^j
Calcium (from diet alone) (n=1,716)	El Zein, ³ 2020	683	Mean daily intake (mg)	814 ± 22.2	792 ± 28.7	0.590 ^f	N/R
	Mei, ⁶ 2021	1,033	Mean daily intake (mg) (SE)	1104 (9.4)	1110 (22.2)	0.79 ⁱ	RD = 1.04 (1.01–1.08), p = 0.01 ^j
Breakfast (n=13,720)	Laska, ⁴ 2021	13,720	4+ d/w ^o	60%	48%	< 0.0001 ^g	N/R
Fast food (n=13,720)	Laska, ⁴ 2021	13,720	≥ several times/w	11%	16%	< 0.0001 ^g	N/R

Dietary outcomes	First author, year	Sample size	Variable	Food secure (FS)	Food insecure (FI)	P value	Regression models
Overall dietary pattern (n=4,775)	Maciel, ⁵ 2022	4,775	Diet quality classification (very poor, poor, good, very good, excellent)	1.1%, 8.0%, 48.5%, 41.1%, 1.3%	Mild FI: 1.8%, 9.0%, 57.5%, 31.2%, 0.6%; Moderate FI: 1.4%, 8.5%, 62.6%, 26.9%, 0.5%; Severe FI: 2.4%, 12.8%, 50.2%, 34.6%, 0.0%	< 0.001 ^c	AOR ^p (by diet quality classification, very poor as reference category): Poor 0.73 (0.41–1.29), p = 0.276; Good 0.72 (0.42–1.23), p = 0.230; Very good 0.46 (0.27–0.79), p = 0.005; Excellent 0.26 (0.11–0.65), p = 0.004

^aThe number of total subjects from the included studies; ^b/d = per day; ^cDifferences assessed by chi-squared test; ^dN/R = not reported; ^eeq = equivalents; ^fDifferences assessed by t-test or Mann-Whitney U test; ^gLogistic regression, adjusted for student gender, race/ethnicity, and relationship status, parent education and income, and clustering within school; ^hAdjusted odd ratio (95% confidence interval), adjusted for age, gender, race/ethnicity (reference category is food secure); ⁱDifferences assessed by simple linear regression with a gamma distribution and a log-link function; ^jRelative difference (95% confidence interval), adjusted for age, sex, race/ethnicity, first-generation status, and Pell Grant status (reference category is food secure); ^kSE = standard error; ^ltsp = teaspoon; ^mDifferences assessed by Wilcoxon rank-sum test; ⁿ/w = per week; ^od/w = days per week; ^pAdjusted odd ratio (95% confidence interval), adjusted for race, income change during the pandemic, and weight change during the pandemic.

4.7 Systematic review update references

1. Boone HE, Gutschall MD, Farris AR, Fasczewski KS, Holbert D, McArthur LH. Comparisons of cooking, dietary, and food safety characteristics of food secure and food insecure sophomores at a university in Appalachia. *J Appalach Health*. 2021;3(4):89-108. doi:10.13023/jah.0304.08
2. Davitt ED, Heer MM, Winham DM, Knoblauch ST, Shelley MC. Effects of COVID-19 on university student food security. *Nutrients*. 2021;13(6):1932. doi:10.3390/nu13061932
3. El Zein A, Colby SE, Zhou W, et al. Food insecurity is associated with increased risk of obesity in US college students. *Curr Dev Nutr*. 2020;4(8):nzaa120. doi:10.1093/cdn/nzaa120
4. Laska MN, Lenk K, Lust K, McGuire CM, Porta CM, Stebleton M. Sociodemographic and health disparities among students screening positive for food insecurity: findings from a large college health surveillance system. *Prev Med Rep*. 2021;21:101297. doi:10.1016/j.pmedr.2020.101297
5. Maciel BLL, Lyra CO, Gomes JRC, et al. Food insecurity and associated factors in Brazilian undergraduates during the COVID-19 pandemic. *Nutrients*. 2022;14(2):358. doi:10.3390/nu14020358
6. Mei J, Fulay AP, Wolfson JA, Leung CW. Food insecurity and dietary intake among college students with unlimited meal plans at a large, Midwestern university. *J Acad Nutr Diet*. 2021;121(11):2267-2274. doi:10.1016/j.jand.2021.04.009
7. Ryan RA, Murphy B, Deierlein AL, Lal S, Parekh N, Bihuniak JD. Food insecurity, associated health behaviors, and academic performance among urban university undergraduate students. *J Nutr Educ Behav*. 2022;54(3):269-275. doi:10.1016/j.jneb.2021.08.008

Chapter Five. International tertiary education students experienced difficulties in dietary transitions in Australia: a qualitative study

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5.1 Publication details

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5.2 Author contribution

I Yumeng Shi (the candidate) was the primary researcher involved in the development of the interview guide, conducted all semi-structured interviews, and completed the coding and interpretative phenomenological analysis. The second author (Nematullah Hayba) contributed to the coding and interpretative phenomenological analysis. Professor Margaret Allman-Farinelli contributed to the study design and the development of the interview guide. I wrote the first draft of this manuscript for publication. All authors reviewed and revised the manuscript draft.

5.3 Introduction to chapter

After the review of existing evidence, this chapter will start to introduce the mixed methods research of this thesis, beginning with a qualitative study. This qualitative study explored dietary experiences of international students attending an Australian university.

5.4 Abstract

Issue Addressed: More attention to the diet and nutritional status of international students in Australian universities is indicated. This qualitative research aimed to provide an in-depth understanding of dietary changes among international students after they arrived in Australia.

Methods: Semi-structured interviews were conducted with international students from China and India who were studying at a large urban Australian university. An approach of interpretative phenomenological analysis was employed for coding and data analysis.

Results: A total of 14 interviews were included. International students were able to consume more international foods, dairy products, and animal proteins in Australia as a result of increased exposure to a larger variety of these foods compared with their home countries. However, they experienced some difficulties in eating vegetables and authentic traditional foods due to limited availability and higher prices in Australia. It was challenging for these students to live independently and cook for themselves for the first time with a limited food budget and time, but many students improved their cooking skills over time. Less frequent main meals with more snacking sessions were reported. Weight fluctuations were commonly experienced and craving for traditional foods no longer accessible may negatively impact mental health.

Conclusions: International students adapted to the Australian food environment but believed the food choices available did not meet their food preferences or perhaps nutritional requirements.

So What: Some intervention from universities and/or government may be needed to ease the barriers to consumption of affordable and desirable meals in a time-saving manner for international students.

Key words: dietary acculturation; food access; food preference; international students; university

5.5 Introduction

International education has become an essential segment of the tertiary education sector in recent decades globally.¹ International students choose to leave their home country to pursue tertiary education degrees in a foreign country.² In Australia, more than 400,000 international students enrolled in tertiary education institutions in 2020 and almost 60% of these students were from China and India.³ The proportion of international students was higher than 20% across Australian universities in 2019.⁴ During the COVID-19 pandemic, the number of international students studying onshore decreased due to the temporary closure of the Australian border from early 2020 until 2021.⁵

People, who migrate to a foreign country with an unfamiliar cultural and social environment, including international students, often experience the process of acculturation which may cause behavioural shifts or acculturative stress.⁶ Exposure to the new food environment in the host country may include the adoption of the new food culture but some maintenance of the original diet might persist.⁷ Dietary acculturation has been observed in both immigrants and international students.^{8,9} Many negative changes in food consumption and meal patterns were voiced, for example, lower intakes of fruits and vegetables, higher consumption of snacks, and irregular meals.¹⁰⁻¹⁴ In contrast, there might also be some positive changes, for example, the adoption of healthy foods by learning from domestic peers.¹⁵

The direction and process of dietary acculturation could be affected by many factors. Environmental factors such as food availability, price, quality and convenience substantially contribute to the dietary acculturation of international students.^{12,16-20} However, a range of migrant communities in Australia have created a food environment with diverse international cuisines, including Chinese and Indian that helps although accessibility and affordability of

these foods may vary in different areas.²¹ The direction and extent of dietary acculturation may also be affected by individual characteristics and circumstances, such as curiosity about novel foods, time constraints, and skills in preparing traditional or local dishes.^{8,22-24}

Few studies have investigated the dietary experience of international students studying in Australia and the reasons for their food choices. With a high proportion of international students in the Australian context, it is essential to focus more on the health and nutritional status of these students to improve their overall experience in Australia. Therefore, this qualitative research aims to provide an in-depth understanding of the experiences of international students after they arrive in Australia, and how these factors influence their food decisions and might lead to changes in food habits from those at home.

5.6 Materials and methods

5.6.1 Study design

The phenomenological approach is appropriate for exploring lived experiences in a population group facing significant transitions.²⁵ It was employed as the theoretical framework to guide this qualitative research to explore the dietary changes of international students after they translocated to Australia. The consolidated criteria for reporting qualitative research (COREQ) checklist was followed at each stage of this study.²⁶ This study was approved by the Human Research Ethics Committee of The University of Sydney (approval number 2020/006).

5.6.2 Participants, screening questionnaire and recruitment

Purposive and snowball sampling were used to recruit participants in this study. Eligible participants were aged 18-30 years, current international students from China or India (the two major source countries of international students in Australia), studying in the first or second

year of their current tertiary education degree, have stayed in Australia for at least 2 months but no more than 2 years. Dietetic students were not eligible as their food habits might be less representative. Questions regarding the inclusion criteria were included in an online screening questionnaire. Participants were recruited through posting flyers across the campus and online recruitment methods (eg, webpages for recruiting volunteers for research, and social media). Students who were interested in the study could check their eligibility by completing the screening questionnaire and then provide their consent via an online platform, Research Electronic Data Capture (REDCap).²⁷ Participants were recruited from a large university with about 70,000 students that included 29,500 internationals in Sydney, New South Wales (NSW).⁴ Sydney is the economic centre of Australia with more than 5.5 million people. Just as the study began in March 2020, the Australian borders closed as a result of the COVID-19 pandemic and international students were not allowed to enter until December 2021. Many eligible international students went back to their home country during this period and no new students could study onshore, so few students were recruited from late 2020 until early 2022. Hence recruitment continued until April 2022. Each participant who completed the interview received a \$20 gift voucher for supermarket groceries to compensate for their time (the amount was not listed in the recruitment advertisement).

5.6.3 Data collection

Semi-structured interviews were used to collect data. An interview invitation email was sent to each eligible participant who signed the consent, and a maximum of three follow-up emails were sent if there was no response. The duration of the interviews ranged from 50 to 105 minutes. Due to COVID-19 restrictions, all interviews were conducted via Zoom, an online platform for video conferencing. The students were able to choose the most comfortable and convenient places for them to be interviewed by the researcher, one at a time and mostly in

their homes. Participants were not known to the interviewer prior to the study. The interview guide was developed by the main researcher and other members of the research group based on the literature review and the dietary acculturation model proposed by Satia-Abouta et al.,^{7,9} and modified after pilot interviews with four international students and three colleagues in the research group (please see Table 5.1).

Table 5.1. The interview guide of a qualitative study exploring dietary changes and food security status among international tertiary education students in Australia.

Sections	Questions
Sociodemographic factors	Eg, length of stay in Australia, living arrangement in Australia and home country, adequacy of cooking facilities in Australia
Dietary acculturation	
<i>Changes in food procurement</i>	When you live in your country, who normally does food shopping in your family? Who normally does food shopping in Australia? Where do you go? How far? How do you get there? How often? What kind of food would you buy in Australia? What do you think of the food that you can buy in those stores, compared to home? Probe for food availability, prices and quality. Can you tell me about your criteria when choosing food products?
<i>Changes in food preparation</i>	Who is mainly responsible for cooking in your family in China/India? In Australia? How often do you prepare your own meals in Australia? Any reasons for the frequency? Have you ever tried/learned cooking before you came here? How did you learn? Would you like to share some dishes you made? What would you say about your skills in cooking before and after living in Australia?
<i>Different patterns of dietary intake</i>	Could you please take me through what you would eat and drink on a typical day in Australia? What about a typical day in China/India? Probe for snacking, beverage intake, weekend variances, meal regularity, food group intakes, eating out experience and eating on campus in both home country and Australia. For students staying in Australia more than a year — any changes between your current diet and what you ate when you first arrived in Australia? Any other things you want to add, about the differences in your diet or the food between two countries?
<i>Other experiences and impacts</i>	In those changes in eating habits, can you tell me what influences you the most? How do you feel about the changes overall? How did the changes affect you? Probe for weight changes, physical health, mental health and study.
Food security	Can you always get enough food in Australia? Can you always get the food you want in Australia? Probe for reasons and coping strategies. How did it affect you when you did not have enough access? What do you think about the role of the university in supporting students to get the food they want?

The adequacy of the sample size was guided by the concept of ‘information power’ which indicates that the more relevant information held by the sample, the fewer participants are needed.²⁸ Malterud and colleagues suggested that ‘the size of a sample with sufficient information power depends on (a) the aim of the study, (b) sample specificity, (c) use of established theory, (d) quality of dialogue, and (e) analysis strategy’.²⁸ The information power was continuously monitored during the process of data collection. The sampling stopped when the information power was considered adequate for the purpose of this study. All interviews were audio-recorded and transcribed by the main researcher within 48 hours after each interview. Notes were taken during the interviews and transferred to the transcripts after the interviews. Transcripts were returned to the participants for corrections and comments.

5.6.4 Data analysis

Two researchers (Y.S. and N.H.) coded the transcripts independently by using Interpretative Phenomenological Analysis (IPA). Both deductive and inductive coding were applied. The coding tree is shown in supplementary file 1. To analyse each transcript individually, a four-step approach from Smith et al. was followed: (1) the transcript was read several times to familiarise coders with the contents; (2) detailed exploratory notes and comments, including both descriptive and interpretative levels were produced; (3) emergent themes were developed by mapping the connections and patterns from the previous notes; (4) interrelationships across emergent themes were explored and discussed by two coders.²⁵ The next stage was to find patterns across participants and reconfigure the themes to represent the group as agreed upon by two coders. NVivo (QSR International) was used to complete the analysis. Disagreements between the two coders were addressed by discussion or consulting a third expert (M.A.-F.).

5.6.5 Research team

The main researcher was an international Ph.D. student from China, who had studied in Australia for more than 5 years at the time of conducting the interviews. These characteristics and the aim of this research were introduced to the participant at the beginning of each interview. The main researcher is also an Accredited Practising Dietitian, but this was not pointed out to participants to avoid concerns about judgements on their dietary habits when answering questions. She had completed training courses in conducting qualitative research and had previous experience in qualitative data analysis. The other two researchers (one Ph.D. and one Ph.D. candidate) are also dietitians and have previous experience in conducting and publishing nutrition and qualitative research.

5.7 Results

5.7.1 Sample characteristics

Of 89 respondents to the online screening questionnaire, 16 of 38 eligible participants provided consent but two students did not respond to the interview invitation email. Therefore, a total of 14 eligible participants were interviewed. The mean (\pm SD) interview time was 71 (\pm 14) minutes. The demographic characteristics of each participant are summarised in Table 5.2. The mean (\pm SD) age of the sample was 22.4 (\pm 2.9) years. The sample was predominately female students ($n = 11$) and evenly distributed between undergraduates and postgraduates. Eight students were from China and six from India. The majority have stayed in Australia for more than 6 months and were living with flatmates or friends in shared accommodations at the time of the interview. Most participants had a weekly food budget within the range of \$AU30 to \$AU100.

Table 5.2. Demographic characteristics of participants (n=14) in a qualitative study exploring dietary changes and food security status among international tertiary education students in Australia.

ID	Age	Gender	Country of origin	Education	Length of stay in Australia	Living status in Australia	Weekly food budget (AUD)*
1	23	Female	China	Undergraduate	3–6 m	Shared accommodation	31–60
2	20	Male	China	Undergraduate	> 1 y	On campus	61–100
3	23	Female	China	Postgraduate	7–12 m	Shared accommodation	61–100
4	27	Female	India	Postgraduate	> 1 y	Shared accommodation	31–60
5	27	Female	India	Postgraduate	> 1 y	Shared accommodation	31–60
6	19	Female	India	Undergraduate	7–12 m	Shared accommodation	0–30
7	23	Female	China	Postgraduate	7–12 m	Shared accommodation	61–100
8	20	Male	China	Undergraduate	7–12 m	Living alone	61–100
9	19	Female	India	Undergraduate	7–12 m	Shared accommodation	61–100
10	23	Female	China	Postgraduate	> 1 y	Living alone	61–100
11	19	Female	China	Undergraduate	> 1 y	Shared accommodation	31–60
12	21	Female	India	Undergraduate	7–12 m	Shared accommodation	31–60
13	26	Female	China	Postgraduate	> 1 y	Shared accommodation	200
14	24	Male	India	Postgraduate	< 3 m	Shared accommodation	31–60

*AUD = Australian dollar

5.7.2 Interpretative phenomenological analysis

Six major themes with nine minor themes were revealed by using the IPA. The major themes included: 1) changes in food procurement and preparation affected by psychosocial and environmental factors, 2) changes in dietary patterns, 3) different experience in eating outside the home, 4) interference caused by COVID-19, 5) impacts on health and study, and 6) compromised food security. The international students' views on dietary changes and the influencing factors and impacts are explained in these themes below. Selective quotations of all themes are displayed in supplementary file 2.

5.7.3 Changes in food procurement and preparation affected by psychosocial and environmental factors

5.7.3.1 Independence and familiarity

Most students lived with parents or families in their home country, and it was their first experience of living independently when they came to live in Australia. Meals were always prepared by parents or other family members at home, or they were able to rely on the canteen foods when they lived on campus in their home country. However, they now had to start managing their own budget and cooking for themselves when they moved to Australia.

In China, I thought that I had fewer opportunities to choose what kind of things I eat, I didn't think that what kinds of foods I need. However in Australia, I have to do this, I need to make choices and I need to think about the food, so after I'm going to bed, I always think that what kind of foods I eat tomorrow. So I always need to make a schedule about this, but in China, I just go to the canteen and see what kinds of foods are there, or at home I just need to eat what food my parents cooked for me. (Aged 23 years, Female, from China, stayed in Australia for 7-12 months)

Many expressed the transition as challenging. However, the transition became easier as they increased familiarity with local food sources and prices in addition to different cooking methods. Most (10 out of 14) students rarely or never cooked in their home country, but they cooked every day or at least every week in Australia.

5.7.3.2 Convenience and time constraints

Most participants could go to a large western supermarket within walking distance of their accommodation in Australia to get their main groceries once or twice weekly, and some were able to buy from the supermarket near the campus on their way home; others needed to take public transport. Traditional food groceries were purchased less frequently, perhaps fortnightly or less. Only one student had relatives in Australia, and her cousin was able to visit her with traditional Indian groceries. Chinese students had easier access to their traditional grocery stores compared with Indian students as Indian grocery stores were often further away from where they lived. In contrast, Indian students reported that it was much more convenient to go food shopping in India as they had street vendors selling fresh foods near home.

When choosing food products and cooking methods in Australia, convenience became very important for many participants. They often preferred to have meals that were easy to make, especially during exam periods. Many students purchased more convenience and frozen foods because they found that more varieties of frozen foods were available in Australia and they mostly relied on fresh foods in their home country. However, some students did not consume frozen options due to their perception it was less fresh and healthfulness was diminished in these products.

Time was one of the main barriers to cooking in Australia among students in our sample. Study and other social events made the time for meal preparation limited. Moreover, the whole process of preparing ingredients, cooking and cleaning took a lot of time. Traditional Chinese and Indian dishes required even longer time to prepare, so they often cooked more than one meal at a time. Limited time availability also contributed to less consumption of vegetables because some students found their perishable nature meant they spoiled before they were cooked

and then they avoided buying such vegetables. To save time during exam periods, some students chose simpler and quicker cooking methods (eg, steaming and stir-frying), while some gave up cooking and ordered takeaways or had more ready-to-eat meals (eg, instant noodles) that required minimal preparation such as heating or addition of boiling water.

5.7.3.3 Food availability and affordability

Participants were able to find some novel foods but also experienced some difficulties in finding their traditional foods in Australia. For example, more varieties of dairy products, animal protein sources, and international foods were available compared with their home country, and this contributed to higher consumption of these foods in Australia. Conversely, it was hard for them to find some specific traditional vegetables, snacks and ingredients in Australia. Both Chinese and Indian students mentioned difficulties in finding proper rice as the type they usually had at home was either not easily available (eg, limited stock or the package size was too large for them to take home) or too expensive in Australia. Thus they had to switch to other types of rice and grain foods. Both positive and negative comments on the variety of fruits in Australia were reported, but the overall consumption of fruits tended to be similar in Australia and the home country.

The price of fresh fruits and vegetables are much higher here. And other traditional things we can't buy here in the nearest supermarket, but we have to go to Indian market to buy them. (In India,) there are supermarkets also and markets, but the food is easily available over there. To cook some Indian dishes that need specific things which we can't find from the supermarket here in Australia. Specifically have to go the Indian stores to buy Indian ones to get them. (27, Female, India, more than a year)

Food prices in Australia were generally perceived as much more expensive than in China and India by considering the currency, but two students thought the prices were similar or cheaper in Australia by comparing food prices with local household income. Vegetables were often criticised as too expensive in Australia, and this prevented their purchase of fresh vegetables, so some students chose frozen or canned alternatives. Milk and meat were considered to be cheaper than in their home country by some students. Healthy and fresh foods were found to be more expensive and to have less chance for discounts than unhealthy and processed foods in Australia. Traditional food products were often costly.

5.7.3.4 Food quality, taste and nutrition

While some participants prioritised food prices when choosing food products, others prioritised food quality, for example, freshness, taste and nutritional values. Some students noticed a better quality of milk and meat in Australia, especially among Chinese students. Some common (eg, mango) and traditional foods that were available in both Australia and home countries were believed to taste differently according to a few students.

Many of those interviewed started to pay more attention to nutrition when they chose food products and prepared meals after they lived alone in Australia. A few students would read Health Star Ratings (ie, a front-of-pack labelling system in Australia) and the nutritional information panel on foods while in the Australian supermarkets to guide purchasing, and they did not have these habits back home. Some students avoided purchasing yoghurt with high sugar contents, while some switched to self-perceived healthier snack options (eg, popcorn and healthy cookies). In meal preparations, a few Chinese students mentioned that they tried to put less oil and salt to make a lighter taste when they cooked in Australia, and one of them also

altered the proportion of food groups in her meals, that is, she tended to have more meat and vegetables but less grains in a meal compared to what she ate in China.

5.7.3.5 Cooking facilities and skills

In Australia, all participants had a private or shared kitchen in their accommodation. However, using the shared kitchen sometimes meant waiting during peak hours. Another limitation of cooking was the sensitive fire alarms in Australia, which made those cooking methods with a large amount of smoke (eg, flash-frying) unfeasible. Limited space in shared refrigerators and freezers restricted the amount of food that could be purchased by some.

Speaking about sharing (the kitchen) and given that I'm not living with someone that I know for such a long time, it's actually quite chaotic sometimes. We find it cook, and we don't usually cook together because food preferences are so different. Most of the time we take turns to cook but because I would like to really try to avoid all of us being stuck in the kitchen at the same time, so I do meal prep, so most of the time I would cook more than a meal and I store in the fridge and then I will just reheat them and it's quick and easy, that's my strategies (laugh). (23, Female, China, 7-12 months)

A minority of students had cooking experience before they came to Australia. Almost all participants (12 out of 14) considered that their cooking skills improved since they lived in Australia. A few would contact their mothers at home for cooking instructions, but this ceased over time. Online recipes, friends and flatmates were major sources for cooking assistance. They learned some Western dishes and cooking methods (eg, potato dishes and how to use the oven) from local friends, and learned other Asian dishes from their Asian flatmates. For those

who were able to cook with friends, they enjoyed experimenting with new recipes together. Some students tried baking (eg, pineapple bun) with friends in Australia which was a new experience for them.

5.7.4 Changes in dietary patterns

5.7.4.1 Changes in the habits of consuming main meals

For most breakfast had been varied but in a traditional style and prepared by their parents whether in China or India. However, many people only had coffee or cereal with milk in Australia as they were easy and quick to prepare in the morning.

Lunch and dinner in their home country were also usually traditional styles. A few students mentioned the habit of having a light dinner in their families. The international students might eat lunch and dinner at home or in the canteen on campus, and some students would order online meal deliveries if they were alone at home or at the workplace. In Australia, many students tended to have a simple lunch and a larger dinner that required more preparation. When students went to campus, they purchased some food for lunch or took sandwiches or leftover food with them. They were more willing to cook for dinner, and both traditional (eg, curries with flatbread and stir-fries with rice) and Western dishes (eg, burgers and pasta) were prepared. Some students described a pattern of continuing change in cooking. For example, a female student from China cooked mostly western dishes at first and altered to traditional Chinese styles after a while, and then she began to cook a mixture of both styles.

5.7.4.2 Reduced meal regularity and increased snacking

The regularity of meals generally reduced among these international students. Most of them had three main meals in their home country, but they only consumed two main meals in

Australia, for example, having brunch when they got up late, having a light lunch or dinner, or replacing a meal with a snacking session.

I think mostly the food just I used to eat like three meals back home, but I just eat like two meals now. I feel like at the same time I eat like more and less food, like my one meal is more concentrated in quantity, and back home I used to eat like three meals a day, so they were smaller in quantities, I guess that. I feel back home, it used to be more stable and standardised. (19, Female, India, 7-12 months)

Both healthy and unhealthy snacks were reported, such as fruits, yoghurt, chocolate and potato chips. Some people argued that there was less need for snacking in the home country as more options were available for them to choose from at main meals. The reduction in the number of main meals may also be caused by time and financial constraints in Australia. In addition, changes in the timing of meals were noticed by a few students.

5.7.5 Different experience in eating outside the home

5.7.5.1 Less enjoyable experience in eating out and takeaways

The frequency of dining out and ordering takeaways reduced among international students when they lived in Australia compared with their experience at home and they were able to sample fewer cuisine types. Having fewer friends in Australia contributed to the reduction of eating outside the home. Eating out was often considered as a social event with friends, for example, a pizza party to discuss a group task and celebrations. The frequency of eating out appeared to be higher on vacations. A student reported that she ordered more takeaways during exams as she was too stressed to care about cooking. They noticed that eating in restaurants

and the delivery cost were significantly more expensive than in China and India, and many of them only had a limited food budget.

Asian restaurants and fast foods were the most popular eating out choices among participants. Chinese students were generally satisfied with the taste of foods in Australian restaurants even though some tastes did not perfectly match their personal preferences. The taste of foods at Chinese restaurants in Australia might not be as authentic as in their hometowns but still acceptable. However, most Indian students had a negative impression of Indian and fast-food restaurants. Indian dishes in Australia were too sweet and not spicy enough for them, while pizza and burgers tasted bland compared with what they had in India. Moreover, fewer vegetarian options were available in Australian restaurants, and they did not offer different levels of spicy as in India. Other popular Asian cuisines in Australia, for example, Japanese, Korean and Thai, received more positive comments from these students.

5.7.5.2 Less satisfied with foods on campus in Australia

In Australia, some students purchased meals on campus regularly when they had classes (eg, 2-4 times per week), while some tried foods on campus very occasionally. Compared with the campus foods in Australia, our participants were more satisfied with their experience in Chinese and Indian schools or universities. Canteens in their countries were considerably cheaper, more convenient and had more food varieties ready for them to choose from.

I think the canteen food in China is much cheaper. Sometimes you can feel full just with less than RMB10 in school canteen, so the price is the first big difference. And also the variety is another big difference. Like the Wentworth building, the restaurant they provide Asian foods, just a few meals I think, but in China, in my

school canteen, they have a variety (of choices), that's another difference...I think for the flavouring, the food in Australia is not much spicy as that in China, even if the food said it's spicy. (20, Male, China, 7-12 months)

Some students were able to find a few tasty choices at a reasonable cost on the campus in Sydney, but it was not very enjoyable for them to eat on campus in general (including meals provided by student accommodations) by considering both prices and tastes. Nevertheless, a few students were delighted with the opportunities to have free meals from student events on campus, which was a new experience for them.

5.7.6 Interference caused by COVID-19

The COVID-19 pandemic had negatively impacted the dietary experience of international students in Australia. Some students experienced difficulties in food shopping during lockdowns, for example, limited stock of rice, they had to take turns to go food shopping so the quantity and food types might not be ideal, and accessibility of Indian groceries declined. Reduced meal regularity and less opportunities for eating out with friends were also reported. Transitioning from studying on campus to online classes affected the meal regularity and food choices of some students, and they reported weight fluctuations.

5.7.7 Impacts on health and study

The overall comments on dietary changes after the arrival in Australia were mixed among our participants. Four students believed that they had a less healthy diet (eg, less vegetable intake, excessive snacks and irregular meals), while two students considered their diet to be healthier as they paid more attention to nutrition while they lived independently in Australia. Five people

noticed both less healthy and healthier dietary habits, and others felt about the same or were not sure.

Twelve out of 14 students reported weight changes after they arrived in Australia, including weight gain, weight loss and fluctuations in between. Common reasons for weight gain were more frequent late-night meals and a higher intake of snacks and ready-to-eat meals. Those having less frequent main meals in Australia experienced weight loss as their overall food intake reduced. A few students noticed their weight gain after the first few months and then they tried to lose weight by eating less, substituting unhealthy snacks with healthier ones and exercising.

Some impacts of dietary changes on physical health, sleep, mental health and academic life were reported by our participants. Some reported unusual symptoms like excessive snacking leading to a bleeding nose and throat pain, and oily food causing vomiting. One female student considered that her physical discomforts might be derived from eating less vegetables. Two students reported interactions between their diet and sleep. One student found that she had evening meals earlier than in China so she slept earlier to avoid feeling hungry at night in Australia, and another one was more motivated to have breakfast after a satisfying sleep and she felt more energetic for classes when breakfast was not skipped. The craving and inability to have traditional snacks upset some students. Food had been considered as the daily highlight of one student while in India, but she felt disappointed with her food experience in Australia. On the positive side, living closer to campus was felt to provide more time to cook between and after classes and this was beneficial for studying.

5.7.8 Compromised food security

Many participants experienced some difficulties in getting sufficient quantities of food that they wanted in Australia. Some people had a limited food budget and the high food prices in Australia were a barrier and some experienced financial hardships due to COVID-19 or other reasons.

In terms of access yes, food is accessible but the price hinders in it. For example, I would get something that is cheaper and more filling over something that is healthier. (19, Female, India, 7-12 months)

Their coping strategies included cutting meal sizes, dividing meals, buying cheaper alternatives or discounted items, making a careful meal plan within budget and getting free or discounted products from food pantries, for example, the food pantry that newly operated on campus during the pandemic. Many of them could not find their preferred foods as they had at home, and some were upset and sad about this issue, while others just accepted it. International students wanted the university food outlets to provide more varieties of foods with more discounts for students and organise more nutrition education to improve both nutrition knowledge and food preparation skills.

5.8 Discussion

This study provided an in-depth understanding of international students' food experiences after their arrival in Australia. Students from China and India underwent dietary acculturation, and they were able to have both local and familiar home foods in Australia. Managing food budgets and cooking for themselves for the first time was challenging, but many of them improved their cooking skills during their stay in Australia. Time availability for cooking and differences in food availability and prices between their home country and Australia contributed to their dietary changes. Less vegetables and higher protein intake were commonly reported among our international students. Reduced meal regularity and less frequent eating out also occurred. These issues require more attention and interventions from tertiary institutions to assist their international students in having a better dietary experience and being more food secure. Possible intervention points may include education, peer-supported programs to introduce the food supply in Australia and cooking with new ingredients, and subsidised canteens containing international students' preferred foods.

The maintenance of the original diet with the incorporation of elements of the local diet in the host country has been commonly reported by previous studies of international students.^{22,29,30} Lower consumption of vegetables, higher consumption of animal protein products, and changed types of grain foods were found in international students from both this and other studies.^{11-13,22,31-33} In contrast, some studies reported reduced frequency of consuming meat groups in Asian and Arab students in the United States but the portion sizes were not assessed.^{17,34} Among our international students, changes in consuming these food groups may largely be influenced by the differences in the food availability and affordability between the host country and their home countries. Similar to our findings, some qualitative research conducted in the United Kingdom and the United States also observed less regular meal

patterns and changes in the meal timing among international students from Asia and other countries.^{24,31,32} Transitioning from living with parents to independent living and busy study schedules may contribute to these changes from our international students' experiences because meals were no longer prepared for them and they had limited time to manage their meals.

The dietary habits of international students constantly changed during their stay in the host country. Among our participants, some changed their cooking styles over time and some behaved differently after weight gain, such as choosing healthier snacks and having fewer main meals. With longer stay and increased familiarity with the local food environment in addition to accumulated experience in cooking and independent living, it was common for international students to keep adjusting their diet throughout their journey in the host country.^{15,30,35} They may be more interested in having local styles or prefer to move back to their original diets over time to find the most appropriate practice for themselves.^{30,35} Compared with the extent of the changes in the first 3 months after arrival, fewer dietary changes might be made at a later stage according to a quantitative study conducted in international students attending a university in England.³⁶

Of psychosocial factors that influenced the dietary changes of international students, living independently for the first time was substantial in our sample. They did not need to worry about food in their home country because their parents and canteens could fulfil their food preferences and nutritional needs. To overcome the difficulties in this transition, international students often acquired and enhanced skills in managing time (eg, cooking in bulk) and budget (eg, comparing prices and tastes between brands and looking for discounted items), and preparing meals (eg, learning new recipes with friends), and these strategies were also reported by other international students from previous studies.^{19,37} Cooking with friends appeared to be

more enjoyable and time-efficient than cooking alone in our and other international students from Asia, and this might be influenced by the collectivistic cultures in Asian countries.^{19,38} Students in this study improved their nutrition literacy through self-learning in Australia as it was not their responsibility to think about this issue when living with parents, although the credibility of the online resources they used and the accuracy of their knowledge needs confirmation.^{39,40} Nutrition knowledge seemed to be less critical when our students experienced high-stress levels and a shortage of time as they tended to prioritise convenience and eat more ready-to-eat meals and takeaways during exam periods. International students often tend to prioritise studying and Asian cultures place a strong emphasis on academic success for students.^{24,41}

Compared with food environments in China and India, most students perceived the Australian one to be less convenient and more expensive. In Australia, they needed to employ more effort to purchase enough varieties of foods that they wanted, but another reason for the perception of better convenience at home may be less need for grocery shopping when they lived there because their parents did that. Considering the currency and limited food budget, the cost of fresh groceries and eating out were much higher and less affordable for international students compared with the prices of eating at home both in Australia and elsewhere.^{16,24} Traditional Chinese and Indian foods were available in Australia, but it was still difficult to find authentic foods at a reasonable cost. Also, bringing traditional foods or asking parents to post them from home was less feasible for international students in Australia than those in other countries due to customs restrictions on bringing food items into Australia.^{24,42,43} When eating out in Australia, our students tended to be more critical of the taste of cuisines from their own country as the dishes have been westernised to fit local tastes, especially Indian students, but they were more tolerant with cuisines from other Asian countries. The COVID-19 lockdowns caused

some temporary interruptions in food shopping and eating patterns of international students in Australia.

Weight changes were prevalent among international students in Australia and other countries.^{15,24} Weight gain might be caused by higher consumption of fast foods or other unhealthy choices, but it was not uncommon for international students to lose weight at first due to insufficient cooking skills, meal skipping and mental stress.^{24,35} The associations between dietary acculturation and mental health have been raised across themes in this study, such as having more takeaways when stressed during exams, feeling disappointed with unpleasurable food experiences in Australia, and sadness due to the inability to have preferred traditional options. Negative impacts of dietary changes on their mental and physical health need to be increasingly recognised by tertiary institutions in order to maximise both health status and academic performance of international students.⁴⁴ International students rarely identified any direct impacts of dietary changes on their academic life from this and previous studies,⁹ and it might be hard for them to evaluate this association. More quantitative research to measure both dietary acculturation and academic achievements may be useful.

Food security was an issue for students in our sample. Limited food budgets forced them to reduce the size of meals or purchase cheaper substitutes. Less vegetable intake and meal skipping during their stay in Australia may contribute to inadequate nutrition and other health risks.^{45,46} Their food preferences could not be fully satisfied due to the limited availability of traditional foods, and this may lead to negative impacts on their mood. Many international students thought that they would be able to have their preferred foods again when they return home, and this helps them to overcome the difficulties of not having those foods in Australia and other host countries.³⁷ A food hub was newly operated by Foodbank Australia on the

campus where this study took place during the COVID-19 pandemic to support international students, and some of our participants collected free hampers from this pantry. International students were found to be a new food insecure group in Australia during the pandemic,⁴⁷ but fortunately, more food assistance services were available for this vulnerable group during the difficult time.^{48,49} More subsidised university canteens, which were available to our international students in their home countries, might be an appropriate intervention for supporting food-insecure international students in Australia.⁵⁰

This study provided an in-depth understanding of dietary changes among international students in Australia and has several strengths. Our study was able to capture students from the two main source countries of international students in Australia. The inclusion of students with different lengths of stay in Australia provided us the opportunity to understand further changes after their initial transitions. The coding process was conducted by two researchers with qualitative coding experience and involved consultation with another researcher who had more experience in qualitative research. There were also some limitations in this study. Due to the difficulties in recruiting international students during the COVID-19 pandemic, we only recruited students from one urban university in the largest city in Australia. Different food availability and access in other universities and less urban areas may contribute to different dietary experiences compared with our participants. International students who have stayed for longer than 2 years in Australia may experience more changes in their diet over time. Our sample was predominantly female, did not capture students older than 30 years, and may not be representative of different living circumstances. However, the transferability of this qualitative research was achieved by providing the contextual information of the participating university and demographic characteristics of participants and comparing the results between this sample and international students from other contexts. Another limitation is the volunteer

bias. Our participants might be more concerned about diet and nutrition than other international students in general, but information-rich cases were needed for this qualitative research.

While the interviews did not probe deeply into students’ suggestions for any policy actions clearly, to improve the dietary experience of international students in Australia, more actions from the universities and government may be required. The conventional misunderstanding that international students are affluent and would likely not have food budget issues appears ill conceived. Tertiary education institutions should be responsible to organise interventions to help their international students enjoy preferred and healthy food options in Australia, and practical recommendations are provided in Table 5.3. To further examine the prevalence and severity of food insecurity among international students in Australia, more quantitative research will be needed in this student group, and this is currently being investigated by our research team.

Table 5.3. Recommendations for tertiary education institutions to help international students improve their food experience in Australia.

Issues	Recommended interventions
Dietary acculturation	Peer programs could be organised for newly arrived international students to familiarise them with the local food environment more quickly, and the peer international students with a rich experience of healthy eating on a budget could be invited to share their strategies in food shopping and cooking with students from the same region. ⁵¹
Nutrition/food literacy	Education programs on nutrition and skills training in cooking should be continued to be provided. More diverse communication channels to reach more international students and deliver simple but important messages related to food acquisition, nutrition and culinary knowledge should be considered to inform them how to eat in real-world settings. ⁵²
Food access/campus food environment	A more culturally diverse and healthier food environment on campus is needed. More affordable prices or discounts based on assessment of financial need would help students procure suitable food in a more timely and affordable way, e.g., subsidised canteens. ⁵⁰

5.9 Conclusions

International students experienced challenges in eating a healthy diet with preferred foods and regular meals in Australia. Leaving parents and familiar environments to live independently in a foreign country predominantly contributed to their changes in food consumption and meal patterns. Weight fluctuations were common, and their mental health might be negatively affected by their inability to consume the traditional food items they preferred. Interventions to address their difficulties in food availability, accessibility and affordability in addition to time management skills might help the international students to experience healthier and more pleasurable eating in Australia.

5.10 References

1. Knight J, de Wit H. Internationalization of higher education: past and future. *Int High Educ.* 2018;(95):2-4.
2. United Nations Educational Scientific and Cultural Organization (UNESCO) Institute for Statistics. *Global Education Digest 2006 Comparing Education Statistics Across the World.* 2006 [cited 2022 Dec 29]. Available from: http://uis.unesco.org/sites/default/files/documents/global-education-digest-2006-comparing-education-statistics-across-the-world-en_0.pdf
3. Department of Education, Skills and Employment, Australian Government. *End of Year Summary of International Student Data 2020.* 2021 [cited 2022 Dec 29]. Available from: <https://internationaleducation.gov.au/research/international-student-data/Documents/MONTHLY%20SUMMARIES/2020/Full%20year%20summary.pdf>
4. Department of Education, Skills and Employment, Australian Government. *Onshore higher education international students as a proportion of all students by university, 2019.* 2020 [cited 2022 Dec 29]. Available from: https://internationaleducation.gov.au/research/research-snapshots/Documents/RS_International%20students%20at%20universities.pdf
5. Department of Education, Skills and Employment, Australian Government. *International students outside Australia due to COVID 19.* 2021 [cited 2022 Dec 29]. Available from: https://internationaleducation.gov.au/research/research-snapshots/Documents/RS_COVID-19%20update%20March%202021.pdf
6. Berry JW. Acculturation: living successfully in two cultures. *Int J Intercult Relat.* 2005;29(6):697-712.
7. Satia-Abouta J, Patterson RE, Neuhouser ML, Elder J. Dietary acculturation: applications to nutrition research and dietetics. *J Am Diet Assoc.* 2002;102(8):1105-18.
8. Aljaroudi R, Horton S, Hanning RM. Acculturation and dietary acculturation among Arab Muslim immigrants in Canada. *Can J Diet Pract Res.* 2019;80(4):172-8.
9. Shi Y, Lukomskyj N, Allman-Farinelli M. Food access, dietary acculturation, and food insecurity among international tertiary education students: a scoping review. *Nutrition.* 2021;85:111100.
10. Almohanna A, Conforti F, Eigel W, Barbeau W. Impact of dietary acculturation on the food habits, weight, blood pressure, and fasting blood glucose levels of international college students. *J Am Coll Health.* 2015;63(5):307-14.
11. Lee J, Gao RR, Kim JH. Acculturation and changes in dietary behavior and anthropometric measures among Chinese international students in South Korea. *Nutr Res Pract.* 2015;9(3):304-12.
12. Papadaki A, Scott JA. The impact on eating habits of temporary translocation from a Mediterranean to a Northern European environment. *Eur J Clin Nutr.* 2002;56(5):455-61.
13. Reeves SL, Henry CJ. Dietary change, energy balance and body weight regulation among migrating students. *Int J Food Sci Nutr.* 2000;51(6):429-38.

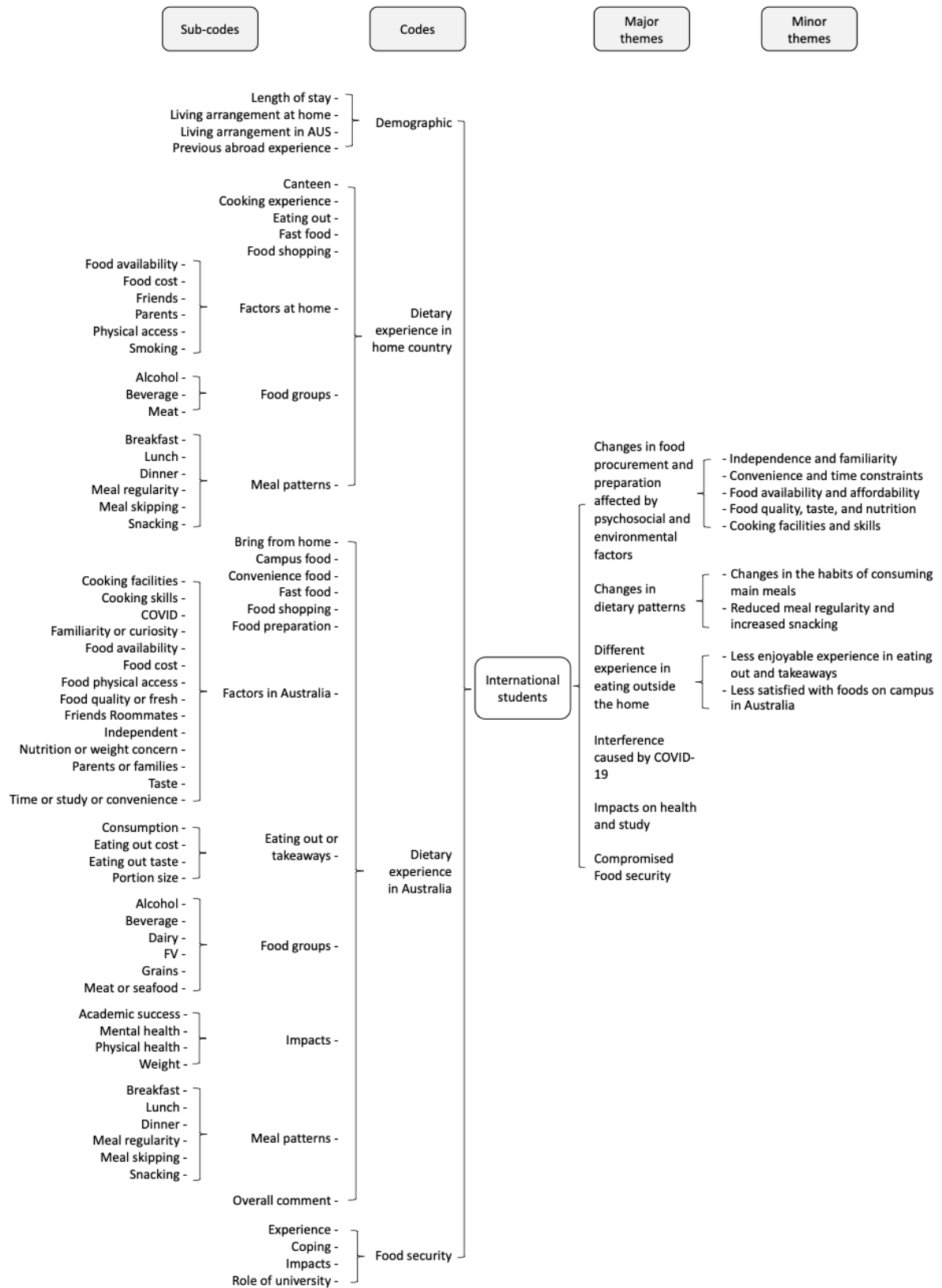
14. Vilela S, Santos S, Padrao P, Caraher M. Length of migration and eating habits of Portuguese university students living in London, United Kingdom. *Ecol Food Nutr.* 2014;53(4):419-35.
15. Wu B, Smith C. Acculturation and environmental factors influencing dietary behaviors and body mass index of Chinese students in the United States. *Appetite.* 2016;103:324-35.
16. Alloh FT, Tait D, Taylor C. Away from Home: Away from home: a qualitative exploration of health experiences of Nigerian students in a U.K. university. *J Int Stud.* 2018;8(1):1-20.
17. Brittin HC, Obeidat BA. Food practices, changes, preferences and acculturation of Arab students in US universities. *Int J Consum Stud.* 2011;35(5):552-9.
18. Danquah AO, Odjoji Y, Graham-Acquaah S, Steiner-Asiedu M. A pilot study of the dietary and physical activity behaviours of international students: implications for health promotion. *Afri J Food Sci.* 2010;4(3):86-92.
19. Leu JH, Banwell C. Looking for a taste of home: a qualitative study of the health implications of the diets of Australian-based Southeast Asian students. *Glob J Health Sci.* 2016;8(3):101-12.
20. O'Mara J, Waterlander W, Nicolaou M. Exploring the role of the food environment in dietary acculturation: a study amongst Moroccan immigrants in the Netherlands. *Int J Environ Res Public Health.* 2021;18(7):3328.
21. Lai MY, Khoo-Lattimore C, Wang Y. A perception gap investigation into food and cuisine image attributes for destination branding from the host perspective: the case of Australia. *Tour Manag.* 2018;69:579-95.
22. Alakaam AA, Castellanos DC, Bodzio J, Harrison L. The factors that influence dietary habits among international students in the United States. *J Int Stud.* 2015;5(2):104-20.
23. Jiang Y, Nagao-Sato S, Overcash F, Reicks M. Associations between acculturation and diet and health indicators among U.S. Asian adults: NHANES 2011-2016. *J Food Compost Anal.* 2021;102:104061.
24. O'Sullivan N, Amirabdollahian F. Loyal tongue, liberal mind: international students' experiences on dietary acculturation in England. *J Int Stud.* 2016;6(1):107-27.
25. Smith JA, Larkin MH, Flowers P. Interpretative phenomenological analysis : theory, method and research. London: SAGE; 2008.
26. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Quality Health Care.* 2007;19(6):349-57.
27. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377-81.
28. Malterud K, Siersma VD, Guassora AD. Sample size in qualitative interview studies: guided by information power. *Qual Health Res.* 2016;26(13):1753-60.
29. Amos S, Lordly D. Picture this: a photovoice study of international students' food experience in Canada. *Can J Diet Pract Res.* 2014;75(2):59-63.

30. Cappellini B, Yen DA-w. Little emperors in the UK: acculturation and food over time. *J Bus Res.* 2013;66(8):968-74.
31. Corcoran N. Exploring Exploring international students' food choices using photovoice techniques. *J Int Stud.* 2018;8(1):175-93.
32. Hartwell HJ, Edwards JSA, Brown L. Acculturation and food habits: lessons to be learned. *Br Food J.* 2011;113(11):1393-405.
33. Saccone BH, Obeng CS. Food choices and eating patterns of international students in the United States: a phenomenological study. *Int Public Health J.* 2015;7(4):357-61.
34. Pan Y-L, Dixon Z, Himburg S, Huffman F. Asian students change their eating patterns after living in the United States. *J Am Diet Assoc.* 1999;99(1):54-7.
35. Yan Z, FitzPatrick K. Acculturation and health behaviors among international students: a qualitative approach. *Nurs Health Sci.* 2016;18(1):58-63.
36. Edwards JS, Hartwell HL, Brown L. Changes in food neophobia and dietary habits of international students. *J Human Nutr Diet.* 2010;23(3):301-11.
37. Brown L, Edwards J, Hartwell H. A taste of the unfamiliar. Understanding the meanings attached to food by international postgraduate students in England. *Appetite.* 2010;54(1):202-7.
38. Yen DA, Cappellini B, Wang CL, Nguyen B. Food consumption when travelling abroad: Young Chinese sojourners' food consumption in the UK. *Appetite.* 2018;121:198-206.
39. Gkouskou K, Markaki A, Vasilaki M, Roidis A, Vlastos I. Quality of nutritional information on the Internet in health and disease. *Hippokratia.* 2011;15(4):304-7.
40. Liu X, Chen H, Zhou Q, Zhang H, Asawasirisap P, Kearney J. Knowledge, attitude and practices (KAP) towards diet and health among international students in Dublin: a cross-sectional study. *Int J Environ Res Public Health.* 2020;17(9):3182.
41. Cheng KM. Educational Systems: Asia. In: Smelser NJ, Baltes PB, editors. *International Encyclopedia of the Social & Behavioral Sciences.* Oxford: Pergamon; 2001. p. 4333-8.
42. Lockie GM, Dickerson JWT. Food-choice and nutrient-intakes of male Nigerian students in Aberdeen. *J Human Nutr Diet.* 1991;4(4):263-72.
43. Department of Agriculture, Water and the Environment, Australian Government. Bringing or mailing goods to Australia. 2022 [cited 2022 Dec 29]. Available from: <https://www.awe.gov.au/biosecurity-trade/travelling/bringing-mailing-goods#:~:text=each%20consignment%20must%20be%20packed,to%20arrival%20in%20Australian%20territory>
44. King N, Rivera D, Cunningham S, Pickett W, Harkness K, McNevein SH, et al. Mental health and academic outcomes over the first year at university in international compared to domestic Canadian students. *J Am Coll Health.* Published online 2021 Oct 4.
45. Blekkenhorst LC, Sim M, Bondonno CP, Bondonno NP, Ward NC, Prince RL, et al. Cardiovascular health benefits of specific vegetable types: a narrative review. *Nutrients.* 2018;10(5):595.

46. Kumari S, Prasad R, Verma A. Effect of meal skipping on nutritional status of college students of Prayagraj. *Pharma Innov.* 2019;8(10):135-9.
47. Louie S, Shi Y, Allman-Farinelli M. The effects of the COVID-19 pandemic on food security in Australia: a scoping review. *Nutr Diet.* 2022;79(1):28-47.
48. Boseley M. ‘Keeps us going’: how Foodbank is helping international students survive Melbourne’s lockdown. *The Guardian.* 2021 Sept 30.
49. Study NSW. COVID-19 Help Hub for international students—Food assistance. 2022 [cited 2022 Dec 29]. Available from: <https://www.study.sydney/programs/food-assistance>
50. Jeffrey C, Dyson J, Scrinis G. Hunger for change: student food insecurity in Australia. *Geoforum.* 2022;136:186-93.
51. Yan Z, Finn K, Cardinal BJ, Bent L. Promoting health behaviors using peer education: a demonstration project between international and American college students. *Am J Health Educ.* 2014;45(5):288-96.
52. Luongo G, Tucker R, Hutchinson C, Dhaliwal R. The outcomes of the community cooking workshops for international students at Simon Fraser university. *J Int Stud.* 2018;8(4):1549-68.

5.11 Supplementary files

Supplementary file 1. Coding tree



Supplementary file 2. Themes with selective quotations

Major themes	Minor themes	Selective quotations
Changes in food procurement and preparation affected by psychosocial and environmental factors	Independence and familiarity	<p><i>In China, I thought that I had fewer opportunities to choose what kind of things I eat, I didn't think that what kinds of foods I need. However in Australia, I have to do this, I need to make choices and I need to think about the food, so after I'm going to bed, I always think that what kind of foods I eat tomorrow. So I always need to make a schedule about this, but in China, I just go to the canteen and see what kinds of foods are there, or at home I just need to eat what food my parents cooked for me. (Aged 23 years, Female, from China, stayed in Australia for 7-12 months)</i></p> <p><i>When I came, I wouldn't normally which thing I should get from where, veggies I would have Harris Farm, and other things grocery and staples are from Aldi or Coles, so I was pretty confused at that time, but that's not the case now. I'm pretty confident which thing to buy from where. (27, Female, India, more than a year)</i></p>
	Convenience and time constraints	<p><i>I feel it's the time because the cooking takes a lot of time. If I need to work or study, I need to go to the campus, I prefer to do some simple cooking, or just buy some vegetables or fruits, it's more quick. (23, Female, China, more than a year)</i></p> <p><i>I try to cook on weekends but sometimes if I do have...I'm not really able to cook much, so I generally because I have classes almost every day, I buy something to eat from the University, like USU Eats has sandwiches, salads and pasta, so I generally buy that, because I'm overloading this semester, I have five units so I don't really have a lot of time to do anything at all, plus with all the assignments going on, it's generally like me just buying stuff to eat. (19, Female, India, 7-12 months)</i></p>
Food availability and affordability		<p><i>The price of fresh fruits and vegetables are much higher here. And other traditional things we can't buy here in the nearest supermarket, but we have to go to Indian market to buy them. (In India,) there are supermarkets also and markets, but the food is easily available over there. To cook some Indian dishes that need specific things which we can't find from the supermarket here in Australia. Specifically have to go the Indian stores to buy Indian ones to get them. (27, Female, India, more than a year)</i></p> <p><i>I think in the first few weeks when I first arrived, I was like, wow, I cannot buy this, it's like I can buy five of the same thing in China than here, but now I'm getting used to it but I will still go for the half priced stuff. So I will check the catalogue every week before I go shopping, so I know what's half priced so I will put them into the shopping list and I'll go for it. (20, Male, China, more than a year)</i></p>
	Food quality, taste, and nutrition	<p><i>The milk is in very high quality, because in China, there's not much fresh milk... And for beef, I think the quality is also better than in China. Other things, I didn't see much difference. (20, Male, China, 7-12 months)</i></p>

Major themes	Minor themes	Selective quotations
Changes in food procurement and preparation affected by psychosocial and environmental factors (Cont.)	Food quality, taste, and nutrition (Cont.)	<i>I think I just go for the Health Star Rating and the price of the products. I learnt about (the Health Star Rating) in Australia. Back in India I never paid attention to nutrition part because my parents bought grocery and they paid attention to these things. (27, Female, India, more than a year)</i>
	Cooking facilities and skills	<p><i>Speaking about sharing (the kitchen) and given that I'm not living with someone that I know for such a long time, it's actually quite chaotic sometimes. We find it cook, and we don't usually cook together because food preferences are so different. Most of the time we take turns to cook but because I would like to really try to avoid all of us being stuck in the kitchen at the same time, so I do meal prep, so most of the time I would cook more than a meal and I store in the fridge and then I will just reheat them and it's quick and easy, that's my strategies (laugh). (23, Female, China, 7-12 months)</i></p> <p><i>I think I made a great progress in my cooking skills, because my friends called me kitchen killer when I was in China, and my parents didn't allow me to go into the kitchen. However in here, I need to cook by myself everyday, so I always put the theory into practice. Also, I always talk with mom that once I'm back to China, I will make a big meal for them, my family. (23, Female, China, 7-12 months)</i></p>
Changes in dietary patterns	Changes in the habits of consuming main meals	<p><i>For Australia, I often wake up for breakfast, it's like bread and milk, I just have one bowl of milk and I bake, for the bread machine, I used that to cook like two breads, and with some jams or peanut butter on that. I think that's it. In the weekends sometimes I cook the eggs as well, but normally like in school days, I just have that because it's more convenient...Back in China, my parents used to prepare many kinds of things for the breakfast, is like some nuts, and just like different kinds of things like also pork floss and sesame, those things and my family tend to prepare me really variety of kind of things for my breakfast, but I didn't eat them all in China. (19, Female, China, more than a year)</i></p> <p><i>In Australia, I ate western style wildly during the first half year. My personal habit is that I will keep eating one thing if I love it. In the first half year, there was restrict lock down at that time, limitations on groceries and no chance to eat out, so I bought a lot of steak. I cooked steak for every meal, apart from breakfast I had milk and cereals, but I had steak for both lunch and dinner. After half a year, I don't want to eat steak any more. Then I turned to cook Chinese food, really don't want to have steak and even not milk and cereals. I started to eat Chinese food as a compensation, no western things. There are more western restaurants in Australia, but I still try to find Chinese restaurants as much as I can, I totally turned my eating habits at home, became very Chinese style. After the release of lock down from last October or November, my diet kind of reached a balance between Chinese and western food. (26, Female, China, more than a year)</i></p>

Major themes	Minor themes	Selective quotations
Changes in dietary patterns (Cont.)	Changes in the habits of consuming main meals (Cont.)	<i>When I have class, I would generally prepare lunch at a day before at night, and take it with me to the class, and then I would get up quickly and make cereal, then go to class and take lunch there, and then come back to cook for dinner. That was pretty hectic actually, because I didn't mind to cook two meals, one for the next day lunch and one for the night, because that's pretty difficult if you get up early in the morning and make lunch that early morning, but it has not same any more now, I only cook once proper dinner. (27, Female, India, more than a year)</i>
	Reduced meal regularity and increased snacking	<i>I think mostly the food just I used to eat like three meals back home, but I just eat like two meals now. I feel like at the same time I eat like more and less food, like my one meal is more concentrated in quantity, and back home I used to eat like three meals a day, so they were smaller in quantities, I guess that. I feel back home, it used to be more stable and standardised. (19, Female, India, 7-12 months)</i> <i>And then some snacks in between (lunch and dinner), so sometimes will be something like popcorns for now. I have been switching to have popcorns pretty much now, because sometimes I do want to snack on something when I'm having classes. I found popcorns might be a healthier option of food, so I go for popcorns before dinner. I used to have chips quite often but have been snacking more in the past 6 months so decided to opt for healthier options. Sometimes before dinner, if I still feel hungry, I might go for another fruit, maybe an apple or maybe some strawberries. (23, Female, China, 7-12 months)</i>
Different experience in eating outside the home	Less enjoyable experience in eating out and takeaways	<i>It's quite expensive on the speak for, because we are in Australia, you can't get the Asian food at the same price as Hong Kong, not as readily available, but everything is expensive here (laugh), especially eating out, but if you eat out then you have to have the expectation of a higher budget, so that's why I try to avoid going out, especially with dining in restaurants, because they charge you the service charge too. (23, Female, China, 3-6 months)</i> <i>I think my best comparison would be Subway because they have Subway both in India and here. First of all, the actual menu different. I think India has a lot more variety and a lot more vegetarian friendly variety. And here I feel like if you're getting any vegetarian option, it always be like just tofu, or some like veggie patty, there's always like one thing. But in India you know, you would have like they're like these Indian things, but then you have like different types of patties or the spice level and all these different things in India. (24, Male, India, less than 3 months)</i>
	Less satisfied with foods on campus in Australia	<i>I think the canteen food in China is much cheaper. Sometimes you can feel full just with less than RMB10 in school canteen, so the price is the first big difference. And also the variety is another big difference. Like the Wentworth building, the restaurant they provide Asian foods, just a few meals I think, but in China, in my school canteen, they have a variety (of choices), that's another difference...I think for the flavouring, the food in Australia is not much spicy as that in China, even if the food said it's spicy. (20, Male, China, 7-12 months)</i> <i>I think it's not the same, (the Indian food on our campus is) not the same as Indian, it's more sweeter. The taste is towards sweet, it's not spicy here, it's not like Indian taste here. (27, Female, India, more than a year)</i>

Major themes	Minor themes	Selective quotations
Interference caused by COVID-19	No minor themes	<p><i>It's mainly because we cannot go out a lot this year. For the first year I go out like, I go to the city once or twice each month, but not a lot this year. I think I've never been to the city this year so far. I really miss. (20, Male, China, more than a year)</i></p> <p><i>From the start of last semester (August 2021). Almost half a year. We had face-to-face classes since mid-2020 and June/July 2021, no lock downs, so I have a regular lifestyle. But after the lock down, it became not that regular. (26, Female, China, more than a year)</i></p>
Impacts on health and study	No minor themes	<p><i>In my first semester when I arrived, I gained weight... I used to portion my diet from the second semester, so that's why I lost weight. (27, Female, India, more than a year)</i></p> <p><i>I feel sometimes if I skip the breakfast...I feel like I want to sleep more, maybe because of the glucose level in the morning. I feel like I don't want to wake up and do the zoom lesson and just want to stay in bed. But when I have a nice sleep and wake up early in the morning and feel good, then I feel like having breakfast. It's kind of like a cycle, but I don't know which one cause the other. (23, Female, China, 3-6 months)</i></p>
Compromised Food security	No minor themes	<p><i>If I don't have enough money for that one week because of the money didn't come in from my parents or the bank, then I have to buy cheaper alternatives. (23, Female, China, 3-6 months)</i></p> <p><i>In terms of access yes, food is accessible but the price hinders in it. For example, I would get something that is cheaper and more filling over something that is healthier. (19, Female, India, 7-12 months)</i></p> <p><i>I think I found it (a food pantry) online, and I was searching about all these, because like every time I used to go to Woolworths or something, it used to cost a lot like \$100, it just go away. So I was looking for cheaper options for my groceries, and then I came across this place. It's not open every day, but they have their open timings, and I saw that's pretty close to the uni, so I just randomly went for a check. It was pretty good, I got the same amount of groceries for \$30, so it's like cheaper for me. (21, Female, India, 7-12 months)</i></p>

5.12 Conclusion to chapter

This qualitative study showed that international students experience many challenges in having a healthy diet with preferred food choices in Australia. Although they may have sufficient quantity of food, they may not be able to meet their perceived nutritional requirements and food preferences, which are important dimensions of food security. The next chapter (**Chapter Six**) will investigate the prevalence of food insecurity in international students and compare with domestic students.

Chapter Six. Food insecurity among international and domestic students in an Australian university two years into the global COVID-19 pandemic

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6.1 Publication details

A modified version of this chapter has been submitted to the *European Journal of Clinical Nutrition* for consideration.

6.2 Author contribution

I Yumeng Shi (the candidate) was the primary researcher involved in the design of the study, the development of the questionnaire, the data collection and analysis. Professor Margaret Allman-Farinelli contributed to the study design, the development of the questionnaire, and thematic analysis. I wrote the first draft of this manuscript for publication, and both authors reviewed and revised the manuscript draft. The authors acknowledge the technical assistance in statistical analysis by Kathrin Schemann of the Sydney Informatics Hub, a Core Research Facility of The University of Sydney.

6.3 Introduction to chapter

The qualitative study in the previous chapter (**Chapter Five**) found that international students faced challenges in achieving food security in Australia, especially for meeting perceived nutritional requirements and food preferences. This chapter will investigate whether international students have a higher risk of food insecurity than domestic students through a food security survey in an Australian university.

6.4 Abstract

Background/Objectives: To explore the differences in the prevalence, sociodemographic determinants, and impacts of food insecurity between international and domestic students in an Australian university during the COVID-19 pandemic.

Subjects/Methods: A cross-sectional online survey. The questionnaire contained the 18-item Household Food Security Survey Module to assess food security status. Logistic regression models were used to analyse the associations between student characteristics and food insecurity. A total of 467 students (376 domestic and 91 international students) attending a large university in Sydney completed the survey between October 2021 and May 2022.

Results: Compared with domestic students (13.0% food insecure), international students (18.7% food insecure) had higher odds of being food insecure in our sample (OR = 2.02, 95% CI 1.01–4.07, $p = 0.013$). Different risk factors for food insecurity were identified in these two student groups, e.g., being undergraduates and living outside the parental home for domestic students, and for international students living in accommodation that provided meals which did not suit their preferences and experiencing changes in living arrangements due to the pandemic. Lower fruit intake was reported by food-insecure domestic students. Poor wellbeing was reported by both food-insecure domestic and international students. International students with food insecurity were more likely to use food assistance services than food-insecure domestic students.

Conclusions: International students experienced a higher risk of food insecurity than domestic students during the pandemic in Australia. More tailored interventions to address food insecurity need to be developed for international and domestic students by considering their different experiences.

Key words:

Food insecurity; college; international students; coping strategies; university students

6.5 Introduction

Even in high-income countries, food security, as a basic human right, cannot be fully achieved in the general population.¹ The Food and Agriculture Organization define food security as ‘when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life’.² In Australia, disadvantaged groups, such as the Aboriginal and Torres Strait Island population and people living in rural areas were found to have an elevated risk of food insecurity prior to the COVID-19 pandemic.^{3,4} Casual workers and international students became newly food insecure after the outbreak of COVID-19 in early 2020.⁵

Job changes and income losses during the COVID-19 pandemic have worsened food insecurity in Australia as less budget was available for food.⁵ The imbalance between the increased demand and disrupted food supply caused unavailability of food during lockdowns across Australia.⁵ A similar increase in the prevalence of food insecurity has been identified in the United States (US) and Canada.^{6,7} Several lockdowns occurred in different states of Australia in 2020 and 2021. Sydney was in lockdown from June to October 2021. International students were not permitted to arrive in Australia from March 2020 until December 2021 due to the closure of the national borders.^{8,9}

Research prior to COVID-19 indicated a significant proportion of tertiary education students experienced food insecurity while studying.¹⁰ Challenges in living independently from parents and financial pressure contributed to the inability to obtain sufficient and appropriate food among students while receiving tertiary education.^{11,12} Factors associated with food security status in tertiary education students varied within different contexts, such as age, year of study, ethnicity, living arrangements, and sources of financial support.¹²⁻¹⁴ Food insecurity has been

associated with compromised physical and mental health in addition to academic outcomes in tertiary education students.¹⁵⁻¹⁷ Coping mechanisms of food-insecure tertiary education students were often reported by studies conducted in North America, but in Australia they have rarely been measured.^{18,19}

Some research showed international students who leave their home country to receive tertiary education in a foreign country were more likely to experience food insecurity than their domestic peers.^{20,21} Financial hardship caused by higher tuition fees and unfamiliarity with a new food environment may lead to a higher risk of being food insecure in international students.²⁰ Moreover, international students were not eligible for the government support payments during the COVID-19 pandemic.²² However, the determinants and impacts of food insecurity have rarely been identified among international students specifically.

This study aimed to i) detect the prevalence of food insecurity among students in a large Australian university during the COVID-19 pandemic, ii) explore the differences between international and domestic students in the prevalence, sociodemographic determinants, and impacts of food insecurity, and how the students cope with food insecurity.

6.6 Materials and methods

6.6.1 Study design

This cross-sectional online survey was conducted in a large Australian university in Sydney, New South Wales (NSW). An online platform, Research Electronic Data Capture (REDCap), was used to implement and manage the survey.²³ The study was approved by the Institutional Human Ethics Review Board.

6.6.2 Participants

Domestic and international students aged 18 to 30 years who were not completing and had not completed nutrition degrees were eligible to participate in this study. Most university students are young adults and were the focus of this study as challenges faced by more mature students may be different. Students were recruited for a sub-study simultaneously, which measured dietary intake, and nutrition students would be less representative of students in general. To recruit participants, convenience and snowball sampling were used. Advertisement flyers were posted in the buildings and libraries on campus and online recruiting methods were employed, e.g., announcements through an online learning management system of the institution and electronic newsletters. Participants who were interested in the survey were asked to complete a screener first and eligible participants were directed to the consent form and the survey hosted on REDCap. Participants who completed the survey were eligible for a lucky draw of ten supermarket gift vouchers, \$50 for each but the value was not displayed in the advertisements. The target sample size was 360 domestic and 90 international students through a power calculation using the Sample Size Calculators supported by the Clinical and Translational Science Institute of the University of California San Francisco.²⁴

6.6.3 Data collection

The online survey was open from October 2021 to May 2022. The majority of participants joined the study after the new semester began from February 2022. The final questionnaire contained 81 items to collect data on food security status, sociodemographic characteristics, diet-related behaviours, health and academic outcomes. A pilot survey was tested with 22 students, and the questionnaire was modified based on their responses and feedback. For example, the option of “prefer not to say” was added to the questions about financial status,

and more explanations of coping strategies were provided to increase the clarity of questions for respondents.

The 18-item Household Food Security Survey Module (HFSSM) from the US Department of Agriculture (USDA) was used to assess the food security status of students in the past 12 months.²⁵ The HFSSM contained 10 questions for all households and an additional eight questions for households with children. Participants having dependent children were required to answer those additional eight questions for the food security status of children. The levels of food security were classified into four categories, including high, marginal, low, and very low food security.²⁵ The screening question in this tool was also included in the questionnaire as a single-item tool, “Which of these statements best describes the food eaten in your household in the last 12 months?”²⁵ Five possible responses to this question were “enough of the kinds of food we want to eat”, “enough but not always the kinds of food we want”, “sometimes not enough to eat”, “often not enough to eat”, and “don’t know”.

Sociodemographic characteristics were collected through basic demographic questions (e.g., age, gender, and current academic degree), and further questions on living arrangements, financial and employment status. To detect the impacts of the COVID-19 pandemic on the food security status of domestic and international students, changes in living arrangements (with an open-ended question for details), employment, income, and financial support were asked.²⁶

Dietary-related factors and outcomes were questioned, e.g., adequacy of cooking facilities, self-perceived cooking skills, the frequency of cooking and eating out, weekly food budget, the awareness of food relief programs, and whether the accommodation (other than own or parental home) provided meals. The questions for participants to estimate their daily intake of fruits and

vegetables were derived from the National Nutrition and Physical Activity Survey 2011–12.²⁷ The recommended daily intakes for vegetables and fruits were 5-6 serves (5 serves for females and 6 serves for males) and 2 serves, respectively, for young adults according to the Australian Dietary Guidelines.²⁸ A four-item tool to measure cooking self-efficacy previously validated in tertiary education students was used, with a total score range from 4 to 20.²⁹ Common strategies to cope with food insecurity that have been reported by tertiary education students from previous studies were listed for participants to indicate their frequency of using them,^{18,19} and they were able to specify their own strategies.

Health and academic outcomes were also collected. Weight and height were reported by participants to calculate their body mass index (BMI), and the following classification criteria were used: underweight (below 18.5 kg/m²), normal weight (18.5-24.9), overweight (25.0-29.9), and obesity (30.0 and above).³⁰ Participants were asked to provide a self-rating for their physical and mental health status, respectively.³¹ Their mental health status was further measured by the WHO-5 Well-Being Index with a total raw score range from 0 to 25, a five-item tool that has been used in tertiary education students.^{32,33} A score below 13 is an indication for poor wellbeing and further testing for depression.³³ The impacts of food security status on academic outcomes were assessed from three perspectives, including attendance of classes, academic performance, and withdrawal from courses.³⁴ At the end of the survey, an open-ended question asked respondents to provide comments on any food security issues and/or the survey.

6.6.4 Data analysis

To describe food security status with associated factors and outcomes in university students, percentages were used for categorical variables, and means and standard deviations (SD) were used for continuous variables. For data analysis, high and marginal food security were

combined as the food-secure group, while low and very low food security were combined as the food-insecure group according to the USDA questionnaire.²⁵ To compare the differences in categorical variables, the Chi-squared test and Fisher's exact test were used. To compare the differences in continuous variables, the independent sample t-test was used for normal data and the Mann-Whitney U test was used for non-normal data. For the above comparisons, the Bonferroni correction was applied, and the level of significance was set at $p < 0.001$ to allow for the comparison of 39 variables. For questions related to the financial status, the option of 'prefer not to say' was not included in the analysis.

For logistic regression modelling, only categorical predictors that met the Chi-squared test assumptions were used. Univariate binary logistic regression models were used to determine the risk factors of being food insecure in domestic and international students, respectively. A multivariable binary logistic regression model was built using a forward stepwise approach. The final model was used to determine the odds of experiencing food insecurity among international students compared with domestic students. Financial income was considered as a confounder a priori and tested, and the percent change in regression estimates for domestic versus international students was calculated for the final model with and without 'weekly financial income'. The results of logistic regression models were reported as odds ratios (OR) with 95% confidence intervals (CI), with p values < 0.05 considered statistically significant. The goodness of fit test was used to check the model fit, and residual plots (e.g., residuals versus predicted values, and standardised Pearson residuals versus leverage) were used for checking the presence of outliers. All statistical analysis was performed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, US).

A thematic analysis was conducted to summarise the comments on food security from the final open-ended question. Inductive coding was employed for the development of themes, i.e., the themes were derived from the collected data. Representative quotations were selected for each theme.

6.7 Results

Of 1325 students who were interested in this study, 991 students passed the eligibility check, and 469 respondents completed the survey (response rate of 47%). Two respondents were excluded from the analysis because their age was beyond our eligible range. Of 467 respondents included for data analysis, there were 376 domestic students (80.5%) and 91 international students (19.5%). Our sample was predominantly female (74.9%), undergraduate (73.0%), and full-time students (91.2%).

6.7.1 Prevalence of food insecurity

The prevalence of food insecurity assessed by the 18-item HFSSM was 13.0% (95% CI 3.6%–22.5%) and 18.7% (95% CI 0.2%–37.2%) in domestic and international students, respectively ($p = 0.165$). The proportion of high, marginal, low, and very low food security in each student group is shown in Table 6.1 and did not differ ($p = 0.280$). By using the single-item screening question, the percentage answering “Enough of the kinds of food we want to eat” was significantly lower among international students (57.1%) than domestic students (70.5%, $p = 0.042$).

Table 6.1. The food security status in all, domestic, and international students attending an Australian university.

Food security status	All students (n = 467), n (%)	Domestic students (n = 376), n (%)	International students (n = 91), n (%)
High food security	339 (72.6)	280 (74.5)	59 (64.8)
Marginal food security	62 (13.3)	47 (12.5)	15 (16.5)
Low food security	39 (8.4)	28 (7.4)	11 (12.1)
Very low food security	27 (5.8)	21 (5.6)	6 (6.6)

6.7.2 Sociodemographic factors

Sociodemographic characteristics are shown in Table 6.2 by food security status in domestic and international students. In univariate logistic regression models, the following predictors were significant. For domestic students, four factors were significantly associated with their food security status. Firstly, undergraduate students had higher odds of being food insecure (OR = 2.93, 95% CI 1.21–7.12, $p = 0.017$) than postgraduate students. Secondly, compared with students in the second or third year, first-year students (OR = 2.48, 95% CI 1.21–5.06, $p = 0.013$) and students in the fourth year or above of their degree (OR = 3.83, 95% CI 1.48–9.88, $p = 0.006$) were more likely to experience food insecurity. Thirdly, domestic students living in accommodations other than the parental home had an elevated risk of food insecurity (OR = 3.86, 95% CI 2.02–7.37, $p < 0.001$) compared with those living in their parental homes. Lastly, domestic students who lost employment income due to the COVID-19 pandemic were more likely to be food insecure (OR = 2.68, 95% CI 1.40–5.13, $p = 0.003$) than those who did not experience the loss. For international students, only one sociodemographic factor was significantly associated with their food security status in our sample. International students who experienced living arrangement changes due to the pandemic had an increased risk of food insecurity (OR = 3.50, 95% CI 1.15–10.59, $p = 0.027$) compared with those without changes. From responses to an open-ended question about the experience of changing living arrangements due to the pandemic, it was common for domestic students to move back to their

parental homes, and moving to less expensive premises was reported in both domestic and international students.

When comparing the characteristics of food-insecure students between domestic and international students, the proportion experiencing living arrangement changes due to the pandemic was significantly higher ($p < 0.001$) in food-insecure international students than domestic students. None of the food-insecure international students received any financial support from the government during the pandemic, compared with 57% of food-insecure domestic students.

The final multivariable binary logistic regression model included three predictors, i.e., domestic or international students, academic degree, and financial income. After adjusting for the academic degree and financial income, international students had a higher risk of experiencing food insecurity (OR = 2.02, 95% CI 1.01–4.07, $p = 0.049$) than domestic students (see Table 6.3). Weekly financial income from employment and other sources was included in this logistic regression model irrespectively of its p value ($p = 0.128$) because its inclusion substantially changed the regression estimates. The goodness of fit test showed strong evidence ($p = 0.019$) that this final model outperformed the null model (i.e., the model without any predictors). There was no presence of outliers after checking residual plots.

Table 6.2. Sociodemographic characteristics by food security status in the sample of domestic and international students attending an Australian university.^a

Sociodemographic characteristics	All students (n = 467), n (%)	Domestic students		p value	International students		p value
		Food secure (n = 327), n (%)	Food insecure (n = 49), n (%)		Food secure (n = 74), n (%)	Food insecure (n = 17), n (%)	
Age (years, mean ± SD)	21.4 ± 3.3	21.3 ± 3.4	21.6 ± 3.5	0.584 ^b	21.5 ± 3.3	21.6 ± 2.4	0.382 ^b
Gender							
Female	350 (74.9)	248 (75.8)	39 (79.6)	0.821 ^c	50 (67.6)	13 (76.5)	0.813 ^d
Male	109 (23.3)	73 (22.3)	9 (18.4)		23 (31.1)	4 (23.5)	
Other	8 (1.7)	6 (1.8)	1 (2.0)		1 (1.4)	0 (0.0)	
Aboriginal or Torres Strait Islander origin (domestic students only, n = 376)							
No	371 (98.7)	324 (99.1)	47 (95.9)	0.129 ^d	NA ^e	NA	NA
Yes	5 (1.3)	3 (0.9)	2 (4.1)		NA	NA	NA
Length of stay in Australia (international students only, n= 91)							
2 years or less	43 (47.3)	NA	NA	NA	37 (50.0)	6 (35.3)	0.273 ^c
More than 2 years	48 (52.7)	NA	NA	NA	37 (50.0)	11 (64.7)	
Country of origin (international students only, n= 91)							
China	40 (44.0)	NA	NA	NA	30 (40.5)	10 (58.8)	0.171 ^c
Other	51 (56.0)	NA	NA	NA	44 (59.5)	7 (41.2)	
Enrolment status							
Full time student	426 (91.2)	291 (89.0)	44 (89.8)	0.866 ^c	74 (100.0)	17 (100.0)	NA
Part time student	41 (8.8)	36 (11.0)	5 (10.2)		0 (0.0)	0 (0.0)	
Current academic degree							
Undergraduate	341 (73.0)	232 (70.9)	43 (87.8)	0.013 ^c	55 (74.3)	11 (64.7)	0.547 ^d
Postgraduate	126 (27.0)	95 (29.1)	6 (12.2)		19 (25.7)	6 (35.3)	

Sociodemographic characteristics (cont.)	All students (n = 467), n (%)	Domestic students		p value	International students		p value
		Food secure (n = 327), n (%)	Food insecure (n = 49), n (%)		Food secure (n = 74), n (%)	Food insecure (n = 17), n (%)	
Year of current degree							
First	216 (46.3)	144 (44.0)	28 (57.1)	0.019 ^c	36 (48.6)	8 (47.1)	0.384 ^d
Second	126 (27.0)	88 (26.9)	7 (14.3)		24 (32.4)	7 (41.2)	
Third	84 (18.0)	65 (19.9)	5 (10.2)		13 (17.6)	1 (5.9)	
Four or above	41 (8.8)	30 (9.2)	9 (18.4)		1 (1.4)	1 (5.9)	
Marital status							
Never married	430 (92.1)	297 (90.8)	47 (95.9)	0.406 ^d	71 (95.9)	15 (88.2)	0.233 ^d
Married or other	37 (7.9)	30 (9.2)	2 (4.1)		3 (4.1)	2 (11.8)	
Dependent children							
No	465 (99.6)	325 (99.4)	49 (100.0)	1.000 ^d	74 (100.0)	17 (100.0)	NA
Yes	2 (0.4)	2 (0.6)	0 (0.0)		0 (0.0)	0 (0.0)	
Current accommodation							
On campus accommodation	42 (9.0)	21 (6.4)	7 (14.3)	< 0.001 ^d	12 (16.2)	2 (11.8)	1.000 ^d
Parental home	227 (48.6)	206 (63.0)	15 (30.6)		5 (6.8)	1 (5.9)	
Renting accommodation	168 (36.0)	80 (24.5)	24 (49.0)		51 (68.9)	13 (76.5)	
Other	30 (6.4)	20 (6.1)	3 (6.1)		6 (8.1)	1 (5.9)	
Living with ^f							
Parents	225 (48.2)	202 (61.8)	16 (32.7)	NA	7 (9.5)	0 (0.0)	NA
Other family members	168 (36.0)	136 (41.6)	14 (28.6)		15 (20.3)	3 (17.6)	
Friends/roommates	120 (25.7)	71 (21.7)	20 (40.8)		24 (32.4)	5 (29.4)	
Alone	64 (13.7)	17 (5.2)	8 (16.3)		30 (40.5)	9 (52.9)	
Other	32 (6.9)	22 (6.7)	7 (14.3)		2 (2.7)	1 (5.9)	
Employment status							
No employment	154 (33.0)	80 (24.5)	14 (28.6)	0.536 ^c	48 (64.9)	12 (70.6)	0.653 ^c
Employed	313 (67.0)	247 (75.5)	35 (71.4)		26 (35.1)	5 (29.4)	
Weekly working hours (employed students only, n = 313)							
Less than 20 hours	227 (72.5)	176 (71.3)	27 (77.1)	0.468 ^c	22 (84.6)	2 (40.0)	0.062 ^d
20 hours or more	86 (27.5)	71 (28.7)	8 (22.9)		4 (15.4)	3 (60.0)	

Sociodemographic characteristics (cont.)	All students (n = 467), n (%)	Domestic students		p value	International students		p value
		Food secure (n = 327), n (%)	Food insecure (n = 49), n (%)		Food secure (n = 74), n (%)	Food insecure (n = 17), n (%)	
Sources of financial support ^f							
Parents	281 (60.2)	188 (57.5)	13 (26.5)	NA	65 (87.8)	15 (88.2)	NA
Employment salary	237 (50.7)	184 (56.3)	27 (55.1)		22 (29.7)	4 (23.5)	
Scholarships	54 (11.6)	35 (10.7)	6 (12.2)		12 (16.2)	1 (5.9)	
Loans	31 (6.6)	21 (6.4)	7 (14.3)		3 (4.1)	0 (0.0)	
Other	88 (18.8)	68 (20.8)	14 (28.6)		5 (6.8)	1 (5.9)	
Not receiving financial support	36 (7.7)	28 (8.6)	7 (14.3)		0 (0.0)	1 (5.9)	
Weekly financial income (include employment and/or other income) (n = 420) ^g							
\$500 or less	279 (66.4)	205 (65.3)	28 (63.6)	0.830 ^c	38 (77.6)	8 (61.5)	0.291 ^d
More than \$500	141 (33.6)	109 (34.7)	16 (36.4)		11 (22.4)	5 (38.5)	
<i>Changes caused by COVID-19</i>							
Living arrangement (e.g., moved to less expensive premises) ^h							
No	416 (89.1)	304 (93.0)	44 (89.8)	0.389 ^d	59 (79.7)	9 (52.9)	0.031 ^d
Yes	51 (10.9)	23 (7.0)	5 (10.2)		15 (20.3)	8 (47.1)	
Job changes (e.g., lost your employment or worked less hours)							
No	274 (58.7)	182 (55.7)	20 (40.8)	0.052 ^c	59 (79.7)	13 (76.5)	0.748 ^d
Yes	193 (41.3)	145 (44.3)	29 (59.2)		15 (20.3)	4 (23.5)	
Employment income decreased (n = 427) ^g							
No	288 (67.4)	208 (68.0)	19 (44.2)	0.002 ^c	52 (82.5)	9 (60.0)	0.081 ^d
Yes	139 (32.6)	98 (32.0)	24 (55.8)		11 (17.5)	6 (40.0)	
Experienced any difficulties in finding jobs							
No	326 (69.8)	236 (72.2)	29 (59.2)	0.063 ^c	52 (70.3)	9 (52.9)	0.170 ^c
Yes	141 (30.2)	91 (27.8)	20 (40.8)		22 (29.7)	8 (47.1)	
Received any government support payment (n = 451) ^g							
No	266 (59.0)	172 (54.6)	20 (42.6)	0.123 ^c	57 (79.2)	17 (100.0)	0.065 ^d
Yes	185 (41.0)	143 (45.4)	27 (57.4)		15 (20.8)	0 (0.0)	

Sociodemographic characteristics (cont.)	All students (n = 467), n (%)	Domestic students		p value	International students		p value
		Food secure (n = 327), n (%)	Food insecure (n = 49), n (%)		Food secure (n = 74), n (%)	Food insecure (n = 17), n (%)	
Received any support payment from other sources (n = 449) [§]							
No	424 (94.4)	305 (95.9)	42 (91.3)	0.249 ^d	61 (89.7)	16 (94.1)	1.000 ^d
Yes	25 (5.6)	13 (4.1)	4 (8.7)		7 (10.3)	1 (5.9)	

^ap < 0.001 was considered statistically significant as the Bonferroni correction was applied for multiple comparisons; ^bp value based on Mann-Whitney U test; ^cp value based on Chi-squared test; ^dp value based on Fisher's exact test; ^eNA = not applicable; ^fa multiple-response question; [§]For questions related to the financial status, the option of 'prefer not to say' was not included in the analysis. The number of students answering 'prefer not to say' in these questions are listed here: weekly financial income (n=47), employment income decreased (n=40), received any government support payment (n=16), received any support payment from other sources (n=18); ^hfollowed by an open-ended question for respondents to type their changes in living arrangements caused by the COVID-19 pandemic.

Table 6.3. Results of the final multivariable binary logistic regression model to assess the association of food security status with sociodemographic characteristics in a sample of Australian university students (n = 467).^a

Variable	Category	Adjusted Odds Ratio	95% CI	P value
Domestic or international	Domestic (reference)	1.00		
	International	2.02	1.01, 4.07	0.049
Academic degree	Postgraduate (reference)	1.00		
	Undergraduate	2.60	1.18, 5.74	0.018
Weekly financial income	\$500 or less (reference)	1.00		
	>\$500	1.62	0.87, 3.03	0.128

^aAdjusted for each variable in the model.

6.7.3 Dietary factors and outcomes

Diet-related factors and outcomes are shown by food security status among domestic and international students in Table 6.4. For domestic students, cooking self-efficacy and the proportion of students meeting recommendations for fruit intake were significantly lower in food-insecure students. For international students, the provision of meals in accommodation other than their own home (e.g., residential colleges and homestay) were associated with higher odds of food insecurity (OR = 4.55, 95% CI 1.18–17.53, p = 0.028) than those living in accommodations without provided meals.

6.7.4 Health and academic outcomes

Physical and mental health, and academic outcomes are shown by food security status among domestic and international students in Table 6.4. The mean score of the Well-Being Index in both domestic and international students with food insecurity was below 13, indicating poor wellbeing. Both food-insecure domestic (OR = 1.94, 95% CI 1.06–3.57, p = 0.032) and international students (OR = 2.98, 95% CI 1.01–8.78, p = 0.048) were more likely to experience poor wellbeing than their food-secure peers. The impacts of food security status on class

attendance, academic performance, and withdrawal from courses were reflected by domestic students.

6.7.5 Coping strategies

To cope with food insecurity, it was common for both domestic and international students to purchase cheaper and less ideal options (e.g., substitute traditional ingredients), have less healthy meals, and save meals for later (Table 6.5). All food-insecure international students had experience in purchasing cheaper or processed foods. Among food-insecure students, the percentage of students that obtained food assistance was significantly higher in international students (64.7%) than in domestic students (16.3%, $p < 0.001$). In addition, having two main meals only was reported by an international student, and bin diving (i.e., finding food items from dumpsters) was reported by a domestic student among respondents who specified their own coping strategies.

Table 6.4. Dietary factors and health/academic outcomes by food security status in domestic and international students attending an Australian university.^a

Dietary factors and health/academic outcomes	All students (n = 467), n (%)	Domestic students		p value	International students		p value
		Food secure (n = 327), n (%)	Food insecure (n = 49), n (%)		Food secure (n = 74), n (%)	Food insecure (n = 17), n (%)	
<i>Dietary factors and outcomes</i>							
Does your accommodation provide meals? (n = 221) ^b							
No	188 (85.1)	87 (81.3)	30 (93.8)	0.091 ^c	60 (90.9)	11 (68.8)	0.034 ^d
Yes	33 (14.9)	20 (18.7)	2 (6.3)		6 (9.1)	5 (31.3)	
Are you aware of any food relief programs that are available to you?							
No	289 (61.9)	199 (60.9)	34 (69.4)	0.251 ^c	51 (68.9)	5 (29.4)	0.003 ^c
Yes	178 (38.1)	128 (39.1)	15 (30.6)		23 (31.1)	12 (70.6)	
Weekly food budget							
\$0-30	52 (11.1)	41 (12.5)	6 (12.2)	0.158 ^c	3 (4.1)	2 (11.8)	0.347 ^d
\$31-60	127 (27.2)	91 (27.8)	13 (26.5)		18 (24.3)	5 (29.4)	
\$61-100	215 (46.0)	146 (44.6)	28 (57.1)		33 (44.6)	8 (47.1)	
> \$100	73 (15.6)	49 (15.0)	2 (4.1)		20 (27.0)	2 (11.8)	
Adequacy of cooking facilities							
Adequate	405 (86.7)	302 (92.4)	41 (83.7)	0.057 ^d	52 (70.3)	10 (58.8)	0.361 ^c
Inadequate	62 (13.3)	25 (7.6)	8 (16.3)		22 (29.7)	7 (41.2)	
Self-perceived cooking skills							
Excellent	99 (21.2)	74 (22.6)	11 (22.4)	0.592 ^c	12 (16.2)	2 (11.8)	0.307 ^d
Good	208 (44.5)	144 (44.0)	18 (36.7)		34 (45.9)	12 (70.6)	
Fair	117 (25.1)	80 (24.5)	13 (26.5)		22 (29.7)	2 (11.8)	
Poor	43 (9.2)	29 (8.9)	7 (14.3)		6 (8.1)	1 (5.9)	
Cooking self-efficacy (mean ± SD)	15.20 ± 3.43	15.68 ± 3.43	13.90 ± 3.09	< 0.001 ^e	14.39 ± 3.18	13.35 ± 3.48	0.348 ^e
Cooking frequency							
3 days/week or less	262 (56.1)	199 (60.9)	28 (57.1)	0.620 ^c	28 (37.8)	7 (41.2)	0.799 ^c
4+ days/week	205 (43.9)	128 (39.1)	21 (42.9)		46 (62.2)	10 (58.8)	

Dietary factors and health/academic outcomes (cont.)	All students (n = 467), n (%)	Domestic students		p value	International students		p value
		Food secure (n = 327), n (%)	Food insecure (n = 49), n (%)		Food secure (n = 74), n (%)	Food insecure (n = 17), n (%)	
Eating out frequency							
3 days/week or less	421 (90.1)	304 (93.0)	44 (89.8)	0.389 ^d	59 (79.7)	14 (82.4)	1.000 ^d
4+ days/week	46 (9.9)	23 (7.0)	5 (10.2)		15 (20.3)	3 (17.6)	
Vegetable intake							
Less than 5 serves	415 (88.9)	282 (86.2)	49 (100.0)	0.006 ^c	68 (91.9)	16 (94.1)	1.000 ^d
5 serves or more	52 (11.1)	45 (13.8)	0 (0.0)		6 (8.1)	1 (5.9)	
Fruit intake							
Less than 2 serves	260 (55.7)	158 (48.3)	38 (77.6)	< 0.001 ^c	50 (67.6)	14 (82.4)	0.229 ^c
2 serves or more	207 (44.3)	169 (51.7)	11 (22.4)		24 (32.4)	3 (17.6)	
Health outcomes							
Self-perceived physical health status							
Excellent	59 (12.6)	46 (14.1)	2 (4.1)	0.006 ^c	8 (10.8)	3 (17.6)	0.332 ^d
Good	208 (44.5)	148 (45.3)	17 (34.7)		38 (51.4)	5 (29.4)	
Fair	161 (34.5)	111 (33.9)	21 (42.9)		22 (29.7)	7 (41.2)	
Poor or very poor	39 (8.4)	22 (6.7)	9 (18.4)		6 (8.1)	2 (11.8)	
BMI (mean ± SD)	22.35 ± 4.08	22.56 ± 4.19	22.11 ± 2.85	0.921 ^e	22.09 ± 4.33	19.87 ± 2.96	0.109 ^e
BMI category							
Underweight	50 (11.2)	32 (10.1)	5 (10.9)	0.460 ^c	9 (13.2)	4 (25.0)	0.131 ^d
Normal weight	312 (70.0)	218 (69.0)	35 (76.1)		47 (69.1)	12 (75.0)	
Overweight or obese	84 (18.8)	66 (20.9)	6 (13.0)		12 (17.6)	0 (0.0)	
Self-perceived mental health status							
Excellent	43 (9.2)	32 (9.8)	2 (4.1)	0.007 ^c	8 (10.8)	1 (5.9)	0.061 ^d
Good	154 (33.0)	107 (32.7)	12 (24.5)		32 (43.2)	3 (17.6)	
Fair	172 (36.8)	120 (36.7)	14 (28.6)		29 (39.2)	9 (52.9)	
Poor or very poor	98 (21.0)	68 (20.8)	21 (42.9)		5 (6.8)	4 (23.5)	
WHO-5 Well-Being Index (mean ± SD)	13.30 ± 5.05	13.51 ± 4.87	10.73 ± 5.28	0.001 ^e	14.43 ± 5.02	11.88 ± 5.70	0.069 ^f
WHO-5 Well-Being Index category							
Normal	272 (58.2)	194 (59.3)	21 (42.9)	0.030 ^c	50 (67.6)	7 (41.2)	0.043 ^c
Poor wellbeing (below 13)	195 (41.8)	133 (40.7)	28 (57.1)		24 (32.4)	10 (58.8)	

Dietary factors and health/academic outcomes (cont.)	All students (n = 467), n (%)	Domestic students		p value	International students		p value
		Food secure (n = 327), n (%)	Food insecure (n = 49), n (%)		Food secure (n = 74), n (%)	Food insecure (n = 17), n (%)	
<i>Does the sufficiency of the food you can get ever affect your study?</i>							
Class attendance							
Does not affect	310 (66.4)	244 (74.6)	20 (40.8)	< 0.001 ^c	41 (55.4)	5 (29.4)	0.053 ^c
Affects	157 (33.6)	83 (25.4)	29 (59.2)		33 (44.6)	12 (70.6)	
Academic performance							
Does not affect	227 (48.6)	182 (55.7)	12 (24.5)	< 0.001 ^c	31 (41.9)	2 (11.8)	0.020 ^c
Affects	240 (51.4)	145 (44.3)	37 (75.5)		43 (58.1)	15 (88.2)	
Withdrawal from courses							
Does not affect	397 (85.0)	292 (89.3)	34 (69.4)	< 0.001 ^c	59 (79.7)	12 (70.6)	0.516 ^d
Affects	70 (15.0)	35 (10.7)	15 (30.6)		15 (20.3)	5 (29.4)	

^ap < 0.001 was considered statistically significant as the Bonferroni correction was applied for multiple comparisons; ^bstudents living in accommodations other than the parental home and own property were asked to answer this question; ^cp value based on Chi-squared test; ^dp value based on Fisher's exact test; ^ep value based on Mann-Whitney U test; ^fp value based on independent sample t test.

Table 6.5. Coping strategies used by domestic and international university students when they were not able to obtain sufficient and appropriate food in Australia.

Coping strategies	All respondents			Food insecure respondents		
	Domestic students (n = 376), %	International students (n = 91), %	p value	Domestic students (n = 49), %	International students (n = 17), %	p value
Purchased cheap/discounted, processed food.	80.1	90.1	0.025 ^a	98.0	100.0	1.000 ^b
Ate less healthy meals to eat more food.	56.1	73.6	0.002 ^a	98.0	94.1	0.452 ^b
Saved food for later.	80.1	90.1	0.025 ^a	98.0	94.1	0.452 ^b
Substituted ideal (e.g., traditional) ingredients.	73.4	85.7	0.014 ^a	95.9	94.1	1.000 ^b
Stretched (i.e., spread out) food to make it last longer.	52.1	64.8	0.029 ^a	95.9	82.4	0.103 ^b
Shared food or groceries (e.g., with friends, roommates, or family members).	76.6	76.9	0.947 ^a	89.8	94.1	1.000 ^b
Sought employment or worked more hours.	55.3	51.6	0.528 ^a	93.9	82.4	0.172 ^b
Ate more than normal when food was plentiful.	66.5	76.9	0.054 ^a	91.8	88.2	0.643 ^b
Delayed or not buying academic supplies.	43.4	47.3	0.501 ^a	85.7	82.4	0.709 ^b
Used less or delayed paying utilities or services.	31.9	44.0	0.030 ^a	81.6	82.4	1.000 ^b
Attended events offering free food.	53.7	58.2	0.437 ^a	67.3	64.7	0.842 ^a
Borrowed money from family or friends, applied for loans, purchased food using credit card.	28.7	39.6	0.045 ^a	55.1	64.7	0.490 ^a
Obtained food from food bank or other food relief programs providing free or discounted food.	6.6	37.4	< 0.001 ^a	16.3	64.7	< 0.001 ^b
Other ^c	4.3	11.0	0.012 ^a	18.4	35.3	0.185 ^b

^ap value based on Chi-squared test; ^bp value based on Fisher's exact test; ^cfollowed by an open-ended question for respondents to type other coping strategies.

6.7.6 Additional comments on food security

In the final open-ended question of this survey, 35 respondents provided their comments on the survey and/or their food security status. Their comments on the food security status and associated factors were summarised into seven themes and selective quotations in each theme are shown in Table 6.6. The themes were centred on where the students lived (supporting the finding living with parents enabled food security), limited access to foods international students preferred, physical disability leading to food security risk, nutrition (healthfulness compromised), time and mental stresses (compromised food security), food assistance programs (awareness) and cost of food limiting amount and choice.

Table 6.6. Selected quotations from open-ended question on food security status of survey respondents attending an Australian university.

Themes	Quotations
Living alone or with parents	<i>The biggest issue for me is actually cooking for a single person, when most items in stores are cheaper to buy in bulk but this isn't really appropriate when you're cooking for one (25 years*, female, domestic)^a.</i> <i>My parents let me live at home rent free and provide all my meals as they can afford to do this! Not having to worry about such expenses means I can focus on my uni work and trying to eat more healthy (28 years, female, domestic).</i>
Food unavailability for international students	<i>My diet has radically changed when I first moved to Australia because of the unavailability of my usual cooking ingredients (spice, vegetables, I usually boil green veggies like cabbage, pak choy, etc.) so some of the greenery which I can easily find in Vietnam is more expensive and more difficult to find here in Australia. Therefore, I rely a lot on frozen veggies (which I consider not really the best choice) and I have noticed some kind of decline in my health namely I feel like I have more heat in my body than usual (18 years, female, international).</i>
Reduced food access caused by disabilities	<i>Although I have access to ingredients, I am disabled and it is very difficult for me to prepare my own food, so I often skip meals and/or eat unhealthily because of access issues (20 years, non-binary, domestic).</i>
Nutritional considerations	<i>I wouldn't say I often go hungry, but I defiantly do not eat nutritiously. For example, I eat 2 min noodles with a couple eggs for dinner or lunch almost every day because it's very cheap and filling. Or I eat a lot of veggies because they are the cheapest to buy and quickest to cook (25 years, female, domestic).</i>

Themes	Quotations
Nutritional considerations (cont.)	<p><i>Nutrition is very important to me, and I perceive myself to budget food appropriately. Habitually I eat at home and am confident cooking which is cheaper and healthier for me. When I have had limited finances, I have shared groceries and ate more basic food stuffs. I have never needed food bank or others (20 years, male, domestic).</i></p>
Time constraints and mental health affected food security status	<p><i>My study affects my food eating patterns due to stress and time restriction around meals periods. I eat less healthy foods and have to un-mindfully cram them down my throat. My appetite also gets suppressed and I'll miss meals entirely (23 years, male, domestic).</i></p> <p><i>On the other hand often time it is my uni program (MD) that prevents me from having 3 meals a day as classes are packed in so tightly and they make very little accommodation for travel between class venues (sometimes across the city to different hospitals) so that we have to skip lunch in order to commute (24 years, female, domestic).</i></p> <p><i>I am more awake & able to participate in classes after eating, but sometimes school and work are so busy I don't have time to cook or shop and I get tired (19 years, female, domestic).</i></p> <p><i>Food security isn't really an issue for me. However, my mental health and stress levels greatly impact my ability to abstain food for myself, prepare food and eat food. Often I find I haven't eaten for one or two days not because I can't afford food, or because food isn't there, but because food is too overwhelming (25 years, female, domestic).</i></p>
The use and awareness of food assistance services	<p><i>I actually liked the mention of the food banks as that enabled me to research into these corporations, as if I am eligible, this would greatly assist me (21 years, female, domestic).</i></p> <p><i>I think the information regarding food support for USYD international student is lack, they should've spread more about it (30 years, female, international).</i></p>
Cost of food and limiting food	<p><i>When things are cheaper even when I don't like it I buy it (21 years, female, domestic).</i></p> <p><i>Sometimes I find that I can't stay at uni and study for too long because I'm hungry and avoid packing heaps of food because I need it to last me longer at home (23 years, female, domestic).</i></p>

^aDemographic characteristics of the respondent (age, gender, domestic or international student).

6.8 Discussion

International students were twice as likely to experience food insecurity than domestic students during the COVID-19 pandemic. Undergraduates also had a higher risk of being food insecure, but this was only significant in domestic students. Undergraduate domestic students who left their parental home may be more vulnerable to food insecurity while they were still adjusting to the university life and independent living. International students left their home country and adapted to the new environment by themselves, and this may contribute to the higher risk of food insecurity regardless of being undergraduate or postgraduate students. Additional challenges in the inability to access and enjoy their preferred food in Australia and financial difficulties due to the pandemic likely compound the problem of food security. International students were more likely to use food assistance services as they experienced loss of casual employment and more food assistance programs were available for them during the pandemic.^{5,22,35} Also, academic stress and time pressure may lead to lower food security by being unable to access and prepare food, as commented upon by our respondents. Negative impacts of food insecurity on dietary outcomes were reported by domestic students. Poor wellbeing was found in both domestic and international students with food insecurity.

Findings from previous studies that measured differences in the risk of food insecurity between domestic and international students on campus were mixed. Similar to our findings, Blundell et al. and Soldavini et al. reported a higher risk of food insecurity in international students compared with domestic students assessed using the 10-item food security assessment tool in Canada and the US.^{14,20} However, no significant differences were reported between domestic and international students from two previous Australian studies conducted in Queensland pre-COVID in 2011 and 2014.^{36,37} One of them used the 18-item assessment tool, and the other one used both single- and multi-item tools to measure food security status among university students.^{36,37} Similar to our findings, another two more recent Australian studies

conducted in Tasmania in March 2020 (prior to the COVID-19 pandemic in Australia) and March 2022 (during the pandemic) reported a higher risk of food insecurity in international students than domestic students.^{38,39} One of them used the 6-item short form USDA Food Security Survey Module,³⁸ and the other one used a single-item measure.³⁹ The differences in the cost of living over the years between cities in different states may contribute to the differences observed in food security status because Sydney is the most expensive city to live in Australia.⁴⁰ The prevalence of household food insecurity was about 4% in Australia assessed by using a single-item question in the 2011–12 Australian Health Survey,³ but there have been no further updates on the national data since then. The affirmative response to the question “In the last 12 months, were there any times that you ran out of food and couldn’t afford to buy any more?” was classified to be food insecure.⁴¹ The single-item measure may underestimate the prevalence of food insecurity and this question does not encompass the additional dimension of whether people had access to nutritious foods and the food they preferred.⁴²

A few sociodemographic factors were found to be associated with food insecurity among domestic students but not international students in this study. Some previous studies in the US have analysed the differences in the risk factors of food insecurity between undergraduate and postgraduate students,^{14,43} but none disaggregated between domestic and international students. Undergraduate students were commonly found to be more vulnerable to food insecurity than postgraduate students among tertiary education students overall, and this was similar to our findings in domestic students.^{12,14,43} A higher risk of food insecurity has been detected in freshmen from the US,⁴⁴ however, Reynolds et al. reported an increased risk in students in higher years.¹³ In our domestic students, both first-year students and students in the fourth year or above were more likely to be food insecure than students in other years. Most food insecure domestic students in the first year and the fourth year or above were undergraduates. It is

hypothesised that this may be because first-year undergraduate students may have not yet adapted to independent living,¹² while undergraduates in Honours degrees may be preoccupied with research and have less time for food matters. Postgraduate students may have more experience in living independently and increased abilities to earn more income from employments requiring higher-level skills.¹² Previous research in another Australian university showed Aboriginal and Torres Strait Island students were more likely to be food insecure,¹² but the sample of students was too small in this study to make a judgement. The positive association between lower income and food insecurity has been previously reported among university students,³⁶ but in the current study we found a greater odds of being food insecure in students with higher income albeit the association was not statistically significant. This might be explained by the high proportion of domestic students living with parents as these students may be supported financially and do not pay for all their food and other living expenses.

The COVID-19 pandemic has exacerbated challenges for tertiary education students, including food insecurity.⁴⁵ In our sample, financial difficulties during the pandemic were associated with food insecurity, including changes in living arrangements such as moving to less expensive premises among international students, and the loss of income among domestic students. Similar findings were reported by tertiary education students in the US.^{45,46} Owens et al. found those students who experienced changes in living arrangements and negative changes in income were more likely to be food insecure during the pandemic.⁴⁶ Soldavini et al. reported the loss of employment as a risk factor and moving home to live with families as a protective factor for food insecurity among tertiary education students at the early stage of the pandemic.⁴⁵

Several dietary factors and outcomes were found to be associated with food insecurity in tertiary education students in this study. In domestic students, lower cooking self-efficacy was

reported by food-insecure students compared with food-secure ones. This was consistent with a previous study conducted in a Southeastern US university, which also found lower cooking self-efficacy scores in students with very low food security.²⁹ The quality of meals prepared by local accommodation appeared to be problematic in our study. International students living in accommodations that provided meals were more food insecure than those without provided meals, but this association was not found in domestic students. The unavailability of familiar ingredients in Australia was mentioned by one of our international students. Meals prepared by local accommodations may not be customised to meet the food preferences of international students.

Substituting ideal or traditional ingredients was commonly used as a coping strategy among our international students. To cope with the insufficiency of food, buying cheaper alternatives and sacrificing nutritional quality were prevalent in both our study and other studies in tertiary education students.^{18,19} As a result, for our domestic students, it was harder for the food-insecure to meet the recommendation for daily fruit intake from the Australian Dietary Guidelines compared with food-secure ones.²⁸ Lower consumption of healthy foods was frequently reported among food-insecure students previously.⁴⁷

The association between food insecurity and poorer physical and mental health has been frequently reported by other studies in tertiary education students.^{16,31} Poor wellbeing was found in our food-insecure domestic and international students. The mean scores of Well-Being Index in our food-secure students were barely above the clinical cut off. The mental health problems among general tertiary education students may be worsened by the COVID-19 pandemic and another study has reported the high and increased prevalence of mental health issues in this group.⁴⁸ El Zein et al. found a greater odds of obesity in food-insecure students

from universities in the US,⁴⁹ but this was not reflected in our sample. The sufficiency of food negatively impacted academic outcomes in our domestic students. However, this was not reported by our international students as their main purpose of coming to Australia was to complete their tertiary education and the class attendance was required by the student visa.⁵⁰ Negative academic outcomes, such as lower grade point averages, were found to be associated with food insecurity in other studies conducted among tertiary education students and this association might be mediated by mental health.^{17,51} Some of our respondents stated that stress and tight academic schedules negatively affected their food choices and meal regularity (e.g., less healthy choices and skipping meals) as they had insufficient time and were too overwhelmed to take care of their nutrition. A higher rate of food insecurity has been reported during final assessment periods, a time of intense study and stress, compared with the beginning of a semester from a longitudinal study in US freshmen.⁵²

Food-insecure international students were more likely to use food relief services than domestic students in this study. Previous research indicated that tertiary education students often lacked awareness of available food assistance programs and the rate of utilisation was low,⁵³ but more than 70% of our international students with food insecurity were aware of these services and 65% used them. Although the financial support from the Australian government due to the COVID-19 pandemic was limited and international students mostly ineligible, an increased number of food relief programs were operated by charitable organisations (e.g., OzHarvest and Foodbank Australia) for international students to cope with food insecurity during the pandemic.²² The annual report from Foodbank Australia found an increased number of international students seeking food assistance during the COVID-19 pandemic.²²

One of the strengths of this study was to examine the differences in the risk factors and impacts of food insecurity between international and domestic students. There are some limitations in this study. The survey was conducted in a single university in Sydney, the largest city and with the highest cost of living in Australia, and had a smaller number of international students than might be expected due to the pandemic, and female students were overly represented in this study as frequently occurs in studies concerning food and nutrition content.⁵⁴ Compared with the national data on tertiary education students in Australia in 2020,⁵⁵ our sample had a larger proportion of female (74.9% in our sample vs 56.4% in the national data) and undergraduate (73.0% vs 66.4%) students, and a smaller proportion of international (19.5% vs 30.1%) and part-time students (8.8% vs 30.3%). Students older than 30 years were not included in this study. Therefore, the results from this study might not be generalisable to all tertiary education students in Australia. The number of students replying to the open-ended question was less than 1% and fewer in international students but the qualitative data adds to the interpretation of the quantitative data. The answers from respondents may be affected by different understanding and interpretations of survey questions. Students experiencing food insecurity may be more likely to respond to this survey, which may cause the overestimation of the actual prevalence of food insecurity. On the other hand, the prevalence may be underestimated due to the stigma to admit the insufficiency of food, especially for international students.

6.8.1 Implications

The prevalence and negative impacts of food insecurity among both domestic and international tertiary education students in Australia necessitates the tertiary education sector should be more aware of this public health issue. The information on available food assistance services and other methods to seek help should be widely promoted to increase awareness among all students, e.g., through orientations, online teaching systems, and newsletters. However, this

should be addressed in a more systematic manner so that charities should not need to play the major role. Tertiary institutions should take the responsibility to address students' financial difficulties in purchasing nutritious and preferred foods. The regular monitoring of the prevalence of food insecurity among domestic and international students may provide a guide to the necessary investment on this human rights issue. Better food environments on campus including student accommodation could help students have easier access to nutritious food that they enjoy and prefer especially when they experience stress and time pressure during their studies. Food environment interventions may include providing subsidised meals in canteens on campus and a reasonable distribution of left over foods in food outlets and student accommodations.⁵⁶ For future research, a more diverse sample of international students from multiple universities might be needed to detect further impacts of food insecurity in these students and differences compared with their domestic peers. Future comparisons between campuses in areas with different socioeconomic status may contribute to a more complete picture of food insecurity among tertiary education students on a national scale. This research has been conducted during the COVID-19 pandemic using a cross-sectional study design so we have no comparison with a pre-COVID period and cannot predict how this will change in the new "COVID normal". It might be expected that as employment of international students resumes the impacts may lessen from a financial aspect, but this is not the entire solution as can be seen in the results we present with preferences needing to be addressed.

6.9 Conclusions

International students have a higher risk of experiencing food insecurity than domestic students attending an Australian university during the COVID-19 pandemic. Different risk factors for being food insecure were identified in these two student groups. For international students, living in a different food environment compared with their home country may contribute to being food insecure as their food preferences were more difficult to satisfy than domestic students. An association between food insecurity and poorer mental health outcomes was found in both domestic and international students. Reduced ability to consume healthy foods and regular meals when experiencing stress and time management issues should also be addressed. Future interventions to alleviate food insecurity should consider the difficulties for both domestic and international students. Mandatory policies to improve campus food environments, increasing specific financial support for food access, and wider dissemination of food-related knowledge such as information on sourcing foods, food relief programs, nutrition, building cooking skills and providing recipes could help address these inequities.

6.10 References

1. Pollard CM, Booth S. Food insecurity and hunger in rich countries—it is time for action against inequality. *Int J Environ Res Public Health*. 2019;16(10):1804.
2. Food and Agriculture Organization of the United Nations (FAO). *The State of Food Insecurity in the World 2001*. FAO: Rome, Italy, 2002.
3. Australian Bureau of Statistics (2015) Australian Health Survey: nutrition - state and territory results. <https://www.abs.gov.au/statistics/health/health-conditions-and-risks/australian-health-survey-nutrition-state-and-territory-results/latest-release#key-findings> (accessed 31 July, 2022).
4. Australian Bureau of Statistics (2015) 4727.0.55.005 - Australian Aboriginal and Torres Strait Islander Health Survey: nutrition results - food and nutrients, 2012-13. <https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4727.0.55.005~2012-13~Main%20Features~Food%20Security~36> (accessed 31 July, 2022).
5. Louie S, Shi Y, Allman-Farinelli M. The effects of the COVID-19 pandemic on food security in Australia: a scoping review. *Nutr Diet*. 2022;79(1):28-47.
6. Fitzpatrick KM, Harris C, Drawve G, Willis DE. Assessing food insecurity among US adults during the COVID-19 pandemic. *J Hunger Environ Nutr*. 2021;16(1):1-18.
7. Idzerda L, Gariépy G, Corrin T, Tarasuk V, McIntyre L, Neil-Sztramko S, et al. What is known about the prevalence of household food insecurity in Canada during the COVID-19 pandemic: a systematic review. *Health Promot Chronic Dis Prev Can*. 2022;42(5):177-187.
8. Australian Bureau of Statistics (2022) Effects of COVID-19 strains on the Australian economy. <https://www.abs.gov.au/articles/effects-covid-19-strains-australian-economy> (accessed 31 July, 2022).
9. Department of Education and Department of Employment and Workplace Relations, Australian Government (2021) Borders set to reopen to international students. <https://www.dese.gov.au/covid-19/announcements/borders-set-reopen-international-students> (accessed 31 July, 2022).
10. Lee SD, Hanbazaza M, Ball GDC, Farmer A, Maximova K, Willows ND. Food insecurity among postsecondary students in developed countries. *Br Food J*. 2018;120(11):2660-2680.
11. Olfert MD, Hagedorn-Hatfield RL, Houghtaling B, Esquivel MK, Hood LB, MacNeill L, et al. Struggling with the basics: food and housing insecurity among college students across twenty-two colleges and universities. *J Am Coll Health*. 2021; <https://doi.org/10.1080/07448481.2021.1978456>.
12. Whatnall MC, Hutchesson MJ, Patterson AJ. Predictors of food insecurity among Australian university students: a cross-sectional study. *Int J Environ Res Public Health*. 2019;17(1):60.
13. Reynolds E, Johnson C, Jamieson JA, Mawhinney H. Prevalence and correlates of food insecurity among students attending a small, rural Canadian university. *Can J Diet Pract Res*. 2018;79(3):125-128.

14. Soldavini J, Berner M, Da Silva J. Rates of and characteristics associated with food insecurity differ among undergraduate and graduate students at a large public university in the Southeast United States. *Prev Med Rep.* 2019;14:100836.
15. Coffino JA, Spoor SP, Drach RD, Hormes JM. Food insecurity among graduate students: prevalence and association with depression, anxiety and stress. *Public Health Nutr.* 2021;24(7):1889-1894.
16. Hagedorn RL, Olfert MD, MacNell L, Houghtaling B, Hood LB, Savoie Roskos MR, et al. College student sleep quality and mental and physical health are associated with food insecurity in a multi-campus study. *Public Health Nutr.* 2021;24(13):4305-4312.
17. Raskind IG, Haardörfer R, Berg CJ. Food insecurity, psychosocial health and academic performance among college and university students in Georgia, USA. *Public Health Nutr.* 2019;22(3):476-485.
18. Farahbakhsh J, Ball GD, Farmer AP, Maximova K, Hanbazaza M, Willows ND. How do student clients of a university-based food bank cope with food insecurity? *Can J Diet Pract Res.* 2015;76(4):200-203.
19. Waity JF, Huelskamp A, Russell J. Collaborating to assess and address food insecurity on a college campus: a case study at a mid-sized, regional university. *Innov High Educ.* 2020;45:405–417.
20. Blundell L, Mathews M, Bowley C, Roebbothan B. Determining student food insecurity at Memorial University of Newfoundland. *Can J Diet Pract Res.* 2019;80(1):14-21.
21. Olauson C, Engler-Stringer R, Vatanparast H, Hanoski R. Student food insecurity: examining barriers to higher education at the University of Saskatchewan. *J Hunger Environ Nutr.* 2018;13(1):19-27.
22. Foodbank Australia. *Foodbank hunger report 2020.* Foodbank Australia: Sydney, Australia, 2020.
23. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377-381.
24. Kohn MA, Senyak J (2021) Sample Size Calculators. University of California San Francisco (UCSF) Clinical and Translational Science Institute (CTSI); <https://sample-size.net/sample-size-proportions/> (accessed 25 March, 2023).
25. Economic Research Service, The United States Department of Agriculture (2020) U.S. Household Food Security Survey Module. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#household> (accessed 31 July, 2022).
26. Kent K, Murray S, Penrose B, Auckland S, Visentin D, Godrich S, et al. Prevalence and socio-demographic predictors of food insecurity in Australia during the COVID-19 pandemic. *Nutrients.* 2020;12(9):2682.
27. Australian Bureau of Statistics (2013) 4363.0.55.001 - National Nutrition and Physical Activity Survey Questionnaire. <https://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/734DF823586D5AD9CA25>

- [7B8E0014A387/\\$File/national%20nutrition%20and%20physical%20activity%20survey%202011-12%20questionnaire.pdf](#) (accessed 31 July, 2022).
28. National Health and Medical Research Council (2013) Australian Dietary Guidelines Summary. Canberra: National Health and Medical Research Council; https://www.eatforhealth.gov.au/sites/default/files/content/The%20Guidelines/n55a_australian_dietary_guidelines_summary_131014_1.pdf (accessed 31 July, 2022).
 29. Knol LL, Robb CA, McKinley EM, Wood M. Very low food security status is related to lower cooking self-efficacy and less frequent food preparation behaviors among college students. *J Nutr Educ Behav*. 2019;51(3):357-363.
 30. Weir CB, Jan A. BMI Classification Percentile And Cut Off Points. In: *StatPearls*. StatPearls Publishing, Treasure Island (FL), 2022.
 31. Becerra MB, Becerra BJ. Psychological distress among college students: role of food insecurity and other social determinants of mental health. *Int J Environ Res Public Health*. 2020;17(11):4118.
 32. Downs A, Boucher L, Campbell D, Polyakov A. Using the WHO–5 Well-Being Index to identify college students at risk for mental health problems. *J Coll Stud Dev*. 2017;58:113-117.
 33. Psychiatric Research Unit, WHO Collaborating Center for Mental Health (1998) WHO (Five) Well-Being Index (1998 version). <https://www.psykiatri-regionh.dk/who-5/Documents/WHO-5%20questionnaire%20-%20English.pdf> (accessed 31 July, 2022).
 34. Silva MR, Kleinert WL, Sheppard AV, Cantrell KA, Freeman-Coppadge DJ, Tsoy E, et al. The relationship between food security, housing stability, and school performance among college students in an urban university. *J Coll Stud Retent: Res Theory Pract*. 2017;19(3):284-299.
 35. Study NSW (2022) COVID-19 help hub for international students – food assistance. <https://www.study.sydney/programs/food-assistance> (accessed 31 July, 2022).
 36. Gallegos D, Ramsey R, Ong KW. Food insecurity: is it an issue among tertiary students? *High Educ*. 2014;67(5):497-510.
 37. Hughes R, Serebryanikova I, Donaldson K, Leveritt M. Student food insecurity: the skeleton in the university closet. *Nutr Diet*. 2011;68(1):27-32.
 38. Kent K, Visentin D, Peterson C, Ayre I, Elliott C, Primo C, et al. Severity of food insecurity among Australian university students, professional and academic staff. *Nutrients*. 2022;14(19):3956.
 39. Murray S, Peterson C, Primo C, Elliott C, Otlowski M, Auckland S, et al. Prevalence of food insecurity and satisfaction with on-campus food choices among Australian university students. *International Journal of Sustainability in Higher Education*. 2021;22(4):731-746.
 40. O'Hare M (2021) Sydney, Melbourne on list of the world's top 20 most expensive cities. <https://7news.com.au/business/money/sydney-melbourne-on-list-of-the-worlds-top-20-most-expensive-cities-c-4785041> (accessed 31 July, 2022).
 41. Australian Bureau of Statistics (2013) 4363.0.55.001 - Australian Health Survey: Users' Guide, 2011-13.

<https://www.abs.gov.au/ausstats/abs@.nsf/lookup/1F1C9AF1C156EA24CA257B8E001707B5?opendocument> (accessed 31 July, 2022).

42. McKechnie R, Turrell G, Giskes K, Gallegos D. Single-item measure of food insecurity used in the National Health Survey may underestimate prevalence in Australia. *Aust N Z J Public Health*. 2018;42(4):389-395.
43. Hiller MB, Winham DM, Knoblauch ST, Shelley MC. Food security characteristics vary for undergraduate and graduate students at a Midwest university. *Int J Environ Res Public Health*. 2021;18(11):5730.
44. Martinez SM, Webb K, Frongillo EA, Ritchie LD. Food insecurity in California's public university system: what are the risk factors? *J Hunger Environ Nutr*. 2018;13(1):1-18.
45. Soldavini J, Andrew H, Berner M. Characteristics associated with changes in food security status among college students during the COVID-19 pandemic. *Transl Behav Med*. 2021;11(2):295-304.
46. Owens MR, Brito-Silva F, Kirkland T, Moore CE, Davis KE, Patterson MA, et al. Prevalence and social determinants of food insecurity among college students during the COVID-19 pandemic. *Nutrients*. 2020;12(9):2515.
47. Shi Y, Davies A, Allman-Farinelli M. The association between food insecurity and dietary outcomes in university students: a systematic review. *J Acad Nutr Diet*. 2021;121(12):2475-2500.e2471.
48. Li Y, Wang A, Wu Y, Han N, Huang H. Impact of the COVID-19 pandemic on the mental health of college students: a systematic review and meta-analysis. *Front Psychol*. 2021;12:669119.
49. El Zein A, Colby SE, Zhou W, Shelnett KP, Greene GW, Horacek TM, et al. Food insecurity is associated with increased risk of obesity in US college students. *Curr Dev Nutr*. 2020;4(8):nzaa120.
50. Department of Education and Training, Australian Government (2018) Standard 8: Overseas student visa requirements. <https://internationaleducation.gov.au/regulatory-information/Documents/National%20Code%202018%20Factsheets/Standard%208.pdf> (accessed 31 July, 2022).
51. Marmolejo C, Banta JE, Siapco G, Baba Djara M. Examining the association of student mental health and food security with college GPA. *J Am Coll Health*. 2022; <https://doi.org/10.1080/07448481.2022.2058327>.
52. Bruening M, van Woerden I, Todd M, Laska MN. Hungry to learn: the prevalence and effects of food insecurity on health behaviors and outcomes over time among a diverse sample of university freshmen. *Int J Behav Nutr Phys Act*. 2018;15(1):9.
53. Buch K, Langley S, Johnson T, Coleman N. A university-community partnership to combat food insecurity among college students. *Partnerships : A Journal of Service-Learning and Civic Engagement*. 2016;7:16-26.
54. Thorpe MG, Kestin M, Riddell LJ, Keast RSJ, McNaughton SA. Diet quality in young adults and its association with food-related behaviours. *Public Health Nutr*. 2014;17(8):1767-1775.
55. Department of Education and Department of Employment and Workplace Relations, Australian Government (2022) 2020 Student summary tables.

<https://www.dese.gov.au/higher-education-statistics/resources/2020-student-summary-tables> (accessed 31 July, 2022).

56. Jeffrey C, Dyson J, Scrinis G. Hunger for change: student food insecurity in Australia. *Geoforum*. 2022;136:186-193.

6.11 Conclusion to chapter

Our survey found that international students had a higher risk of experiencing food insecurity in Australia. Negative impacts of food insecurity on mental health were reported in both domestic and international students, and food-insecure domestic students also reported negative dietary and academic outcomes. The following chapter (**Chapter Seven**) will assess the diet quality in these two student groups and investigate the association between diet quality and food insecurity.

Chapter Seven. Diet quality among students attending an Australian university is compromised by food insecurity and less frequent intake of home-cooked meals: a cross-sectional survey using the validated Healthy Eating Index for Australian Adults (HEIFA-2013)

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7.1 Publication details

This chapter presents the manuscript entitled “Diet quality among students attending an Australian university is compromised by food insecurity and less frequent intake of home cooked meals. A cross-sectional survey using the validated Healthy Eating Index for Australian Adults (HEIFA-2013)” published in *Nutrients*, 2022, Volume 14, Issue 21: 4522, doi: 10.3390/nu14214522. The manuscript is presented in the journal format.

7.2 Author contribution

I Yumeng Shi (the candidate) was the primary researcher involved in the study design and data collection and analysis. Dr Amanda Grech contributed to data analysis. Professor Margaret Allman-Farinelli contributed to the study design, data collection and analysis. I wrote the first draft of this manuscript for publication, and all authors reviewed and revised the manuscript draft.

7.3 Introduction to chapter



This chapter includes a dietary assessment sub-study of the food security survey in the last chapter (**Chapter Six**). The overall diet quality of domestic and international students attending an Australian university was measured and compared. The association between diet quality and student characteristics, including food security status, will be discussed.

7.4 Manuscript

(Appears on next page)

Article

Diet Quality among Students Attending an Australian University is Compromised by Food Insecurity and Less Frequent Intake of Home Cooked Meals. A Cross-Sectional Survey Using the Validated Healthy Eating Index for Australian Adults (HEIFA-2013)

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Abstract: Poor diet quality is commonly reported in young adults. This study aimed to measure the diet quality of students attending a large Australian university (including domestic and international students), and to examine the effect of food security status and other key factors likely to impact their diet quality. Using the Automated Self-Administered 24-h recall Australian version, a cross-sectional survey collected dietary recalls from domestic and international students in one university in Sydney. Diet quality was assessed using the validated Healthy Eating Index for Australian Adults (HEIFA-2013) which gives a score out of 100. Food security status was measured by the 18-item Household Food Security Survey Module. Differences in the mean HEIFA-2013 scores by student characteristics were determined by analysis of covariance. A total of 141 students completed one dietary recall. The mean HEIFA-2013 score for students was low (mean 52.4, 95% CI 50.0–54.8). Food-insecure students had a poorer diet quality (mean 43.7, 95% CI 35.7–51.8) than their food-secure peers (mean 53.2, 95% CI 50.8–55.7, $p = 0.027$). The mean HEIFA-2013 score was similar in domestic (mean 52.5, 95% CI 49.9–55.2) and international students (mean 51.9, 95% CI 46.3–57.5, $p = 0.845$). Those reporting self-perceived excellent cooking skills and higher cooking frequency had better diet quality. Interventions to improve food and nutrition knowledge and skills and address food insecurity may help tertiary education students cook more frequently and achieve better diet quality.

Keywords: diet quality; food insecurity; nutrition insecurity; young adults; nutrition; 24-h recall; HEIFA-2013; university; college

1. Introduction

Many young adults start to develop their independent lifestyle after the commencement of tertiary studies, including the management of their own meals [1,2]. Unhealthy dietary habits have been frequently reported among students attending tertiary education institutions in many high-income countries [3–5]. Some common unhealthy dietary practices included breakfast skipping, low consumption of fruits, vegetables, and whole grains, and high consumption of fast-food, saturated fat, added sugar, and sodium [3–5]. Low adherence to the Mediterranean dietary pattern (a healthy way of eating) was often found in students in European universities [6,7].

The overall diet quality has been measured in tertiary education students by using different diet quality indices based on national dietary guidelines (e.g., Healthy Eating Index) or specific dietary patterns (e.g., Mediterranean Diet Quality Index) [6,8]. Both

sociodemographic and environmental factors have been reported to be associated with the diet quality of tertiary education students, including gender, living alone or with parents, ethnic backgrounds, socioeconomic status, and campus food environments [5,9–11]. Compared with domestic peers, international students experienced extra transitions including dietary acculturation when they relocate to a new country [12]. However, whether these additional challenges contribute to any differences in the overall diet quality between international and local students remains unclear.

The poorer diet quality of tertiary education students was found to be correlated with other unhealthy lifestyle behaviours and appeared to be associated with negative health and academic outcomes [13–17]. Lower physical activity levels and more screen time were observed in students with poorer diet quality [9,10,14]. Some studies showed that diet quality was negatively associated with the risk of metabolic diseases (e.g., obesity) in this student population [13,14]. Moreover, associations between diet quality and mental health were also observed. Quehl et al. reported higher levels of depression in female students with lower diet quality scores [15]. Furthermore, a positive association between diet quality and academic performance (e.g., grade point average) was noted [16,17].

Experiencing food insecurity is not uncommon in tertiary education students in Australia and other developed countries [18–20]. Having sufficient nutritious and preferred foods is important for achieving food and nutrition security [21]. International students tended to be more vulnerable to food insecurity than domestic students [12]. In the total community of tertiary education students, poorer dietary outcomes, e.g., lower intakes of fruits and vegetables, and higher intakes of added sugar, have been previously reported in food-insecure students compared with food-secure students [22].

To date, limited studies of diet quality and outcomes have been investigated among tertiary education students and analyses are mostly as an undifferentiated group [8,17]. In an Australian context, only separate dietary components, such as the consumption of fruits, vegetables, and takeaway foods, have been previously investigated in food-secure and -insecure tertiary education students [20], but not yet the overall quality of diet. This study aims to measure the overall diet quality of students (both domestic and international students) from an Australian university, and to compare the differences in the diet quality by food security status, cooking, sociodemographic, health, and environmental factors.

2. Materials and Methods

2.1. Study Design

As part of a larger cross-sectional food security survey conducted in a large Australian university in Sydney, New South Wales (NSW), we recruited participants to take part in a dietary survey to assess their diet quality. The study was approved by the Institutional Human Ethics Review Board.

2.2. Participants

Eligible participants included current domestic and international students aged 18 to 30 years who were not completing or had completed a nutrition course. The larger food security survey (unpublished) recruited participants from among university students through convenience and snowball sampling between October 2021 and May 2022. Advertisement flyers were posted on campus and through online platforms, e.g., announcements through an online learning management system of the institution and social media. Participants who completed the survey were asked if they had interest to participate in a dietary recall sub-study, and they were able to provide their consent through a secure online survey platform, Research Electronic Data Capture (REDCap, Version 12.2.1).

Of 467 respondents who completed the large survey, 258 participants provided consent to participate in the dietary recall sub-study. A drawing of ten \$50 supermarket gift vouchers was conducted among the participants who completed dietary recalls. The value of the vouchers was not displayed in advertising materials.

2.3. Data Collection

Participants were asked to complete two 24-h dietary recalls (24HR) via the Automated Self-Administered 24-h Dietary Assessment Tool Australian version (ASA24-Aus), which is an online platform for completing self-administered dietary recalls and food records [23]. To collect dietary recalls, the ASA24-Aus followed a multiple-pass approach to collect information on food and drink items in each meal or snack session, preparation methods, additional ingredients, portion size, and forgotten items. The Australian Food, Supplement and Nutrient Database (AUSNUT) 2011–13 is applied in this ASA24 version [24]. Individual login details to ASA24-Aus were sent to each participant via email. Instructions and assistance were provided for participants to complete 24HR on two non-consecutive days, a weekday and a weekend day. Reminder emails were sent to encourage more participants to complete dietary recalls. The data collection opened from October 2021 until July 2022. This was impacted by the COVID-19 pandemic as Australian borders were closed for international until December 2021.

Student characteristics (e.g., age, gender, current academic degree, cooking frequency, and self-rated physical and mental health) were collected in the larger food security survey. Food security status in the past 12 months was assessed by using the 18-item Household Food Security Survey Module (HFSSM) from the United States (U.S.) Department of Agriculture [25]. Students with dependent children answered all 18 questions in the HFSSM [25], while students without children answered the first 10 questions only. The levels of food security were categorised into four categories based on the sum of affirmative responses to the HFSSM: high (no affirmative responses), marginal (1–2), low (3–7 for students with children, 3–5 for students without children), and very low food security (8–18 for students with children, 6–10 for students without children) [25]. High and marginal food security were then combined as the food secure group, while low and very low food security were combined as the food insecure group [25].

WHO-5 Well-being Index, a five-item tool, was used to further assess mental health status and it has been used in tertiary education students [26,27]. The total raw score ranges from 0 to 25, and a score below 13 is indicating poor wellbeing and further testing for depression [27].

2.4. Diet Quality Index

The Healthy Eating Index for Australian Adults (HEIFA-2013) was used to assess the overall diet quality of domestic and international students from an Australian university. The HEIFA-2013 was developed based on the most recent Australian Dietary Guidelines (ADG) in 2013 to reflect compliance with this national guideline [28]. This tool has been validated in Australian young adults through dietary data collected by weighed food records, food frequency questionnaires, and 24HR [29,30].

The HEIFA-2013 contains 11 components and the total score ranges from 0 to 100. The following nine components have a value of 10 marks for each, including fruits (5 marks for total intake and 5 marks for the variety of consumption), vegetables (5 marks for total intake and 5 marks for the variety), grains (5 marks for total intake and 5 marks for wholegrains intake), total intake of dairy products, total intake of meat and alternatives, total intake of discretionary foods, fat intake (5 marks for saturated fatty acids and 5 marks for mono- and poly-unsaturated fatty acids), sodium intake, and the intake of added sugar; with another 5 marks for each of the water and alcohol intake.

The criteria for full marks of each component followed the recommendations for male and female adults aged from 19 to 50 years in the ADG [28], and the serve size followed the Australian Guide to Healthy Eating (AGHE) [31]. The serve size with the criteria for full and no marks for each component are shown in Table 1. Marks were given incrementally between full and no marks. Taking dairy intake as an example, 2.5 serves or more will be given a full 10 marks, and then 8 marks for 2.0–2.4 serves, 6 marks for 1.5–1.9 serves, 4 marks for 1.0–1.4 serves, 2 marks for 0.5–0.9 serves, and no marks if less than 0.5 serve was consumed. Further details of this tool have been published previously [30,32].

Table 1. Serve sizes and criteria for full and no marks of each component in the Healthy Eating Index for Australian Adults (HEIFA-2013).

Component	Serve Size/Unit	Criteria for Full Marks	Criteria for No Marks
Fruit			
Total intake	150 g fresh fruit, 30 g dried fruit, 125 g fruit juice	≥2.0 serves	<0.5 serve
Variety	150 g fresh fruit (pome, berry, citrus, stone, tropical, and other fruit)	≥2 types	<2 types
Vegetable			
Total intake	75 g vegetables and legumes, 125 g vegetable juice	Male: ≥6 serves, Female: ≥5 serves	<1 serve
Variety	75 g vegetables and legumes (green, starchy, orange, and other vegetable, and legumes)	≥1 serve of green, starchy, orange, and other vegetable, ≥0.5 serve of legumes (1 mark for each type)	<1 serve of each type (green, starchy, orange, and other vegetable) and <0.5 serve of legumes
Grains			
Total intake	500 kJ	≥6 serves	<1 serve
Wholegrains	500 kJ	≥3 serves	<1 serve
Meat and alternatives	65 g red meat/offal, 80 g poultry, 100 g fish/seafood, 120 g eggs, 170 g meat alternatives, 30 g nuts/seeds	Male: ≥3.0 serves, Female: ≥2.5 serves	Male: <1 serve, Female: <0.5 serve
Dairy	250 mL milk, 200 mL yoghurt, 550 kJ cheese, 200 mL custard	≥2.5 serves	<0.5 serve
Discretionary choices	375 mL beverages, 600 kJ foods	Male: <3.0 serves, Female: <2.5 serves	Male: ≥6.0 serves, Female: ≥5.5 serves
Fat			
Saturated	Percentage of energy intake	≤10%	>12%
Unsaturated	250 kJ	Male: ≥4.0 serves, Female: ≥2.0 serves	Male: <1.0 serves, Female: <0.5 serve
Sodium	mg	≤1610 mg	>2300 mg
Added sugar	Percentage of energy intake	≤5%	>10%
Water	Proportion of water consumed relative to other beverages	≥50%	<10%
Alcohol	1 standard drink (10 g of alcohol)	≤20 g of alcohol	>20 g of alcohol

2.5. Data Analysis

To calculate the HEIFA-2013 [30], the first dietary recall of each participant was used. A single dietary recall is a valid assessment of group means [33]. Of participants who completed the first recall, a subset completed the second recall. As an additional analysis, for participants who completed two recalls, the average intakes of two days were calculated and HEIFA-2013 determined (see Figure 1 for details of single and two-day recalls). To calculate food group intakes, mixed dishes were disaggregated into separate ingredients based on the recipe file from AUSNUT 2011–13 [24]. The fat and sodium intakes were derived from the output analysis file from the ASA24-Aus. The intake of added sugar was not one of the variables in the ASA24-Aus output and was calculated by merging the file of reported food items from participants with the nutrient file from AUSNUT 2011–13 and summing total daily intake for each person [24]. The calculation of the HEIFA-2013 was conducted via SAS version 9.4 (SAS Institute, Cary, NC, USA).

For misreporting, the ratio of energy intake to estimated basal metabolic rate (EI: BMR) was calculated for each participant [34]. The Schofield equation was used for estimating BMR based on self-reported weight [35], and three participants were excluded from the analysis as they did not report weight. Another two participants were excluded from the analysis because they did not specify male or female, and the HEIFA-2013 was a sex-specific measure. The mean HEIFA-2013 scores were adjusted by the continuous variable EI: BMR to allow for differences in accuracy of self-report and estimation of the diet quality and interpretation of the association between the diet quality and student characteristics.

The adjusted mean HEIFA-2013 total scores and differences by student characteristics were determined by analysis of covariance. The Mann–Whitney U test was used to compare the differences in the scores of individual components of the HEIFA-2013 by food security status because the data was not normally distributed. Statistical analysis was performed by using IBM SPSS Statistics version 25.0 (IBM Corp, Armonk, NY, USA).

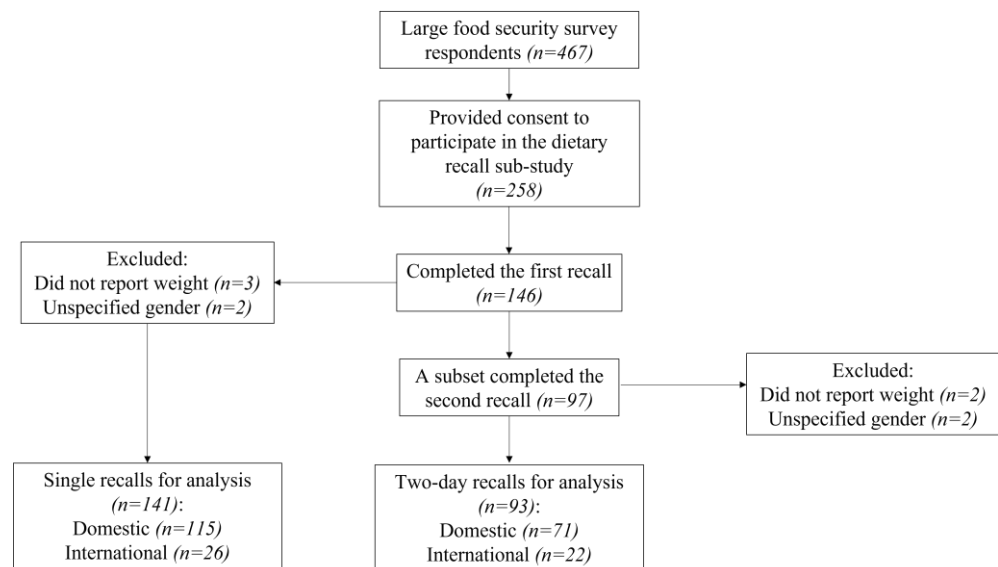


Figure 1. Flow diagram describing sample size.

3. Results

A total of 146 participants completed the first recall, with similar response rates in domestic (31%) and international students (30%). Of these students, a subset ($n = 97$) completed the second recall. After exclusion, 141 students (115 domestic and 26 international) who completed a single recall were included for data analysis, and the subset of 93 students (71 domestic and 22 international) who completed two recalls were included for an additional analysis (see Figure 1).

Our sample ($n = 141$) was predominantly female (81%) and undergraduate (74%) students. More than half of participants (59%) lived at the parental home, and 69% were employed. Nine percent of students in this sample were food insecure.

From the first recalls, the mean HEIFA-2013 score was 52.5 (95% CI 49.9–55.2) in domestic students and 51.9 (95% CI 46.3–57.5) in international students after adjusting for EI: BMR ($p = 0.845$). The mean HEIFA-2013 scores of domestic and international students are shown by sociodemographic characteristics in Table 2 and by diet and health-related characteristics in Table 3.

Among sociodemographic factors, only changes caused by the COVID-19 pandemic were found to be associated with diet quality in our sample. Domestic students who experienced difficulties in finding employment due to the pandemic had a lower score for diet quality than those without such experiences. International students who experienced changes in living arrangements (e.g., moved to shared accommodations) had a higher score for diet quality than those without changes.

Students with food insecurity (mean 43.7, 95% CI 35.7–51.8) were found to have a lower score for diet quality than food-secure students (mean 53.2, 95% CI 50.8–55.7, $p = 0.027$), but this association was significant in only domestic students due to the insufficient statistical power in international students. Domestic students with self-perceived excellent cooking skills and higher cooking frequency (4 days or more per week) had a higher score for diet quality than those with poorer skills and lower cooking frequency. Better diet quality was also associated with better self-reported physical health status in domestic students.

A subset of students completed two recalls ($n = 93$, see Figure 1), and the HEIFA-2013 score for each of these students was calculated based on their average intake of two days. The mean HEIFA-2013 score in domestic (mean 51.9, 95% CI 48.9–54.9) and international students (mean 53.9, 95% CI 48.4–59.3) remained low and similar ($p = 0.536$). The mean HEIFA-2013 scores of domestic and international students by student characteristics from average intakes can be seen in Table S1.

Table 2. Mean scores of Healthy Eating Index for Australian Adults (HEIFA-2013) by sociodemographic characteristics from domestic and international students attending a large Australian university ¹.

Sociodemographic Characteristics	Total (n = 141)				Domestic (n = 115)				International (n = 26)			
	N (%)	Mean	95% CI	p	N (%)	Mean	95% CI	p	N (%)	Mean	95% CI	p
Age												
18–22 years	102 (72)	51.2	48.4–54.0	0.098	83 (72)	51.4	48.2–54.6	0.157	19 (73)	49.9	43.7–56.2	0.323
23–30 years	39 (28)	55.7	51.2–60.2		32 (28)	55.7	50.6–60.9		7 (27)	56.2	45.4–67.0	
Gender												
Female	114 (81)	52.3	49.6–54.9	0.779	93 (81)	52.3	49.3–55.4	0.679	21 (81)	52.0	46.1–57.9	0.770
Male	27 (19)	53.1	47.7–58.6		22 (19)	53.8	47.5–60.1		5 (19)	50.1	37.9–62.2	
Current academic degree												
Undergraduate	104 (74)	51.9	49.1–54.7	0.480	84 (73)	52.1	48.9–55.3	0.560	20 (77)	50.9	44.7–57.0	0.633
Postgraduate	37 (26)	53.9	49.2–58.5		31 (27)	53.9	48.7–59.2		6 (23)	54.1	42.4–65.8	
Marital status												
Never married	132 (94)	52.2	49.7–54.6	0.403	106 (92)	52.3	49.5–55.1	0.423	26 (100)	51.6	46.4–56.8	NA ²
Married or other	9 (6)	56.3	46.9–65.8		9 (8)	56.4	46.7–66.2		0 (0)	NA	NA	
Current accommodation												
Parental home	83 (59)	52.4	49.3–55.5	0.956	81 (70)	52.0	48.7–55.2	0.469	2 (8)	72.3	55.1–89.6	NP ³
Other than parental home	58 (41)	52.5	48.8–56.2		34 (30)	54.2	49.1–59.2		24 (92)	49.9	45.0–54.8	
Employment status												
No employment	44 (31)	52.8	48.5–57.1	0.829	28 (24)	53.2	47.6–58.7	0.823	16 (62)	52.1	45.3–58.9	0.821
Employed	97 (69)	52.3	49.4–55.1		87 (76)	52.4	49.3–55.6		10 (38)	50.9	42.3–59.5	
Weekly working hours												
Less than 20 h	77 (79)	51.3	48.1–54.6	0.200	69 (79)	51.7	48.2–55.1	0.343	8 (80)	49.2	35.5–62.8	NP
20 h or more	20 (21)	56.0	49.6–62.3		18 (21)	55.3	48.6–62.0		2 (20)	59.4	30.2–88.6	
Weekly income (AUD) ⁴												
\$500 or less	98 (74)	51.1	48.2–53.9	0.053	82 (73)	51.1	47.9–54.2	0.071	16 (80)	50.8	43.1–58.5	NP
More than \$500	35 (26)	56.6	51.8–61.4		31 (27)	56.7	51.5–61.9		4 (20)	57.8	40.3–75.3	
Changes caused by COVID-19												
Living arrangement ⁵												
No	123 (87)	51.6	49.1–54.2	0.083	104 (90)	52.3	49.4–55.1	0.431	19 (73)	48.2	42.7–53.8	0.024
Yes	18 (13)	57.9	51.3–64.5		11 (10)	56.0	47.1–64.8		7 (27)	60.8	51.6–70.0	
Job changes ⁶												
No	84 (60)	52.1	49.0–55.2	0.740	64 (56)	52.4	48.7–56.1	0.864	20 (77)	51.0	45.0–57.1	0.669
Yes	57 (40)	52.9	49.1–56.7		51 (44)	52.9	48.8–57.0		6 (23)	53.7	42.6–64.7	
Difficulties in finding jobs												
No	98 (70)	53.9	51.0–56.7	0.070	81 (70)	54.6	51.4–57.7	0.028	17 (65)	50.5	43.9–57.1	0.574
Yes	43 (30)	49.1	44.8–53.4		34 (30)	48.0	43.1–52.9		9 (35)	53.7	44.5–62.8	

Table 2. Cont.

Sociodemographic Characteristics	Total (n = 141)				Domestic (n = 115)				International (n = 26)			
	N (%)	Mean	95% CI	p	N (%)	Mean	95% CI	p	N (%)	Mean	95% CI	p
Employment income loss												
No	87 (69)	51.7	48.6–54.8	0.524	69 (65)	52.0	48.5–55.6	0.702	18 (86)	50.3	43.3–57.4	NP
Yes	40 (31)	53.5	48.9–58.1		37 (35)	53.2	48.3–58.1		3 (14)	57.8	40.5–75.2	
Received any government support payment												
No	81 (59)	52.3	49.1–55.4	0.784	60 (54)	52.6	48.8–56.4	0.931	21 (81)	51.1	45.2–57.0	0.650
Yes	57 (41)	52.9	49.2–56.7		52 (46)	52.9	48.8–57.0		5 (19)	54.0	41.9–66.1	
Received any support payment from other sources												
No	130 (95)	52.0	49.5–54.5	0.352	108 (96)	52.3	49.4–55.1	0.222	22 (92)	50.8	44.9–56.6	NP
Yes	7 (5)	57.2	46.4–68.0		5 (4)	60.6	47.4–73.8		2 (8)	48.6	29.2–68.0	

¹ Mean scores adjusted for energy intake (EI): basal metabolic rate (BMR) through analysis of covariance (ANCOVA), the potential range of HEIFA-2013 was 0–100; ² Not applicable;

³ Not enough power; ⁴ Weekly income, include employment and/or other income; ⁵ Living arrangement changes, e.g., moved to less expensive premises; ⁶ Job changes, e.g., lost employment or worked less hours.

Table 3. Mean scores of Healthy Eating Index for Australian Adults (HEIFA-2013) by diet and health-related characteristics from domestic and international students attending a large Australian university. ¹.

Diet and Health-Related Characteristics	Total (n = 141)				Domestic (n = 115)				International (n = 26)			
	N (%)	Mean	95% CI	p	N (%)	Mean	95% CI	p	N (%)	Mean	95% CI	p
Food security status ²												
Food secure	129 (91)	53.2	50.8–55.7	0.027	105 (91)	53.5	50.7–56.3	0.035	24 (92)	52.1	46.6–57.6	NP ³
Food insecure	12 (9)	43.7	35.7–51.8		10 (9)	43.3	34.2–52.4		2 (8)	46.0	27.0–65.1	
Does your accommodation provide meals? ⁴												
No	48 (89)	52.2	48.5–55.9	0.662	26 (87)	54.6	49.1–60.1	NP	22 (92)	49.2	44.0–54.3	NP
Yes	6 (11)	49.7	39.2–60.3		4 (13)	46.6	31.9–61.2		2 (8)	57.6	40.5–74.7	
Weekly food budget (AUD)												
\$0–30	18 (13)	48.2	41.6–54.9	0.157	18 (16)	48.3	41.5–55.1	0.129	0 (0)	NA ⁵	NA	0.610
\$31–60	43 (30)	55.7	51.4–60.0		37 (32)	55.7	50.9–60.4		6 (23)	55.7	44.6–66.9	
\$61–100	62 (44)	52.6	49.0–56.1		48 (42)	53.5	49.3–57.6		14 (54)	49.4	42.1–56.7	
>\$100	18 (13)	48.4	41.8–55.0		12 (10)	46.2	37.8–54.5		6 (23)	52.7	41.6–63.8	
Adequacy of cooking facilities												
Adequate	125 (89)	52.6	50.0–55.1	0.727	107 (93)	52.9	50.1–55.8	0.398	18 (69)	50.6	44.3–57.0	0.559
Inadequate	16 (11)	51.2	44.1–58.3		8 (7)	48.3	38.0–58.7		8 (31)	53.9	44.4–63.4	
Self-perceived cooking skills												
Excellent	26 (18)	59.0	53.6–64.5	0.015	21 (18)	60.8	54.6–67.0	0.009	5 (19)	52.0	39.6–64.4	0.906
Good	62 (44)	49.4	45.9–52.9		48 (42)	49.0	44.9–53.1		14 (54)	50.6	43.2–58.1	
Fair or poor	53 (38)	52.7	48.9–56.5		46 (40)	52.6	48.5–56.8		7 (27)	53.4	42.8–64.0	
Cooking frequency												
3 days/week or less	75 (53)	49.1	45.9–52.2	0.003	65 (57)	49.3	45.8–52.9	0.007	10 (38)	47.2	39.0–55.4	0.170
4+ days/week	66 (47)	56.3	52.9–59.6		50 (43)	56.9	52.8–60.9		16 (62)	54.4	47.9–60.9	
Eating out frequency												
3 days/week or less	128 (91)	52.4	49.9–54.9	0.880	106 (92)	52.6	49.8–55.5	0.998	22 (85)	51.2	45.4–57.0	NP
4+ days/week	13 (9)	53.0	45.1–60.9		9 (8)	52.6	42.8–62.4		4 (15)	53.9	40.4–67.5	
Self-rated physical health status												
Excellent or good	85 (60)	54.6	51.6–57.7	0.027	67 (58)	55.2	51.6–58.7	0.031	18 (69)	52.6	46.1–59.1	0.593
Average or poorer	56 (40)	49.1	45.3–52.8		48 (42)	49.0	44.9–53.2		8 (31)	49.4	39.6–59.3	
BMI category ⁶												
Underweight	13 (9)	45.9	38.1–53.7	0.202	9 (8)	45.6	35.8–55.4	0.313	4 (15)	45.5	31.4–59.5	NP
Normal weight	101 (72)	52.7	49.9–55.6		81 (70)	52.9	49.6–56.1		20 (77)	52.3	46.2–58.4	
Overweight or obesity	27 (19)	54.4	48.8–59.9		25 (22)	54.4	48.3–60.4		2 (8)	57.2	38.0–76.4	
Self-rated mental health status												
Excellent or good	62 (44)	51.3	47.7–54.9	0.420	48 (42)	51.6	47.3–55.8	0.525	14 (54)	50.4	43.1–57.6	0.596
Average or poorer	79 (56)	53.3	50.1–56.5		67 (58)	53.4	49.8–56.9		12 (46)	53.1	45.3–60.9	
WHO-5 Well-being index category												
Normal	78 (55)	53.3	50.1–56.5	0.414	62 (54)	53.9	50.2–57.6	0.319	16 (62)	51.1	44.3–57.8	0.783
Poor wellbeing (below 13)	63 (45)	51.3	47.7–54.9		53 (46)	51.1	47.1–55.1		10 (38)	52.5	44.0–61.1	

¹ Mean scores adjusted for energy intake (EI):basal metabolic rate (BMR) through analysis of covariance (ANCOVA), the potential range of HEIFA-2013 was 0–100; ² Food security status was assessed by the 18-item Household Food Security Survey Module; ³ Not enough power; ⁴ A question for students lived outside parental or own home; ⁵ Not applicable; ⁶ BMI cut-offs, underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²) and obesity (≥30.0 kg/m²).

The scores of individual components in HEIFA-2013 are compared between food-secure and -insecure students in Table 4. Students with food insecurity tended to consume less wholegrains (based on first recalls) and more added sugar (based on average intakes from two recalls) than food-secure students.

Table 4. Median scores of individual components of Healthy Eating Index for Australian Adults (HEIFA-2013) by food security status among students attending a large Australian university.

HEIFA-2013 Individual Components	First Recalls ¹			Two Recalls ²		
	Median (IQR) ³		<i>p</i> ⁴	Median (IQR)		<i>p</i> ⁴
	Food Secure (<i>n</i> = 129)	Food Insecure (<i>n</i> = 12)		Food Secure (<i>n</i> = 86)	Food Insecure (<i>n</i> = 7)	
Fruit total intake	0.0 (3.8)	0.6 (2.5)	0.667	1.3 (3.8)	1.3 (3.8)	0.926
Fruit variety	0.0 (5.0)	0.0 (0.0)	0.184	0.0 (5.0)	0.0 (5.0)	1.000
Vegetable total intake	2.0 (4.0)	1.5 (2.0)	0.620	2.0 (3.0)	2.0 (2.0)	0.349
Vegetable variety	1.0 (2.0)	1.0 (2.0)	0.454	1.0 (2.0)	1.0 (2.0)	0.808
Grains total intake	2.5 (2.9)	2.1 (3.1)	0.787	2.5 (1.7)	1.7 (2.5)	0.161
Wholegrains intake	0.0 (2.0)	0.0 (0.0)	0.044	0.0 (2.0)	0.0 (1.0)	0.648
Meat and alternatives	8.0 (7.0)	7.0 (10.0)	0.636	9.0 (6.0)	10.0 (8.0)	1.000
Dairy	4.0 (6.0)	2.0 (6.0)	0.141	4.0 (4.0)	2.0 (2.0)	0.421
Discretionary choices	7.5 (7.5)	3.8 (8.8)	0.228	7.5 (7.5)	5.0 (10.0)	0.559
Saturated fat	0.0 (5.0)	0.0 (4.4)	0.811	0.0 (2.5)	0.0 (2.5)	1.000
Unsaturated fat	5.0 (0.0)	5.0 (0.0)	0.725	5.0 (0.0)	5.0 (0.0)	0.383
Sodium	5.0 (10.0)	0.0 (9.0)	0.646	0.0 (5.0)	5.0 (10.0)	0.433
Added sugar	5.0 (8.0)	5.0 (10.0)	0.437	5.0 (10.0)	0.0 (5.0)	0.006
Water	5.0 (0.0)	5.0 (0.0)	0.739	5.0 (0.0)	5.0 (0.0)	1.000
Alcohol	5.0 (0.0)	5.0 (0.0)	1.000	5.0 (0.0)	5.0 (0.0)	0.631

¹ Calculated the HEIFA-2013 based on the first dietary recalls of 141 students; ² The subset of 93 students completed two dietary recalls, calculated the HEIFA-2013 based on the average intake of two recalls; ³ IQR = interquartile range; ⁴ Mann–Whitney U test.

4. Discussion

Poor diet quality was found in both domestic and international students attending an Australian university. Food insecurity was associated with lower diet quality score in domestic students. Among international students the association could not be confirmed due to a small sample size but there appeared to be some association. Self-perceived excellent cooking skills and higher cooking frequency were found to be protective factors for better diet quality. Solutions to alleviate food insecurity and enhance food literacy among tertiary education students may facilitate the improvement of their diet quality.

The association of food insecurity with poorer dietary outcomes in university students has been previously reported by a systematic review, although the results were not consistently significant across studies [22]. The association between the overall diet quality and food security status was rarely measured using validated dietary assessment tools in this student group [22]. In our study, significantly lower overall diet quality and whole grains intake were found in food-insecure domestic students compared with food-secure ones, but this association could not be confirmed in international students due to the small sample. From previous studies investigating the strategies tertiary education students used in coping with food insecurity, food insecure students often had to choose less expensive and less healthy alternatives [36,37]. In Australia, the prices of healthy food options were generally higher than less healthy options, and this has also been reported for food outlets on campus [38,39]. Moreover, the cost of living in Sydney where the study was conducted, remained the highest in the country [40]. The prevalence of food insecurity in Australia appeared to increase during the COVID-19 pandemic [41]. Food insecure students may not have sufficient income or financial support to consistently afford healthy meals.

Considering the association between food insecurity and poorer diet quality in our sample, food assistance services may be helpful for them. Food assistance services may

improve the diet quality of their recipients when more fresh and healthy options were provided, e.g., fruits, vegetables, and whole grains, but the improvement might be limited if the provided options were in low nutritional quality [42,43]. More programs were provided for international students in NSW and on campus during the COVID-19 pandemic [44]. From the hunger report by Foodbank Australia in 2021 [45], dietary needs of people receiving food hampers were not fully achieved, such as meeting special dietary requirements and the need for cultural foods. A small number of students in our sample used these services, and thus the impact of using food assistance services on the diet quality of food-insecure students could not be judged from this study.

The overall diet quality of domestic and international students was generally low in our sample, but no significant differences were found between the two groups. A large-scale survey conducted in another Australian university reported different eating behaviours between domestic and international students, i.e., higher intakes of fruits and vegetables in domestic students, and higher intakes of grains and soft drinks in international students [46]. Compared with 24HR collected from the Australian Bureau of Statistics (ABS) 2011–2012 National Nutrition and Physical Activity Survey, the diet quality score of our students was slightly higher than among young adults from the national data with a total HEIFA-2013 score of 41.6 [32]. This may result from the higher socioeconomic status and tertiary education level of these students compared with the general population of young adults [32,47]. Students with more interest in food and nutrition might have been more willing to participate in our study.

The association between food preparation and better diet quality in young adults has been previously reported by an Australian study for students completing a nutrition degree and a population-based longitudinal study in the U.S [48,49]. Similarly, the higher cooking frequency was associated with better diet quality in our domestic students, although the association was not significant in international students. The previous Australian study also reported that lower frequency of takeaway and convenience meal consumption was associated with better diet quality [49], but the association between the frequency of eating out and diet quality was not detected here. The frequency of cooking and eating out among students might be affected by their cooking skills, time availability, and the pandemic [50,51]. Most choices from the menus of popular online food delivery outlets in Australia and New Zealand were found to be nutritionally poor [52].

The findings here imply that improving food literacy among tertiary education students may increase their confidence and frequency of cooking to achieve better diet quality. Increasing nutrition knowledge only might not be enough for students to translate this into dietary practices [9]. Food literacy covers more aspects of the required abilities for healthy eating, e.g., skills in planning, management, selection, and preparation [53]. A four-week food literacy program was effective for Australian adults with low-to-middle income as participants were able to improve their food literacy and maintain their positive changes in dietary behaviours after the program [54,55]. Similar programs could be regularly organised by universities and tailored for tertiary education students with different characteristics to increase their abilities in preparing healthy meals when facing time and financial constraints.

Food environment and purchasing on campus may affect the diet quality of tertiary education students, although this was not measured in our study. Previous studies from the U.S. and Australia found more frequent purchases of foods and beverages on campus were associated with poorer diet quality and less healthy eating habits, such as less frequent breakfast and higher consumption of energy-dense, nutrient-poor choices [56–58]. Higher availability of healthy options with cheaper prices were often suggested by food environment audits on campus and student surveys [38,56,59].

The strengths of this study include the measurement of the overall diet quality among domestic and international students through 24HR and a validated assessment tool (HEIFA-2013), and the investigation of the association between food security status and diet quality among students in an Australian university. There are also several limitations.

The sample size of international students was small, and this contributed to insufficient power to detect statistical significance between different characteristics in this student group. In comparison with the national data on tertiary education students in Australia in the academic year of 2020 [60], our sample had an overrepresentation of females (81% in our sample vs. 56% in Australia) and undergraduate students (74% vs. 66%), and an underrepresentation of international students (18% vs. 30%). The findings from this study might not be generalisable to university students in other areas of Australia. This is a snapshot survey and used one-day recalls from participants to estimate group means. For participants who completed two recalls, the average intake of two days was used in this study, while a different statistical method was used to estimate usual intake from national surveys with large sample sizes [61,62]. Causal statements cannot be made due to the nature of the cross-sectional design.

To improve the diet quality of tertiary education students, solutions to address food insecurity and increase cooking skills could be helpful. Tailored food literacy programs, including regular nutrition education and cooking classes, may help students learn and use nutrition knowledge and increase their abilities for cooking. More interventions to improve the availability of affordable healthy meals on campus might also be beneficial for students with limited time for cooking. Food assistance services may need to be more available for food-insecure students, and the nutritional quality and cultural appropriateness of provided foods may require improvements to meet different dietary needs of students. For future research, a larger sample of international students could be recruited. This study was conducted during the COVID-19 pandemic and less international students studied onshore in Australia due to the border closures. Future longitudinal studies could be conducted to compare what happens to the diet quality and food insecurity in tertiary education students after the global pandemic.

5. Conclusions

In conclusion, diet quality was generally poor in both domestic and international students. In domestic students, food insecurity was associated with poorer diet quality, and better cooking skills and higher cooking frequency were associated with better diet quality. More contributing factors in international students might be detected by further studies with a larger sample. More specific programs to improve food literacy and address food insecurity in tertiary education students may facilitate the improvement of their diet quality.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/nu14214522/s1>, Table S1: Mean scores of Healthy Eating Index for Australian Adults (HEIFA-2013) by student characteristics from domestic and international students who completed two dietary recalls.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Human Research Ethics Committee of The University of Sydney (approval number 2021/745, 27 October 2021).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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References

1. El Ansari, W.; Stock, C.; Mikolajczyk, R.T. Relationships between food consumption and living arrangements among university students in four European countries—A cross-sectional study. *Nutr. J.* **2012**, *11*, 28. [CrossRef] [PubMed]
2. Nelson, M.C.; Story, M.; Larson, N.I.; Neumark-Sztainer, D.; Lytle, L.A. Emerging adulthood and college-aged youth: An overlooked age for weight-related behavior change. *Obesity* **2008**, *16*, 2205–2211. [CrossRef] [PubMed]
3. Ramón-Arбуés, E.; Granada-López, J.M.; Martínez-Abadía, B.; Echániz-Serrano, E.; Antón-Solanas, I.; Jerue, B.A. Factors Related to Diet Quality: A Cross-Sectional Study of 1055 University Students. *Nutrients* **2021**, *13*, 3512. [CrossRef] [PubMed]
4. Satalic, Z.; Baric, I.C.; Keser, I. Diet quality in Croatian university students: Energy, macronutrient and micronutrient intakes according to gender. *Int. J. Food Sci. Nutr.* **2007**, *58*, 398–410. [CrossRef] [PubMed]
5. Tay, M.E.; Foster, E.; Stevenson, L.; Brownlee, I. The Adherence of Singaporean Students in Different Educational Institutions to National Food-Based Dietary Guidelines. *Nutrients* **2020**, *12*, 2995. [CrossRef] [PubMed]
6. Baldini, M.; Pasqui, F.; Bordoni, A.; Maranesi, M. Is the Mediterranean lifestyle still a reality? Evaluation of food consumption and energy expenditure in Italian and Spanish university students. *Public Health Nutr.* **2009**, *12*, 148–155. [CrossRef] [PubMed]
7. Karam, J.; Bibiloni, M.D.M.; Serhan, M.; Tur, J.A. Adherence to Mediterranean Diet among Lebanese University Students. *Nutrients* **2021**, *13*, 1264. [CrossRef] [PubMed]
8. Williams, R.A.; Rose, A.M.; Bruno, R.S.; Hanks, A.S.; Kennel, J.A.; McDonald, J.D.; Labyk, A.N.; Gunther, C. Examination of the relationship of diet quality with cardiometabolic risk factors in apparently healthy college students. *J. Educ. Health Promot.* **2019**, *8*, 148. [CrossRef]
9. Suliga, E.; Ciesła, E.; Michel, S.; Kaducakova, H.; Martin, T.; Śliwiński, G.; Braun, A.; Izova, M.; Lehotska, M.; Koziel, D.; et al. Diet Quality Compared to the Nutritional Knowledge of Polish, German, and Slovakian University Students—Preliminary Research. *Int. J. Environ. Res. Public Health* **2020**, *17*, 9062. [CrossRef]
10. Telleria-Aramburu, N.; Arroyo-Izaga, M. Risk factors of overweight/obesity-related lifestyles in university students: Results from the EHU12/24 study. *Br. J. Nutr.* **2022**, *127*, 914–926. [CrossRef] [PubMed]
11. Zurita-Ortega, F.; San Román-Mata, S.; Chacón-Cuberos, R.; Castro-Sánchez, M.; Muros, J.J. Adherence to the Mediterranean Diet Is Associated with Physical Activity, Self-Concept and Sociodemographic Factors in University Student. *Nutrients* **2018**, *10*, 966. [CrossRef]
12. Shi, Y.; Lukomskyj, N.; Allman-Farinelli, M. Food access, dietary acculturation, and food insecurity among international tertiary education students: A scoping review. *Nutrition* **2021**, *85*, 111100. [CrossRef] [PubMed]
13. Jalloun, R.A.; Maneerattanasuporn, T. Comparison of diet quality among female students in different majors at Taibah University. *Nutr. Health* **2021**, *27*, 133–140. [CrossRef]
14. Landry, M.J.; Asigbee, F.M.; Vandyousefi, S.; Khazaee, E.; Ghaddar, R.; Boisseau, J.B.; House, B.T.; Davis, J.N. Diet Quality Is an Indicator of Disease Risk Factors in Hispanic College Freshmen. *J. Acad. Nutr. Diet.* **2019**, *119*, 760–768. [CrossRef] [PubMed]
15. Quehl, R.; Haines, J.; Lewis, S.P.; Buchholz, A.C. Food and Mood: Diet Quality is Inversely Associated with Depressive Symptoms in Female University Students. *Can. J. Diet. Pract. Res.* **2017**, *78*, 124–128. [CrossRef] [PubMed]
16. El Hajj, J.S.; Julien, S.G. Factors Associated with Adherence to the Mediterranean Diet and Dietary Habits among University Students in Lebanon. *J. Nutr. Metab.* **2021**, *2021*, 6688462. [CrossRef] [PubMed]
17. Whatnall, M.C.; Patterson, A.J.; Burrows, T.L.; Hutchesson, M.J. Higher diet quality in university students is associated with higher academic achievement: A cross-sectional study. *J. Hum. Nutr. Diet.* **2019**, *32*, 321–328. [CrossRef] [PubMed]
18. Blundell, L.; Mathews, M.; Bowley, C.; Roebothan, B. Determining Student Food Insecurity at Memorial University of Newfoundland. *Can. J. Diet. Pract. Res.* **2019**, *80*, 14–21. [CrossRef] [PubMed]
19. Bruening, M.; Argo, K.; Payne-Sturges, D.; Laska, M.N. The Struggle Is Real: A Systematic Review of Food Insecurity on Postsecondary Education Campuses. *J. Acad. Nutr. Diet.* **2017**, *117*, 1767–1791. [CrossRef]
20. Gallegos, D.; Ramsey, R.; Ong, K.W. Food Insecurity: Is It an Issue among Tertiary Students? *High. Educ.* **2014**, *67*, 497–510. [CrossRef]
21. Food and Agriculture Organization of the United Nations (FAO). *Rome Declaration on World Food Security and World Food Summit Plan of Action*; FAO: Rome, Italy, 1996.
22. Shi, Y.; Davies, A.; Allman-Farinelli, M. The Association Between Food Insecurity and Dietary Outcomes in University Students: A Systematic Review. *J. Acad. Nutr. Diet.* **2021**, *121*, 2475–2500.e2471. [CrossRef] [PubMed]
23. National Cancer Institute. Automated Self-Administered 24-Hour (ASA24®) Dietary Assessment Tool. Available online: <https://epi.grants.cancer.gov/asa24/> (accessed on 10 September 2022).
24. Food Standards Australia New Zealand. AUSNUT 2011–2013. Available online: <https://www.foodstandards.gov.au/science/monitoringnutrients/ausnut/pages/default.aspx> (accessed on 10 September 2022).

25. Economic Research Service, The United States Department of Agriculture. U.S. Household Food Security Survey Module. Available online: <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/survey-tools/#household> (accessed on 10 September 2022).
26. Downs, A.; Boucher, L.; Campbell, D.; Polyakov, A. Using the WHO-5 Well-Being Index to Identify College Students at Risk for Mental Health Problems. *J. Coll. Stud. Dev.* **2017**, *58*, 113–117. [[CrossRef](#)]
27. Psychiatric Research Unit WHO Collaborating Center for Mental Health. WHO (Five) Well-Being Index (1998 Version). Available online: <https://www.psykiatri-regionh.dk/who-5/Documents/WHO-5%20questionnaire%20-%20English.pdf> (accessed on 10 September 2022).
28. National Health and Medical Research Council. Australian Dietary Guidelines Summary. Available online: https://www.eatforhealth.gov.au/sites/default/files/content/The%20Guidelines/n55a_australian_dietary_guidelines_summary_131014_1.pdf (accessed on 10 September 2022).
29. Grech, A.; Rangan, A.; Allman-Farinelli, M. Social Determinants and Poor Diet Quality of Energy-Dense Diets of Australian Young Adults. *Healthcare* **2017**, *5*, 70. [[CrossRef](#)] [[PubMed](#)]
30. Roy, R.; Hebden, L.; Rangan, A.; Allman-Farinelli, M. The development, application, and validation of a Healthy eating index for Australian Adults (HEIFA—2013). *Nutrition* **2016**, *32*, 432–440. [[CrossRef](#)] [[PubMed](#)]
31. National Health and Medical Research Council. Australian Guide to Healthy Eating. Available online: <https://www.eatforhealth.gov.au/> (accessed on 10 September 2022).
32. Grech, A.; Sui, Z.; Siu, H.Y.; Zheng, M.; Allman-Farinelli, M.; Rangan, A. Socio-Demographic Determinants of Diet Quality in Australian Adults Using the Validated Healthy Eating Index for Australian Adults (HEIFA-2013). *Healthcare* **2017**, *5*, 7. [[CrossRef](#)] [[PubMed](#)]
33. Freedman, L.S.; Guenther, P.M.; Dodd, K.W.; Krebs-Smith, S.M.; Midthune, D. The population distribution of ratios of usual intakes of dietary components that are consumed every day can be estimated from repeated 24-hour recalls. *J. Nutr.* **2010**, *140*, 111–116. [[CrossRef](#)] [[PubMed](#)]
34. Black, A.E. The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying diet reports of poor validity. *Eur. J. Clin. Nutr.* **2000**, *54*, 395–404. [[CrossRef](#)] [[PubMed](#)]
35. Schofield, W.N. Predicting basal metabolic rate, new standards and review of previous work. *Hum. Nutr. Clin. Nutr.* **1985**, *39*, 5–41. [[PubMed](#)]
36. Brescia, S.A.; Cuite, C.L. Understanding Coping Mechanisms: An Investigation into the Strategies Students Use to Avoid, Manage, or Alleviate Food Insecurity. *J. Coll. Character* **2019**, *20*, 310–326. [[CrossRef](#)]
37. Waity, J.F.; Huelskamp, A.; Russell, J. Collaborating to Assess and Address Food Insecurity on a College Campus: A Case Study at a Mid-Sized, Regional University. *Innov. High. Educ.* **2020**, *45*, 405–417. [[CrossRef](#)]
38. Shi, Y.; Wang, Q.; Norman, C.; Allman-Farinelli, M.; Colagiuri, S. It Is Time to Make Policy for Healthier Food Environments in Australian Universities. *Nutrients* **2018**, *10*, 1909. [[CrossRef](#)] [[PubMed](#)]
39. Wellard, L.; Havill, M.; Hughes, C.; Watson, W.L.; Chapman, K. Energy-dense fast food products cost less: An observational study of the energy density and energy cost of Australian fast foods. *Aust. N. Z. J. Public Health* **2015**, *39*, 544–545. [[CrossRef](#)]
40. O'Hare, M. Sydney, Melbourne on List of the World's Top 20 Most Expensive Cities. Available online: <https://7news.com.au/business/money/sydney-melbourne-on-list-of-the-worlds-top-20-most-expensive-cities-c-4785041> (accessed on 10 September 2022).
41. Louie, S.; Shi, Y.; Allman-Farinelli, M. The effects of the COVID-19 pandemic on food security in Australia: A scoping review. *Nutr. Diet.* **2022**, *79*, 28–47. [[CrossRef](#)]
42. Andreyeva, T.; Tripp, A.S.; Schwartz, M.B. Dietary Quality of Americans by Supplemental Nutrition Assistance Program Participation Status: A Systematic Review. *Am. J. Prev. Med.* **2015**, *49*, 594–604. [[CrossRef](#)] [[PubMed](#)]
43. Efrati Philip, D.; Baransi, G.; Shahar, D.R.; Troen, A.M. Food-Aid Quality Correlates Positively With Diet Quality of Food Pantry Users in the Leket Israel Food Bank Collaborative. *Front. Nutr.* **2018**, *5*, 123. [[CrossRef](#)] [[PubMed](#)]
44. Study NSW. COVID-19 Help Hub for International Students—Food Assistance. Available online: <https://www.study.sydney/programs/food-assistance> (accessed on 10 September 2022).
45. Foodbank Australia. Foodbank Hunger Report 2021. Available online: <https://reports.foodbank.org.au/foodbank-hunger-report-2021/?state=au> (accessed on 10 September 2022).
46. Whatnall, M.C.; Patterson, A.J.; Chiu, S.; Oldmeadow, C.; Hutchesson, M.J. Determinants of eating behaviours in Australian university students: A cross-sectional analysis. *Nutr. Diet.* **2020**, *77*, 331–343. [[CrossRef](#)] [[PubMed](#)]
47. Marchese, L.; Livingstone, K.M.; Woods, J.L.; Wingrove, K.; Machado, P. Ultra-processed food consumption, socio-demographics and diet quality in Australian adults. *Public Health Nutr.* **2022**, *25*, 94–104. [[CrossRef](#)] [[PubMed](#)]
48. Larson, N.I.; Perry, C.L.; Story, M.; Neumark-Sztainer, D. Food Preparation by Young Adults Is Associated with Better Diet Quality. *J. Am. Diet. Assoc.* **2006**, *106*, 2001–2007. [[CrossRef](#)]
49. Thorpe, M.G.; Kestin, M.; Riddell, L.J.; Keast, R.S.J.; McNaughton, S.A. Diet quality in young adults and its association with food-related behaviours. *Public Health Nutr.* **2014**, *17*, 1767–1775. [[CrossRef](#)] [[PubMed](#)]
50. Olfert, M.D.; Wattick, R.A.; Saurborn, E.G.; Hagedorn, R.L. Impact of COVID-19 on college student diet quality and physical activity. *Nutr. Health* **2022**, 2601060221086772. [[CrossRef](#)] [[PubMed](#)]

51. Soldavini, J.; Berner, M. Characteristics associated with cooking frequency among college students. *Int. J. Gastron. Food Sci.* **2021**, *23*, 100303. [[CrossRef](#)]
52. Partridge, S.R.; Gibson, A.A.; Roy, R.; Malloy, J.A.; Raeside, R.; Jia, S.S.; Singleton, A.C.; Mandoh, M.; Todd, A.R.; Wang, T.; et al. Junk Food on Demand: A Cross-Sectional Analysis of the Nutritional Quality of Popular Online Food Delivery Outlets in Australia and New Zealand. *Nutrients* **2020**, *12*, 3107. [[CrossRef](#)] [[PubMed](#)]
53. Vidgen, H.A.; Gallegos, D. Defining food literacy and its components. *Appetite* **2014**, *76*, 50–59. [[CrossRef](#)] [[PubMed](#)]
54. Begley, A.; Paynter, E.; Butcher, L.; Bobongie, V.; Dhaliwal, S.S. Identifying Who Improves or Maintains Their Food Literacy Behaviours after Completing an Adult Program. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4462. [[CrossRef](#)] [[PubMed](#)]
55. Begley, A.; Paynter, E.; Butcher, L.M.; Dhaliwal, S.S. Effectiveness of an Adult Food Literacy Program. *Nutrients* **2019**, *11*, 797. [[CrossRef](#)] [[PubMed](#)]
56. Hutchesson, M.J.; Whatnall, M.C.; Patterson, A.J. On-campus food purchasing behaviours and satisfaction of Australian university students. *Health Promot. J. Austr.* **2022**, *33*, 649–656. [[CrossRef](#)]
57. Roy, R.; Rangan, A.; Hebden, L.; Louie, J.C.Y.; Tang, L.M.; Kay, J.; Allman-Farinelli, M. Dietary contribution of foods and beverages sold within a university campus and its effect on diet quality of young adults. *Nutrition* **2017**, *34*, 118–123. [[CrossRef](#)]
58. Whatnall, M.C.; Soo, Z.M.; Patterson, A.J.; Hutchesson, M.J. University Students Purchasing Food on Campus More Frequently Consume More Energy-Dense, Nutrient-Poor Foods: A Cross-Sectional Survey. *Nutrients* **2021**, *13*, 1053. [[CrossRef](#)] [[PubMed](#)]
59. Pelletier, J.E.; Laska, M.N. Campus food and beverage purchases are associated with indicators of diet quality in college students living off campus. *Am. J. Health Promot.* **2013**, *28*, 80–87. [[CrossRef](#)] [[PubMed](#)]
60. Department of Education and Department of Employment and Workplace Relations, Australian Government. 2020 Student Summary Tables. Available online: <https://www.dese.gov.au/higher-education-statistics/resources/2020-student-summary-tables> (accessed on 10 September 2022).
61. O’Leary, F.; Grech, A.; Sui, Z.; Cheng, H.; Rangan, A.; Hirani, V. Older Australians are eating more protein: Secondary analysis of the 1995 & 2011/12 national nutrition surveys. *Eur. J. Clin. Nutr.* **2020**, *74*, 588–597. [[CrossRef](#)]
62. Tooze, J.A.; Midthune, D.; Dodd, K.W.; Freedman, L.S.; Krebs-Smith, S.M.; Subar, A.F.; Guenther, P.M.; Carroll, R.J.; Kipnis, V. A New Statistical Method for Estimating the Usual Intake of Episodically Consumed Foods with Application to Their Distribution. *J. Am. Diet. Assoc.* **2006**, *106*, 1575–1587. [[CrossRef](#)] [[PubMed](#)]

Table S1. Mean scores of Healthy Eating Index for Australian Adults (HEIFA-2013) by student characteristics from domestic and international students who completed two dietary recalls.¹

Student characteristics	Total (<i>n</i> = 93)				Domestic (<i>n</i> = 71)				International (<i>n</i> = 22)			
	N	Mean	95% CI	P	N	Mean	95% CI	P	N	Mean	95% CI	P
Sociodemographic												
Age												
18-22 years	67	50.9	47.9-54.0	0.079	52	50.4	46.8-54.1	0.110	15	52.4	46.1-58.7	0.448
23-30 years	26	56.1	51.2-61.1		19	56.1	50.1-62.2		7	56.9	47.2-66.6	
Gender												
Female	75	51.9	48.9-54.8	0.434	58	51.5	48.0-55.0	0.577	17	53.1	47.4-58.8	0.592
Male	18	54.5	48.5-60.5		13	53.9	46.3-61.4		5	56.3	45.6-66.9	
Current academic degree												
Undergraduate	67	51.9	48.8-55.0	0.566	51	51.3	47.6-55.1	0.551	16	53.6	47.6-59.6	0.893
Postgraduate	26	53.6	48.6-58.6		20	53.5	47.5-59.5		6	54.4	44.3-64.5	
Marital status												
Never married	87	52.6	49.9-55.3	0.569	65	52.2	48.8-55.5	0.645	22	53.8	48.9-58.7	NA ²
Married or other	6	49.5	39.1-59.9		6	49.5	38.6-60.5		0	NA	NA	
Current accommodation												
Parental home	54	51.4	48.0-54.9	0.400	52	50.8	47.1-54.5	0.234	2	69.4	53.7-85.1	NP ³
Other than parental home	39	53.7	49.6-57.8		19	55.1	49.0-61.2		20	52.3	47.5-57.0	
Employment status												
No employment	31	54.6	50.0-59.1	0.242	18	55.1	48.7-61.4	0.259	13	54.0	47.5-60.6	0.912
Employed	62	51.3	48.1-54.5		53	50.9	47.2-54.5		9	53.5	45.6-61.4	
Weekly working hours												
Less than 20 hours	51	51.5	48.0-55.1	0.740	44	51.5	47.6-55.4	0.461	7	51.8	40.0-63.7	NP
20 hours or more	11	50.1	42.5-57.7		9	48.0	39.3-56.6		2	59.9	35.8-83.9	
Weekly income (AUD) ⁴												
\$500 or less	64	51.5	48.3-54.7	0.509	50	51.2	47.4-55.0	0.545	14	52.2	45.6-58.7	NP
More than \$500	24	53.5	48.3-58.8		20	53.4	47.3-59.4		4	55.5	42.3-68.7	

Student characteristics	Total (<i>n</i> = 93)				Domestic (<i>n</i> = 71)				International (<i>n</i> = 22)			
	N	Mean	95% CI	P	N	Mean	95% CI	P	N	Mean	95% CI	P
Changes caused by COVID-19												
Living arrangement ⁵												
No	80	51.4	48.6-54.2	0.070	64	51.2	47.9-54.5	0.170	16	52.2	46.5-58.0	0.281
Yes	13	58.4	51.4-65.3		7	58.6	48.5-68.6		6	58.1	48.7-67.5	
Job changes ⁶												
No	61	52.1	48.9-55.4	0.789	45	51.9	47.9-55.9	0.988	16	52.7	46.8-58.5	0.442
Yes	32	52.9	48.4-57.4		26	52.0	46.7-57.2		6	56.9	47.3-66.4	
Difficulties in finding jobs												
No	65	52.8	49.6-55.9	0.652	51	52.5	48.7-56.2	0.602	14	53.9	47.4-60.3	0.979
Yes	28	51.5	46.7-56.3		20	50.6	44.6-56.6		8	53.7	45.1-62.4	
Employment income loss												
No	61	51.4	48.1-54.6	0.338	46	51.2	47.3-55.1	0.489	15	51.8	45.2-58.3	NP
Yes	23	54.4	49.1-59.6		20	53.6	47.8-59.5		3	59.5	44.6-74.3	
Received any government support payment												
No	57	53.4	50.0-56.7	0.409	39	53.7	49.4-58.0	0.264	18	52.6	47.2-58.1	NP
Yes	35	51.1	46.8-55.4		31	50.0	45.2-54.8		4	59.1	47.6-70.6	
Received any support payment from other sources												
No	88	51.9	49.2-54.6	NP	70	51.8	48.6-55.0	NP	18	52.1	46.8-57.4	NP
Yes	3	56.6	42.0-71.1		1	60.1	33.3-86.9		2	54.7	38.7-70.6	
Diet and health-related characteristics												
Food security status ⁷												
Food secure	86	52.9	50.2-55.6	0.163	66	52.4	49.2-55.7	0.253	20	54.5	49.3-59.7	NP
Food insecure	7	45.9	36.4-55.4		5	45.3	33.4-57.2		2	47.4	30.9-63.8	
Does your accommodation provide meals? ⁸												
No	32	55.0	50.6-59.4	NP	14	57.4	48.9-65.9	NP	18	52.8	47.6-58.1	NP
Yes	4	48.2	35.8-60.7		2	50.9	27.3-74.6		2	47.8	32.1-63.4	

Student characteristics	Total (n = 93)				Domestic (n = 71)				International (n = 22)			
	N	Mean	95% CI	P	N	Mean	95% CI	P	N	Mean	95% CI	P
Weekly food budget (AUD)												
\$0-30	15	53.8	47.1-60.4	0.580	15	53.8	46.9-60.6	0.123	0	NA	NA	0.208
\$31-60	26	52.2	47.1-57.2		21	50.2	44.5-55.9		5	60.9	50.6-71.1	
\$61-100	39	53.5	49.4-57.6		28	54.8	49.8-59.7		11	50.0	43.2-56.8	
> \$100	13	48.0	40.9-55.1		7	42.1	32.2-51.9		6	54.9	45.8-64.1	
Adequacy of cooking facilities												
Adequate	87	51.7	49.0-54.4	0.046	70	51.8	48.6-55.0	0.372	17	51.4	46.2-56.6	0.055
Inadequate	6	62.4	52.2-72.6		1	63.9	37.2-90.7		5	62.1	52.5-71.7	
Self-perceived cooking skills												
Excellent	16	57.1	50.8-63.4	0.180	12	57.6	50.0-65.2	0.119	4	55.8	43.6-68.0	0.908
Good	35	50.0	45.7-54.3		23	48.0	42.5-53.5		12	53.8	46.8-60.9	
Fair or poor	42	52.6	48.7-56.5		36	52.6	48.2-57.0		6	52.5	42.5-62.5	
Cooking frequency												
3 days/week or less	50	49.3	45.9-52.8	0.013	42	49.1	45.1-53.1	0.033	8	50.2	42.1-58.3	0.253
4+ days/week	43	55.9	52.2-59.7		29	56.1	51.2-60.9		14	55.9	49.8-62.0	
Eating out frequency												
3 days/week or less	85	52.7	49.9-55.4	0.486	66	52.1	48.7-55.4	0.804	19	54.8	49.5-60.1	NP
4+ days/week	8	49.3	40.3-58.4		5	50.5	38.1-62.8		3	47.4	34.0-60.9	
Self-rated physical health status												
Excellent or good	50	54.8	51.2-58.4	0.058	34	54.9	50.3-59.5	0.085	16	54.5	48.5-60.6	0.653
Average or poorer	43	49.6	45.7-53.5		37	49.2	44.9-53.6		6	51.9	41.8-62.0	
BMI category ⁹												
Underweight	10	46.7	38.7-54.6	0.237	7	44.1	34.0-54.1	0.237	3	52.3	38.1-66.4	NP
Normal weight	65	53.7	50.5-56.8		48	53.2	49.4-57.1		17	54.8	49.0-60.7	
Overweight or obesity	18	50.9	44.8-57.0		16	51.5	44.7-58.4		2	47.7	30.7-64.6	
Self-rated mental health status												
Excellent or good	40	49.8	45.9-53.8	0.093	29	49.8	44.8-54.7	0.262	11	49.9	43.3-56.5	0.096
Average or poorer	53	54.3	50.9-57.8		42	53.4	49.3-57.5		11	57.7	51.1-64.4	

Student characteristics	Total (<i>n</i> = 93)				Domestic (<i>n</i> = 71)				International (<i>n</i> = 22)			
	N	Mean	95% CI	P	N	Mean	95% CI	P	N	Mean	95% CI	P
WHO-5 Well-being index category												
Normal	51	52.7	49.1-56.2	0.810	37	52.9	48.5-57.3	0.518	14	52.0	45.8-58.2	0.316
Poor wellbeing (below 13)	42	52.0	48.1-56.0		34	50.9	46.3-55.5		8	57.0	48.9-65.2	

¹ Mean scores adjusted for energy intake (EI):basal metabolic rate (BMR) through analysis of covariance (ANCOVA), the potential range of HEIFA-2013 was 0-100; ² Not applicable; ³ Not enough power; ⁴ Weekly income, include employment and/or other income; ⁵ Living arrangement changes, e.g., moved to less expensive premises; ⁶ Job changes, e.g., lost employment or worked less hours; ⁷ Food security status was assessed by the 18-item Household Food Security Survey Module; ⁸ A question for students lived outside parental or own home; ⁹ BMI cut-offs, underweight (<18.5 kg/m²), normal weight (18.5-24.9 kg/m²), overweight (25.0-29.9 kg/m²) and obesity (≥30.0 kg/m²).

7.5 Conclusion to chapter

Poorer diet quality was found in food-insecure tertiary education students compared with food-secure students, although the association was significant in domestic students only from our sample. Higher cooking skills and cooking frequency appeared to be beneficial for achieving higher diet quality. Recommendations for achieving high food security and improving diet quality in international and domestic students based on the evidence from this thesis will be provided in the final chapter (**Chapter Eight**).

Chapter Eight. Conclusions and recommendations

8.1 Introduction to chapter

In this final chapter of the thesis, key research findings from all five studies in this PhD will be summarised. Recommendations for future practice will be provided for tertiary education institutions to implement plans for improving food security status and diet quality among domestic and international students. Directions for future research on dietary experiences of domestic and international tertiary education students will be indicated.

8.2 Key research findings

In this thesis, the mixed methods research design was applied to identify barriers and enablers to the achievement of food security and better diet quality for tertiary education students in Australia, and to develop recommendations for future practice and research based on the qualitative and quantitative evidence.

8.2.1 Scoping and systematic reviews

To facilitate the design of the qualitative and quantitative studies, a scoping review and a systematic review were conducted. The scoping review (**Chapter Three**) summarised existing evidence on dietary acculturation and food insecurity among international students in any country. International students often adopt some local dietary habits but maintain some of their original habits while studying in the host country. Students may oscillate between the local and traditional diets over time. Individual and environmental factors contribute to the changes in food group consumption and meal patterns, and these changes contribute to weight changes and other health impacts. Negative dietary changes (e.g., less intake of fruits and vegetables) and health impacts (e.g., digestive problems and feelings of guilt) are frequently reported. International students are more likely to be food insecure than domestic students based on a

small number of studies, but food security status among international students in Australia has been rarely studied. These findings were used to inform the development of the interview guide for the qualitative study (**Chapter Five**) to explore dietary experiences of international students in Australia.

The systematic review (**Chapter Four**) grouped current evidence on dietary outcomes by food security status in tertiary education students. Poorer dietary outcomes were reported in food-insecure students, although the findings were not consistently significant across studies. These outcomes focused on food group and nutrient intakes (e.g., less fruits, vegetables, and whole grains, and more added sugar) and reduced meal regularity, but the overall diet quality was rarely measured using validated tools in food-secure and -insecure students. Therefore, the association between overall diet quality and food security status in this population group was researched in a quantitative study (**Chapter Seven**). Findings from the systematic review and the earlier scoping review guided the design of the questionnaire for a food security survey conducted in domestic and international students receiving tertiary education in Australia (**Chapter Six**).

8.2.2 Mixed methods research

The next stage of the research used a mixed methods research design and started with a qualitative study (**Chapter Five**) using semi-structured interviews to explore dietary experiences of international students attending an Australian university. The second stage of the mixed methods research design included two quantitative studies, with a food security survey (**Chapter Six**) and a dietary recall sub-study (**Chapter Seven**).

8.2.2.1 Qualitative evidence

In this study, international students from China and India voiced their challenges in having a healthy diet with preferred foods and regular meals while in Australia. Becoming independent was a critical contributing factor to changes in their diets. For many students, the period after coming to Australia was their first time managing and preparing their own meals; when living in their home country, everything was prepared by parents or other family members at home, and thus they did not need to think about food and nutrition. When they had classes in their home countries, they were able to rely on the canteens on campus because familiar foods were provided with sufficient variety and affordable prices. However, they reported that these were not offered by food outlets on campus in Australia.

When purchasing and preparing food in Australia, convenience was extremely important for these students as many did not have enough time nor the skills to cook complex dishes; for example, traditional dishes and some vegetables require more time and effort to cook. Living in shared accommodation also sometimes restricted what they could prepare due to a busy communal kitchen or limited storage spaces, but many students improved their cooking skills by learning with friends or flatmates in Australia. The inability to find traditional vegetables and snacks in Australia upset some students. Fresh food groceries and eating out were perceived to be more expensive than in their home countries. Issues in food availability and affordability sometimes meant fewer preferred options for main meals and contributed to reduced meal regularity among some students in Australia. Regarding food security, international students tended to have sufficient amounts of food to avoid hunger, but they reported that they experienced major challenges in meeting nutritional needs and food preferences during their residence in Australia.

8.2.2.2 Quantitative evidence

The second stage of the mixed methods research design included two quantitative studies: a cross-sectional survey of food security and associated factors (**Chapter Six**) and a sub-study measuring dietary intakes (**Chapter Seven**). International students were found to be twice as likely to experience food insecurity than domestic students during the COVID-19 pandemic. The overall diet quality of both domestic and international students was low, with no statistical difference between the two student groups.

Different risk factors were associated with food insecurity in domestic (e.g., being undergraduates, living outside the parental home, and experiencing employment income loss during the pandemic) and international students (e.g., experiencing changes in living arrangements due to the pandemic). International students living in accommodation that provided meals were more likely to be food insecure than those without provided meals because the meals were unlikely to meet their preferences and cultural needs. This was consistent with a response from one of the international students in the qualitative study who reported dissatisfaction with the taste of meals provided by the student accommodation. The impacts of time and financial constraints on food security status and meal regularity were also found in both the food security survey and the qualitative research. Financial difficulties during the pandemic may have worsened food insecurity among domestic and international students due to the reduced budget for food.

The food security survey found that food insecurity in domestic students was associated with lower intakes of fruits. This result was consistent with the findings from the dietary recall sub-study, which found an association between lower overall diet quality and food insecurity in domestic students. The dietary recall sub-study also found protective factors for better diet

quality in domestic students, including higher self-perceived cooking skills and higher cooking frequency. In a small sample of international students, the association between diet quality and food security status or other factors could not be determined due to insufficient statistical power.

Poorer self-perceived physical health status was reported by domestic students with poorer diet quality. Both domestic and international students with food insecurity reported compromised wellbeing compared with their food-secure peers. For international students, the inability to meet their cultural food preferences in Australia may contribute to poorer mental health, according to the evidence from the qualitative study. On the other hand, stress and mental health status may affect students' food choices and meal patterns, according to comments from interviewees and survey respondents on their food security status. No association was found between overall diet quality and mental health from the sample in the quantitative study. Domestic students participating in the survey reported food insecurity negatively impacted their academic performance, attendance at classes and withdrawal from courses, but this was not reflected by international students.

8.2.3 Impacts of the COVID-19 pandemic

The sample sizes in the qualitative and quantitative studies were affected by the COVID-19 pandemic as limited recruitment methods could be used during lockdowns, and international students were not allowed to arrive in Australia between March 2020 and December 2021. The long time frame of the recruitment in the qualitative study was because it was difficult to find new international students as many students went back to their home country after the first outbreak, we did another wave of data collection in early 2022 after the national borders reopened for international students. Because only a small sample of international students could be recruited, only a small number of food-insecure international students were identified from

the food security survey, and fewer were included in the dietary assessment sub-study. This contributed to insufficient statistical power to determine the association between food insecurity and diet quality in international students.

Food insecurity and mental health of students worsened due to the COVID-19 pandemic. Negative impacts of the pandemic on these issues were seen in both this research and other studies conducted during this period. Some students may have had financial difficulties due to high tuition fees and living expenses pre-COVID, and this may have worsened by the loss of casual employment during the pandemic.¹ Domestic students had the opportunity to move back to the parental home to alleviate financial difficulties, but the family support for international students worsened due to reduced opportunities for family reunions caused by international travel restrictions during the pandemic. Food access and grocery shopping were negatively impacted by various restrictions during lockdowns.^{2,3} For international students, their access to traditional groceries became problematic as those stores tended to be further away from their accommodation and it was less convenient to travel during the pandemic. Poor mental health was prevalent among tertiary education students during the pandemic.⁴ Our food security survey found that students' self-rated mental health and WHO-5 Well-Being Index scores were generally low. The sources of an increased level of stress may include increased financial and academic concerns, fear of infection and worry about their loved ones, and reduced social interactions.⁵ The association between food insecurity and mental health in tertiary education students may be mediated by these changes in their life.

8.3 Future directions

8.3.1 Recommendations for future practice

Tertiary education institutions need to be more aware of difficulties for both domestic and international students in achieving a healthy diet, and the prevalence of food insecurity among these two student groups should be regularly monitored. There is a disconnect between the belief of many about international students' financial situation and the reality. The conventional understanding in the public in general is that international students are from rich backgrounds, which was mentioned by one of our participants in the qualitative study. They seemed to be less likely to have issues with food security, but limited budget may be left after paying tuition fees, rents, and other living costs which are quite expensive in Australia,⁶ and our work has revealed many students struggle to procure a healthy diet.

Policy reform in food offerings on campus appear to be necessary. More culturally appropriate options should be provided for international students from different countries. Healthy meal options need to be offered with more affordable prices or more discounts, and additional programs could be organised during exam periods, such as free healthy snacks in food outlets. This would make healthy and preferred choices more convenient for students by addressing their time and financial constraints. Policies for improving food environments are available for schools and health facilities, such as the NSW Healthy School Canteen Strategy and the Healthy Food and Drink in NSW Health Facilities for Staff and Visitors Framework,^{7,8} but not yet for universities in Australia. However, the University Food Environment Assessment (Uni-Food) tool has been developed by an Australian national expert panel to benchmark the healthiness, equity, and environmental sustainability of food environments on campus, and the tool has been used in a few universities across Australia.⁹ Some universities have launched their own initiatives to investigate and address their food environment problems on campus,

for example, Healthy Sydney University by The University of Sydney,¹⁰ and The Good Food Project by the University of New South Wales.¹¹ These initiatives need to be implemented consistently to fulfill dietary requirements of different students.

To further address financial difficulties among tertiary education students, more partnerships with external facilities could be built to provide more skilled and appropriate work opportunities to supplement students' food budgets. Partnerships between campus food outlets and nearby grocery stores could offer financial incentives for selecting healthy food options. For example, collaborating with communities to run a campus-based farmers' market was feasible in a public university in the US.¹² Tertiary institutions' smartphone apps could incorporate functions to offer vouchers for fresh food groceries and cultural restaurants with healthy options.

Students from our studies showed an interest in receiving nutrition education and having cooking classes. Improving food literacy includes disseminating not only nutrition knowledge, but also information on food sources and skills in time and budget management.^{13,14} Nutrition intervention programs could be regularly operated throughout the academic year to reach more students. The promotion of these programs should be enhanced so more students are aware of the availability of this assistance.

An example of a successful intervention to improve food literacy in tertiary education students is a Nutrition and Culinary in the Kitchen Program implemented in a Brazilian university. The program contained five interactive cooking classes and one workshop on purchasing food in a food market over six weeks.¹⁵ The intervention group reported increased self-efficacy of accessing and cooking healthy foods at a six-month follow-up.¹⁵ In Australia, cooking classes

could be organised in on-campus student accommodation with shared kitchens, and visits to a supermarket and a farmers' market could be included to show different sources of fresh and healthy choices and explain the Australian food labelling systems.

Another community-based approach may also be effective. The Healthy Active Living community intervention incorporates healthy eating and physical activities, and was implemented by a Canadian university for their first-year students.¹⁶ This program provided a systematic exposure to interventions on healthy active lifestyle behaviours through structured activities (e.g., cooking competitions and adventure-based outdoor physical activities) across the academic year. An increased level of physical activity and higher consumption of fruits and vegetables were reported by students living in the Healthy Active Living community.¹⁶ The combination of nutrition intervention with other healthy behaviours might be more interesting and appealing for young adults in universities. The university where the current research was conducted has an online unit of study that provides information about healthy eating, physical activity, sleep, alcohol and harmful substances, and emotional and social wellbeing. However, it is an elective unit of study. The Canadian community-based method could be applied by individual tertiary education institutions in Australia, through diligent design by a multidisciplinary team to meet specific needs of their students.

Apart from traditional face-to-face or online nutrition workshops, other web-based formats might be worth trying to circulate nutrition knowledge. Online quiz games could be designed based on different topics related to healthy eating (e.g., food labels and key dietary recommendations) to make the education program more attractive and interactive for students.¹⁷ This could be launched via the online teaching system in all Australian universities to make it visible to more students.

Peer programs could be organised for newly arrived international students to smooth the process of dietary acculturation. For example, senior international students who had rich experiences in cooking on a budget could share their suggestions on food shopping and preparation in Australia through specific online communication channels or cooking classes in person on a regular basis. For instance, the availability of discounted seasonal fruits and vegetables with imperfect appearances in supermarkets, such as “The Odd Bunch” and “Imperfect Picks”, could be promoted to international students who are not familiar with local food environments. Easy and healthy recipes with local ingredients might be helpful for them to better adapt to the Australian food environments. To alleviate cravings for home foods, students from the same country or region may be grouped together to learn to cook their traditional dishes and share with others, and this may also contribute positively to their mental health.

Measurement of food security status among domestic and international students needs to be conducted regularly by each tertiary education institution. This may be included in a priori or an evaluation survey of nutrition intervention programs or a regular satisfaction survey about food environments on campus. More voices from students may be heard by adding open-ended questions for them to describe their challenges, seek help, and provide their suggestions. Subsequently, the prevalence of food insecurity and responses from students could facilitate the decision making of tertiary institutions to specify their interventions in reducing food insecurity on campus.

The availability of food assistance programs that specifically provided for international students increased during the COVID-19 pandemic. Food pantries may need to be consistently available on or near campuses for both domestic and international students in Australian

universities through partnerships with charitable organisations such as Foodbank Australia and OzHarvest. Campus food pantries are prevalent in US and Canadian universities.^{18,19} Common barriers for students to access food pantries would need to be addressed during the implementation. Details of the available services and how to seek help when facing issues in maintaining food security need wider dissemination, as the awareness of available services is often low.¹⁸ Social stigma may be reduced by regular communication, such as emails, explaining that food insecurity is a recognised problem for students and advertising food pantries, to destigmatise food insecurity and use of food pantries. Offering discounted groceries instead of free food hampers may be helpful for addressing the stigma. Food pantries should also be available at convenient times for students, outside class times. The provision of food options needs to be culturally responsive to meet dietary and nutritional requirements of international students. The sustainability of food pantries may be improved by the cooperation between food industry, the government, and food pantries to optimise the policies for food redistribution and the reduction of food waste.²⁰

Considering the interactions between mental health and dietary experiences in both domestic and international students, mental health care also needs more attention while improving food security and diet quality. The monitoring of food insecurity could be actioned simultaneously with mental health screening. Mental health support services need to be easily accessible for food-insecure students and international students with issues accessing preferred foods if they experience any mental health problems.

8.3.2 Future research

The recruitment of international students in our studies was limited by the COVID-19 pandemic. Future research should recruit more international students for further investigation

of risk factors for food insecurity and poor diet quality in this student group, and further comparison between domestic and international students. The recruitment of students from different settings may find further contributing factors; for example, socioeconomic status and environmental factors among students living in different areas in Australia (e.g., rural areas) may lead to different experiences of food security and diet quality. To be more representative, more male students should be recruited. Longitudinal studies may show the changes in students' experiences at different stages throughout the academic year, for example, during teaching weeks, exam periods, and vacations.

Experiences of domestic and international students with marginal food security is worthy of further investigation. Marginally food-insecure students may have worries about food quantity and quality, and this may contribute to poor outcomes compared with highly food-secure students.^{21,22} A larger sample size could allow further analysis by four food security categories (i.e., high, marginal, low, and very low food security) instead of two (i.e., food secure and insecure). Alternatively, some studies classified marginal food security into the food-insecure group.²³ Moreover, the modification of existing food security assessment tools to match the understanding and circumstances of tertiary education students might be required. A new customised tool may be beneficial to more accurately estimate the prevalence of food insecurity in this population group, e.g., considering more about their food preferences, nutritional needs, and constraints on time and cooking. Future research may need to consider more perspectives of food security by following the new six-dimension framework of food security.^{24,25} Compared with the previous four-dimension framework²⁶ (mentioned in Chapter One, figure 1.2), two new dimensions are agency (the capacity of individuals or groups to make decisions about food independently) and sustainability (food system can contribute to long-term regeneration of natural, social, and economic systems).^{24,25}

Interdisciplinary research into both nutrition and mental health in tertiary education students could be established to consider the interactions between these two aspects among participants. Qualitative evidence could be collected from students with both nutrition/food security and mental health issues. The mechanisms of interactions between these two aspects of participants' experiences could then be explored for the purpose of designing tailored interventions to improve both simultaneously.

Academic outcomes could be quantitatively measured in future research to investigate whether food insecurity and poor diet quality negatively impact academic outcomes among domestic and international students. This may help tertiary education institutions raise awareness of the need to implement interventions to improve dietary experiences of their students. The evaluation of intervention programs would be critical to check their effectiveness and adjust the design of interventions. Positive impacts from follow-up studies may prompt more funding for continuous practices, and the feedback from participants would facilitate a better design of the program to improve the participation rate and effectiveness.

8.4 Conclusion to chapter and thesis

In summary, international students in our studies experience challenges in having a nutritious diet with preferred foods in Australia and are more likely to be food insecure than domestic students. However, the overall diet quality is poor in both domestic and international students, without statistically significant differences. Food insecurity is associated with poorer mental health in both student groups. Domestic students with food insecurity have poorer academic outcomes and a lower overall diet quality than food-secure domestic students. Higher self-perceived cooking skills and cooking frequency appear to be protective factors for better diet quality in domestic students.

To address food insecurity and poor diet quality in domestic and international students, Australian tertiary education institutions need to be more aware of these issues and their negative impacts on students. More investment might be required to develop and implement intervention programs. Policies to improve food availability and affordability in food environments on campus need to be in place. Strategies for addressing financial difficulties and providing food assistance services on campus may help food-insecure students. Availability of culturally appropriate foods in food outlets and food assistance programs on campus is critical for international students. Food literacy programs need to be organised regularly for students with different backgrounds, which may include nutrition education, peer programs, cooking classes, and grocery shopping tours. More actions need to be urgently taken by tertiary education facilities in Australia to assist domestic and international students to achieve food security and better diet quality in order for them to have a better life during their tertiary studies.

8.5 References

1. Bennett CJ, Christian M, Phan S, McCabe M, Cornish K, Kleve S. Food insecurity during COVID-19: an Australian university experience. *Health Soc Care Community*. 2022;30(6):e5401-e5411. doi:10.1111/hsc.13962
2. Louie S, Shi Y, Allman-Farinelli M. The effects of the COVID-19 pandemic on food security in Australia: a scoping review. *Nutr Diet*. 2022;79(1):28-47. doi:10.1111/1747-0080.12720
3. Kent K, Murray S, Penrose B, et al. The new normal for food insecurity? A repeated cross-sectional survey over 1 year during the COVID-19 pandemic in Australia. *Int J Behav Nutr Phys Act*. 2022;19(1):115. doi:10.1186/s12966-022-01347-4
4. Chen T, Lucock M. The mental health of university students during the COVID-19 pandemic: an online survey in the UK. *PLoS One*. 2022;17(1):e0262562. doi:10.1371/journal.pone.0262562
5. Son C, Hegde S, Smith A, Wang X, Sasangohar F. Effects of COVID-19 on college students' mental health in the United States: interview survey study. *J Med Internet Res*. 2020;22(9):e21279. doi:10.2196/21279
6. OYA School - Complete College Guidance. Challenges faced by international students in Australia. Accessed March 3, 2023. <https://oyaschool.com/challenges-faced-by-international-students-in-australia/>
7. NSW Government. The NSW Healthy School Canteen Strategy. Accessed September 17, 2022. <https://www.health.nsw.gov.au/health/Publications/food-drink-criteria.pdf>
8. NSW Ministry of Health. Healthy Food and Drink in NSW Health Facilities for Staff and Visitors Framework. Accessed September 17, 2022. <https://www.health.nsw.gov.au/health/Publications/hfd-framework.pdf>
9. Mann D, Kwon J, Naughton S, et al. Development of the University Food Environment Assessment (Uni-Food) Tool and process to benchmark the healthiness, equity, and environmental sustainability of university food environments. *Int J Environ Res Public Health*. 2021;18(22):11895. doi:10.3390/ijerph182211895
10. Healthy Sydney University. *Healthy Sydney University 2017 Impact Report*. The University of Sydney; 2017.
11. Inside UNSW. Teams across UNSW Sydney collaborate to create a high-quality food environment. Accessed September 17, 2022. <https://www.inside.unsw.edu.au/campus-life/teams-across-unsw-sydney-collaborate-create-high-quality-food-environment>
12. Ward RK, Blackley D, Brooks B. The development and implementation of a student-led farmers' market on a public university campus. *J Hunger Environ Nutr*. 2014;9(1):81-95. doi:10.1080/19320248.2013.873007
13. Vidgen HA, Gallegos D. Defining food literacy and its components. *Appetite*. 2014;76:50-59. doi:10.1016/j.appet.2014.01.010
14. Fingland D, Thompson C, Vidgen HA. Measuring food literacy: progressing the development of an international food literacy survey using a content validity study. *Int J Environ Res Public Health*. 2021;18(3):1141. doi:10.3390/ijerph18031141
15. Bernardo GL, Jomori MM, Fernandes AC, Colussi CF, Condrasky MD, Proença R. Positive impact of a cooking skills intervention among Brazilian university students:

- six months follow-up of a randomized controlled trial. *Appetite*. 2018;130:247-255. doi:10.1016/j.appet.2018.08.014
16. Brown DM, Bray SR, Beatty KR, Kwan MY. Healthy active living: a residence community-based intervention to increase physical activity and healthy eating during the transition to first-year university. *J Am Coll Health*. 2014;62(4):234-242. doi:10.1080/07448481.2014.887572
 17. Belogianni K, Ooms A, Ahmed H, et al. Rationale and design of an online educational program using game-based learning to improve nutrition and physical activity outcomes among university students in the United Kingdom. *J Am Coll Nutr*. 2019;38(1):23-30. doi:10.1080/07315724.2018.1476929
 18. Brito-Silva FK, Wang W, Moore CE, et al. College campus food pantry program evaluation: what barriers do students face to access on-campus food pantries? *Nutrients*. 2022;14(14):2807. doi:10.3390/nu14142807
 19. Hanbazaza M, Kebbe M, Perez A, et al. Food insecurity among international post-secondary students studying on a Canadian campus: a qualitative description study. *Can J High Educ*. 2021;51(2):33-45. doi:10.47678/cjhe.vi0.188977
 20. Capodistrias P, Szulecka J, Corciolani M, Strøm-Andersen N. European food banks and COVID-19: resilience and innovation in times of crisis. *Socioecon Plann Sci*. 2022;82:101187. doi:10.1016/j.seps.2021.101187
 21. Brescia SA, Cuite CL. Underestimating college student food insecurity: marginally food secure students may not be food secure. *Nutrients*. 2022;14(15):3142. doi:10.3390/nu14153142
 22. Gamba RJ, Schmeltz MT, Ortiz N, et al. 'Spending all this time stressing and worrying and calculating': marginal food security and student life at a diverse urban university. *Public Health Nutr*. 2021;24(10):2788-2797. doi:10.1017/s1368980021001300
 23. Kent K, Visentin D, Peterson C, et al. Severity of food insecurity among Australian university students, professional and academic staff. *Nutrients*. 2022;14(19):3956. doi:10.3390/nu14193956
 24. Clapp J, Moseley WG, Burlingame B, Termine P. Viewpoint: the case for a six-dimensional food security framework. *Food Policy*. 2022;106(2022):102164. doi:10.1016/j.foodpol.2021.102164
 25. High Level Panel of Experts on Food Security and Nutrition. *Food security and nutrition: building a global narrative towards 2030*. World Food Security; 2020.
 26. FAO Agricultural and Development Economics Division. Policy brief: food security. Accessed September 17, 2022. https://www.fao.org/fileadmin/templates/faoitally/documents/pdf/pdf_Food_Security_Cocept_Note.pdf

Appendix I: Review protocols and the food security questionnaire

1. Scoping review protocol

(Appears on next page)

Food access, dietary acculturation, and food insecurity among international tertiary education students: a scoping review protocol

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ABSTRACT

Objective: This scoping review aims to synthesize existing evidence on dietary changes and food security status of international students who attend tertiary education facilities. Factors affecting nutrition and health, academic and psychological outcomes will also be examined.

Introduction: More and more students choose to complete higher education in a foreign country, and these international students often have to establish new dietary habits in an unfamiliar culture and food environment. Nutritional status and food insecurity for college students have been frequently discussed, but similar issues for international students receive less attention.

Inclusion criteria: Quantitative and qualitative studies that investigate international students within tertiary education institutions in any country will be considered for inclusion. Eligible studies should include changes in dietary behaviors and food patterns, with associated factors, after students arrive in the host country. Studies that assess food insecurity among international students will also be included.

Methods: The electronic databases, including MEDLINE, CINAHL, ERIC, Global Health, CENTRAL and PsycINFO, will be searched. The language of articles will be limited to English. A three-step strategy will be employed for screening. Two reviewers will conduct screening and data extraction. A draft data charting form will be used to extract data from included studies and modified as required for the final extraction. The patterns of dietary changes and food security status with influencers will be charted and summarized.

Keywords acculturation; college; dietary habits; food security; international students

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Introduction

With expanding globalization, the number of international students in the higher education sector is continuously increasing across the world.¹ This population of students leave their home country and temporarily immigrate to a foreign country in order to pursue post-secondary qualifications in tertiary education facilities.² They make a substantial contribution to the income of the host countries.¹ In Australia, international education remains the

third largest export industry, contributing \$32.4 billion to the economy in the 2017–2018 financial year, and this income continues to increase.³ However, the well-being and nutritional status of these students receive relatively little attention. Many countries require international students to be covered by health insurance prior to their arrival, but appropriate nutrition education and assistance in healthy eating are not routinely provided.^{4,5}

When students commence their study in tertiary institutions, it may be their first time living alone and making decisions for themselves, including food choices.⁶ Additionally, college students often have to deal with socioeconomic and academic pressures.⁷ Compared to domestic students, international students face more challenges to subsist and study in a foreign country, including dealing with an unfamiliar culture, language barriers, a lack of

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sociopsychological support and financial difficulties.⁸ A recent study from the US showed that both stress levels and depressive symptoms were significantly higher in international students than in domestic students.⁷ All these stressors may impact on their health and nutrition behaviors in different ways.

When people move to a foreign country and try to assimilate into a different society, it is common to experience culture shock.⁹ Acculturation has been reported among immigrants and international students, which includes the adaptation to the culture of the host country.^{10,11} From a nutritional perspective, they attempt to adapt to the food culture of the host country due to the unfamiliarity of the food environment, with different food availability and access compared with home.¹² As the period of their residence lengthens, they may further adopt local food habits.¹³ Alternatively, they may move towards their original diets as they become more familiar with food supplies in the host country. For example, some students in the US have tried to revert to their original diets when they realize that eating fast foods, typical in the American diet, is less healthy as these foods are high in fat, sugar and salt.^{11,14}

The food choices of international students may also be influenced by food services in the universities.¹² At the initial stage after arrival, the food available in the tertiary institutions may be their main food source while staying on campus. International students have been found to treat traditional dishes as a reminder of home, and these may help them to address their homesickness.¹⁵ Therefore, it is important for food services on campus to consider the cultural needs of different cultural groups.¹⁶

Food security is another factor influencing dietary behaviors. It represents the ability to not only eat enough foods but also to eat healthily.¹⁷ Food insecurity for college students has been identified as an important issue,^{18,19} although few studies have focused on international students. Lack of nutritional knowledge, food preparation skills, cooking facilities and time may be common for both local and foreign students.²⁰ However, higher tuition fees with extra living costs (e.g. transportation and accommodation), an unfamiliar food environment and limited information on sources of available food may contribute to worsen the situation for international students.²¹

The poor diet of college students and its association with weight gain and chronic diseases have been frequently reported.^{22,23} Similar issues have also been noted among migrant population groups,²⁴ but less is known for college students. This specific population group is more likely to live without family and take care of themselves from all perspectives in a strange environment.²⁵ Additionally, the negative impact on their psychological health during the process of acculturation could affect nutrition and food habits.^{10,11}

Because of the complex challenges for international college students, governments and tertiary institutions need existing evidence on nutritional problems as well as examples of solutions. Therefore, the aim of this scoping review is to synthesize the current literature on the nutrition, dietary habits, food security and antecedent behaviors of international students at the college level.

After conducting a pilot search in PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews and *JBI Evidence Synthesis*, no existing or in-progress scoping reviews or systematic reviews on the topic were identified.

The objective of this scoping review is to synthesize existing evidence on dietary changes and the food security status of international students who attend tertiary education facilities. Factors affecting nutrition and health, academic and psychological outcomes will also be examined.

Review questions

Three research questions will be used to guide this review: i) What changes in food consumption and dietary behaviors do international students make when attending tertiary education institutions in a foreign country? ii) What are the factors influencing this consumption, and are there any changes over time? iii) Are they experiencing food insecurity?

Inclusion criteria

Participants

This review will consider studies that involve international students enrolled in tertiary education institutions. This population is defined as students who leave their home country for the sole purpose of studying in a foreign country to acquire a higher education degree. It does not include those born in foreign countries who have migrated to the host country.

Concept

Studies that explore changes in food consumption, dietary habits and meal patterns, as well as food security status will be considered for inclusion. Factors contributing to dietary changes and food security status, and health (e.g. weight change), academic (e.g. grade point average) and psychological outcomes (e.g. depression) will also be considered.

Context

The proposed review will include studies that are set in tertiary education institutions in any country. All types of tertiary education will be eligible for inclusion, e.g. higher education, post-secondary education, polytechnic, university, college and Technical and Further Education (TAFE). Students may live on campus (e.g. residential colleges) or in private accommodation.

Types of sources

All quantitative, qualitative and mixed methods study designs will be considered for inclusion in the proposed scoping review. In addition, dissertations for research degrees will be considered. The language of included articles will be limited to English. The year of publication will not be limited.

Methods

This scoping review will be conducted according to the methodology for scoping reviews recommended by JBI.²⁶

Search strategy

The search strategy intends to identify original published and unpublished studies by following the three-step strategy recommended by JBI.²⁶ An initial limited search was conducted in MEDLINE and PsycINFO to find articles on the topic. A full search strategy was developed based on keywords identified from the titles and abstracts of relevant articles and the index terms used to classify the articles, with assistance from a research librarian. The second step will be a full search in the electronic databases listed by using all identified keywords and index terms. The search strategy will be modified and adapted for each selected information source. The third step will screen the reference lists of included articles and search unpublished studies for additional papers. The search strategy for MEDLINE is listed in Appendix I.

Information sources

Selected electronic databases will be searched, including MEDLINE (via Ovid), CINAHL (via EBSCO), ERIC (via Ovid), Global Health (via Ovid), CENTRAL (via Ovid) and PsycINFO (via Ovid). Unpublished studies will be searched in ProQuest Dissertations and Theses, and Open Access Theses and Dissertations.

Study selection

All detected records from the full search will be collected and imported into EndNote X9.2 (Clarivate Analytics, PA, USA). After removing duplicates, two independent reviewers will screen the titles and abstracts to assess them against the inclusion criteria for this review. Full texts of articles for consideration will be retrieved and their citation details uploaded into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI; JBI, Adelaide, Australia). Two reviewers will then independently assess the full text of potentially included papers against the inclusion criteria in detail. For articles that do not meet the inclusion criteria, reasons for exclusion will be recorded and reported in the scoping review. Any disagreements between the reviewers during the screening process will be resolved through discussion or with a third reviewer. The results of the search at each stage of the selection process will be reported and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses for scoping reviews (PRISMA-ScR) flow diagram.²⁷

Data extraction

Two independent reviewers will use a data charting form to extract data from included articles identified through the selection process. Details of participants (e.g. country/area of origin, age, length of stay in the host country), country of the study, study aims, research design, methods of data collection, sampling strategy, data analysis, primary outcomes (i.e. dietary changes and food security status), secondary outcomes (i.e. associated factors and health, academic and psychological outcomes) and implications of the study will be extracted from the full-text articles. Appendix II shows a draft data charting form that will be used. The modification of the form will be made as necessary during the trial process of extracting data from a selection of included papers and recorded in the final scoping review report.

Agreement between the two reviewers during the data extraction process will be achieved through discussion or consultation with a third reviewer. Authors of papers will be contacted if missing or additional data needs to be requested.

Data presentation

Tables and/or diagrams will be used to present the extracted data. The charted results will include year of publication, country of the study, detailed descriptions of participating international students (e.g. sample size, home country, age, length of stay), methodology, changes in dietary behaviors and eating habits based on the associated factors, food security status of international students and relevant outcomes (e.g. weight change, academic performance and psychological outcomes) and implications of the study. In addition, quotations from the qualitative studies will be presented thematically in a tabular form (see Appendix II). A narrative summary will be provided with the charted results to describe how the results reflect the objective and the research questions of the scoping review. The findings of this review will be used to inform investigations of dietary practices among international students in Australian tertiary institutions to ultimately improve their food and overall experience while studying in Australia.

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References

1. Organisation for Economic Co-operation and Development (OECD) iLibrary. Education at a Glance 2019: OECD Indicators. Paris: OECD Publishing. [Internet]. 2019 [cited 9 Oct 2019]. Available from: <https://doi.org/10.1787/f8d7880d-en>.
2. UNESCO Institute for Statistics. Global Education Digest 2006: Comparing Education Statistics Across the World Montreal: UNESCO UIS. [Internet]. 2006 [cited 9 Oct 2019]. Available from: http://uis.unesco.org/sites/default/files/documents/global-education-digest-2006-comparing-education-statistics-across-the-world-en_0.pdf.
3. Australian Government Department of Education and Training. Research snapshot: 2017 export income to Australia from international education activity in 2017. Canberra: Australian Government Department of Education and Training. [Internet]. 2018 [cited 9 Oct 2019]. Available from: <https://internationaleducation.gov.au/research/Research-Snapshots/Documents/Export%20Income%20CY%202017.pdf>.
4. Paswan AK, Ganesh G. Higher education institutions: satisfaction and loyalty among international students. *J Mark High Educ* 2009;19(1):65–84.
5. Poljski C, Quiazon R, Tran C. Ensuring rights: improving access to sexual and reproductive health services for female international students in Australia. *J Int Stud* 2014;4(2):150–63.
6. Gram M, Hogg M, Blichfeldt BS, MacLaran P. Intergenerational relationships and food consumption: the stories of young adults leaving home. *Young Consum* 2015;16(1):71–84.
7. Acharya L, Jin L, Collins W. College Life Is Stressful Today – Emerging Stressors and Depressive Symptoms in College Students. *J Am Coll Health* 2018;66(7):655–64.
8. Yeh CJ, Inose M. International students' reported English fluency, social support satisfaction, and social connectedness as predictors of acculturative stress. *Couns Psychol Q* 2003;16(1):15–28.
9. Kim YY. *Becoming intercultural: an integrative theory of communication and cross-cultural adaptation* Thousand Oaks, California: Sage; 2001; 340.
10. Berry JW. Acculturation: Living successfully in two cultures. *Int J Intercult Relat* 2005;29(6):697–712.
11. Yan Z, FitzPatrick K. Acculturation and health behaviors among international students: a qualitative approach. *Nurs Health Sci* 2016;18(1):58–63.
12. Wu B, Smith C. Acculturation and environmental factors influencing dietary behaviors and body mass index of Chinese students in the United States. *Appetite* 2016;103:324–35.
13. Brittin HC, Obeidat BA. Food practices, changes, preferences and acculturation of Arab students in US universities. (Special Issue: Home economics: an international perspective.). *Int J Consum Stud* 2011;35(5):552–9.
14. Saecone BH, Obeng CS. Food choices and eating patterns of international students in the United States: a phenomenological study. *Int Public Health J* 2015;7(4):357–61.
15. Brown L, Edwards J, Hartwell H. A taste of the unfamiliar. Understanding the meanings attached to food by international postgraduate students in England. *Appetite* 2010;54(1):202–7.
16. Ruetzler T. Food, beverage, and service quality: does culture impact satisfaction with university food services? *J Culinary Sci Technol* 2008;6(4):308–24.

17. Food and Agriculture Organization of the United Nations (FAO). Rome declaration on world food security and world food summit plan of action. Rome: FAO. [Internet].1996 [cited 9 Oct 2019]. Available from: <http://www.fao.org/3/w3613e/w3613e00.htm>.
18. Bruening M, Argo K, Payne-Sturges D, Laska MN. The struggle is real: a systematic review of food insecurity on postsecondary education campuses. *J Acad Nutr Diet* 2017;117(11):1767–91.
19. Micevski DA, Thornton LE, Brockington S. Food insecurity among university students in Victoria: A pilot study. *Nutr Diet* 2014;71(4):258–64.
20. Martinez SM, Webb K, Frongillo EA, Ritchie LD. Food insecurity in California’s public university system: what are the risk factors? *J Hunger Environ Nutri* 2018;13(1): 1–18.
21. Calder MJ, Richter S, Mao Y, Kovacs Burns K, Mogale RS, Danko M. international students attending Canadian universities: their experiences with housing, finances, and other issues. *Can J High educ* 2016;46(2):92–110.
22. Racette SB, Deusinger SS, Strube MJ, Highstein GR, Deusinger RH. Changes in weight and health behaviors from freshman through senior year of college. *J Nutr Educ Behav* 2008;40(1):39–42.
23. Rhodes D, Kramer A, Whitlock A, Cox C. Comparison of US and Indian college students’ health behaviors that contribute to the development of chronic diseases. *Health Educ* 2016;48(1):2–8.
24. Gilbert PA, Khokhar S. Changing dietary habits of ethnic groups in Europe and implications for health. *Nutr Rev* 2008;66(4):203–15.
25. Perez-Cueto F, Verbeke W, Lachat C, Remaut-De Winter AM. Changes in dietary habits following temporal migration. The case of international students in Belgium. *Appetite* 2009;52(1):83–8.
26. Peters MDJ, Godfrey C, Mclnerney P, Baldini Soares C, Khalil H, Parker D. Chapter 11: Scoping Reviews. In: Aromataris E, Munn Z (Editors). *JBIR Reviewer’s Manual* [Internet]. Adelaide: JBI; 2017 [cited 9 Oct 2019]. Available from: <https://reviewersmanual.joannabriggs.org/>.
27. Tricco AC, Lillie E, Zarin W, O’Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;169(7): 467–73.

Appendix I: Search strategy

MEDLINE (Ovid), search conducted in September 2019.

Group	Search	Query	Records retrieved
International students	1	exp Students/	119,952
	2	(international or foreign* or overseas or abroad or asia* or china or chinese or malaysia* or nepal* or india or indian or ethnic*).tw.	1,037,875
	3	1 and 2	9616
	4	(Student* adj3 (international or foreign* or overseas or abroad or asia* or china or chinese or malaysia* or nepal* or india or indian or ethnic*)).tw.	5779
	5	(Study adj3 (abroad or foreign* or overseas)).tw.	765
	6	(Education adj3 (international or abroad or foreign* or overseas)).tw.	1135
	7	or/3-6	13,985
Tertiary education	8	exp Universities/	38,466
	9	(tertiary adj3 (education or institution* or learning)).tw.	4530
	10	(education adj2 (technical or post-secondary or postsecondary or higher or further or continu*)).tw.	38,938
	11	(TAFE or polytechnic* or college* or campus* or universit*).tw.	437,905
	12	or/8-11	486,491
	13	3 and 12	4339
(Population)	14	7 or 13	13,985
Dietary changes	15	exp Diet/	267,065
	16	Eating/	51,215
	17	exp Nutrition Surveys/	24,474
	18	Nutrition Assessment/	14,223
	19	exp Meals/	4933
	20	Feeding Behavior/	78,689
	21	Food Preferences/	13,601
	22	Fasting/	34,119
	23	(Diet* adj3 (habit* or pattern* or practice* or chang* or quality or intake* or behavio?r* or acculturation)).tw.	86,841
	24	(Eat* adj3 (habit* or pattern* or behavio?r*)).tw.	18,931
	25	(Food* adj3 (habit* or quality or choice* or acculturation)).tw.	14,473
	26	(Nutrition* adj3 (chang* or intake* or quality or status or maintain* or maintenance or poor)).tw.	48,193
	27	(Intake* adj3 (energy or nutrient*)).tw.	35,278
28	(Meal* adj3 (skip* or miss* or pattern*)).tw.	1773	
29	or/15-28	482,097	

<i>(Continued)</i>			
Group	Search	Query	Records retrieved
Food types	30	exp Food/	1,238,264
	31	exp Beverages/	131,417
	32	(Food* adj3 (fresh or fast or out or outdoor or outside or home or tradition* or cultural or western or ethnic* or local)).tw.	11,785
	33	((Consum* or intake*) adj3 (food* or fruit* or vegetable* or meat* or snack* or dairy)).tw.	97,650
	34	(snack* or take away).tw.	7616
	35	(out* adj (dine or dining or eat*)).tw.	119
	36	or/30-35	1,350,001
Factors	37	Hunger/	5226
	38	Cooking/	11,310
	39	(food* adj3 (prepar* or environment* or access* or availab* or suppl* secur* or insecur* or cost*)).tw.	28,041
	40	(knowledge adj3 (nutrition* or diet* or food*)).tw.	4565
	41	(cook* adj3 (skill* or knowledge or practice* or facilit*)).tw.	592
	42	(hunger* or hungry).tw.	10,488
	43	or/37-42	54,626
(Concepts)	44	29 or 36 or 43	1,651,814
Final	45	14 and 44	767

Appendix II: Data extraction and presentation

Draft data charting form

Article information	Description of participants
Author:	Sample size:
Year of publication:	Area of origin:
Country:	Age:
Aims/objectives:	Gender:
Study design:	Level of education:
Methods of data collection:	Length of stay:
Sampling strategy:	Living status:
Data analysis:	Marital status:
Outcomes/key findings	
Primary outcomes	<i>Changes in food, meal and dietary patterns/percentage of food insecurity:</i>
Secondary outcomes	<i>Factors:</i>
	<i>Impacts (physical/psychological health and academic)/coping strategies for food insecurity:</i>
Implications	
<i>Recommendations/future research:</i>	

Quotations from qualitative studies

Themes	Quotations from articles
e.g. Theme 1	Format 1: Typical description quoted from the article [Author, year]. Format 2: "Quotes from participants in the study" (demographic information of the participant) [Author, year].

2. Systematic review protocol

(Appears on next page)

A systematic review of food insecurity and dietary outcomes in higher education students
Yumeng Shi, Alyse Davies, Margaret Allman-Farinelli

To enable PROSPERO to focus on COVID-19 registrations during the 2020 pandemic, this registration record was automatically published exactly as submitted. The PROSPERO team has not checked eligibility.

Citation

Yumeng Shi, Alyse Davies, Margaret Allman-Farinelli. A systematic review of food insecurity and dietary outcomes in higher education students. PROSPERO 2020 CRD42020196196 Available from: https://www.crd.york.ac.uk/prospERO/display_record.php?ID=CRD42020196196

Review question

What is the association between food insecurity and dietary outcomes in students at college-level from current literature?

Searches

Electronic bibliographic databases, including MEDLINE, EMBASE, ERIC, PsycINFO, Global Health, CINAHL, CENTRAL, Scopus and Web of Science will be searched. Search dates will start from 30 June. Language will be restricted to English and no limitations on publication period.

Searches will be re-run before the final analysis and reference lists of included studies will be checked to identify any further studies. Unpublished studies will be searched in ProQuest Dissertations and Theses, and Open Access Theses and Dissertations. Additionally, MedNar and site searches in Google will be used for searching grey literature.

Types of study to be included

All primary study designs will be eligible for inclusion, but not qualitative studies.

Condition or domain being studied

Food insecurity and dietary outcomes in college students.

Participants/population

Inclusion: any current students in tertiary education settings.

Exclusion: staff in tertiary education settings and students in primary and secondary education sector will not be included.

Intervention(s), exposure(s)

Exposure: Food security/insecurity. Food security refers to consistent access to food for providing adequate nutrition for all people. Food security can be measured from four dimensions, including food availability, access, utilisation and stability. Food availability refers to the adequacy of food supply; food access includes both economic and physical access; food utilisation relates to food and nutrient intake; and food stability means the consistency of achieving first three dimensions over time.

Comparator(s)/control

Not applicable.

Main outcome(s)

Dietary outcomes may include consumption and consumption frequency of food groups, energy and nutrients intake, meal pattern and diet quality. These outcomes may be measured by questionnaires or dietary assessment tools (e.g. food frequency questionnaire, food diary, 24-hour recall) in both food secure and insecure students.

* Measures of effect

Odds ratios may be included to show the differences in dietary outcomes in students with different food security status.

Additional outcome(s)

Not applicable.

* Measures of effect

Not applicable.

Data extraction (selection and coding)

Study selection

The identified studies from full search will be imported to EndNote for screening. Decisions will be recorded in EndNote. Titles and abstracts will be screened against the inclusion criteria by two reviewers independently. For the studies with the potential to be included, full text will be retrieved and attached in EndNote. Two reviewers will screen them against the inclusion and exclusion criteria independently. Reasons for exclusion at this stage will be recorded and reported in the PRISMA diagram. Disagreements between two reviewers will be solved through discussion between each other or consultation with a third reviewer.

Data extraction

A data extraction form will be used for extracting data from included studies. For each included study, author, year, country of the study, research aims, study design, methods of data collection for exposure and outcome factor, analysis, demographics of participants, description of setting, food security status, dietary outcomes and implications of the study will be extracted. The measures of frequency and association between food insecurity and dietary outcomes in the studies will also be extracted. Extracted data will be recorded in spreadsheet and checked by a second reviewer. Disagreements will be discussed between two reviewers or addressed by consulting a third expert. The authors of included studies will be contacted if there are any additional details or missing data required.

Risk of bias (quality) assessment

The quality of included studies will be assessed through different checklists from Joanna Briggs Institute, e.g. checklist for analytical cross-sectional studies and checklist for cohort studies. Multiple aspects of the study will be assessed such as sampling strategy, methods of data collection and analysis. The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) will be used to evaluate the overall quality of evidence. The results of assessments will be recorded with data extraction in the spreadsheet. Quality assessment will be conducted by two independent reviewers. Two reviewers will discuss disagreements or consult a third reviewer to achieve agreements.

Strategy for data synthesis

Considering the heterogeneity in study designs and measurements of exposure and outcomes across the included studies, a narrative synthesis is planned for this review. Demographics of study participants, the measurement tool of food security status, exposure and outcomes will be summarised and synthesised.

The differences in dietary outcomes between food secure and insecure students, and other reported associations between the exposure and outcomes will also be synthesised.

Analysis of subgroups or subsets

If there is enough data, subgroups analysis might be applicable.

- Demographics of participants
 - o Undergraduate/postgraduate
 - o Gender
 - o Living status (e.g. accommodation, live with someone or alone)

o Sources of incomes

- Different measurement tools of exposure (e.g. single/multi-item)
- Different types of dietary outcomes (e.g. food groups/nutrients intake)

Contact details for further information

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Collaborators

Monica Cooper. The University of Sydney

Type and method of review

Systematic review

Anticipated or actual start date

30 June 2020

Anticipated completion date

30 June 2021

Funding sources/sponsors

No funding is received for this systematic review. The lead reviewer (YS) is funded by China Scholarship Council (CSC) Postgraduate Research Scholarship to support her PhD candidature. The second reviewer (AD) is supported by an Australian Government Research Training Program (RTP) PhD Scholarship. MAF has received funding from National Health and Medical Research Council (NHMRC), Australian Research Council, New South Wales (NSW) Health and Cancer Council NSW for other projects. None of the funders will affect the conduct of the review.

Conflicts of interest

Language

English

Country

Australia

Stage of review

Review Ongoing

Subject index terms status

Subject indexing assigned by CRD

Subject index terms

MeSH headings have not been applied to this record

Date of registration in PROSPERO

30 July 2020

Date of first submission

30 June 2020

Details of any existing review of the same topic by the same authors

None.

Stage of review at time of this submission

Stage	Started	Completed
Preliminary searches	Yes	Yes
Piloting of the study selection process	No	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

The record owner confirms that the information they have supplied for this submission is accurate and complete and they understand that deliberate provision of inaccurate information or omission of data may be construed as scientific misconduct.

The record owner confirms that they will update the status of the review when it is completed and will add publication details in due course.

Versions

30 July 2020

PROSPERO

This information has been provided by the named contact for this review. CRD has accepted this information in good faith and registered the review in PROSPERO. The registrant confirms that the information supplied for this submission is accurate and complete. CRD bears no responsibility or liability for the content of this registration record, any associated files or external websites.

3. Food security questionnaire

(Appears on next page)

Module 1 Demographics

Please complete the 1st module below.

Thank you!

Please answer all questions, then click submit to enter the next module. Thank you!

Age (years)

Gender

- Female
- Male
- Prefer to type
- Prefer not to say

Domestic or international student?

- Domestic
- International

Are you of Aboriginal or Torres Strait Islander origin? (for domestic students only)

- Yes
- No

Length of stay in Australia
(for international students only)

- Less than 3 months
- 3 months to a year
- More than a year to 2 years
- More than 2 years

Which do you see as your home country?
(for international students only)

- China
- India
- Nepal
- Malaysia
- Vietnam
- Other

Please state

Enrolment status

- Full-time student
- Part-time student

What is the degree you are studying at the moment?

- Undergraduate
- Postgraduate (including Higher Degree by Research)

Which year you're studying in your current degree?

- First
- Second
- Third
- Four and above

Marital status

- Never married
- Married or De facto relationship
- Separated/divorced/widowed
- Other

Do you have any dependent children (under the age of 18 years)?

- Yes
- No

Module 2 Living Employment And Financial Status

Please complete the 2nd module below.

Thank you!

Please answer all questions, then click submit to enter the next module. Thank you!

Where do you live at the moment?

- On campus accommodation
- Parental home
- Own property
- Renting accommodation
- Other

Who do you live with?

- Parents
- Other family members
- Friends/roommates
- Alone
- Other

Employment status

- Full-time job
- Part-time or casual job
- No employment

Weekly working hours

- 1-19 hours
- 20-37 hours
- 38 hours or more

Weekly income (include employment and/or other income, e.g. scholarships)

- ≤\$500
- \$501-1000
- \$1001-1500
- \$1501-2000
- >\$2000
- Prefer not to say

Sources of financial support

- Parents
- Employment salary
- Scholarships
- Loans
- Other
- Not receiving financial support

COVID-19 related changes

Has COVID-19 pandemic directly impacted your living arrangement?

- Yes
- No

Please indicate your experience in changing living arrangement (e.g., moved to less expensive premises).

Have you experienced any job changes (e.g., lost your employment or worked less hours) during COVID-19 pandemic?

- Yes
- No

Has your employment income decreased due to COVID-19 pandemic?

- No impact
- < 25%
- 25-49%
- 50-74%
- 75-99%
- 100%
- Prefer not to say

Have you experienced any difficulties in finding jobs during COVID-19 pandemic?

- Yes
- No

Have you received any government support payment?

- Yes
- No
- Prefer not to say

Have you received any support payment from the sources other than the government?

- Yes
- No
- Prefer not to say

Module 3 Food Access

Please complete the 3rd module below. Already halfway through!

Thank you!

Please answer all questions, then click submit to enter the next module. Thank you!

These next questions are about the food eaten in your household in the last 12 months, and whether you were able to afford the food you need.

Which of these statements best describes the food eaten in your household in the last 12 months?

- Enough of the kinds of food we want to eat
- Enough but not always the kinds of food we want
- Sometimes not enough to eat
- Often not enough to eat
- Don't know

Here are several statements that people have made about their food situation. For these statements, please tell us whether the statement was **OFTEN true, **SOMETIMES** true, or **NEVER** true for your household in the last 12 months.**

	Often true	Sometimes true	Never true	Don't know
We worried whether our food would run out before we got money to buy more.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The food that we bought just didn't last, and we didn't have money to get more.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We couldn't afford to eat balanced meals.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did you experience the following situations in the last 12 months?

	Yes	No	Don't know
Did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Did you ever eat less than you felt you should because there wasn't enough money for food?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Were you ever hungry but didn't eat because there wasn't enough money for food?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did you lose weight because there wasn't enough money for food?

How often did this (cut the size of meals or skip meals) happen?

- Almost every month
 Some months but not every month
 Only 1 or 2 months
 Don't know

In the last 12 months, did you or other adults in your household ever not eat for a whole day because there wasn't enough money for food?

- Yes
 No
 Don't know

How often did this (not eat for a whole day) happen?

- Almost every month
 Some months but not every month
 Only 1 or 2 months
 Don't know

Now here are several statements that people have made about the food situation of their children. For these statements, please tell us whether the statement was OFTEN true, SOMETIMES true, or NEVER true in the last 12 months for your child/children living in the household who are under 18 years old.

	Often true	Sometimes true	Never true	Don't know or Refused to answer
We relied on only a few kinds of low-cost food to feed our child/children because we were running out of money to buy food.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
We couldn't feed our child/children a balanced meal, because we couldn't afford that.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Our child was/The children were not eating enough because we just couldn't afford enough food.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did the following situations happen in the last 12 months?

	Yes	No	Don't know
Did you ever cut the size of your child's/any of the children's meals because there wasn't enough money for food?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did your child/any of the children ever skip meals because there wasn't enough money for food?

Was your child/were the children ever hungry but you just couldn't afford more food?

Did your child/any of the children ever not eat for a whole day because there wasn't enough money for food?

How often did this (skip meals) happen?

- Almost every month
- Some months but not every month
- Only 1 or 2 months
- Don't know

Module 4 Diet-related Behaviours

Please complete the 4th module below. This is the second last module. Almost there!

Thank you!

Please answer all questions, then click submit to enter the next module. Thank you!

Does your accommodation (e.g. residential college or homestay) provide meals?

- Yes
 No

How much do you spend on foods and drinks (include groceries, takeaway, and eating out) per week (for yourself)?

- \$0-30
 \$31-60
 \$61-100
 More than \$100

Please specify

How would you comment on your access to essential cooking facilities (e.g. kitchen, fridge, cooking utensils)?

- Adequate
 Somewhat inadequate (some limitations)
 Inadequate

How would you comment on your cooking skills?

- Excellent
 Good
 Fair
 Poor

Which best describes your confidence in completing each of the tasks listed?

	Extremely confident	Very confident	Moderately confident	Not very confident	Not at all confident
I can cook a nutritious meal.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can cook a meal in a short amount of time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can cook a nutritious meal without spending a lot of money.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I can follow a recipe.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How often do you usually cook?

- Every day
 4-6 days per week
 1-3 days per week
 Less frequent than 1 day per week
 Never

Are you aware of any food relief programs (e.g. from USU, OzHarvest, Foodbank Australia) that are available to you?

- Yes
 No

How many serves of vegetables do you usually eat each day? (Examples of one serve of vegetables are provided below)

- Less than 1 serve
 1 serve
 2 serves
 3 serves
 4 serves
 5 serves
 More than 5 serves
 Don't eat

Examples of one serve of vegetables:

- ½ cup cooked green or orange vegetables (for example, broccoli, spinach, carrots or pumpkin)
- ½ cup cooked dried or canned beans, peas or lentils (preferably with no added salt)
- 1 cup green leafy or raw salad vegetables
- ½ cup sweet corn
- ½ medium potato or other starchy vegetables (sweet potato, taro or cassava)
- 1 medium tomato

What is a serve of vegetables*?

A standard serve is about 75g (100–350kJ) or:

- ½ cup cooked green or orange vegetables (for example, broccoli, spinach, carrots or pumpkin)
- ½ cup cooked dried or canned beans, peas or lentils
- 1 cup green leafy or raw salad vegetables
- ½ cup sweet corn
- ½ medium potato or other starchy vegetables (sweet potato, taro or cassava)
- 1 medium tomato



*With canned varieties, choose those with no added salt

How many serves of fruit do you usually eat each day? (Examples of one serve of fruit are provided below)

- Less than 1 serve
 1 serve
 2 serves
 3 serves
 4 serves
 5 serves
 More than 5 serves
 Don't eat

Examples of one serve of fruit:

- 1 medium apple, banana, orange or pear
- 2 small apricots, kiwi fruits or plums
- 1 cup diced or canned fruit (no added sugar)
- 125ml (½ cup) fruit juice (no added sugar)
- 30g dried fruit (for example, 4 dried apricot halves, 1½ tablespoons of sultanas)

What is a serve of fruit?

A standard serve is about 150g (350kJ) or:

- 1 medium apple, banana, orange or pear
- 2 small apricots, kiwi fruits or plums
- 1 cup diced or canned fruit (no added sugar)

Or only occasionally:

- 125ml (½ cup) fruit juice (no added sugar)
- 30g dried fruit (for example, 4 dried apricot halves, 1½ tablespoons of sultanas)



How often do you usually eat out (including home delivery, Uber Eats, pick-up and take-away) per week?

- Every day
- 4-6 days
- 1-3 days
- Less frequent than 1 day per week
- Never

How often do you experience the following situations when you are not able to obtain sufficient and appropriate foods in Australia?

	Often	Sometimes	Rarely	Never
Obtained food from food bank or other food relief programs providing free or discounted food.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Attended events offering free food.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Stretched (i.e., spread out) food to make it last longer.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ate more than normal when food was plentiful.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ate less healthy meals to eat more food.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Purchased cheap/discounted, processed food.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sharing food or groceries (e.g., with friends, roommates, or family members).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Saving food for later.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Substituted ideal (e.g. traditional) ingredients.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Borrowed money from family or friends, applied for loans, purchased food using credit card.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sought employment or worked more hours.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Delayed or not buying academic supplies.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Used less or delayed paying utilities or services.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Please specify your strategies

Module 5 My Health And Wellbeing

Please complete the final module below.

Thank you!

Please answer all questions, then click submit. Thank you!

A. Physical health

- 1) Self-perceived physical health status
- Excellent
 Good
 Average
 Poor
 Very poor

2) Height (cm)

3) Weight (kg)

B. Mental health

- 4) Self-perceived mental health status
- Excellent
 Good
 Average
 Poor
 Very poor

Please indicate for each of the five statements which is closest to how you have been feeling over the last two weeks.

	All the time	Most of the time	More than half of the time	Less than half of the time	Some of the time	at no time
5) I have felt cheerful and in good spirits.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6) I have felt calm and relaxed.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7) I have felt active and vigorous (i.e., energetic).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8) I woke up feeling fresh and rested.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9) My daily life has been filled with things that interest me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

C. Your study**Does the sufficiency of the food you can get ever affect your study?**

	Does not affect	Slightly affects	Moderately affects	Very much affects
10) Class attendance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11) Academic performance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12) Withdrawal from courses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

-
- 13) Please feel free to leave any comments or thoughts regarding this survey or food security.
-

Please feel free to download the contact details for support services if you have any concerns about having adequate food or your mental health. You've already received this information if you have downloaded the Participant Information Statement.

[Attachment: "Support Services.pdf"]

Support Services

For all students:

Food assistance	<u>Oz Harvest Market</u> Location: 95 Wellington St, Waterloo Contact details: Phone - 1800 108 006; Email - info@ozharvest.org Link: https://www.ozharvest.org/ozharvest-market-waterloo/
	<hr/> <u>Addi Road Food Pantry</u> Locations: Camperdown - 31 Pyrmont Bridge Rd, Camperdown; Marrickville - Addison Road Community Centre, 142 Addison Road, Marrickville Contact details: Phone - (02) 9568 7633; Email - info@addiroad.org.au Link: https://addiroad.org.au/the-food-pantry/
Mental health support	See more information here: https://www.sydney.edu.au/students/counselling-and-mental-health-support.html

For international students:

Food assistance	<u>USYD Food Hub</u> Location: The University of Sydney Camperdown/Darlington campus: Level 3 Wentworth Building, opposite Laneway Café Contact details: Email - b.pinney@usu.edu.au Link: https://events.humanitix.com/usyd-food-hub-february
	<hr/> More available food assistance services in NSW see this link: https://www.study.sydney/programs/food-assistance
Student support	For international student enquiries and concerns, email international.support@sydney.edu.au

Appendix II: Ethics approvals

1. Qualitative study

Ethics approval letter	Page 329-331
Participant information statement	Page 332-335
Consent questions on REDCap	Page 336
Recruitment flyer	Page 337

Friday, 14 February 2020

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.: 2020/006

Project Title: A qualitative study of dietary patterns in international students

Authorised Personnel: Allman-Farinelli Margaret; Shi Yumeng;

Approval Period: 14 February 2020 to 14 February 2024

First Annual Report Due: 14 February 2021

Documents Approved:

Date Uploaded	Version Number	Document Name
03/02/2020	Version 2	Student association contact email_final
03/02/2020	Version 2	Consent via REDCap_final
03/02/2020	Version 2	Demographic questionnaire_final
03/02/2020	Version 2	Recruitment flyer_final
03/02/2020	Version 2	University website post_final
03/02/2020	Version 2	Interview guide_final
03/02/2020	Version 2	Participant Information Statement_final
03/02/2020	Version 2	REDCap recruitment process flow_final
03/02/2020	Version 2	Social media post_final

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
 - Serious or unexpected adverse events (which should be reported within 72 hours).
 - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.



- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,

Associate Professor Michael Skilton
Chair, Health Review Committee (Low Risk)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) [National Statement on Ethical Conduct in Human Research \(2007\)](#) and the NHMRC's [Australian Code for the Responsible Conduct of Research \(2007\)](#)

Wednesday, 21 October 2020

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret,

Your request to modify this project, which was submitted on 23 September 2020, has been considered.

This project has been approved to proceed with the proposed amendments.

Protocol Number: 2020/006
Protocol Title: A qualitative study of dietary patterns in international students

Annual Report Due: 14 February 2021

Documents Approved:

Date Uploaded	Version Number	Document Name
23/09/2020	Version 1	Email to students in Curtin University

Please contact the ethics office should you require further information.

Sincerely,



Dr Clifton Chan
Chair
Modification Review Committee Chair (MRC 3)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) [National Statement on Ethical Conduct in Human Research \(2018\)](#) and the NHMRC's [Australian Code for the Responsible Conduct of Research \(2018\)](#)



ABN 15 211 513 464

MARGARET ALLMAN-FARINELLI
Professor of Dietetics

Level 4 East
Charles Perkins Centre, D17
The University of Sydney
NSW 2006 AUSTRALIA
Telephone: +61 2 9036 7045
Facsimile: +61 2 8627 1605
Email: margaret.allman-farinelli@sydney.edu.au
Web: <http://www.sydney.edu.au/>

A qualitative study of dietary patterns in international students

PARTICIPANT INFORMATION STATEMENT

(1) What is this study about?

You are invited to take part in a research study about dietary changes made by international students after coming to Australia, with associated factors and outcomes. This study will facilitate the development of recommendations for international students to improve diet quality.

You have been invited to participate in this study because you meet the required characteristics for this study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the study. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving consent to take part in this study you are telling us that you:

- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) Who is running the study?

The study is being carried out by the following researchers:

- Margaret Allman-Farinelli, Professor of Dietetics, The University of Sydney.
- Yumeng Shi, PhD candidate, The University of Sydney

Yumeng Shi is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney. This will take place under the supervision of Professor Margaret Allman-Farinelli.

(3) What will the study involve for me?

After you complete the screening questionnaire to determine your eligibility for the study, you will be asked to provide your consent to participate the study and answer a few demographic questions on REDCap, such as age, level of education, living status and length of stay in Australia. You are then invited to have a face-to-face semi-structured interview with the researcher in person or through an online software (Zoom). In-person interviews will be conducted in a meeting room in Charles Perkins Centre of The University of Sydney. An appointment will be arranged between you and the researcher at a convenient time. The questions in the interview will focus on your dietary habits and meal patterns in your home country and after coming to Australia, factors that influence any changes, weight change before and after commencing study in Australia, perceived impacts of dietary changes on your health and academic performance. Questions regarding your food security status will also be included. The interview will be audio-recorded to enable researchers to analyse the data after the interviews have finished. The transcript of the interview will be provided for you to review through email within two weeks after the interview.

(4) How much of my time will the study take?

The demographic questions will take less than 5 minutes to complete.
The interview will take approximately 45 to 90 minutes to complete.

(5) Do I have to be in the study? Can I withdraw from the study once I've started?

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of Sydney and any other participated universities.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by either telling the researcher at any time during the interview or emailing researchers at any time before and after the interview. There will be no consequences of withdrawing the study.

You are free to stop the interview at any time. Unless you say that you want us to keep them, any recordings will be erased and the information you have provided will not be included in the study results. You may also refuse to answer any questions that you do not wish to answer during the interview.

(6) Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study. Participation in this study should not involve any physical or mental discomfort. If, however, you find any interview questions to be offensive or invasive, you are free to refuse to answer them or withdraw from the interview.

(7) Are there any benefits associated with being in the study?

A \$20 gift voucher will be provided for you to compensate your time after completing the interview. Additionally, you will be provided information on healthy eating at the end of the session.

(8) What will happen to information about me that is collected during the study?

All data collected in this study and the audio recording of the interview will be stored confidentially and only be used for analysis, no third parties will have access to your information. You will not be identified in the recordings – your name will not be referred after the start of recording. The study results may be published in journals, conference presentations, and student theses, and your information will be anonymous. We may use quotes to report results, but you will not be identified from these quotes. The electronic data will be stored on a network storage of The University of Sydney, only the researchers of this study will have access to them.

Your information will be stored securely and will only be disclosed with your permission, except as required by law. Study findings may be published, and you will not be individually identifiable in these publications.

By providing your consent, you are agreeing to us collecting personal information about you for the purposes of this research study. Your information will only be used for the purposes outlined in this Participant Information Statement, unless you consent otherwise.

(9) Can I tell other people about the study?

Yes, you are welcome to tell other people about the study.

(10) What if I would like further information about the study?

When you have read this information, Yumeng Shi will be available to discuss it with you further and answer any questions you may have. If you would like to know more at any stage during the study, please feel free to contact Yumeng Shi, PhD candidate, via email yshi7693@uni.sydney.edu.au.

(11) Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. You can tell us that you wish to receive feedback by answering the relevant consent questions on REDCap. This feedback will be in the form of a one-page lay summary. You will receive this feedback after the study is finished.

(12) What if I have a complaint or any concerns about the study?

Research involving humans in Australia is reviewed by an independent group of people called a Human Research Ethics Committee (HREC). The ethical aspects of this study have

been approved by the HREC of the University of Sydney [2020/006]. As part of this process, we have agreed to carry out the study according to the *National Statement on Ethical Conduct in Human Research (2007)*. This statement has been developed to protect people who agree to take part in research studies.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the university using the details outlined below. Please quote the study title and protocol number.

The Manager, Ethics Administration, University of Sydney:

- **Telephone:** +61 2 8627 8176
- **Email:** human.ethics@sydney.edu.au
- **Fax:** +61 2 8627 8177 (Facsimile)

This information sheet is for you to keep

Consent questions on REDCap

Please click [here](#) to download 'Participant Information Statement'. [Attach PIS]

I have read the Participant Information Statement.	Yes/No
<p>I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.</p> <p>I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of Sydney or any other participating universities now or in the future.</p> <p>I understand that I can withdraw from the study at any time.</p> <p>I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.</p> <p>I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.</p> <p>I understand that the results of this study may be published, but these publications will not contain my name or any identifiable information about me.</p>	Yes/No
I consent to:	
<ul style="list-style-type: none"> • Audio-recording 	Yes/No
<ul style="list-style-type: none"> • Being contacted about future studies 	Yes/No
<ul style="list-style-type: none"> • Permanent archiving of study materials 	Yes/No
Feedback	
<ul style="list-style-type: none"> • I would like to review my interview transcripts 	Yes/No
<ul style="list-style-type: none"> • I would like to receive feedback about the overall results of this study 	Yes/No



Want to share your FOOD experience in Australia?

- How do you feel about Australian foods?
- Any changes in your diet since you came here?
- Any difficulties in finding what you want to eat?



WHAT'S
**YOUR
STORY?**

TELL US NOW!

Face-to-face conversation
45-90 minutes
In-person/Zoom

Participants to be:

- ✓ Aged 18 to 30 years
- ✓ Current international student from China or India
- ✓ Studying in the first/second year of your current degree in Australia
- ✓ Has stayed in Australia for at least 2 months but no more than 2 years
- ✓ Not completing a nutrition course

Please scan the QR code or use the link below to check your eligibility.
If you have any questions, please contact us by email.



<https://redcap.sydney.edu.au/surveys/?s=C7C3D3WCKY>



Yumeng Shi
yshi7693@uni.sydney.edu.au



2. Pilot survey

Ethics approval letter	Page 339-340
Participant information statement	Page 341-344
Consent questions on REDCap	Page 345
Recruitment flyer	Page 346

Friday, 2 July 2021

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.: 2021/445
Project Title: Assessing food security status among university students in Australia: a pilot survey
Authorised Personnel: Allman-Farinelli Margaret; Shi Yumeng;
Approval Period: 02/07/2021 to 02/07/2025
First Annual Report Due: 02/07/2022

Documents Approved:

Date Uploaded	Version Number	Document Name
01/07/2021	Version 2	Participant information statement_pilot survey_final
01/07/2021	Version 2	Student association contact email_pilot survey_final
01/07/2021	Version 2	Food security questionnaire_pilot survey_final
01/07/2021	Version 2	Support services
07/05/2021	Version 1	REDCap flow_pilot survey
07/05/2021	Version 1	Recruitment flyer_pilot survey
07/05/2021	Version 1	Consent via REDCap_pilot survey
07/05/2021	Version 1	Social media post_pilot survey
07/05/2021	Version 1	University website post_pilot survey

Condition/s of Approval

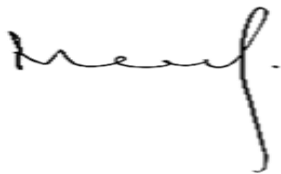
- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
 - Serious or unexpected adverse events (which should be reported within 72 hours).
 - Unforeseen events that might affect continued ethical acceptability of the project.

- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.
- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,



Associate Professor Mark Arnold
Chair, Human Research Ethics Committee (HREC 2)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) [National Statement on Ethical Conduct in Human Research \(2018\)](#) and the NHMRC's [Australian Code for the Responsible Conduct of Research \(2018\)](#)

Participant Information Statement



Research Study: Assessing food security status among university students in Australia: a pilot survey

Professor Margaret Allman-Farinelli (Responsible Researcher)
Sydney School of Nursing, Faculty of Medicine and Health
Phone: +61 2 9036 7045 | Email: margaret.allman-farinelli@sydney.edu.au
Yumeng Shi (PhD student) | Email: yshi7693@uni.sydney.edu.au

1. What is this study about?

We are conducting a research study about assessing food security status among international and domestic students in Australian universities and testing the face validity of our questionnaire designed for this survey. This pilot study will help us to improve the content of the questionnaire and launch a large-scale survey at a later stage. Taking part in this study is voluntary.

Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

2. Who is running the study?

The study is being carried out by the following researchers:

- Margaret Allman-Farinelli, Professor of Dietetics, Sydney School of Nursing, The University of Sydney
- Yumeng Shi, PhD candidate, School of Life and Environmental Sciences, Faculty of Science, The University of Sydney

Yumeng Shi is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney.

3. Who can take part in the study?

We are seeking current undergraduate and postgraduate students studying in Australia who are aged 18-30 years and are not enrolling in a nutrition course.

You have been invited to take part in this study because you meet the required characteristics for this study.

4. What will the study involve for me?

If you decide to take part in this study, you will be asked to:

- Complete a food security survey. It will take less than 15 minutes. Questions are divided into five modules, including demographics, employment and financial status, food security module, diet-related behaviours, and health/well-being.
- At the end of each module, you will be asked to provide comments or suggestions regarding the content and wording of the questionnaire items.

5. Can I withdraw once I've started?

Being in this study is completely voluntary and you do not have to take part.

Your decision will not affect your current or future relationship with the researchers or anyone else at The University of Sydney.

If you decide to take part in the study and then change your mind, you can withdraw by discontinuing the survey, or notifying the student researcher by email.

If you choose to withdraw, we will not collect any more information from you. Please let us know at the time you withdraw what you would like us to do with information we have collected about you up to that point.

6. Are there any risks or costs?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

Contact details for support services are provided below if you have any concerns about having adequate food or your mental health:

Services for all students:

Food assistance	<p><u>Oz Harvest Market</u> Location: 95 Wellington St, Waterloo Contact details: Phone - 1800 108 006; Email - info@ozharvest.org Link: https://www.ozharvest.org/ozharvest-market-waterloo/</p> <hr/> <p><u>Addi Road Food Pantry</u> Locations: Camperdown - 31 Pymont Bridge Rd, Camperdown; Marrickville - Addison Road Community Centre, 142 Addison Road, Marrickville Contact details: Phone - (02) 9568 7633; Email - info@addiroad.org.au Link: https://addiroad.org.au/the-food-pantry/</p> <hr/> <p>Mental health support</p>	<p>See more information here: https://www.sydney.edu.au/students/counselling-and-mental-health-support.html</p>
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Services for international students:

Food assistance	<u>USYD Food Hub</u> Location: The University of Sydney Camperdown/Darlington campus: Level 3 Wentworth Building, opposite Laneway Café Contact details: Email - b.pinney@usu.edu.au Link: https://events.humanitix.com/usyd-food-hub-february
	More available food assistance services in NSW see this link: https://www.study.sydney/programs/food-assistance
Student support	For international student enquiries and concerns, email international.support@sydney.edu.au

7. Are there any benefits?

You will not receive any direct benefits from being in the study.

8. What will happen to information that is collected?

By providing your consent, you are agreeing to us collecting information about you for the purposes of this study.

Any information you provide us will be stored securely and we will only disclose it with your permission, unless we are required by law to release information. We are planning for the study findings to be published.

You will not be individually identifiable in these publications.

All data collected in this study will be stored confidentially and only be used for analysis, no third parties will have access to your information. The study results may be published in student theses, and your information will be anonymous. The electronic data will be stored on a network storage of The University of Sydney, only the researchers of this study will have access to them.

9. Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. If you are interested in receiving feedback, please answer the relevant question on the online consent form and provide your contact details at the end of the survey. This feedback will be in the form of a brief lay summary.

10. What if I would like further information?

When you have read this information, the following researcher/s will be available to discuss it with you further and answer any questions you may have:

- Yumeng Shi, email: yshi7693@uni.sydney.edu.au, phone: 61 2 8627 9567.

11. What if I have a complaint or any concerns?

The ethical aspects of this study have been approved by the Human Research Ethics Committee (HREC) of The University of Sydney [2021/445] according to the *National Statement on Ethical Conduct in Human Research (2007)*.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University:

Human Ethics Manager
human.ethics@sydney.edu.au
+61 2 8627 8176

This information sheet is for you to keep

Consent questions on REDCap

Please click [here](#) to download 'Participant Information Statement'. [Attached PIS]

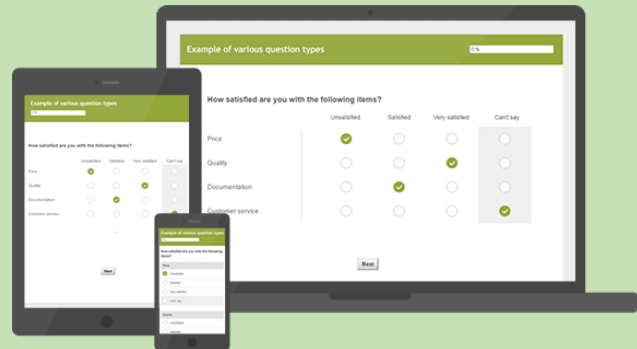
The details of my involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.	Yes/No
<p>I understand the purpose of the study is to investigate food security status among international and domestic students in Australian universities and to test the validity of the questionnaire designed for this survey.</p> <p>I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.</p> <p>I understand that in this study I will be required to complete a food security survey.</p> <p>I understand that being in this study is completely voluntary.</p> <p>I am assured that my decision to participate will not have any impact on my relationship with the research team or the University of Sydney.</p> <p>I understand that I am free to withdraw from this study at any time and that I can choose to withdraw any information I have already provided (unless the data has already been de-identified or published).</p> <p>I have been informed that the confidentiality of the information I provide will be protected and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.</p> <p>I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.</p>	Yes/No
I consent to being contacted for future studies.	Yes/No
I would like to receive feedback about the overall results of this study.	Yes/No
Please provide your preferred email address.	Text box
I understand that after I sign and return this consent form it will be retained by the researcher, and that I may request a copy at any time.	Yes/No
Your name	Text box
Signature	Signature
Date	Text box

Food security SURVEY



Are you always able to obtain sufficient and appropriate foods?

WE WANT TO HEAR FROM YOU
Online survey



Participants to be:

- ✓ Aged 18 to 30 years
- ✓ Current undergraduate or postgraduate students studying in Australia
- ✓ Not completing a nutrition course



Please scan the QR code to complete the survey or contact us by email for more details.



Yumeng Shi - yshi7693@uni.sydney.edu.au

3. Quantitative studies

Ethics approval letter	Page 348-349
Participant information statement	Page 350-353
Consent questions (survey) on REDCap	Page 354
Consent questions (dietary recalls) on REDCap	Page 355
Recruitment flyer	Page 356

Wednesday, 27 October 2021

Prof Margaret Allman-Farinelli
School of Life and Environmental Sciences (SOLES); Faculty of Science
Email: margaret.allman-farinelli@sydney.edu.au

Dear Margaret,

The University of Sydney Human Research Ethics Committee (HREC) has considered your application.

I am pleased to inform you that after consideration of your response, your project has been approved.

Details of the approval are as follows:

Project No.: 2021/745
Project Title: Assessing food access and meal patterns among university students in Australia
Authorised Personnel: Allman-Farinelli Margaret; Shi Yumeng;
Approval Period: 27 October 2021 to 27 October 2025
First Annual Report Due: 27 October 2022

Documents Approved:

Date Uploaded	Version Number	Document Name
05/10/2021	Version 2	Consent via REDCap_final
05/10/2021	Version 2	Recruitment emails_final
05/10/2021	Version 1	Recruitment emails_course coordinator
05/10/2021	Version 2	Recruitment flyer_final
05/10/2021	Version 2	Participant information statement_final
05/10/2021	Version 1	Screening questions
05/10/2021	Version 2	University website post_final
27/08/2021	Version 1	Food security questionnaire
27/08/2021	Version 1	Social media post
27/08/2021	Version 1	Study flowchart

Condition/s of Approval

- Research must be conducted according to the approved proposal.
- An annual progress report must be submitted to the Ethics Office on or before the anniversary of approval and on completion of the project.
- You must report as soon as practicable anything that might warrant review of ethical approval of the project including:
 - Serious or unexpected adverse events (which should be reported within 72 hours).
 - Unforeseen events that might affect continued ethical acceptability of the project.
- Any changes to the proposal must be approved prior to their implementation (except where an amendment is undertaken to eliminate *immediate* risk to participants).
- Personnel working on this project must be sufficiently qualified by education, training and experience for their role, or adequately supervised. Changes to personnel must be reported and approved.
- Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, as relevant to this project.

- Data and primary materials must be retained and stored in accordance with the relevant legislation and University guidelines.
- Ethics approval is dependent upon ongoing compliance of the research with the *National Statement on Ethical Conduct in Human Research*, the *Australian Code for the Responsible Conduct of Research*, applicable legal requirements, and with University policies, procedures and governance requirements.
- The Ethics Office may conduct audits on approved projects.
- The Chief Investigator has ultimate responsibility for the conduct of the research and is responsible for ensuring all others involved will conduct the research in accordance with the above.

This letter constitutes ethical approval only.

Please contact the Ethics Office should you require further information or clarification.

Sincerely,



Dr Haryana Dhillon
Chair
Human Research Ethics Committee (HREC 3)

The University of Sydney of Sydney HRECs are constituted and operate in accordance with the National Health and Medical Research Council's (NHMRC) [National Statement on Ethical Conduct in Human Research \(2018\)](#) and the NHMRC's [Australian Code for the Responsible Conduct of Research \(2018\)](#)

Participant Information Statement



Research Study: Assessing food access and meal patterns among university students in Australia

Professor Margaret Allman-Farinelli (Responsible Researcher)
Sydney School of Nursing, Faculty of Medicine and Health
Phone: +61 2 9036 7045 | Email: margaret.allman-farinelli@sydney.edu.au
Yumeng Shi (PhD student) | Email: yshi7693@uni.sydney.edu.au

1. What is this study about?

We are conducting a research study assessing students' access to food and meal patterns among Australian university students and comparing the differences between international and domestic students. This study will ultimately contribute to the development of recommendations for international and domestic students in Australia to improve their diet quality. Taking part in this study is voluntary.

Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

2. Who is running the study?

The study is being carried out by the following researchers:

- Margaret Allman-Farinelli, Professor of Dietetics, Sydney School of Nursing, Faculty of Medicine and Health, The University of Sydney
- Yumeng Shi, PhD candidate, School of Life and Environmental Sciences, Faculty of Science, The University of Sydney

Yumeng Shi is conducting this study as the basis for the degree of Doctor of Philosophy at The University of Sydney.

3. Who can take part in the study?

We are seeking current students studying in Australia who are aged 18-30 years. Both international and domestic students are eligible. However, those studying a nutrition or dietetics course or who have already completed one are not eligible.

You have been invited to take part in this study because you meet the required characteristic for this study.

4. What will the study involve for me?

If you decide to take part in this study, you will be asked to:

- Complete a food access survey. It will take approximately 15 minutes. Questions are divided into five modules, including demographics, employment and financial status, food access module, diet-related behaviours, and health/well-being.
- Complete two 24-hour dietary recalls (you will have the opportunity to decide whether you would like to participate in this part of the study after the completion of the survey above). Each recall will take approximately 25-30 minutes. You will need to recall your food intakes on the previous day (from midnight to midnight) on an online platform called 'Automated Self-Administered 24-hour Dietary Assessment Tool'. Eating occasions (e.g., breakfast, lunch, dinner, and snack), and food and drink items will be reported. A detailed instruction guide and login information will be provided for you by the student researcher. The student researcher will also be available to answer your queries at any time via emails.

5. Can I withdraw once I've started?

Being in this study is completely voluntary and you do not have to take part.

Your decision will not affect your current or future relationship with the researchers or anyone else at The University of Sydney.

If you decide to take part in the study and then change your mind, you can withdraw by stopping the survey or dietary recalls, or notifying the student researcher by email. You will not be eligible for any of the lucky draws if you withdraw before the completion of the food access survey. If you completed the survey but decide to withdraw before the completion of two dietary recalls, you will still be eligible for the lucky draws from survey participants but not eligible for the second-round lucky draws from the respondents of dietary recalls.

If you choose to withdraw, we will not collect any more information from you. Please let us know at the time you withdraw what you would like us to do with information we have collected about you up to that point.

6. Are there any risks or costs?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

Contact details for support services are provided below if you have any concerns about having adequate food or your mental health:

Services for all students:

Food assistance	<u>Oz Harvest Market</u> Location: 95 Wellington St, Waterloo Contact details: Phone - 1800 108 006; Email - info@ozharvest.org Link: https://www.ozharvest.org/ozharvest-market-waterloo/
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Addi Road Food Pantry

Locations: Camperdown - 31 Pyrmont Bridge Rd, Camperdown;
Marrickville - Addison Road Community Centre, 142 Addison Road,
Marrickville

Contact details: Phone - (02) 9568 7633; Email - info@addiroad.org.au

Link: <https://addiroad.org.au/the-food-pantry/>

**Mental
health
support**

See more information here:

<https://www.sydney.edu.au/students/counselling-and-mental-health-support.html>

Services for international students:

**Food
assistance****USYD Food Hub**

Location: The University of Sydney Camperdown/Darlington campus:
Level 3 Wentworth Building, opposite Laneway Café

Contact details: Email - b.pinney@usu.edu.au

Link: <https://events.humanitix.com/usyd-food-hub-february>

More available food assistance services in NSW see this link:

<https://www.study.sydney/programs/food-assistance>

**Student
support**

For international student enquiries and concerns, email

international.support@sydney.edu.au

7. Are there any benefits?

Two rounds of lucky draws will be conducted. There will be 10 winners from each round and each winner will get a \$50 Coles/Myer gift card. The first round will be conducted among participants who completed the food access survey, and the second round will be conducted among participants who completed two dietary recalls.

8. What will happen to information that is collected?

By providing your consent, you are agreeing to us collecting information about you for the purposes of this study.

Any information you provide us will be stored securely and we will only disclose it with your permission, unless we are required by law to release information. We are planning for the study findings to be published.

You will not be individually identifiable in these publications.

All data collected in this study will be stored confidentially and only be used for research analysis, no third parties will have access to your information. The study results may be published in journals, conference presentations, and student theses, and your information will be anonymous. The electronic data will be stored on a secure network

storage of The University of Sydney, only the researchers of this study will have access to them.

9. Will I be told the results of the study?

You have a right to receive feedback about the overall results of this study. If you are interested in receiving feedback, please answer the relevant question and provide your contact details on the online consent form. This feedback will be in the form of a brief lay summary.

10. What if I would like further information?

When you have read this information, the following researcher/s will be available to discuss it with you further and answer any questions you may have:

- Yumeng Shi, email: yshi7693@uni.sydney.edu.au, phone: 61 2 8627 9567.

11. What if I have a complaint or any concerns?

The ethical aspects of this study have been approved by the Human Research Ethics Committee (HREC) of The University of Sydney [2021/745] according to the *National Statement on Ethical Conduct in Human Research (2007)*.

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the University:

Human Ethics Manager
human.ethics@sydney.edu.au
+61 2 8627 8176

This information sheet is for you to keep

Consent questions (survey) on REDCap

Please click [here](#) to download 'Participant Information Statement'. [Attached PIS]

The details of my involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.	Yes/No
<p>I understand the purpose of the study is to investigate students' access to food and meal patterns among international and domestic students in Australian universities.</p> <p>I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.</p> <p>I understand that in this study I will be required to complete a food access survey.</p> <p>I understand that being in this study is completely voluntary.</p> <p>I am assured that my decision to participate will not have any impact on my relationship with the research team or the University of Sydney.</p> <p>I understand that I am free to withdraw from this study at any time and that I can choose to withdraw any information I have already provided (unless the data has already been de-identified or published).</p> <p>I have been informed that the confidentiality of the information I provide will be protected and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.</p> <p>I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.</p>	Yes/No
I would like to receive feedback about the overall results of this study.	Yes/No
Please provide your preferred email address	Text box
I understand that after I sign and return this consent form it will be retained by the researcher, and that I may request a copy at any time.	Yes/No
Your name	Text box
Signature	Signature
Date	Text box

Consent questions (dietary recalls) on REDCap

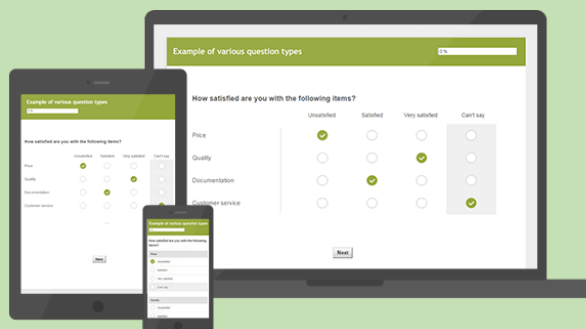
Please click [here](#) to download 'Participant Information Statement'. [Attached PIS]

The details of my involvement have been explained to me, and I have been provided with a written Participant Information Statement to keep.	Yes/No
<p>I understand the purpose of the study is to investigate students' access to food and meal patterns among international and domestic students in Australian universities.</p> <p>I acknowledge that the risks and benefits of participating in this study have been explained to me to my satisfaction.</p> <p>I understand that in this study I will be required to complete two 24-hour dietary recalls.</p> <p>I understand that being in this study is completely voluntary.</p> <p>I am assured that my decision to participate will not have any impact on my relationship with the research team or the University of Sydney.</p> <p>I understand that I am free to withdraw from this study at any time and that I can choose to withdraw any information I have already provided (unless the data has already been de-identified or published).</p> <p>I have been informed that the confidentiality of the information I provide will be protected and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.</p> <p>I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.</p>	Yes/No
I would like to receive feedback about the overall results of this study.	Yes/No
Please provide your preferred email address	Text box
I understand that after I sign and return this consent form it will be retained by the researcher, and that I may request a copy at any time.	Yes/No
Your name	Text box
Signature	Signature
Date	Text box

Food access SURVEY

Are you always able to obtain sufficient and appropriate foods?

ONLINE
Approx. 15 minutes



Recall what you ate on the previous day

ONLINE
25-30 minutes



Participants to be:

- ✓ Aged 18 to 30 years
- ✓ Current student studying in Australia
- ✓ Not completing a nutrition course or have completed one previously

20 winners in TWO lucky voucher draws!



Please scan the QR code or contact us by email for more details.



Yumeng Shi - yshi7693@uni.sydney.edu.au



Version 2, 5 Oct 2021

Assessing food access and meal patterns among university students in Australia

Chief investigator: Prof. Margaret Allman-Farinelli

USYD HREC approval number: 2021/745



THE UNIVERSITY OF SYDNEY