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EDITORIAL

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The vital role of nutrition and dietetics in the clinical management of disease and injury

The increased regard for dietetics expertise in a range of workplace settings is a welcome development.[1] Demand is growing for nutrition and dietetics professionals in community-based chronic condition prevention and management, aged care, personalised nutrition, food and agriculture and technology/digital health.[2] Despite the new opportunities for practice, most dietitians in 2022 continue to spend a significant portion of their working lives endeavouring to improve the health of patients and communities, that is, engaged in clinical nutrition. At its core, clinical nutrition is fundamental to the prevention and management of nutritional changes associated with chronic health conditions, or changes that occur because of acute injury. Ancient civilisations with highly developed medical systems not only appreciated the role of food and nutrition in emotional, mental, and spiritual well-being but also clearly recognised the value of clinical nutrition in the management of disease and injury.

In 2022, the aim of a dietitian working in clinical nutrition is to work within the interdisciplinary healthcare team to maintain energy balance and provide sufficient macro- and micronutrient intakes, all the time keeping the patient at the centre of care, and frequently facing many challenges to the delivery of nutrition. Although the greatest number of those who are malnourished or at risk of malnutrition reside in the community. setting,[3] globally, it is accepted that disease- or injury-associated malnutrition affects between 20% and 50% of patients on admission to hospital.[4] Nutritional status further deteriorates over the course of the hospital stay, for between 10% and 65% of patients.[4] Malnutrition (often referred to as undernutrition) consists of a combination of reduced food intake or assimilation, and varying degrees of acute or chronic inflammation, in turn leading to altered body composition and diminished biological function.[5] The inflammation associated with both chronic and acute disease or injury contributes to malnutrition through anorexia and decreased food intake, as well as causing an elevation in resting energy expenditure and increased muscle catabolism. Body composition changes manifest as a decrease in muscle mass, which is, in turn, associated with adverse functional and clinical outcomes.[5] The serious consequences of malnutrition on clinical outcomes led to a global consensus for diagnosing malnutrition in adults in clinical settings[6] in which the role of the dietetics profession is considered key.

As an international member of the Editorial Board, I am honoured to introduce the November edition of *Nutrition & Dietetics*. This issue emphasises our profession's key role in clinical nutrition and the importance of the dietitian in the identification of malnutrition/malnutrition risk and the management of disease. This issue includes studies on a range of clinical topics, most of which have been carried out by dietitians and all of which demonstrate the vital role of the dietitian in clinical nutrition. Furthermore, each of these studies contributes to the evidence base for dietetics practice.

The studies by Ferrie *et al.*,[7] Caruana *et al.*[8] and Wu and Li[9] provide clear evidence that malnutrition remains a significant problem when patients become ill, whether associated with a chronic condition such as kidney[8] or liver disease[9] or with a severe acute condition or injury.[7] Moreover, the study by Ferrie *et al.*[7] provides evidence that in 2022, over one-third (38.5%) of patients admitted to an intensive care unit are malnourished and, consistent with other international literature, that malnutrition is associated with detrimental outcomes in this patient cohort even when age, sex and severity of illness are considered. Higher mortality, longer stay in both intensive care and in hospital, more readmissions to hospital and a higher number of pressure injuries were documented in the malnourished cohort.

The study by Kurmis *et al.*[10] in this issue describes the evidence for clinical nutrition in patients with major burns. Despite the clearly identified rationale for early nutritional support in achieving good clinical outcomes following burns, this study indicated that only 69% of major burns patients in Australia and New Zealand received early enteral feeding, concluding that there is room for improvement in nutritional care. The study authors support the use of protocols to provide evidence-based nutritional care for this patient group in whom appropriate nutrition and dietetics care can crucially influence clinical outcomes.

The study by Zarshenas *et al.*[11] demonstrates that the role of nutrition and dietetics in obesity goes beyond its

prevention and treatment, highlighting the importance of dietetics care for patients undergoing bariatric surgery to prevent future malnutrition. Although bariatric or metabolic surgery is successful in achieving weight loss, to ensure that patients undergoing such surgery maintain adequate nutritional status and remain healthy, ongoing dietetics management is required. These studies[10,11] highlight that evidence-based nutritional care is not always provided and that poor practices can occur, particularly when dietetics staffing is inadequate. The authors of both studies emphasise that patient-centred protocols, developed by dietitians as the experts in nutrition, could contribute towards ensuring optimal health is achieved and maintained over the full lifespan.

While poor clinical outcomes have been documented in these studies, none have documented the resulting financial costs. It is imperative for dietitians to put a value on the cost savings that they can achieve by early and evidence-based, clinically appropriate nutrition interventions, that improve the patient experience and quality of life. The recent scoping review[12] on trends, challenges, opportunities and future needs of the dietetics workforce highlighted that dietitians need to be providers of counselling-based treatment and not solely providers of information. This review clearly articulated that the transfer of information is perceived to only require short-term intervention, whereas therapeutic, counselling style approaches are perceived to be needed over the longer term. Dietitians need to systematically record and report the outcomes of their interventions to ensure that the value of their work is credited accurately.

In 2022, we must all acknowledge the global shortage of dietetics professionals. Indeed, in my own Country, Ireland, we currently have 470 unfilled dietetics posts. The recent recognition of the value of a dietitian within the primary care/community setting is hugely welcomed. However, the development of these positions in the absence of a clearly defined strategy for education of future graduates is unfortunate and has resulted in the movement of experienced and respected dietetics professionals from the acute to the primary care/community setting. This has resulted in staff shortages in many of the acute care clinical settings in which medically complex patients are managed. The clinical studies previously referred to[7–11] demonstrate the complexity of disease conditions that dietitians manage within the acute clinical environment. This is further emphasised by the Letter to the Editor from Roem *et al.*[13] highlighting the challenges that dietitians face within the clinical environment, in particular, with the growing older adult population in whom highly complex medical interventions are increasingly being used.

A collaborative approach between health services management, professional bodies, practising dietitians, and academic institutions should be strived for to ensure an adequate graduate pool that is workforce-ready. This is clearly articulated in the scoping review[12] and is challenging in times of staff shortages. Patient-centred screening tools to identify malnutrition, dietetics leadership, innovative approaches and interdisciplinary working can contribute to the development of evidence-based nutrition care that ensures safe and effective clinical nutrition practices as referenced in the studies included in this issue of *Nutrition & Dietetics*.[7,10,11]

The role of dietetics outside clinical nutrition is increasingly valued. Thus, I would also like to comment on a further two studies published in the November 2022 issue of Nutrition & Dietetics as both provide an important public health perspective. The study by Wilkinson *et al.*[14] explores the diets of mothers and their partners during pregnancy while the study by Fayet-Moore *et al.*[15] focuses on the patterns of discretionary food intake among Australian children. Like those studies emanating from the clinical setting, both these studies reinforce the need for evidence-informed health policies and targeted programmes, in their case to benefit public health.

As an international member of the Nutrition & Dietetics Editorial Board, I take great pleasure and learn much from reading and reviewing the many articles submitted to the journal. I believe that dietetics in Australia, like in Ireland, is well-positioned to take on the many and varied roles identified[2] and that dietitians have both the scientific understanding of food and nutrition and the communication skills to make a real difference to the health of our populations.

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REFERENCES

1. Hickson M, Child J, Collinson A. Future dietitian 2025: informing the development of a workforce strategy for dietetics. *J Hum Nutr Diet*. 2018;31(1):23-32.
2. Boak R, Palermo C, Beck EJ, et al. A qualitative exploration of the future of nutrition and dietetics in Australia and New Zealand: implications for the workforce. *Nutr Diet*. 2022;79:427-437.
3. Crichton M, Craven D, Mackay H, Marx W, de van der Schueren M, Marshall S. A systematic review, meta-analysis and meta-regression of the prevalence of protein-energy malnutrition: associations with geographical region and sex. *Age Ageing*. 2019;48(1):38-48.
4. Cass AR, Charlton KE. Prevalence of hospital-acquired malnutrition and modifiable determinants of nutritional deterioration

during inpatient admissions: a systematic review of the evidence. *J Hum Nutr Diet*. 2022. doi:10.1111/jhn.13009
5. Jensen GL, Cederholm T, Correia MI, et al. GLIM criteria for the diagnosis of malnutrition: a consensus report from the global clinical nutrition community. *J Parenter Enteral Nutr*. 2019;43(1):32-40.
6. Cederholm T, Jensen GL. To create a consensus on malnutrition diagnostic criteria: a report from the global leadership initiative on malnutrition (GLIM) meeting at the ESPEN congress 2016. *J Parenter Enteral Nutr*. 2017 Mar;41(3):311-314.
7. Ferrie S, Weiss NB, Chau HY, Torkel S, Stepniewski ME. Association of subjective global assessment with outcomes in the intensive care unit: a retrospective cohort study. *Nutr Diet*. 2022;79(5):572-581.
8. Caruana L, Nichols L, Lambert K. Malnutrition, symptom burden and predictive validity of the Patient-Generated Subjective Global Assessment in Central Australian haemodialysis patients: a cross-sectional study. *Nutr Diet*. 2022;79(5):555-562.
9. Wu Y-K, Li M, Zhang Y-C, et al. The sarcopenia index is an effective predictor for malnutrition in patients with liver cirrhosis. *Nutr Diet*. 2022;79(5):563-571.
10. Kurmis R, Nicholls C, Singer Y, et al. An investigation of early enteral nutrition provision in major burns patients in Australia and New Zealand. *Nutr Diet*. 2022;79(5):582-589.
11. Zarshenas N, Tapsell LC, Batterham M, et al. Investigating the prevalence of nutritional abnormalities in patients prior to and following bariatric surgery. *Nutr Diet*. 2022;79(5):590-601.
12. Blair M, Mitchell L, Palermo C, Gibson S. Trends, challenges, opportunities, and future needs of the dietetic workforce: a systematic scoping review. *Nutr Rev*. 2022;80(5):1027-1040.
13. Roem K, Compton R, Fourlanos S, McAuley SA. Carbohydrate-counting education for older adults with type 1 diabetes starting first-generation closed-loop therapy: observations from the ORACL trial. *Nutr Diet*. 2022;79(5):647-649.
14. Wilkinson S, Schoenaker D, De Jersey S, et al. Exploring the diets of mothers and their partners during pregnancy: findings from the Queensland Family Cohort pilot study. *Nutr Diet*. 2022;79(5):602-615.
15. Fayet-Moore F, McConnell A, Tuck K, et al. Patterns of discretionary food intake among Australian children and their association with socio-demographic, lifestyle and adiposity measures. *Nutr Diet*. 2022;79(5):623-635.

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ORIGINAL RESEARCH

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Malnutrition, symptom burden and predictive validity of the Patient-Generated Subjective Global Assessment in Central Australian haemodialysis patients: A cross sectional study

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Abstract

Aim: To (i) describe the prevalence of malnutrition among a cohort of central Australian, predominantly Indigenous, haemodialysis patients and (ii) determine the sensitivity and specificity of the Patient Generated Subjective Global Assessment total score for identification of malnutrition in these patients.

Methods: Cross-sectional observational study of all patients attending haemodialysis units within the Central Australia Health Service. Patients were assessed using the Patient-Generated Subjective Global Assessment. Chi-Square tests were used to determine the association between nutritional status and location, age and gender. Receiver Operator Characteristic curves were used to ascertain the predictive validity for malnutrition of the total score.

Results: Indigenous patients comprised 98% of study haemodialysis patients (n = 249/253). One third were male, and 72% were aged between 30 and 59 years. Approximately 29% (74/253) were malnourished, and 93% (69/74) had a total score ≥ 4. The most frequently reported problems that kept malnourished patients from eating were early satiety (32%), no appetite (31%), diarrhoea (26%) and dental problems (24%). Money problems were reported by 32%, as were transport (20%) and depression (19%). The traditional tool cut off score of ≥9 had low sensitivity (50%) for detecting malnutrition. Instead, a score ≥ 3 is suggested due to a higher sensitivity (96%) and specificity (45%).

Conclusion: Malnutrition was found to be common, and we suggest using a Patient-Generated Subjective Global Assessment total score of ≥3 to improve the identification of malnourished individuals in this cohort of predominantly Indigenous haemodialysis patients. This will significantly increase referrals for dietetic intervention.

KEYWORDS
Aboriginal, cross sectional study, haemodialysis, Indigenous, malnutrition, symptom burden

1 | INTRODUCTION

Haemodialysis is one form of renal replacement therapy for those who experience kidney failure. In the most recent census of haemodialysis in Australia (2020), there were approximately 10 916 people undertaking in-centre haemodialysis.[1] However, the burden of haemodialysis is not distributed evenly across the Australian population, and Indigenous people comprise 19% of the total Australian haemodialysis population. These differences are amplified when examined according to the level of geographical remoteness,[2] and gender, with Indigenous females who live in remote areas dominating the dialysis population.[3]

Few studies in Australia have examined the nutritional status of Indigenous Australians who undertake dialysis. Of the single published study of 25 South Australian Aboriginal and 51 non-Aboriginal South Australian haemodialysis patients in two satellite units, it was found that 35% of Aboriginal patients were malnourished.[4] The mean Patient-Generated Subjective Global Assessment (PG-SGA) score was not significantly different from non-Aboriginal patients (4.2 ± 3.6 compared with 4.5 ± 3.4). Unfortunately, the authors did not describe the symptom burden of the patients so it remains unknown what factors may be contributing to the high rate of malnutrition documented.

There are also few studies that have examined the predictive validity of the PG-SGA in the Australian dialysis population, or more specifically the Australian Indigenous dialysis population. Campbell et al.[5] undertook a prospective observational study of 213 individuals from a single metropolitan in-centre haemodialysis unit. The prevalence of malnutrition was estimated to be 23.5% and the median PG-SGA symptom score among the malnourished patients was 3.5 (interquartile range 1.8–7). The most common symptom reported in those who were malnourished was no appetite (60%) and early satiety (36%). A PG-SGA nutrition impact score ≥ 2 was the strongest predictor of mortality with an area under the curve of 0.86 (95% CI: 0.79–0.93) and sensitivity of 76%. To our knowledge, no additional studies have been published in the Australian context.

Given these evidence gaps, and the important health and financial implications of malnutrition among dialysis patients,[6] the aims of this study were to: (i) describe the prevalence of malnutrition among haemodialysis patients in the Central Australia Health Service, a patient population dominated by Indigenous Australians and (ii) determine the sensitivity and specificity of the PG-SGA total score for identification of malnutrition among a cohort of central Australian, predominantly Indigenous, haemodialysis patients.

2 | METHODS

All maintenance haemodialysis patients attending the acute or satellite haemodialysis units in the Central Australia Health Service were approached to participate in the study. Exclusion criteria included patients with known cognitive impairment, or inability of the carer to assist with completion of the PG-SGA; or unavailability of an interpreter/Cultural Liaison Officer to assist with communication and completion of the assessment.

Ethical approval was obtained from the Central Australia Human Research Ethics Committee (Approval number:14–264). Patients were approached by either a dietitian or student dietitian and asked to participate in the study, which included a full nutritional assessment completed by the dietitian, and a physical exam using the PG-SGA tool. The study was conducted in each unit over the course of 1 week in October 2016. Verbal informed consent was obtained from all participants or their guardian.

Dietitians completed the PG-SGA alongside patients. To ensure consistency between assessors, three team training sessions were conducted prior to undertaking the audit. In addition, all assessments were completed in pairs (with a more senior staff member paired with a less experienced staff member) to ensure accuracy of assessments. A script was also provided to dietitians to ensure questioning was consistent during the assessment.

Section three of the PG-SGA (i.e. 'symptoms that have kept me from eating enough during the past 2 weeks') included one additional prompt. This prompt was used when exploring 'other' factors impacting intake and explored if transport impacted access to food. This is widely known to impact the nutritional status in this population group.[7,8] All patients who were identified as malnourished or at risk of malnutrition, that is, with a PG-SGA total score ≥ 4 or Subjective Global Assessment (SGA) category of B or C, were triaged and referred to the renal dietitian attached to the haemodialysis unit for follow up.[9] Those with a PG-SGA total score of ≥ 9 or SGA = C, were triaged as a high priority based on known criteria.[10,11]

Demographic and anthropometric data including dry weight, height, and weight history were obtained from the medical records by the renal dietitian. Where dry weight did not correspond to the weight history recorded on the dialysis charts, clarification was sought from the nephrology team or discussion was held between the renal dietitians known to the patient and the Nurse Unit Manager to determine a more appropriate dry weight to record. Responses from patients regarding the presence of wounds was cross checked with medical record files and data on patients under the care of the wound management team. Ethnicity as reported in the medical file was recorded. Dialysis locations were recorded as one of five dialysis units located within the Alice Springs region. Age was retrieved from the medical record, and for the purposes of this study were categorised as 18–29; 30–59; 60–64; 65–74 and ≥75 years. Self-reported residence was noted and verified by assessors by cross checking against the renal transport bus list (where 95% of patients rely on the bus to get to dialysis). BMI was categorised according to the recommendations from the KDOQI 2020 Clinical Practice Guidelines for Nutrition in Chronic Kidney Disease (CKD).[6]

All statistical analysis was conducted using SPSS software (version 25.0, SPSS Inc., Chicago). Normality of continuous data was determined using the Shapiro–Wilk test. Descriptive data is reported as median and interquartile range or number and proportions. Chi Square tests were used to explore the association between malnutrition status and categorical variables such as gender, place of residence, and dialysis location. The Kruskal–Wallis test or Mann–Whitney *U* was used to explore the relationship between total PG-SGA score, anthropometric variables (e.g. height, weight) and nutritional status. To ascertain the sensitivity and specificity, and optimal PG-SGA total cut off score for identifying malnourished haemodialysis patients, the receiver operating characteristics (ROC) curve was used. An area under the curve (AUC) of 0.9–1 indicates the PG-SGA score was an excellent measure for detecting malnutrition; 0.8–0.89 a good test; and 0.70–0.79 a fair test.[12] Statistical significance was set at a p value of 0.05. Reporting of this study is consistent with the STROBE statement for cross sectional studies.[13]

3 | RESULTS

Over the study period, a total of 253 patients consented to participate in the study (equating to a response rate of 76%). The study sample was around one third male (35%, 89/253, Table 1), with 98% of the recruited participants identifying as Indigenous. Almost three quarters (72%, 183/253) of the sample were aged between 30 and 59 years old; and one quarter (26%, 65/253) were aged ≥60 years. Approximately one third of the sample resided in either hostel accommodation (28%, 70/253, Table 1) or a private residence (36%, 90/253). Approximately one quarter lived in a town camp (27%, 69/253). One third of the sample had a BMI in the healthy range (37%, 93/253, Table 1). Approximately 15% of the sample had a pressure sore or open wound.

The overall prevalence of malnutrition for the Central Australia Health Service haemodialysis population was 29% (74/253, Table 2). Based on PG-SGA Global Assessment categories, 29% (72/253) were classified as mild/moderately malnourished, and <1% (2/253) were classified as severely malnourished (PG-SGA category C). The prevalence of malnutrition did not differ according to age category ($p = 0.38$), gender ($p = 0.78$), dialysis location ($p = 0.08$, data not shown) or a patient's place of residence ($p = 0.38$). There was also no significant difference in malnutrition rate between the Indigenous and non-Indigenous participants ($p = 0.62$).

There were significant differences in the total PG-SGA numerical score between nutritional status categories (Table 2). Those who were malnourished had a median total score of 8.5 (IQR: 6–10); while those who were well nourished had a median total score of 3 (IQR: 2–4, $p < 0.0001$). The most frequently reported problem that kept malnourished haemodialysis patients from eating enough were: money problems (Table 2, 32%, $n = 24/74$); early satiety (32%, $n = 24/74$); dental problems (24%, $n = 18/74$); diarrhoea (26%, $n = 19/74$); and no appetite (31%, $n = 23/74$). Transport was reported as a problem impacting the ability to eat enough by 20% (15/74) of malnourished haemodialysis patients. The proportion of patients overall with a total score ≥ 4 indicating that referral to a dietitian was required was 52% (132/253).

When examining symptoms that impacted eating in the prior 2 weeks, there were many important differences between malnourished and well-nourished groups. This included a higher proportion of dental problems (24%, $p < 0.0001$); depression (19%, $p = 0.004$); diarrhoea (26%, $p < 0.0001$); early satiety (32%, $p < 0.0001$); money problems (32%, $p = 0.02$); nausea (19%, $p = 0.002$); no appetite (31%, $p < 0.0001$); swallowing problems (10%, $p = 0.001$); smells bothering them (12%, $p = 0.003$); taste changes (16%, $p = 0.003$); vomiting (18%, $p = 0.001$); transport issues (20%, $p = 0.003$); and a higher proportion with a total PG-SGA score of ≥4 (93%, $p < 0.001$) among those who were malnourished.

The ROC analysis is shown in Figure 1 and indicated the AUC was 0.894 (95% CI: 0.851–0.936), indicating that the total PG-SGA score was a good test for malnutrition.

TABLE 1 Clinical and demographic characteristics of participants ($n = 253$)

	Total ($n = 253$) number (%)	Well nourished ($n = 179$)	Malnourished ($n = 74$)	p value
Male gender	89 (35)	62 (35)	27 (37)	0.78
Age (years)				0.38
18–29	4 (2)	3 (2)	1 (1)	
30–59	183 (72)	135 (75)	48 (65)	
60–64	31 (12)	20 (11)	11 (15)	
65–74	34 (13)	20 (11)	14 (19)	
75 or over	1 (<1)	1 (<1)	0 (0)	
Proportion over 65 years	35 (14)	21 (12)	14 (19)	0.13
Ethnicity				0.89
Caucasian	4 (2)	2 (1.1)	2 (3)	
Indigenous	249 (98)	177 (99)	72 (97)	
Asian	0 (0)	0 (0)	0 (0)	
Other	0 (0)	0 (0)	0 (0)	
Residence[a]				0.38
Hostel	70 (28)	50 (31)	21 (28)	
Town camp	69 (27)	48(27)	21 (28)	
Private Residence	90 (36)	66 (37)	24 (32)	
Other	23 (9)	15 (8)	8 (11)	
Height, m (range)	1.65 (1.59–1.72)	1.65 (1.59–1.72)	1.65 (1.59–1.7)	0.90
Weight, kg (range)	70.5 (60.5–82.0)	72.5 (64.5–86.0)	60.5 (56.0–77.0)	<0.0001
Body mass index (kg/m^2)				
Underweight BMI: <18.5	14 (6)	6 (3.4)	8 (11)	<0.0001
Healthy weight BMI: 18.5–24.9	93 (37)	53 (30)	40 (54)	
Overweight BMI: 25–29.9	87 (34)	69 (39)	18 (24)	
Obese BMI: ≥30	59 (23)	51 (29)	8 (11)	
Weight loss in previous 6 months				
0–1.9%	225 (89)	165 (92)	60 (81)	0.008
2–5.9%	11 (4)	8 (5)	3 (4)	
6–9.9%	16 (6)	6 (3)	10 (14)	
10–19.9%	1 (<1)	0 (0)	1 (1)	
≥20%	0 (0)	0 (0)	0 (0)	–
Comorbidities				
Cancer	3 (1)	2 (1)	1 (1)	0.88
AIDS	0 (0)	0 (0)	0 (0)	–
Cachexia[b]	0 (0)	0 (0)	0 (0)	–
Trauma	3 (1)	0 (0)	3 (4)	0.02
Pressure sore or open wound	39 (15)	20 (11)	19 (26)	0.004
Fever	2 (<1)	1 (<1)	1 (1)	0.52
Steroids	0 (0)	0 (0)	0 (0)	–

[a]Definitions or description of residence: hostel; transient short term accommodation for people from remote areas who need to access health services or education, and residents receive three meals per day; Town camp: community living areas that are Aboriginal communities within the town of Alice springs; Private residence: Other: Nursing home or private care organisation.

[b]Cachexia refers to Pulmonary or cardiac cachexia. Height and weight reported as median and interquartile range. Ethnicity is reported as the ethnicity recorded in the medical file. BMI range categorisation according to Ikizler et al.[6]

TABLE 2 Malnutrition and nutrition impact symptoms ($n = 253$)

	Total ($n = 253$) number (%)	Well nourished ($n = 179$)	Malnourished ($n = 74$)	*p* value
PG- SGA score	4 (2–7)	3 (2–4)	8.5 (6–10)	<0.0001
PG-SGA category				–
A—well nourished	179 (71)	179	–	
B—mild/mod malnourished	72 (29)	–	72	
C—severely malnourished	2 (<1)	–	2	
Nutrition impact symptoms				–
Constipation *n* (%)	12 (5)	6 (3)	6 (8)	0.11
Dental problems, *n* (%)	32 (13)	14 (8)	18 (24)	<0.0001
Depression, *n* (%)	26 (10)	12 (7)	14 (19)	0.004
Diarrhoea, *n* (%)	31 (12)	12 (7)	19 (26)	<0.0001
Dry mouth, *n* (%)	12 (5)	7 (4)	5 (7)	0.33
Early satiety, *n* (%)	44 (17)	20 (11)	24 (32)	<0.0001
Money problems, *n* (%)	58 (23)	34 (19)	24 (32)	0.02
Mouth sores, *n* (%)	4 (2)	4 (2)	0 (0)	0.20
Nausea, *n* (%)	25 (10)	11 (6)	14 (19)	0.002
No appetite, *n* (%)	32 (13)	9 (5)	23 (31)	<0.0001
Pain, *n* (%)	17 (7)	11 (6)	6 (8)	0.57
Swallowing issues, *n* (%)	9 (4)	2 (1)	7 (10)	0.001
Smells bother me, *n* (%)	14 (6)	5 (3)	9 (12)	0.003
Taste changes, *n* (%)	21 (8)	9 (5)	12 (16)	0.003
Vomiting, *n* (%)	21 (8)	8 (5)	13 (18)	0.001
Transport issues, *n* (%)	28 (11)	13 (7)	15 (20)	0.003
Total PG-SGA score ≥ 4, *n* (%)	132 (52)	63 (35)	69 (93)	<0.001

In this population group of predominantly Indigenous haemodialysis patients, a PG-SGA total cut off score of ≥9 as per the author of the tool[14] only yielded a sensitivity of 50% and specificity of 95%. The sensitivity increased to 96% and specificity of 45% when the total PG-SGA score was lowered to ≥3; and a sensitivity of 100% and specificity of 24% when lowered to a PG-SGA total score ≥ 2. A total score cut off ≥3 was therefore considered the most appropriate score to indicate malnutrition and a critical need for intervention in this cohort of haemodialysis patients. The ROC analysis was repeated with non-Indigenous patients excluded and using boxes 1–4 of the PG-SGA. This did not substantially change the AUC (AUC 0.893; 95% CI: 0.85–0.936), nor alter the cut off score (sensitivity 96% and specificity 54% for score ≥ 2.5) when examining Indigenous patients only. In contrast, the AUC for boxes 1–4 of the PG-SGA was 0.804 (95% CI: 0.743–0.868), indicating it was a good-fair test and not superior to the total PG-SGA score. Table 3 provides coordinates for the ROC analysis for the total PG-SGA score ($n = 253$).

4 | DISCUSSION

This study provides a comprehensive overview of the nutritional status of a large cohort of predominantly Indigenous haemodialysis patients in the Central Australia Health Service. This represented nearly one fifth (16%) of the national Indigenous haemodialysis population in 2016.[15] The key findings were that almost one third (29%) of patients were malnourished and symptoms such as anorexia, early satiety, and diarrhoea were more prevalent in malnourished patients. In addition, dental problems and lack of money were also common in malnourished patients. The other key finding of this study was that a PG-SGA total score of ≥3 appears to be the optimal cut off score for identification of malnutrition in

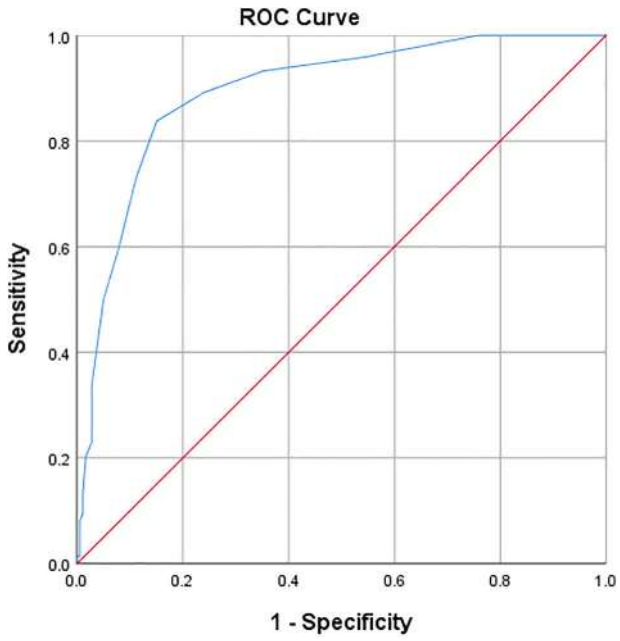

FIGURE 1 Receiver operating characteristics (ROC) curve plot of the sensitivity and specificity of the nutrition impact score component of the Patient-Generated Subjective Global Assessment for predicting malnutrition. The area under the curve of 0.894 (95% CI: 0.851–0.936) indicates a good test.

TABLE 3 Coordinates of the receiver operating characteristics (ROC) curve for total Patient-Generated Subjective Global Assessment score

Score	Sensitivity	1 Specificity	Specificity
0.0	1.000	1.000	0.00
2.0	1.000	0.760	0.240
3.0	0.959	0.547	0.453
4.0	0.932	0.352	0.648
5.0	0.892	0.240	0.760
6.0	0.838	0.151	0.849
7.0	0.730	0.112	0.888
8.0	0.595	0.078	0.922
9.0	0.500	0.050	0.950
10.0	0.338	0.028	0.972
11.0	0.230	0.028	0.972
12.0	0.203	0.017	0.983
13.0	0.135	0.011	0.989
14.0	0.122	0.011	0.989
15.0	0.095	0.011	0.989
17.0	0.081	0.006	0.994
18.0	0.068	0.006	1.00
19.0	0.041	0.006	1.00

this cohort of predominantly Indigenous haemodialysis patients.

The rates of malnutrition in this study are comparable to those previously documented in Australian dialysis populations. A meta-analysis of the global prevalence of protein energy wasting estimated 17.9% of the Australian dialysis population were malnourished.[16] Given that almost all patients in the present study were Indigenous, this increased rate of malnutrition of 29% may indirectly reflect the higher rates of disadvantage and lower socio-economic status of Indigenous people with kidney disease.[17] Our findings also extend on previous research, by providing insight into the nutritional status of a remote dialysis population, with prior studies on the prevalence of malnutrition in Australia conducted in urban metropolitan units.[4,5,11,18] The implications of these findings are concerning, as renal dietitian staffing has repeatedly been shown to be insufficient, both in Australia and abroad.[19–22] Given the level of remoteness, and challenges accessing Indigenous health care interpreters[23–25] which are necessary for providing culturally safe care, it is possible that many haemodialysis patients are not receiving dietetic input when most needed.

The 7-point Subjective Global Assessment is now recommended as the preferred tool for nutrition assessment due to the robust evidence base, particularly for assessment of body composition in dialysis cohorts.[26] However, the 7-point SGA does not include an extensive list of symptoms that are known to impact patients with kidney failure. The value of understanding the symptom burden is clearly demonstrated in the present study, with malnourished patients exhibiting an almost three times greater symptom score than well-nourished patients. The PG-SGA symptom component thus serves as a useful way to help triage patients in a limited resource environment. Notably, though in the present study, lack of transport and money problems were among the most prevalent factors identified. This suggests that addressing malnutrition in this population requires multifaceted cross-sectorial approaches that address both the social determinants of health to improve access to affordable food, as well as treatment of symptoms and underlying potentially medical issues that limit intake.

Strategies to address malnutrition in the Indigenous dialysis population are urgently needed. This includes strategies to identify those at risk. Development of a culturally appropriate, specific malnutrition assessment tool for Indigenous Australians may be useful. Recent work on malnutrition in the central Australian inpatient setting identified that a mid-upper arm circumference of <23 cm demonstrated a strong positive predictive value for malnutrition (96% 95% CI: 89–99.2).[27] The Adult Nutrition Tool,[28] an adaptation of the Malnutrition

Screening Tool[29] is also routinely used in the inpatient setting at Alice Springs Hospital and could be used in the dialysis setting. Exploration of symptoms clusters would also be beneficial. While, it is well known that the symptom burden is high in dialysis patients,[30] examination of how these symptoms cluster together and influence malnutrition risk and quality of life is relatively unexplored. An improved understanding of symptom clusters may assist with treatment priorities and contribute to an improved quality of life.[31]

The critical importance of involving Indigenous consumers in any strategies designed to reduce malnutrition also cannot be understated. A 2016 report identified that more than 75% of all new dialysis patients were required to relocate from a remote community to commence dialysis.[32] This has been reported in previous studies to create a profound sense of dislocation to be away from family and social ties,[33] and more importantly disrupted access to traditional foods, and methods for accessing and consuming these foods.[7] In the present study, approximately one third of participants resided in a hostel (where three meals per day are provided) or another form of temporary accommodation. Despite this, place of residence was not associated with a poorer nutritional status. Future work should explore the nature of food insecurity among Indigenous patients undergoing dialysis, as well as engagement of hostels with consumers regarding meal provision. Potential strategies such as increasing access and availability to traditional foods may be useful. Psychosocial interventions, such as those being tested in the ongoing WICKD trial[34] may also be informative for helping to address the high levels of depression seen in this study, which will also impact oral intake.

There are several strengths to this work. Researchers assisted patients to complete the PG-SGA and ensured training among assessors occurred in the week prior to assessment to reduce intra-assessor variability. Assessors were also dietitians well known to the patient cohort and this may have increased participation and trust among patients. However, there are several limitations. The study was not able to examine relationships between nutritional status and dialysis vintage, dialysis clearances (urea reduction ratios or dialysis adequacy) or any biochemical markers. The findings may not be generalisable to other Australian dialysis units as the proportion of Indigenous patients in this study was significantly higher.

To conclude, this study has found that malnutrition appears to be present in about one in three haemodialysis patients from the Central Australia Health Service. The symptom burden among these patients is also high. Future work should explore symptom clusters to help to develop and triage new models of care, in addition to interventions to assist with financial and social factors impacting nutritional status. In the absence of specific nutritional assessment tools, the authors suggest use of the PG-SGA using a total score of ≥3 to improve the identification of malnourished individuals in this cohort of predominantly Indigenous haemodialysis patients. This will significantly increase referrals for dietetic intervention.

AUTHOR CONTRIBUTIONS

LC and LN designed and conducted the research; KL analysed the data; LC, LN and KL wrote and revised the paper. LC and LN had primary responsibility for the final contents. All authors read and approved the final manuscript. The authors acknowledge Margo Bell and Clare Brown for assistance with data collection.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. ANZDATA Registry. ANZDATA registry. 44th report, chapter 2: prevalence of kidney failure with replacement therapy. In: Australia and New Zealand Dialysis and Transplant Registry. Adelaide, Australia. 2021.
2. Australian Institute of Health and Welfare. Chronic Kidney Disease Cat no: CDK16. 2018.
3. Australian Health Ministers' Advisory Council. Aboriginal and Torres Strait Islander Health Performance Framework 2017 Report, Canberra, 2017.
4. Todd A, Carroll R, Gallagher M, Meade A. Nutritional status of haemodialysis patients: comparison of Australian cohorts of aboriginal and European descent. *Nephrol Ther*. 2013;18(12):790-797.
5. Campbell KL, Bauer JD, Ikehiro A, Johnson DW. Role of nutrition impact symptoms in predicting nutritional status and clinical outcome in hemodialysis patients: a potential screening tool. *J Ren Nutr*. 2013;23(4):302-307.
6. Ikizler TA, Burrowes JD, Byham-Gray LD, et al. KDOQI clinical practice guideline for nutrition in CKD: 2020 update. *Am J Kidney Dis*. 2020;76(3):S1-S107.
7. Cubillo B, McCartan J, West C, Brimblecombe J. A qualitative analysis of the accessibility and connection to traditional food for aboriginal chronic maintenance hemodialysis patients. *Curr Dev Nutrition*. 2020;4(4):nzaa036.
8. Australian Government. Tier 2. Determinants of health. 2.13 Transport 2020. https://www.indigenoushpf.gov.au/measures/2-13-transport.
9. Ottery FD, ed. Rethinking nutritional support of the cancer patient: the new field of nutritional oncology. *Semin Oncol*. 1994;21:770-778.

10. Ottery FD. Definition of standardized nutritional assessment and interventional pathways in oncology. *Nutrition*. 1996;12-(Suppl 1):S15-S19.
11. Desbrow B, Bauer J, Blum C, Kandasamy A, McDonald A, Montgomery K. Assessment of nutritional status in hemodialysis patients using patient-generated subjective global assessment. *J Ren Nutr*. 2005;15(2):211-216.
12. Šimundić A-M. Measures of diagnostic accuracy: basic definitions. *EJIFCC*. 2009;19(4):203-211.
13. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med*. 2007; 147(8):573-577.
14. Ottery FD. Which cut-off scores for nutritional triage recommendations should I use when using the PG-SGA Short Form? Pt-Global PG-SGA /Pt Global Platform 2008. https://pt-global.org/ufaqs/12-which-cut-off-scores-for-nutritional-triage-recommendations-should-i-use-when-using-the-pg%E2%80%91sga-short-form/
15. Australia and New Zealand Dialysis and Transplant Registry. ANZDATA Registry 40th Report, Chapter 10. End Stage Kidney Disease in indigenous peoples of Australia and Aotearoa/New Zealand. Adelaide, Australia 2018.
16. Carrero JJ, Thomas F, Nagy K, et al. Global prevalence of protein-energy wasting in kidney disease: a meta-analysis of contemporary observational studies from the International Society of Renal Nutrition and Metabolism. *J Ren Nutr*. 2018; 28(6):380-392.
17. Ritte RE, Lawton P, Hughes JT, et al. Chronic kidney disease and socio-economic status: a cross sectional study. *Ethn Health*. 2020;25(1):93-109.
18. Campbell KL, Ash S, Zabel R, McFarlane C, Juffs P, Bauer JD. Implementation of standardized nutrition guidelines by renal dietitians is associated with improved nutrition status. *J Ren Nutr*. 2009;19(2):136-144.
19. Crosby CPA, Barnes P, Lambert K, Rounsley K. A survey of renal dietitian staffing in New South Wales. *Nephrol Ther*. 2010;15(Suppl 4):44.
20. Jackson S. Moving the issue of renal dietitian staffing forward: an international perspective. *J Ren Nutr*. 2013;23(4):324. doi:10.1053/j.jrn.2012.09.005
21. Patwardhan ABL, Chan M, Ryan C. A survey of renal dietitian staffing in New South Wales. *Nephrol Ther*. 2004;9:A37.
22. Campbell KL, Murray EM. Allied health services to nephrology: an audit of current workforce and meeting future challenges. *J Ren Care*. 2013;39(1):52-61.
23. Kelly J, Dowling A, McBride K, Keech W, Brown A. In-hospital communication experiences of aboriginal and Torres Strait islander people: a systematic review protocol. *JBI Database System Rev Implement Rep*. 2016;14(10):88-97.
24. Rix EF, Barclay L, Stirling J, Tong A, Wilson S. The perspectives of aboriginal patients and their health care providers on improving the quality of hemodialysis services: a qualitative study. *Hemodial Int*. 2015;19(1):80-89.
25. Kerrigan V, McGrath SY, Majoni SW, et al. "The talking bit of medicine, that's the most important bit": doctors and aboriginal interpreters collaborate to transform culturally competent hospital care. *Int J Equity Health*. 2021;20(1):170.
26. CANUSA Peritoneal Dialysis Study Group. Adequacy of dialysis and nutrition in continuous peritoneal dialysis: association with clinical outcomes. Canada-USA (CANUSA) peritoneal dialysis study group. *J Am Soc Nephrol*. 1996;7(2):198-207.
27. Morris NF, Stewart S, Riley MD, Maguire GP. The burden and nature of malnutrition among patients in regional hospital settings: a cross-sectional survey. *Clin Nutr ESPEN*. 2018;23:1-9.
28. Morris NF, Stewart S, Riley MD, Maguire GP. The indigenous Australian malnutrition project: the burden and impact of malnutrition in aboriginal Australian and Torres Strait islander hospital inpatients, and validation of a malnutrition screening tool for use in hospitals-study rationale and protocol. *Springerplus*. 2016;5(1):1296.
29. Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutrition*. 1999;15(6):458-464.
30. Almutary H, Bonner A, Douglas C. Symptom burden in chronic kidney disease: a review of recent literature. *J Ren Care*. 2013;39(3):140-150.
31. Kalantar-Zadeh K, Lockwood MB, Rhee CM, et al. Patient-centred approaches for the management of unpleasant symptoms in kidney disease. *Nat Rev Nephrol*. 2022;18:185-198.
32. Gorham G CA, Howard K, Evans K. Central Australia Renal Study: Technical Report Update. Report prepared by Menzies School of Health Research for the Australian Government Department of Health, Canberra 2016.
33. Devitt J, McMasters A. They don't last long: aboriginal patient experience of end-stage renal disease in Central Australia. *Nephrol Ther*. 1998;4(s2):S111-S117.
34. Dingwall KM, Sweet M, Cass A, et al. Effectiveness of well-being intervention for chronic kidney disease (WICKD): results of a randomised controlled trial. *BMC Nephrol*. 2021;22(1):136.

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ORIGINAL RESEARCH

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Association of Subjective Global Assessment with outcomes in the intensive care unit: A retrospective cohort study

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Abstract

Aims: This retrospective audit was conducted to investigate the association between outcome and protein-energy malnutrition diagnosed using Subjective Global Assessment (SGA), to evaluate the predictive validity of Subjective Global Assessment in adults admitted to intensive care.

Methods: The audit analysed the medical records of 1034 consecutive adult patients who had nutrition assessment on admission to the intensive care unit between January 2017 and July 2018. Extracted data included patient demographics, nutritional status, outcomes, and Acute Physiology and Chronic Health Evaluation II score. Regression was used to explore the association between Subjective Global Assessment and outcomes.

Results: The prevalence of protein-energy malnutrition was 39.5% (342 patients SGA-B, and 75 patients SGA-C), and there was a significant independent association between Subjective Global Assessment and outcomes both in surgical and non-surgical patients. Compared with well-nourished patients, mortality was significantly higher in the malnourished, during the intensive care admission ($p = 0.007$), in hospital ($p < 0.0001$), at 90 days ($p = 0.001$) and at 180 days ($p = 0.002$). Pressure injuries were more common ($p = 0.01$). Length of stay was longer in intensive care ($p = 0.001$) and in hospital ($p < 0.001$), with increased readmission rate ($p < 0.001$).

Conclusion: Protein-energy malnutrition diagnosed by Subjective Global Assessment had a significant independent association with adverse clinical outcomes in critically ill patients. Subjective Global Assessment appears to have predictive validity in this patient population.

KEYWORDS

critical illness, length of stay, malnutrition, mortality, nutrition assessment

1 | INTRODUCTION

Malnutrition is known to increase the risk of adverse patient outcomes including mortality, morbidity and length of stay in the acute hospital setting.[1,2] Malnutrition is common in hospital patients in Australia[1,3,4] and worldwide.[2] Amongst hospitalised patients, undernutrition (or inadequate nutrient consumption) is combined with disease-related metabolic alterations that promote catabolism, attributable to acute or chronic inflammation.[1,5] The effect on outcomes is due to decline in functional capacity as a result of muscle and fat losses,[6] reduced respiratory and cardiac function, impaired immune function,[7] and a diminished capacity for intestinal absorption.[8] Protein-energy malnutrition may also contribute to fatigue and apathy in patients, ultimately diminishing quality of life. These effects would be expected to apply to all hospital patients including the critically ill who are at even higher risk of lean tissue losses due to the nature of acute illness.[9]

Identifying malnutrition requires a nutritional assessment, and there are several established standardised tools for this purpose. One widely-used example is Subjective Global Assessment (SGA), which classifies nutritional status based on a physical examination and a targeted patient history to gather information about recent change in weight, intake and function, and the presence of nutrition-impact symptoms.[10] Originally developed to assess nutritional status and predict clinical outcomes in surgical patients, the SGA is regarded by many clinicians as the gold standard method for diagnosing protein-energy malnutrition due to its simplicity and reproducibility; it has been validated against alternative measures of nutritional status[11] and as a predictor of outcomes in a variety of clinical areas such as in rehabilitation and geriatrics,[12,13] renal,[14] liver transplant,[15] and oncology patients.[16] It does have some limitations: the subjective nature of the assessment can result in variable inter-rater reliability[17] and, having only three categories, the lack of sensitivity to short-term changes means SGA is not suitable for day-to-day monitoring.[18] Within its intended use as an assessment tool, it incorporates risk factors for altered tissue metabolism and muscle function as well as reduced muscle mass, making it a more holistic and patient-focused measure of nutritional status than 'objective' measures of body composition can be. In the ICU, however, it is still common to find statements in the literature about its lack of validity[19,20] or clinicians raising concerns about its feasibility in the ICU setting when history cannot be obtained from unconscious patients[21] despite the fact that obtaining corroborating history from the patient's family was actually suggested by the SGA's original authors as part of its valid methodology.[22] Despite these expressed doubts, SGA is the most common assessment method used by ICU dietitians in Australia and New Zealand.[23] Its subjective, inferential approach may in fact be helpful in the ICU setting[24] given that objective measurements including anthropometric and biochemical markers may not be reliable as they can be affected by several clinical factors, such as fluid retention and acute phase response which are common during critical illness.[25] In terms of validity, a number of previous studies suggest that SGA has predictive validity with associations between SGA and various ICU outcomes, but many of these studies were small[26–28] or confounded by a failure to adjust for other important outcome influences such as severity of illness[29–31] and this may be why questions remain about the use of SGA in ICU.

The aim of the current study was to examine the predictive validity of SGA in adults admitted to ICU, using a retrospective medical record audit to evaluate the association between SGA and outcomes including mortality, length of stay, time on ventilator, hospital readmission, use of antibiotics, and incidence of pressure injury or positive blood culture, including a large number of patients, and adjusting for relevant confounders such as severity of illness.

2 | METHODS

The study was conducted in the mixed medical/surgical ICU of a large metropolitan tertiary-referral teaching hospital. The retrospective audit included 1034 consecutive adult patients who had been assessed by a dietitian using SGA on admission to the ICU between January 2017 and July 2018. The electronic medical records of these patients were obtained to extract data on patient demographics, nutritional status, outcomes, and Acute Physiology and Chronic Health Evaluation II (APACHE II)[32] score which was used as the measure of severity of illness. Where a patient was readmitted to the ICU within a single hospital admission, only the first ICU admission with a documented SGA was included. The patient's APACHE II score was calculated from the first 24 h of that same ICU admission. The study was approved by the hospital's ethical review committee (approval X19-0059 & 2019/ETH00428, 21 May 2019) and reporting followed the STROBE-nut guidelines.[33]

Consecutive patients were included if there was an SGA score documented by the intensive care dietitian within the first 72 h of ICU admission. Patients were excluded if they were aged <18 years or were readmitted to ICU within the same hospital admission where the previous ICU admission had been included in the audit, see Figure 1 for study flowsheet.

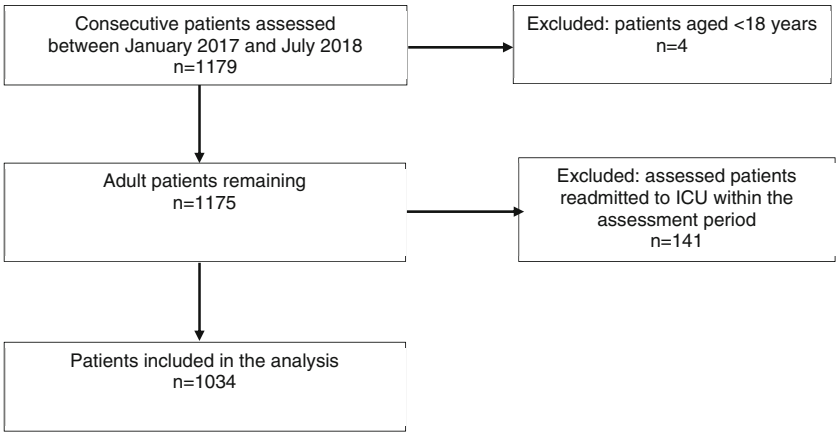

FIGURE 1 Study flowsheet for Intensive Care Unit patients included in the audit

Nutritional status was assessed using SGA upon patient admission to the ICU. The procedure in this ICU is for nursing staff to screen every patient on admission to ICU and then regularly thereafter, using the Malnutrition Screening Tool,[34] and an automatic dietitian referral is made if the tool indicates malnutrition risk (a score of 2 or more). The dietitian is also referred if the patient requires nutrition support or if there are any other nutritional concerns, and SGA is a mandatory part of the initial assessment for all patients referred to the dietitian. For all patients included in the study, the SGA was performed by one of two experienced intensive care dietitians. To complete the assessment, alongside a physical examination, information about previous weight loss, changes in dietary intake, nutrition impact symptoms and functional capacity were collected from the patient where possible, or from a family member and/or patient medical records. The subjective summation of all the information resulted in a score of acceptably nourished (SGA-A), mild to moderately malnourished (SGA-B) or severely malnourished (SGA-C). To reduce variation, agreement on SGA classification was regularly calibrated between the two dietitians at quarterly clinical practice consensus reviews.

To reduce bias, outcomes were extracted from each patient's electronic medical record by researchers who were blinded to the patient's SGA classification. Random patients throughout the dataset had their data checked by a second independent researcher. Length of stay in ICU and in hospital were automatically calculated as 24-hour days within the medical record. To remove the competing risk of mortality which can contribute to survivor bias, patients who died in ICU were excluded from the ICU length-of-stay analysis, and similarly patients who died in hospital were excluded from the hospital length-of-stay. Patient mortality status at 90 and 180 days after ICU admission was also determined from patient medical records. Patients without a deceased status shown in the electronic medical record were assumed to be alive. Length of time on mechanical ventilation, recorded in days, was included in the analysis, but additionally to remove the competing risk of mortality, analyses were performed in survivors only, as well as using the length of time on mechanical ventilation converted to the number of days alive free of ventilation within the first 28 days after ICU admission. Competing-risks regression was also conducted to explore the association between SGA and time on mechanical ventilator. Patients were counted as receiving antibiotics if they received at least one dose of any antimicrobial medication, excluding those administered solely as part of a surgical prophylaxis protocol. Patients were counted as intolerant to enteral nutrition if feeds were significantly interrupted due to gastrointestinal signs or symptoms including abdominal distension or discomfort, vomiting or increased gastric aspirates, resulting in a delay of more than 24 h to commence enteral nutrition or more than 3 days to reach goal feed rate after ICU admission.

For the reporting and simple analyses, patients were divided into three groups according to the SGA score. Study size was determined by the available resources for data collection. Categorical variables were presented as frequency (%). Continuous variables were presented as mean ± standard deviation for normally distributed data, otherwise median (inter-quartile range) was used. Competing-risks regression analysis was performed using SAS Studio 3.8 (SAS Institute Inc, Cary, NC). All other statistical analyses were performed using SPSS Statistics 26.0 (IBM Corp, Armonk, NY). There were no missing data.

Predictive validity of SGA was assessed by exploring the associations between malnutrition classified by SGA, and clinical outcomes, using standard multiple linear and logistic regression analyses to adjust for age, sex, and severity of illness as measured by the APACHE II score. The outcomes investigated were mortality, length of stay, readmission, ventilator days, incidence of positive blood

TABLE 1 Demographic characteristics of patients at time of Intensive Care Unit admission

Demographic characteristic	
Age, years, mean (SD)	59.26 (16.05)
Sex, *n* (%)	
Male	630 (60.9)
Female	404 (39.1)
APACHE II score, mean (SD)	19.93 (7.05)
SGA score, *n* (%)	
A	636 (61.5)
B	327 (31.6)
C	71 (6.9)
Main reason for ICU admission, n (%)	
Surgical	614 (59.4)
Gastrointestinal/abdominal surgical	286 (27.7)
Cardiothoracic surgical	98 (9.5)
Neurological surgical	97 (9.4)
Liver surgical	86 (8.3)
Trauma/orthopaedic surgical	27 (2.6)
Other surgical	20 (1.9)
Medical	420 (40.6)
Respiratory	82 (7.9)
Cardiac medical	77 (7.4)
Neurological medical	75 (7.3)
Gastrointestinal/abdominal medical	56 (5.4)
Sepsis	45 (4.4)
Haematology	26 (2.5)
Liver medical	25 (2.4)
Renal medical	14 (1.4)
Other medical	20 (1.9)
ICU length of stay, days, median (IQR)	7.00 (7.00)
Hospital length of stay, days, median (IQR)	23.00 (24.00)
Days receiving mechanical ventilation, median (IQR)	3.00 (6.00)
Non-ventilated days alive in first 28 days, days, median (IQR)	25.00 (11.00)
Died in ICU, *n* (%)	159 (15.4%)
Died in hospital, *n* (%)	219 (21.2%)

Abbreviations: APACHE, acute physiology and chronic health evaluation score; ICU, intensive care unit; IQR, inter-quartile range; SD, standard deviation; SGA, subjective global assessment (SGA-A acceptably-nourished, SGA-B mild-to-moderately malnourished, SGA-C severely malnourished).

culture, use of antibiotics, incidence of pressure injury, primary route of nutrition support, and intolerance to enteral nutrition. For the regression analyses, preliminary analysis was conducted to ensure no violation of the assumptions of normality, linearity, multi-collinearity and homoscedasticity. The normality of continuous variables was evaluated using the Kolmogorov–Smirnov test. SGA category was dichotomised as acceptably-nourished (SGA-A) versus malnourished (SGA-B + SGA-C). The potential covariates with significant bivariate correlation with the dependent variable were included in the model if collinearity was not identified. Collinearity was assessed using Spearman's rank correlation coefficient and defined as rho ≥0.7. A separate logistic regression was conducted for each of the outcomes of interest (dependent variables) that were dichotomous: mortality

TABLE 2 Patient demographics and outcomes according to Subjective Global Assessment classification

Demographic characteristic	SGA Score		
	A	B	C
Age, years, mean (SD)	58.49 (16.71)	60.75 (14.64)	59.28 (15.94)
Sex, male, *n* (%)	403/636 (63.4%)	190/327 (58.1%)	37/71 (52.1%)
APACHE II score, mean (SD)	19.57 (7.27)	20.48 (6.76)	20.56 (6.21)
Outcome			
Died in ICU, *n* (%)	97/636 (15.3%)	42/327 (12.8%)	20/71 (28.2%)
Died in hospital, *n* (%)	127/636 (20.0%)	65/327 (19.9%)	27/71 (38.0%)
90-day mortality, *n* (%)	137/636 (21.5%)	66/327 (20.2%)	27/71 (38.0%)
180-day mortality, *n* (%)	142/636 (22.3%)	76/327 (23.2%)	28/71 (39.4%)
Readmitted within 90 days, *n* (%)	111/636 (17.5%)	90/327 (27.5%)	15/71 (21.1%)
Readmitted within 180 days, *n* (%)	165/636 (25.9%)	123/327 (37.6%)	22/71 (31.0%)
ICU length of stay, days, median (IQR)	7.00 (8.00)	6.00 (6.00)	7.00 (6.00)
Hospital length of stay, days, median (IQR)	21.00 (21.00)	26.00 (30.00)	34.00 (30.00)
Days receiving mechanical ventilation, median (IQR)	3.00 (7.00)	2.00 (5.00)	1.50 (4.00)
Non-ventilated days alive in first 28 days, days, median (IQR)	24.00 (12.00)	26.00 (7.00)	26.00 (15.00)
Positive blood culture, *n* (%)	124/636 (19.5%)	65/327 (19.9%)	14/71 (19.7%)
Use of antibiotics in ICU, *n* (%)	351/636 (55.2%)	166/327 (50.8%)	39/71 (54.9%)
Received EN as main source of nutrition, *n* (%)	429/636 (67.5%)	188/327 (57.5%)	34/71 (47.9%)
Pressure injury, *n* (%)	79/636 (12.4%)	42/327 (12.8%)	17/71 (23.9%)
Intolerance to enteral nutrition[a]	57/429 (13.3%)	19/188 (10.1%)	4/34 (11.8%)

Abbreviations: APACHE, acute physiology and chronic health evaluation score; EN, enteral nutrition; ICU, intensive care unit; IQR, inter-quartile range; SD, standard deviation; SGA, subjective global assessment (SGA-A acceptably-nourished, SGA-B mild-to-moderately malnourished, SGA-C severely malnourished).
[a]Intolerance to enteral nutrition defined as any gastrointestinal signs or symptoms (abdominal distension or discomfort, increased gastric aspirates, vomiting) significantly delaying/interrupting EN delivery.

at different timepoints (coded as yes or no), antibiotics (yes or no), positive blood culture (yes or no), pressure injury (yes or no), main route of nutrition (enteral nutrition or parenteral nutrition), and intolerance to enteral nutrition (yes or no). A standard multiple regression was conducted for each of the outcomes that were continuous variables: length of stay (days) and time on mechanical ventilation (days). The covariates included in all analyses were: age (years), sex (coded as male or female), APACHE II (points). Overfitting of the model was avoided with no more than three independent covariates included. Goodness of fit was examined using the Hosmer-Lemeshow goodness of fit test and poor fit was defined as $p < 0.05$.

Nine outliers were removed from the regression analysis after being identified by very large Mahalanobis Distance. Across the three independent SGA groups, continuous variables were compared using Welch's Analysis of Variance or Kruskal-Wallis test, and Chi-square test was used for categorical variables. A p value <0.05 was considered statistically significant.

3 | RESULTS

A total of 1034 patient medical records were reviewed in this audit. Patient demographics are shown in Table 1. More patients were male (60.9%) and admitted as surgical ICU patients (59.4%). Men were older with a mean age of 60.63 years (SD 15.04), compared to women whose mean age was 57.12 years (SD 17.30), $p = 0.0006$. At ICU admission, 327 (38.5%) patients were classified as malnourished. Notably, more women than men were malnourished, $p = 0.039$. ICU nutrition protocols were followed, with nutrition support commenced within 24 h of ICU admission in 76% of patients, overall average 16.2 h after arriving in ICU, reaching 100% goal rate average 2.4 days after arriving in ICU.

Table 2 shows the patient demographics and clinical outcomes stratified by SGA score. APACHE II score, age and sex all had a significant independent association with most of these outcomes. After adjusting for these parameters, there was a significant independent influence of nutritional status as diagnosed using SGA, on a variety of

TABLE 3 Association between Subjective Global Assessment classification and Intensive Care Unit outcomes: regression results (adjusted for severity of illness[a])

	Logistic regression analysis (comparing to SGA-A)		
Variables		**Adjusted odds ratio (95% CI)**	***p***
ICU mortality	SGA-B	0.78 (0.52, 1.16)	0.22
	SGA-C	2.20 (1.23, 3.91)	0.007
Hospital mortality	SGA-B	0.94 (0.66, 1.33)	0.71
	SGA-C	2.59 (1.52, 4.41)	<0.001
90-day mortality	SGA-B	0.86 (0.61, 1.21)	0.39
	SGA-C	2.29 (1.35, 3.89)	0.002
180-day mortality	SGA-B	0.98 (0.70, 1.37)	0.90
	SGA-C	2.27 (1.35, 3.85)	0.002
Readmitted within 90 days (survivors)	SGA-B	1.78 (1.30, 2.43)	<0.001
	SGA-C	1.24 (0.69, 2.23)	0.47
Readmitted within 180 days (survivors)	SGA-B	1.74 (1.31, 2.30)	<0.001
	SGA-C	1.29 (0.77, 2.16)	0.33
Incidence of positive blood culture	SGA-B	1.05 (0.75, 1.45)	0.79
	SGA-C	1.06 (0.59, 1.91)	0.84
Use of antibiotics in ICU	SGA-B	0.84 (0.64, 1.10)	0.21
	SGA-C	1.02 (0.62, 1.67)	0.95
Incidence of pressure injury	SGA-B	1.09 (0.74, 1.60)	0.67
	SGA-C	2.12 (1.19, 3.79)	0.01
Intolerance to enteral nutrition[b]	SGA-B	0.70 (0.41, 1.22)	0.21
	SGA-C	0.82 (0.23, 2.43)	0.72

	Multivariate linear regression analysis				
Variables	**R^2**		**β**	**B (95% CI)**	***p***
ICU length of stay (survivors)	0.024	SGA	−0.10	−1.86 (−3.00, −0.73)	0.001
		APACHE II	0.12	0.21 (0.11, 0.31)	<0.001
Hospital length of stay (survivors)	0.020	SGA	0.13	9.79 (5.14, 14.44)	<0.001
		APACHE II	0.06	0.42 (0.00, 0.83)	0.049
Days receiving mechanical ventilation (survivors)	0.070	SGA	−0.19	−1.9 (−2.61, −1.13)	<0.001
		APACHE II	0.21	0.19 (0.12, 0.25)	<0.001
Non-ventilated days alive in first 28 days	0.12	SGA	0.09	1.39 (0.53, 2.26)	0.002
		APACHE II	−0.34	−0.46 (−0.54, −0.38)	<0.001

Abbreviations: APACHE, acute physiology and chronic health evaluation score; ICU, intensive care unit; IQR, inter-quartile range; SD, standard deviation; SGA, subjective global assessment (SGA-A acceptably-nourished, SGA-B mild-to-moderately malnourished, SGA-C severely malnourished).

[a]Severity of illness was determined by the APACHE II score.

[b]Intolerance to enteral nutrition defined as any gastrointestinal signs or symptoms (abdominal distension or discomfort, increased gastric aspirates, vomiting) significantly delaying/interrupting feed delivery.

clinical outcomes in these ICU patients, see Table 3. The results were very similar when analysed separately in surgical patients or non-surgical patients. Overall, severely malnourished patients were significantly more likely to die in ICU (SGA-C vs. SGA-A, $p = 0.007$) or in hospital (SGA-C vs. SGA-A, $p < 0.001$) and had significantly higher 90-day mortality (SGA-C vs. SGA-A, $p = 0.002$) and 180-day mortality (SGA-C vs. SGA-A, $p = 0.002$). Of those patients who survived to ICU discharge, ICU length of stay was significantly longer for the malnourished ($F[21064] = 12.86$, $p < 0.001$), with an R^2 of 0.024, that is, 1.86 days were added to ICU admission for each increase in SGA severity of malnutrition category. Both SGA and APACHE II score were significant independent predictors of ICU length of stay in ICU survivors. Of those patients who survived to hospital discharge, length of stay in hospital was significantly longer for the malnourished ($F[21064] = 11.01$, $p < 0.001$), with an R^2 of 0.02 with a median length of stay 27 days in the malnourished patients (SGA-B/C) compared with 21 days in the SGA-A group. Both SGA and APACHE II score were significant independent predictors of hospital length of stay in

hospital survivors. Malnourished patients were more likely to be readmitted to hospital within 90 days ($p < 0.0001$) or 180 days ($p < 0.0001$) and were more likely to have a documented pressure injury during the admission ($p = 0.004$).

The number of days requiring ventilation was notably lower for malnourished patients, median 2.0 days for SGA-B and 1.5 days for SGA-C, compared with 3.0 days for SGA-A. This was significant ($F[2663] = 26.02$, $p < 0.001$), with an R^2 of 0.07. Both SGA and APACHE II score were significant independent predictors of ventilation days. This difference remained significant ($p < 0.0001$) when competing-risks regression was used to adjust for significant covariates; age, APACHE II score and the competing risk of mortality. Higher APACHE II score was significantly associated with more days of mechanical ventilation, but increasing age was associated with fewer ventilation days.

A slightly higher proportion of severely-malnourished patients (SGA-C) received antibiotics in ICU and/or had a documented positive blood culture, but these differences were not significant. APACHE II score, age and sex were all independent significant predictors of these outcomes. Intolerance to enteral feeds was highly associated with age ($p = 0.01$) and with APACHE II score ($p = 0.024$).

4 | DISCUSSION

In this audit, over one-third of the patients were assessed as malnourished using SGA, a prevalence of protein-energy malnutrition of 38.5% in this mixed population of ICU patients with a mean APACHE II score of 20. Comparable results have recently been reported with SGA in a surgical ICU in Singapore where 40% were malnourished (Chua et al.)[35]; in a Canadian medical ICU where 35% of patients were malnourished and the mean APACHE II score was 21 (Bector et al.),[29] and in a mixed ICU in Turkey where 37% of patients were malnourished and mean APACHE II score was 25 (Sungertekin et al.).[36] Higher malnutrition rates have been reported recently in a range of ICUs, with 55% of patients malnourished in a medical ICU in India (Verghese et al.)[37] and comparable rates reported at two city hospitals in Brazil, by Fontes et al. (54% malnourished)[38] and by Gatterman Pereira et al. (60.5% malnourished).[39] Notably, in both of these latter studies, the majority of patients had elective surgery, were not ventilated >24 h, and APACHE II scores averaged significantly lower, median 15 and mean 11 respectively, illustrating the important consideration that ICU populations vary widely.

In the present study, after adjusting for age, sex and severity of illness (APACHE II score), there was a significant independent association between SGA and outcome including mortality at a number of different timepoints, length of stay in ICU and in hospital, hospital readmission rate, and incidence of pressure injuries. The findings of this study largely accord with those from previous smaller studies investigating the association between outcomes and protein-energy malnutrition according to SGA in an ICU setting. Interestingly, there was no clear dose–response relationship for most of the outcomes (increase in risk between SGA-A and SGA-B and SGA-C), possibly because of the small number of patients classified as SGA-C. Unexpectedly, despite having poorer outcomes otherwise, malnourished patients had fewer days of mechanical ventilation, as did older patients. 'Days of mechanical ventilation' as an outcome variable is difficult to analyse due to a number of competing risks.[41] For example, a shorter length of time requiring mechanical ventilation is a positive outcome if the time was shortened by faster recovery, better respiratory function and earlier extubation, but not if the time was shortened by the death of the patient (competing risk of mortality). How to manage this competing risk in analysis remains controversial. In this study, whether the analysis used competing-risks regression with the full dataset, or whether only survivors were included in the analysis, or whether a composite measure such as 'alive non-ventilated days up to day 28' was used, malnourished and older patients still had significantly shorter ventilation time. This unexpected result may reflect a tendency towards earlier withdrawal of mechanical ventilation, and the use of a wider variety of non-mechanical ventilation strategies, in patients who were anticipated to have a poor outcome due to older age or poor nutritional status.

The SGA was originally validated in surgical patients. After establishing its reliability and construct validity,[10] its criterion (predictive) validity was established using the incidence of infections, use of antibiotics, and length of hospital stay, in surgical patients.[11] Validation in other patient groups has mostly focused on the association of SGA with other measures[16,40] or against outcomes.[12,13,15,16] This audit confirms the ability of the SGA to predict a wider variety of outcomes in critically ill patients, including mortality, ICU length of stay, hospital readmission, and pressure injuries.

Several strengths and limitations are acknowledged for this retrospective audit. The major strengths of this study relate to its large sample size, heterogeneous study population, and consecutive sampling. To the authors' knowledge, this current study has analysed the largest patient dataset published to date. Importantly, these analyses adjusted for confounders and competing risk of mortality.

Age, sex and APACHE II score were found to have significant association with the outcomes, making it important to adjust for these influences. Selection bias arising from the competing risk of mortality is a perennial issue for analyses conducted in critically ill patients and the optimal strategy to address this remains controversial.[41] Also controversial is the use of APACHE II score as a severity of illness measure. The purpose of APACHE II is to predict mortality.[32] Although APACHE II score did have significant association with most of the outcomes considered in this study, not just mortality, it is a 'soft' measure, a composite of a large number of mortality risk predictors, and thus can be only a surrogate measure of illness severity. It therefore may not fully account for the confounding influence of other aspects of the patient's condition at ICU admission, other than when specifically analysing the relationship between SGA and mortality. For that analysis, it has been suggested that a more appropriate method would be to use the calculated hospital mortality risk (which uses the APACHE II score, weighted for the patient's ICU admission indication).[42] This would certainly be more accurate when analysing hospital mortality as an outcome (although it might not have the same direct application to analyses for the other outcomes), but it should be noted that the sigmoid relationship between APACHE II score and calculated hospital mortality risk is quite linear except at the extremes of risk, so for the majority of patients it would make little difference to the analysis.

Other limitations of the study include, firstly, the retrospective nature of the audit and its reliance on the quality and accuracy of medical records documentation available. Due to the resource limitations of the study, it is likely that the mortality and readmission rates were underestimated as only those identified in the patient's electronic medical record were included. This would omit patients who were lost to follow-up, or who received services or died outside the local health system where this was not recorded locally. Secondly, although the number of patient records was large, this audit was conducted only in a single centre, and not all patients in the ICU received a nutritional assessment on admission, reducing the generalisability of the results. The patients identified for nutritional assessment were either referred due to nutritional concerns or were starting nutrition support, and may represent a more nutritionally vulnerable subset of the ICU population with an over-representation of malnourished patients; also there were many more surgical than medical patients, with a younger average age, and thus the associations found may not be representative of the broader patient population in intensive care. To address this, the validity of SGA in the ICU would ideally be established by way of a meta-analysis of the existing diverse studies on this question. However, the conclusion of the current study is that protein-energy malnutrition diagnosed by SGA is significantly associated with adverse clinical outcomes and this supports the predictive validity of SGA as a method of nutrition assessment in the critically ill.

AUTHOR CONTRIBUTIONS

S.F. conceived the research, provided study oversight, and has primary responsibility for the final content. S.F. and N.B.W. drafted the manuscript. S.F., N.B.W., H.Y.C., S.T., and M.E.S. all contributed to the design of the research. All authors contributed to the collection, analysis and interpretation of the data, critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final version of the manuscript.

CONFLICT OF INTEREST

S. Ferrie is an Associate Editor of *Nutrition & Dietetics*. She was excluded from the peer review process and all decision-making regarding this article. This manuscript has been managed throughout the review process by the Journal's Editor-in-Chief. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made. All other authors of this study have no conflicts to report.

DATA AVAILABILITY STATEMENT

Data available on request, subject to ethics approval.

ETHICS STATEMENT

X19-0059 & 2019/ETH00428 Indicators of Nutrition in Critical Illness and Severity of Illness scoring (the INCISI study) approved by the Royal Prince Alfred Hospital Ethics Review Committee.

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REFERENCES

1. Barker LA, Gout BS, Crowe TC. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. *Int J Environ Res Public Health*. 2011;8(2):514-527.
2. Correia MIT, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. *Clin Nutr*. 2003;22(3):235-239.
3. Lazarus C, Hamlyn J. Prevalence and documentation of malnutrition in hospitals: a case study in a large private hospital setting. *Nutr Diet*. 2005;62(1):41-47.

4. Middleton MH, Nazarenko G, Nivison-Smith I, Smerdely P. Prevalence of malnutrition and 12-month incidence of mortality in two Sydney teaching hospitals. *Intern Med J*. 2001;31(8):455-461.
5. Jensen GL, Mirtallo J, Compher C, et al. Adult starvation and disease-related malnutrition: a proposal for etiology-based diagnosis in the clinical practice setting from the international consensus guideline committee. *J Parenter Enteral Nutr*. 2010;34(2):156-159.
6. Norman K, Pichard C, Lochs H, Pirlich M. Prognostic impact of disease-related malnutrition. *Clin Nutr*. 2008;27(1):5-15.
7. Chandra RK. Nutrition and the immune system: an introduction. *Am J Clinic Nutr*. 1997;66(2):460S-463S.
8. Kubrak C, Jensen L. Malnutrition in acute care patients: a narrative review. *Int J Nurs Stud*. 2007;44(6):1036-1054.
9. Plank L, Hill G. Similarity of changes in body composition in intensive care patients following severe sepsis or major blunt injury. *Ann N Y Acad Sci*. 2000;904(1):592-602.
10. Detsky AS, Baker J, Johnston N, Whittaker S, Mendelson R, Jeejeebhoy K. What is subjective global assessment of nutritional status? *J Parenter Enteral Nutr*. 1987;11(1):8-13.
11. Baker JP, Detsky AS, Wesson DE, et al. Nutritional assessment: a comparison of clinical judgment and objective measurements. *New Eng J Med*. 1982;306(16):969-972.
12. Duerksen DR, Yeo TA, Siemens JL, O'Connor MP. The validity and reproducibility of clinical assessment of nutritional status in the elderly. *Nutrition*. 2000;16(9):740-744.
13. Sacks GS, Dearman K, Replogle WH, Cora VL, Meeks M, Canada T. Use of subjective global assessment to identify nutrition-associated complications and death in geriatric long-term care facility residents. *J Am Coll Nutr*. 2000;19(5):570-577.
14. K/DOQI. National Kidney Foundation: clinical practice guidelines for nutrition in chronic renal failure. *Am J Kidney Dis*. 2000;35(2):S1-S140.
15. Stephenson GR, Moretti EW, El Moalem H. Malnutrition in liver transplant patients: preoperative subjective global assessment is predictive of outcome after liver transplantation. *Transplantation*. 2001;72:666-670.
16. Gupta D, Lammersfeld CA, Vashi PG, Burrows J, Lis CG, Grutsch JF. Prognostic significance of subjective global assessment (SGA) in advanced colorectal cancer. *Eur J Clin Nutr*. 2005;59(1):35-40.
17. Steenson J, Vivanti AP, Isenring E. Inter-rater reliability of the subjective global assessment: a systematic literature review. *Nutrition*. 2012;29(1):350-352.
18. Churchill DN, Taylor DW, Keshaviah PR. Adequacy of dialysis and nutrition in continuous peritoneal dialysis: association with clinical outcomes. *J Am Soc Nephrol*. 1996;7:198-207.
19. Kaddoura R, Shanks A, Chapman M, O'Connor S, Lange K, Yandell R. Relationship between nutritional status on admission to the intensive care unit and clinical outcomes. *Nutr Diet*. 2021;78(2):128-134.
20. Singer P, Reintam Blaser A, Berger MM, et al. ESPEN guideline on clinical nutrition in the intensive care unit. *Clin Nutr*. 2019;38:48-79.
21. Lambell K, King S, Ridley E. Identification of malnutrition in critically ill patients via the subjective global assessment tool: more consideration needed? [correspondence]. *J Intensive Care Med*. 2017;32(1):95.
22. Detsky AS, Smalley PS, Chang J. The rational clinical examination. Is this patient malnourished? *JAMA*. 1994;271(1):54-58.
23. Ferrie S, Allman-Farinelli M. Defining and evaluating the role of dietitians in intensive care: state of play. *E-SPEN J*. 2011;6(3):e121-e125.
24. Bector S, Vagianos K, Suh M, Duerksen DR. Authors' response [correspondence]. *J Intensive Care Med*. 2017;32(1):96.
25. Duncan A, Talwar D, McMillan DC, Stefanowicz F, O'Reilly DS. Quantitative data on the magnitude of the systemic inflammatory response and its effect on micronutrient status based on plasma measurements. *Am J Clin Nutr*. 2012;95:64-71.
26. Dias Rodrigues V, Barroso de Pinho N, Abdelhay E, Viola JPB, Correia MI, Martucci RB. Nutrition and immune-modulatory intervention in surgical patients with gastric cancer. *Nutr Clin Pract*. 2017;32(1):122-129.
27. Reeves A, White H, Sosnowski K, Tranh K, Jones M, Palmer M. Energy and protein intakes of hospitalised patients with acute respiratory failure receiving non-invasive ventilation. *Clin Nutr*. 2014;33(6):1068-1073.
28. Sheean PM, Peterson SJ, Zhao W, Gurka DP, Braunschweig CA. Intensive medical nutrition therapy: methods to improve nutrition provision in the critical care setting. *J Acad Nutr Diet*. 2012;112(7):1073-1079.
29. Bector S, Vagianos K, Suh M, Duerksen DR. Does the subjective global assessment predict outcome in critically ill medical patients? *J Intensive Care Med*. 2016;31(7):485-489.
30. Gonzalez MC, Bielemann RM, Kruschardt PP, Orlandi SP. Complementarity of NUTRIC score and subjective global assessment for predicting 28-day mortality in critically ill patients. *Clin Nutr*. 2019;38(6):2846-2850.
31. Rodrigues CN, Henrique JB, Ferreira ARS, Correia MITD. Ultrasonography and other nutrition assessment methods to monitor the nutrition status of critically ill patients. *J Parent Enteral Nutr*. 2021;45(5):982-990.
32. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of diseases classification system. *Crit Care Med*. 1985;13:818-829.
33. Lachat C, Hawwash D, Ocké MC, et al. Strengthening the reporting of observational studies in epidemiology-nutritional epidemiology (STROBE-nut): an extension of the STROBE statement. *Nutr Bull*. 2016;41(3):240-251.
34. Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutrition*. 1999;15(6):458-464.
35. Chua MSH, Chan DKH. Increased morbidity and mortality of emergency laparotomy in elderly patients. *World J Surg*. 2020;44(3):711-720.
36. Sungurtekin H, Sungurtekin U, Oner O, Okke D. Nutrition assessment in critically ill patients. *Nutr Clin Pract*. 2008;23(6):635-641.
37. Verghese PP, Mathai AS, Abraham V, Kaur P. Assessment of malnutrition and enteral feeding practices in the critically ill: a single-Centre observational study. *Indian J Anaesth*. 2018;62(1):29-35.
38. Fontes D, de Vasconcelos GS, Correia MITD. Subjective global assessment: a reliable nutritional assessment tool to predict outcomes in critically ill patients. *Clin Nutr*. 2014;33(2):291-295.

39. Gattermann Pereira T, da Silva FJ, Tosatti JAG, Silva FM. Subjective global assessment can be performed in critically ill surgical patients as a predictor of poor clinical outcomes. *Nutr Clin Pract*. 2019;34(1):131-136.
40. Hirsch S, de Obaldia N, Petermann M, et al. Subjective global assessment of nutritional status: further validation. *Nutrition*. 1991;7(1):35-37.
41. Yehya N, Harhay MO, Curley MA, Schoenfeld DA, Reeder RW. Reappraisal of ventilator-free days in critical care research. *Am J Respir Crit Care Med*. 2019;200(7):828-836.
42. Lew CCH, Wong GJY, Cheung KP, Chua AP, Chong MFF, Miller M. Association between malnutrition and 28-day mortality and intensive care length-of-stay in the critically ill: a prospective cohort study. *Nutrients*. 2018;10:10. doi:10.3390/nu10010010

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ORIGINAL RESEARCH

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An investigation of early enteral nutrition provision in major burn patients in Australia and New Zealand

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Abstract

Aims: Early enteral nutrition (provided within 24 h of admission) is the optimal form of nutritional support for major burn injuries. The aim of this study was to (i) audit early enteral nutrition practices, (ii) identify characteristics of patients who received early enteral nutrition, and (iii) investigate whether early enteral nutrition was associated with in-hospital outcomes.

Methods: An analysis of prospectively collected data from the Burns Registry of Australia and New Zealand was conducted. Specifically, this study focused on major burns patients (defined as burns affecting more than 20% and 15% total body surface area for adult paediatric patients, respectively) admitted to a specialist burn service between 1 July 2016 and 30 June 2019.

Results: Data from 474 major burns patients (88 paediatric patients) revealed 69% received early enteral nutrition. Paediatric patients who received early enteral nutrition were younger than their counterparts who did not receive the same support ($p = 0.04$). Adult patients who received early enteral nutrition sustained larger burns ($p < 0.001$). Early enteral nutrition was not associated with in-hospital mortality following major burn injury in adult patients in either unadjusted ($p = 0.77$) or confounder-adjusted ($p = 0.69$) analyses.

Conclusions: Approximately two-thirds of patients with major burn injuries received early enteral nutrition. Early enteral nutrition was not associated with in-hospital mortality following major burn injury. Further research should focus on modifiable reasons why major burns patients do not receive enteral nutrition within 24 h of admission.

KEYWORDS
burns, enteral nutrition, parenteral nutrition

1 | INTRODUCTION

Nutritional support following major burns (defined as burns affecting more than 20% total body surface area for adult and 15% total body surface area for paediatric patients) is a recognised intervention to support the hypermetabolic response initiated as a result of the inflammatory and endocrine stress responses post-injury.[1] The initiation of early enteral nutrition (commencing within 24 h of admission) is considered the optimal form of nutritional support for major burn injuries[1–3] requiring resuscitation. Early enteral nutrition significantly decreases mortality, length of stay, and in-hospital complications such as gastrointestinal haemorrhage, sepsis, and pneumonia.[4] The provision of nutritional support following burn injuries is affected by age, gender, baseline anthropometric measurements and nutritional status, and the size and severity of injury.[1,5] Whilst the importance of enteral nutrition following burn injury is internationally acknowledged as a component of optimal treatment,[1,3,5] variations in the provision of nutrition support following burn injury in practice have been reported.[6–8] The effects of this variation on patient outcomes are unknown.

Registry data is one way to investigate variations in nutrition support practices and the impact of variations on patient outcomes. Castanon et al. demonstrated improved outcomes in geriatric burn injuries associated with early enteral nutrition.[9] There is a lack of high quality, multicentre nutrition outcome evidence for adults who have sustained burn injuries,[4] and the use of burn registry data may assist in bridging this gap. The aim of this study was to: (i) audit early enteral nutrition practices in paediatric and adult burn patients; (ii) identify characteristics of patients who received enteral nutrition, and (iii) investigate whether early enteral nutrition was associated with in-hospital outcomes (i.e., mortality, discharge disposition, and length of stay) in major burns patients in Australia and New Zealand, using data from the Burns Registry of Australia and New Zealand (BRANZ). It was hypothesised that early enteral nutrition would improve in-hospital outcomes.

2 | METHODS

Since July 2016, the BRANZ has collected the following data regarding enteral/parenteral feeding[10]:

1. (i) 'Did the patient receive enteral or parenteral nutrition during their admission?'; and
2. (ii) 'For an adult with a burn with equal to or greater than 20% total body surface area or a child with a burn equal to or greater than 15% total body surface area was enteral or parenteral feeding commenced within 24 h of admission to the burns service?'

Although the aforementioned data item covers both enteral and parenteral nutrition, hereon enteral nutrition will be used for simplicity's sake in the remainder of the manuscript. Ethical approval for the registry and related research activities were approved by the Monash University Human Research Ethics Committee (reference CF08/2431-2008001248).

Acute admissions data for patients with major burns between 1 July 2016 and 30 June 2019 were extracted from the BRANZ. Patients were excluded from the study if: (a) they were transferred between two BRANZ hospitals, (b) they received end-of-life care on arrival to the BRANZ hospital as their burn was assessed as non-survivable, (c) the cause of their burn was sunburn and they did not require a wound management procedure in theatre, or (d) their age could not be calculated. Intersex patients or patients of indeterminate gender were excluded due to very low volumes in the sample (<0.1%). Patients with missing or invalid burn size data were also excluded.

Age at injury was calculated using date of birth and date of injury data. Patients were stratified as either paediatric (<15 years) or adult (≥16 years) cases. This represents the age of transition from paediatric to adult healthcare providers in Australia. Patients were stratified as either receiving early enteral nutrition or not receiving early enteral nutrition per their responses to the aforementioned enteral nutrition data items. The latter group included patients who did not receive enteral nutrition at any point during

their admission. The primary causes of burn groups were: flame, contact, scald, and other (covering chemical, electrical, friction, radiant heat, and other non-flame causes).[11] Burn depth variables were recoded to determine whether the patient sustained a full thickness burn.

In-hospital mortality was the primary outcome of interest. Time to death, discharge disposition, and hospital length of stay were evaluated as secondary outcomes.

Categorical variables were summarised by frequencies and percentages, while continuous variables were summarised with means and standard deviations or medians and interquartile ranges. Missing data were excluded from calculations. Differences in demographic characteristics, injury event details, in-hospital management, and in-hospital outcomes between patients who did and did not receive enteral nutrition were assessed using chi-square tests for categorical variables and independent samples *t*-tests or Mann–Whitney *U* tests for continuous variables. A mixed effects logistic regression model (accounting for the random effects of the contributing burn service) was performed to determine if there was an association between receiving early enteral nutrition and in-hospital mortality. An unadjusted model was run initially, followed by an adjusted model that accounted for confounders (variables that were associated with both early enteral nutrition and in-hospital mortality; $p < 0.2$). Patients who died within 24 h of admission were excluded from the mixed effects logistic regression model. Unadjusted and risk-adjusted odds ratios and 95% confidence intervals were reported. The model performance (i.e., discrimination) was assessed using the area under the receiver operating characteristic curve. According to Hosmer and Lemeshow, an area under the curve of less than 0.5 shows no discrimination, an area under the curve between 0.7 and 0.8 represents acceptable discrimination, an area under the curve between 0.8 and 0.9 shows excellent discrimination, and an area under the curve equal to or greater than 0.9 represents outstanding discrimination.[12] Propensity matched analysis (i.e., propensity score matching) was also performed as an additional measure of sensitivity to determine the association between early enteral nutrition and in-hospital mortality using the 'teffects psmatch' command. All statistical analyses were performed using Stata Version 14 (StataCorp). A *p*-value <0.05 was considered significant.

3 | RESULTS

There were 10 080 patients registered by the BRANZ between 1 July 2016 and 30 June 2019 (Figure 1). Four hundred and seventy-four patients (4.7%) had major burns. There were 386 adult major burns patients (5.6% of adult patients) and 88 paediatric major burns patients (3.2% of paediatric patients; Table S1).

Of the 88 paediatric major burns included in the study, all but two had valid data on whether they received early enteral nutrition. Sixty-five patients (73.9%) received early enteral nutrition, 11 patients (12.5%) received enteral nutrition after 24 h from admission, while 10 patients (11.4%) did not receive enteral nutrition at any point during

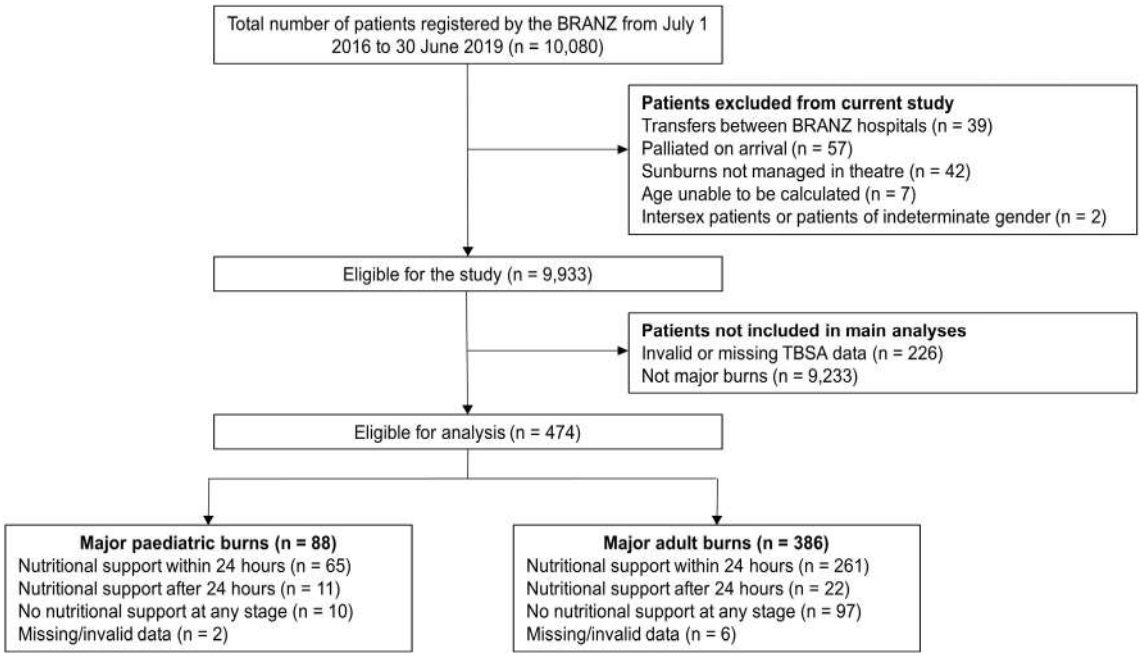

FIGURE 1 Participant flow diagram. BRANZ, Burns Registry of Australia and New Zealand; TBSA, total body surface area

their admission. Paediatric patients who received early enteral nutrition were younger than patients who did not receive early enteral nutrition (median age 3 years vs. 5 years, $p = 0.04$; Table 1). A greater proportion of patients who did not receive early enteral nutrition were admitted on the weekend compared to patients who received early enteral nutrition (67% vs. 38%, $p = 0.02$). There were no differences between paediatric patients who received and did not receive early enteral nutrition with respect to gender ($p = 0.82$), time to admission ($p = 0.36$), injury cause ($p = 0.88$), median burn size ($p = 0.05$), maximal recorded burn depth ($p = 0.55$), and injury intent ($p = 0.09$). The in-hospital management of paediatric major burns patients is summarised in Table S2 (online supplementary material). Table S3 (online supplementary material) displays the in-hospital outcomes for paediatric major burns patients by early enteral nutrition status.

Of the 386 adult major burn patients included, all but six had valid data on whether they received early enteral nutrition. Two hundred and sixty-one patients (67.6%) received early enteral nutrition, 22 patients (5.7%) received enteral nutrition after 24 h from admission, while 97 patients (25.1%) did not receive enteral nutrition at any point during their admission. Patients who received early enteral nutrition had more severe injuries than their counterparts who did not receive the same support, as indicated by a greater median burn size (35% vs. 25%, $p < 0.001$; Table 2), a greater proportion of patients with full thickness burns (69.2% vs. 47.3%, $p < 0.001$), and a greater proportion of patients with an inhalation injury (42.4% vs. 11.3%, $p < 0.001$). A lower proportion of patients with unintentional injuries received early enteral nutrition (74.1% vs. 88.8%, $p = 0.001$). There were no differences between adult patients who

TABLE 1 Demographic and injury event characteristics of paediatric major burns patients by early enteral nutrition status

	Early EN ($N = 65$)	No Early EN ($N = 21$)	*p*-value
Age, median (IQR) years	3.0 (1.0, 7.0)	5.0 (2.0, 13.0)	0.04
Male	39 (60%)	12 (57%)	0.82
Admitted on weekend	25 (38%)	14 (67%)	0.02
Time from injury to admission, median (IQR) hours[a]	4.8 (1.5, 11.0)	3.4 (1.2, 7.3)	0.36
Scald	39 (60%)	13 (62%)	0.88
TBSA, median (IQR) %	25.0 (20.0, 30.0)	20.0 (18.0, 25.0)	0.05
Full thickness burn[b]	20 (33%)	4 (25%)	0.55
Unintentional injury[c]	57 (88%)	21 (100%)	0.09

Note: Data presented as frequency (percentage), unless otherwise specified.
Excludes two patients where nutritional support data was missing or invalid. Data missing for [a]two patients, [b]nine patients and [c]one patient.
Abbreviations: EN, enteral nutrition; IQR, interquartile range; TBSA, total body surface area.

TABLE 2 Demographic and injury event characteristics of adult major burns patients by early enteral nutrition status

	Early EN ($N = 261$)	No Early EN ($N = 119$)	*p*-value
Age, median (IQR) years	39.0 (28.0, 52.0)	37.0 (26.0, 55.0)	0.99
Male	207 (79.3%)	96 (80.7%)	0.76
Admitted on weekend	104 (39.8%)	54 (45.4%)	0.31
Time from injury to admission, median (IQR) hrs	4.6 (2.0, 11.0)	5.3 (2.3, 14.9)	0.14
Flame burn[a]	224 (86.2%)	101 (84.9%)	0.74
TBSA, median (IQR) %	35.0 (26.0, 50.0)	25.0 (22.5, 30.0)	<0.001
Full thickness burn[b]	171 (69.2%)	53 (47.3%)	<0.001
Inhalation injury[c]	108 (42.4%)	13 (11.3%)	<0.001
Unintentional injury[d]	192 (74.1%)	103 (88.8%)	0.001

Note: Data presented as frequency (percentage), unless otherwise specified.
Excludes six patients where nutritional support data was missing or invalid. Data missing for [a]1 patient, [b]21 patients, [c]10 patients and [d]5 patients.
Abbreviations: EN, enteral nutrition; IQR, interquartile range; TBSA, total body surface area.

received and did not receive early enteral nutrition with respect to age ($p = 0.99$), gender ($p = 0.76$), whether the patient was admitted on the weekend ($p = 0.31$), time to admission ($p = 0.14$), and injury cause ($p = 0.74$). The in-hospital management of adult major burns patients is displayed in Table S4 (online supplementary material).

TABLE 3 In-hospital outcomes for adult major burns patients by early EN status

	Early EN ($N = 261$)	No early EN ($N = 119$)	*p*-value
Died	22 (8.4%)	9 (7.6%)	0.77
Time to death, median (IQR) days	6.8 (3.0, 21.2)	0.5 (0.3, 0.9)	<0.001
Died within 24 h of admission?			<0.001
Survived	239 (91.6%)	110 (92.4%)	
Died after 24 h	22 (8.4%)	2 (1.7%)	
Died within 24 h	0 (0.0%)	7 (5.9%)	
Discharge location			<0.001
Home	112 (46.9%)	81 (73.6%)	
Other hospital/healthcare setting	95 (39.7%)	16 (14.5%)	
Other location	32 (13.4%)	13 (11.8%)	
Hospital LOS – surviving patients, median (IQR) days[a]	39.5 (22.5, 71.7)	17.9 (13.0, 26.2)	<0.001
Hospital LOS – all patients, median (IQR) days[a]	38.0 (20.5, 69.8)	16.8 (11.3, 25.4)	<0.001

Note: Data presented as frequency (percentage), unless otherwise specified.
Excludes two patients where nutritional support data was missing or invalid. Data missing for [a]one patient.
Abbreviations: EN, enteral nutrition; IQR, interquartile range; LOS, length of stay.

TABLE 4 Factors associated with in-hospital mortality in adult major burns patients

	Unadjusted		Adjusted	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Early EN		0.03		0.69
No (reference)	1.00		1.00	
Yes	5.06 (1.17–21.91)		1.39 (0.30–6.92)	
Time from injury to admission	0.56 (0.20–1.57)	0.27	–	–
TBSA	1.06 (1.03–1.08)	<0.001	1.04 (1.02–1.07)	<0.001
Full thickness burn		0.008		0.05
No (reference)	1.00		1.00	
Yes	15.12 (2.01–113.51)		8.08 (1.02–64.37)	
Inhalation injury		0.004		0.77
No (reference)	1.00		1.00	
Yes	3.63 (1.52–8.65)		1.40 (0.53–3.73)	
Unintentional injury		0.008		0.98
No (reference)	1.00		1.00	
Yes	0.31 (0.13–0.73)		0.98 (0.36–2.65)	
Theatre within 24 h of admission?		0.78		–
No theatre (reference)	1.00		–	
Not admitted within 24 h	1.45 (0.17–12.45)		–	
Admitted within 24 h	1.05 (0.13–8.48)		–	

Abbreviations: CI, confidence interval; EN, enteral nutrition; OR, odds ratio; TBSA, total body surface area.

Table 3 displays the in-hospital outcomes for adult major burns patients by early enteral nutrition status. There was no association between receiving early enteral nutrition and in-hospital mortality (8.4% vs. 7.6%, $p = 0.77$). Of the patients who died, those who received early enteral nutrition had a greater median time to death (6.8 days vs. 0.5 days, $p < 0.001$). A greater proportion of patients who received early enteral nutrition were discharged to another hospital or healthcare facility (39.7% vs. 14.5%), rather than being discharged to their home or usual place of residence ($p < 0.001$). When considering all patients, those who received early enteral nutrition had a longer median length of stay (39.5 days vs. 17.9 days, $p < 0.001$). A similar result was demonstrated in patients who survived to discharge (38.0 days vs. 16.8 days, $p < 0.001$).

Table 4 displays the unadjusted and adjusted mixed-effects logistic regression models. There was no association between receiving early enteral nutrition and in-hospital mortality after adjusting for relevant confounding factors ($p = 0.69$). The model demonstrated excellent discrimination (area under the curve 0.84, 95% CI 0.75–0.92). A second regression model based on the 'rule of 10 events per variable' containing early enteral nutrition, the percentage of total body surface area burned, and whether the patient sustained an inhalation injury (the first variable being our exposure of interest, the latter two variables were deemed to best account for known sources of confounding) led us to the same conclusions as our original model (Table S5, online supplementary material). The propensity score matching model (coefficient 0.0007; 95% CI −0.11 to 0.11; $p = 0.99$) also did not show an association between early enteral nutrition and in-hospital mortality.

4 | DISCUSSION

Two thirds of all major burn patients were recorded to have received early enteral nutrition following admission to a hospital with a specialist burns service. Paediatric patients receiving early enteral nutrition were younger than patients not receiving early enteral nutrition. This may relate to adolescents being assessed as able to meet their nutrition requirements orally. Adults receiving early enteral nutrition had sustained more severe injuries than their counterparts who did not receive early enteral nutrition. There was no association between early enteral nutrition and in-hospital mortality. However, time to death data indicated all patients who received enteral nutrition survived at least 24 h after admission. Patients who received early enteral nutrition but died survived for longer compared to patients who died without receiving early enteral nutrition. This may be reflective of their less severe injuries at admission, compared to the early mortality group, but with the potential for underlying comorbidities or concomitant trauma-related injuries to complicate care. Patients who received early enteral nutrition remained in hospital for nearly twice as long as patients who did not receive early enteral nutrition. This is likely reflective of the groups injury severity, warranting enteral nutrition to supplement care if patients were not treated with palliative intent upon admission.

It must be acknowledged that length of stay may be considered a poor choice of outcome measure for nutritional interventions as it is influenced by multiple other factors in burn injury care. However, it was included due to the precedence for its use in other studies and the lack of more appropriate functional outcome measures within the BRANZ. The effectiveness of early enteral nutrition versus standard enteral nutrition following burn injury in adults remains unclear.[13] Early initiation of enteral nutrition following burn injury, however, has multiple significant benefits including the preservation of gastrin secretion and motility of the gastrointestinal tract, reduced intestinal permeability, and maintenance of mucosal barrier function,[14] as well as fewer infections complications.[4,15] This is particularly important following burn injuries, as burns patients have higher risks of enteral feed intolerance when compared to other critical care populations.[16] Enteral feed intolerance has been associated with worse clinical outcomes, including increased hospital length of stay.[16] Enteral nutrition support has also been linked to decreased hospital-acquired infections, resulting in a decreased length of stay **of** 4.7 days and significant health care cost savings, within US Medicare.[17,18]

In the meta-analysis conducted by Pu et al., early enteral nutrition was associated with a decreased rate of mortality and a reduced length of stay.[4] The findings of the current study were inconsistent with those of the earlier meta-analysis, with no association observed between early enteral nutrition and mortality, and patients who received early enteral nutrition having a longer length of stay. However, the studies included in the Pu et al. meta-analysis did not specify how in-hospital outcomes were classified. Consequently, it is difficult to comment on if and how these differences contributed to the inconsistent findings of the current study.

The present study's findings of a rate of 30% of major burns patients not receiving early enteral nutrition is higher than the 20% reported by Mosier et al. in their multi-centre trial findings.[15] However, Mosier et al. only included mechanically ventilated adult patients. This may partially explain why the number of patients not receiving early enteral nutrition increased from one in five to one in three in the present study, as mechanically ventilated patients are more likely to receive early enteral nutrition compared to patients capable of consuming

food orally. Mosier et al. were unable to identify logistical, patient, injury, or resuscitation barriers to early enteral nutrition initiation. They proposed provider factors accounted for the variation in early enteral nutrition practices, but did not define or elaborate on what such factors were. The 30% rate is also higher than the 26% rate reported from a 2012 audit of Australian and New Zealand burns services.[7] One reason for not complying with enteral nutrition timing targets was patients being admitted on a weekend (and not being referred to the dietitian until the next weekday) or enteral nutrition not being indicated despite the large burn size (12% of patients). Another reason was patients being able to meet nutritional requirements with oral nutrition support or refusal of enteral feeding tube (26%).[7] These factors, combined with practice variations between services, likely underlies the variance observed in the current study.

The current study's finding that adult patients who received early enteral nutrition had more severe injuries was somewhat inconsistent with Mosier et al., where patients receiving early enteral nutrition only had a smaller mean burn size.[15] However, the difference in inclusion criteria between studies must be noted here as Mosier et al. only included mechanically ventilated patients aged 18 years and older who were admitted within 96 h of injury; none of these criteria applied to the current study. In this study, a greater proportion of adult patients who received early enteral nutrition support had full thickness burns, documented suspicion of an inhalation injury, and a greater median burn size.

Utilisation of BRANZ data allowed for comparison of all patients with a major burn injury admitted to a specialist burns service within Australia and New Zealand. This allowed for a larger cohort of patients in this analysis than what would have been feasible in a prospective design. Data analysis was retrospective, which limited the ability to make causal associations. The BRANZ does not collect any information on the quality or quantity of enteral nutrition provided to patients, nor does it collect data on enteral feed intolerance. Consequently, it was not possible to investigate how enteral nutrition could be optimised (or what the available data tells us) beyond the timing of when enteral nutrition was initiated. The BRANZ also does not collect data in a way that allows for differentiation between patients who receive enteral or parenteral feeding. It is recommended that future revisions of the BRANZ include a data item to identify these separate groups of patients. Additionally, the small number of paediatric admissions limited whether associations between early enteral nutrition and outcomes could be determined. Finally, as the BRANZ does not collect data on why enteral nutrition timing targets were not met, comparison of justification with the prior audit is precluded. The BRANZ should consider creating additional data fields to track feed intolerance, timings and amounts.

Whilst early enteral nutrition initiation rates following severe burn injury were comparable to previous reports, they remain sub-optimal. The smaller proportion of paediatric patients admitted on the weekend who received early enteral nutrition may reflect a lack of dietetics service coverage in burns services. As no such difference was observed in the adult cohort, it may also reflect differences in feeding protocols and practices for weekend admissions between paediatric and adult burn services. However, adult data suggests early enteral nutrition was appropriately commenced in patients with more severe injuries. This may explain why groups receiving early enteral nutrition demonstrated a longer hospital length of stay. Furthermore, the data suggest that for patients who were deemed to have non-survivable injuries (a contraindication to enteral nutrition), enteral nutrition was correctly not initiated as per standard protocols. The authors conclude that the current study's results are due to clinical, not statistical, bias arising from routine and consistent clinical practices for burn care within Australia and New Zealand. The Emergency Management of Severe Burns course (developed and taught by the Australian and New Zealand Burn Association to all health professionals who provide care to patients with an acute and severe burn injury) outlines that all patients with a burn affecting 20% or more of their body receive enteral nutrition *prior* to a decision to engage palliative management is made.[19] Consequently, all life-threatening burns in Australia and New Zealand should follow this treatment decision pathway.

Two-thirds of patients with major burn injuries received early enteral nutrition following admission to a specialist burn service. Early enteral nutrition is appropriately commenced in patients with severe but survivable injuries and withheld from patients displaying contraindications, such as non-survivable injuries. Early enteral nutrition was not associated with in-hospital mortality. Future research into the reasons why major burns patients did not receive enteral nutrition would be beneficial.

AUTHOR CONTRIBUTIONS

RK, CN, and LMT contributed to the conception and design of the research. BJG and LMT contributed to the analysis of data. RK, CN, YS, DWE, FMW, and BJG contributed to the interpretation of the data. RK, CN, and LMT drafted the manuscript. All authors critically revised and approved the final manuscript. The authors acknowledge the BRANZ Steering Committee for their support of this project and for the provision of data.

CONFLICT OF INTEREST

The funding sources had no involvement in the study design, the collection, analysis, and interpretation of data, in the writing of the report, and in the decision to submit the article for publication. The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data are not publicly available due to privacy or ethical restrictions. Information about requesting access to BRANZ data can be found at https://www.monash.edu/medicine/sphpm/branz/data-requests.

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REFERENCES

1. Rousseau AF, Losser MR, Ichai C, et al. ESPEN endorsed recommendations: nutritional therapy in major burns. *Clin Nutr*. 2013;32:497-502. doi:10.1016/j.clnu.2013.02.012
2. *Total Burn Care*. 5th ed. Elsevier; 2018.
3. Australian & New Zealand Burn Association. *Burn Survivor Rehabilitation: Principles and Guidelines for the Allied Health Professional*. Australian & New Zealand Burn Association; 2007.
4. Pu H, Doig GS, Heighes PT, et al. Early enteral nutrition reduces mortality and improves other key outcomes in patients with major burn injury: a meta-analysis of randomized controlled trials. *Crit Care Med*. 2018;46:2036-2042. doi:10.1097/ccm.0000000000003445
5. Prelack K, Dylewski M, Sheridan RL. Practical guidelines for nutritional management of burn injury and recovery. *Burns*. 2007;33:14-24. doi:10.1016/j.burns.2006.06.014
6. Graves C, Saffle J, Cochran A. Actual burn nutrition care practices: an update. *J Burn Care Res*. 2009;30:77-82. doi:10.1097/BCR.0b013e3181921f0d
7. Kurmis R, Heath K, Ooi S, et al. A prospective multi-center audit of nutrition support parameters following burn injury. *J Burn Care Res*. 2015;36:471-477. doi:10.1097/bcr.0000000000000125
8. Masters B, Wood F. Nutrition support in burns–is there consistency in practice? *J Burn Care Res*. 2008;29:561-571. doi:10.1097/BCR.0b013e31817db85f
9. Castanon L, Asmar S, Bible L, et al. Early enteral nutrition in geriatric burn patients: is there a benefit? *J Burn Care Res*. 2020;41(5):986-991. doi:10.1093/jbcr/iraa109
10. Gong J, Singer Y, Cleland H, et al. Driving improved burns care and patient outcomes through clinical registry data: a review of quality indicators in the burns registry of Australia and New Zealand. *Burns*. 2021;47:14-24. doi:10.1016/j.burns.2020.01.005
11. Tracy LM, Rosenblum S and Gabbe BJ. *Burns Registry of Australia and New Zealand (BRANZ) 2018/19 Annual Report*. 2020. Department of Epidemiology and Preventive Medicine, Monash University. https://www.monash.edu/__data/assets/pdf_file/0009/2191752/BRANZ-annual-report18_19_FINAL.pdf.
12. Hosmer DW, Lemeshow S. *Applied Logistic Regression*. 2nd ed. Wiley; 2000.
13. Wasiak J, Cleland H, Jeffery R. Early versus delayed enteral nutrition support for burn injuries. *Cochrane Database Syst Rev*. 2006;Cd005489. doi:10.1002/14651858.CD005489.pub2
14. Chen Z, Wang S, Yu B, et al. A comparison study between early enteral nutrition and parenteral nutrition in severe burn patients. *Burns*. 2007;33:708-712. doi:10.1016/j.burns.2006.10.380
15. Mosier MJ, Pham TN, Klein MB, et al. Early enteral nutrition in burns: compliance with guidelines and associated outcomes in a multicenter study. *J Burn Care Res*. 2011;32:104-109. doi:10.1097/BCR.0b013e318204b3be
16. Heyland DK, Ortiz A, Stoppe C, et al. Incidence, risk factors, and clinical consequence of enteral feeding intolerance in the mechanically ventilated critically ill: an analysis of a multicenter, multiyear database. *Crit Care Med*. 2021;49:49-59. doi:10.1097/ccm.0000000000004712
17. Bechtold ML, Regunath H, Tyler R, et al. Impact of a nutrition support therapy on hospital-acquired infections: a value analysis. *Nutr Clin Pract*. 2021;36:1034-1040. doi:10.1002/ncp.10729
18. Tyler R, Barrocas A, Guenter P, et al. Value of nutrition support therapy: impact on clinical and economic outcomes in the United States. *JPEN J Parenter Enteral Nutr*. 2020;44:395-406. doi:10.1002/jpen.1768
19. EMSB Committee of the Australian and New Zealand Burn Association. *Emergency Management of Severe Burns (EMSB) Course Manual*. 19th ed. Australian and New Zealand Burn Association Ltd; 2021.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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ORIGINAL RESEARCH

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Investigating the prevalence of nutritional abnormalities in patients prior to and following bariatric surgery

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Abstract

Aims: Bariatric surgery remains an effective treatment for the condition of obesity. However it predisposes patients to nutritional deficiencies and related complications. The aim of this study was to identify nutritional abnormalities, weight loss, adherence to supplements, and presence of gastrointestinal symptoms in a cohort of bariatric surgical patients.

Methods: An analysis of the electronic medical records of patients attending a multidisciplinary private clinic in Sydney, Australia from August 2020 to August 2021 was conducted. Data on anthropometric measures, nutritional indices, adherence to supplements and gastrointestinal symptoms preoperatively and then at ≤6 months, 1 and 2 years or more postoperatively were collected.

Results: A total of 231 patients were included in the study. The majority of patients were female (76.2%), with a sleeve gastrectomy (78.8%). Average preoperative BMI was 43.4 ± 7.1 kg/m^2. Weight loss ≥2 years postsurgery was 33.5 ± 12.4 kg. The most common abnormalities preoperatively were: C-reactive protein (47.7%), vitamin D (39%), B_{12} (31%), parathyroid hormone (27.6%) and ferritin (12.7%). Vitamin B_{12} (23.2%), parathyroid hormone (23%), vitamin D (17.7%) and ferritin (15.9%) remained common abnormalities postoperatively.

Adherence to multivitamins was 90% in the first year following surgery, declining to 77% at ≥2 years. Gastrointestinal symptoms were predominantly present in the initial stages following surgery, manifesting thiamin deficiency in 6.5% of patients.

Conclusions: Despite achieving durable weight loss, nutritional and related abnormalities remain an ongoing challenge for bariatric surgery. Adherence to nutrient supplements, gastrointestinal symptoms and related complications are important considerations in addressing the problem.

1 | INTRODUCTION

Bariatric surgery remains an effective treatment for the condition of obesity, with improvements in quality of life, obesity related co-morbidities and subsequently mortality.[1–4] However, bariatric procedures including Roux-en-Y gastric bypass, one anastomosis gastric bypass-mini gastric bypass, sleeve gastrectomy, and laparoscopic adjusted gastric band change the gastrointestinal system, impacting the ingestion, digestion and absorption of nutrients and subsequently result in nutritional deficiencies.[5,6] Commonly reported nutritional concerns include vitamins D, B_{12}, B_1 (thiamin), folate, iron, ferritin and hyperparathyroidism.[5–8] Furthermore, nutritional deficiencies have also been documented in patients presenting for obesity surgery, which may be compounded as a consequence of the surgery.[5,6]

Patients with good nutritional status preoperatively may not show any clinical or subclinical deficiencies in the first few months following surgery. This is predominantly due to the long half-life and the availability of these micronutrients in body storage. One such deficiency is anaemia, which may be related to vitamin B_{12}, folate and/or iron deficiency and can easily be detected and treated.[9] Other nutritional concerns such as vitamin D, calcium and hyperparathyroidism, have longer-term and more complex consequences. These include metabolic bone disease, which requires a multifaceted approach, assessment and a specialised treatment.[10]

In contrast thiamin can become depleted rapidly following surgery.[11] Thiamin is an essential coenzyme for numerous pathways of the nervous system and despite its availability in major food groups, due to its short half-life (9–18 days) and low storage levels in the body (30 mg), levels can become depleted within 20 days of poor dietary intake.[11] Hence its deficiency may occur rapidly and result in acute, severe and irreversible side effects.[12] Foregut symptoms, such as vomiting, lead to dietary and multivitamin intolerances. Suboptimal preoperative nutritional status, compounded by these gastrointestinal symptoms, may increase the risk of thiamin deficiency,[9] which can result in different symptoms such as Wet Beriberi, Dry Beriberi or Wernicke's encephalopathy. Wernicke's encephalopathy affects the central nervous system and if untreated may cause irreversible neurological damage, memory loss and coma with a 10–20% reported mortality rate.[12–14] Several case studies following all procedures have reported neuropathy, polyneuropathy and Wernicke's encephalopathy, related to the acute postgastric reduction surgery syndrome and thiamin deficiency.[13,15–18] However, the symptoms of moderate thiamin deficiency are vague and hence may go undiagnosed for some time.[14]

The aim of this study was to identify the prevalence of nutritional abnormalities (vitamins B_{12}, Active B_{12} (holotranscobalamin), thiamin, folate, vitamin D, intact parathyroid hormone (iPTH), haemoglobin (Hb), iron and ferritin, serum albumin, total protein and C-reactive protein), in a cohort of patients attending a multidisciplinary private bariatric clinic in Australia. Weight loss, adherence to supplementation and the presence of gastrointestinal symptoms were also considered.

2 | METHODS

The study was approved by the University of Wollongong/Illawarra Shoalhaven Local Health District Human Research Ethics Committee (HE:2020/172) and formal consent was not required. This study was reported according to the STROBE checklist.[19] The study accessed electronic medical records of patients who attended a multidisciplinary private clinic in Sydney, Australia from August 2020 to August 2021. Data included anthropometric measures, nutritional indices (vitamins B_{12}, Active B_{12}, thiamin, folate, vitamin D [Serum 25 {OH}], iPTH, iron, albumin and total protein), adherence to supplements, and gastrointestinal symptoms. Data on nutritional values were collected prospectively, preoperatively and then at ≤6 months, 1 and 2 years or more postoperatively.

All patients who attended the clinic during the study period and completed the blood tests were included in the study. They had undergone a multidisciplinary assessment and met the international criteria for bariatric surgery.[5,20] The nutritional counselling and recommendations for the multivitamin and mineral supplements were provided by the dietitian according to the bariatric guidelines.[6,9,20] The multivitamin and mineral supplements recommended included a comprehensive bariatric-specific high-dose multivitamin and mineral supplement aiming to provide 200% of the recommended dietary intake, calcium and vitamin D (aiming for a total of 1200–1500 mg calcium with 800 IU vitamin D). Supplements of iron, vitamins B_{12}, thiamin, folate and additional vitamin D were recommended to meet the requirements of individual patients as required.

A Wedderburn scale was used for measuring weight and body mass index (BMI) (weight [kg]/Height^2 [cm]), weight loss (WL), percentage of total weight loss (%TWL) (weight loss (kg)/Pre op weight × 100) and percentage of Excess Weight Loss (%EWL) were calculated (weight loss (kg)/EW (kg) × 100).

The nutritional and biochemical markers reported were vitamins B_{12}, Active B_{12}, thiamin, folate, D, iPTH, haemoglobin (Hb), iron and ferritin, albumin, total protein and C-reactive protein. Vitamin B_6 levels were not

routinely tested, however, levels were reported if available. Levels of nutrients were assessed based on the standard laboratory values (Table 2).

At the time of each nutritional assessment, adherence to the recommended multivitamin and mineral supplements and reported gastrointestinal symptoms were recorded. Hospital readmissions were noted and data regarding reasons for readmission, course of management, and nutrition management were retrieved.

Data were deidentified prior to analysis. The study was approved by the University of Wollongong/Illawarra Shoalhaven Local Health District Human Research Ethics Committee (HE:2020/172) and for this type of study formal consent was not required.

Descriptive statistics were expressed as mean ± SD for continuous variables (anthropometry and analytical variables) and percentages for categorical data (deficiency or compliance rates). Inferential analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) version 27. Linear mixed models were used to compare baseline and follow-up data and Bonferroni post-hoc test to pair-wise comparisons. A p value <0.05 was considered statistically significant.

3 | RESULTS

The baseline characteristics are described in Table 1. A total of 231 patients had a complete nutrition panel and were all included in the study. The mean age at time of surgery was 47.0 ± 11.8 years, the mean preoperative BMI was 43.4 ± 7.1 kg/m^2 and the majority of patients were female (76.2%). The majority of the procedures were done as a primary procedure (n = 185, 80%), with the main procedure being sleeve gastrectomy (78.8%), followed by gastric bypass (15.6%; Table 1).

The mean weight loss was 30.7 ± 10.6 kg, 37.3 ± 14.1 kg, 33.5 ± 12.4 Kg, at 6, 12 month and 2 or more years following surgery. The weight loss was significantly different at each time point compared to the preoperative weight (p = <0.001), stabilising at 1 year postoperative with no significant difference in measures after 1 year (Figure 1).

Further details on the changes in anthropometrical measures following bariatric procedures are found in Table S1 (online supplementary material).

Prior to bariatric surgery, the most common nutritional disorders, related to vitamins D (39%), B_{12} (31%), ferritin (12.7%) and hyperparathyroidism (27.6%). Folate, Active B_{12}, iron, Hb, total protein and albumin abnormalities were minimal and there was no thiamin deficiency observed preoperatively in this cohort. C-reactive protein levels were elevated in 47.7% of patients (Table 2).

TABLE 1 Baseline characteristics of bariatric patients included in the study

	n = 231
Gender ratio F/M, *n* (%)	176/55 (76.2/23.8)
Age at the time of surgery, years	47.0 ± 11.8
(Range)	(18–73)
Body weight, kg, mean± SD	122.1 ± 23.6
(Range)	(74.4–220.0)
BMI, kg/m^2 ± SD	43.4 ± 7.1
(Range)	(31.0–66.5)
Excess weight, kg, mean± SD	51.5 ± 19.8
Surgery types, *n* (%)	LSG: 182 (78.8%)
	RYGB: 36 (15.6%)
	OAGB: 9 (3.9%)
	LAGB: 3 (1.3%)
	Banded SG: 1 (0.4%)
Primary/Revisional surgery, *n* (%)	185/46 (80/20)
Primary surgery, n (%)	LAGB: 32 (70.0%)
	LSG: 4 (8.7%)
	LAGB and LSG: 8 (17.3%)
	GS: 1 (2.2%)
	Fixed band: 1 (2.2%)
	ESG: 1 (2.2%)

Abbreviations: ESG, endoscopic sleeve gastrectomy; GS, gastric stapling; LAGB, laparoscopic adjusted gastric banding; LSG, laparoscopic sleeve gastrectomy; OAGB, one anastomosis gastric bypass (mini gastric bypass); RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy.

The common nutritional disorders at ≥2 years related to vitamin B_{12} (23.2%), hyperparathyroidism (23%), vitamin D (17.7%) and ferritin (15.9%). Few abnormalities in folate, Active B_{12}, iron, Hb, total protein and albumin were observed but an improvement in C-reactive protein was observed over time. In the period ≤6 months, thiamin deficiency was present in 2.3% patients (n = 2), both with foregut symptoms, necessitating hospital admission for assessment and management. At 1 year, one patient had a thiamin abnormality with clinically reported symptoms (Table 2).

Vitamin B_6 toxicity was an incidental finding in 5 (2.2%) patients, with the range of values being from 1062–6936 nmol/L (normal range 20–190 nmol/L). The reported level of symptoms varied; with some asymptomatic and others reporting neuropathy. The main reason for vitamin B_6 toxicity was self-prescription of supplements such as zinc, magnesium or other high dose multivitamin and mineral supplement. These generally included 30–50 mg of vitamin B_6 in the form of pyridoxine hydrochloride

TABLE 2 Laboratory values and percentage of abnormalities in patients at each assessment point

Biochemical marker (normal range)	Time	*N*	Minimum	Maximum	Mean ± SD	Abnormalities *N* (%)
Thiamin pyrophosphatase (TPP) (66–200 nmol/L)	Pre op	112	75	445	179.6 ± 54.8	0 (0.0)
	≤6/12 post op	88	48	360	165.1 ± 51.6	2 (2.3)
	1 year post op	49	55	340	173.5 ± 65.3	1 (2.1)
	≥2 years post op	63	65	340	177.0 ± 56.9	0 (0.0)
CRP (0.0–0.5 mg/L)	Pre op	109	0.5	48.6	7.7 ± 7.3	52 (47.7)
	≤6/12 post op	83	0.4	24.0	4.5 ± 4.6	21 (25.3)
	1 year post op	48	0.4	85.5	5.5 ± 12.6	6 (12.5)
	≥2 years post op	62	0.4	25.7	2.5 ± 3.6	5 (8.1)
iPTH (1.6–6.9 pmol/L)	Pre op	105	2.0	21.1	6.8 ± 3.4	29 (27.6)
	≤6/12 post op	84	2.0	10.5	5.4 ± 1.9	15 (17.9)
	1 year post op	47	2.7	35.0	6.4 ± 4.8	8 (17.0)
	≥2 years post op	61	2.1	13.7	6.2 ± 2.4	14 (23.0)
Albumin (36–47 g/L)	Pre op	110	35.0	49.0	42.5 ± 2.8	2 (1.8)
	≤6/12 post op	87	35.0	49.0	41.7 ± 3.1	0 (0.0)
	1 year post op	49	30.0	48.0	41.9 ± 3.6	2 (4.0)
	≥2 years post op	62	35.0	50.0	41.8 ± 3.2	0 (0.0)
Vitamin D (50–140 nmol/L) Total deficiency: <50 nmol/L	Pre op	107	14.0	108.0	53.1 ± 19.6	Total: 42 (39) *Mild: 31 (29.0)* *Moderate: 11 (10.3)* *Severe: 0 (0.0)*
Mild deficiency: 30–49 nmol/L Moderate deficiency: 13–29 nmol/L Severe deficiency: <13 nmol/L	≤6/12 post op	86	31.0	149.0	77.5 ± 22.0	Total: 8 (9.3) *Mild: 8 (9.3)* *Moderate: 0 (0.0)* *Severe: 0 (0.0)*
	1 year post op	47	33.0	142.0	76.5 ± 23.7	Total: 5 (10.6) *Mild: 5 (10.6)* *Moderate: 0 (0.0)* *Severe: 0 (0.0)*
	≥2 years post op	62	16.0	253.0	68.8 ± 32.3	Total: 11 (17.7) *Mild: 11 (17.7)* *Moderate: 0 (0.0)* *Severe: 0 (0.0)*
Iron (5–30 μmol/L)	Pre op	112	5.9	37.0	14.7 ± 5.3	1 (0.9)
	≤6/12 post op	87	9.0	117.0	18.6 ± 11.8	0 (0.0)
	1 year post op	49	3.0	28.2	17.3 ± 6.0	2 (4.1)
	≥2 years post op	62	9.0	43.6	20.0 ± 6.6	0 (0.0)
Ferritin (15–200 μg/L)	Pre op	110	9.0	533.0	125.3 ± 119.8	Low: 14 (12.7) High: 12 (10.9)
	≤6/12 post op	87	14.0	559.0	136.2 ± 112.9	Low: 6 (6.9) High: 3 (3.5)
	1 year post op	49	7.0	358.0	107.2 ± 81.8	Low: 7 (14.3) High: 5 (10.2)
	≥2 years post op	63	6.0	344.0	87.7 ± 69.6	Low: 10 (15.9) High: 3 (4.8)
	Pre op	97	150.0	1028.0	350.9 ± 155.7	30 (31.0)

(Continues)

TABLE 2 (Continued)

Biochemical marker (normal range)	Time	N	Minimum	Maximum	Mean ± SD	Abnormalities N (%)
Vitamin B12 (135–650 pmol/L) <250 pmol/L	≤6/12 post op	59	148.0	1042.0	381.8 ± 185.6	16 (27.1)
	1 year post op	42	140.0	1352.0	398.9 ± 228.6	8 (19.0)
	≥2 years post op	56	127.0	845.0	407.3 ± 179.4	13 (23.2)
Active B_{12}* (>35 pmol/L)	Pre op	87	36.0	127.0	82.3 ± 26.0	1 (1.1)
	≤6/12 post op	71	24.0	124.0	65.5 ± 27.3	3 (4.2)
	1 year post op	38	33.0	127.0	71.4 ± 25.3	2 (5.3)
	≥2 years post op	42	26.0	125.0	71.8 ± 29.3	4 (9.5)
Folate (>7.0 nmol/L)	Pre op	111	4.5	54.0	29.4 ± 10.1	1 (0.9)
	≤6/12 post op	85	6.7	53.0	26.3 ± 10.2	1 (1.2)
	1 year post op	51	6.7	54.0	29.9 ± 11.1	1 (2.0)
	≥2 years post op	61	12.7	54.0	30.0 ± 9.6	1 (1.6)
Total protein (64–83 g/L)	Pre op	109	41.0	144.0	71.7 ± 8.6	3 (2.7)
	≤6/12 post op	84	56.0	145.0	69.6 ± 9.5	5 (5.9)
	1 year post op	49	40.0	79.0	67.5 ± 6.0	6 (12.2)
	≥2 years post op	62	57.0	79.0	67.9 ± 3.7	5 (8.1)
Haemoglobin (M) (130–180g/L)	Pre op	23	122.0	166.0	147.5 ± 13.3	1 (4.3)
	≤6/12 post op	12	137.0	164.0	148.3 ± 8.7	0 (0.0)
	1 year post op	8	125.0	152.0	139.1 ± 8.8	1 (12.5)
	≥2 years post op	15	129.0	172.0	147.4 ± 11.5	2 (13.3)
Haemoglobin (F) (119–160)	Pre op	85	106.0	158.0	135.9 ± 9.8	3 (3.5)
	≤6/12 post op	74	112.0	167.0	135.5 ± 11.1	2 (2.7)
	1 year post op	43	106.0	156.0	127.5 ± 9.8	4 (9.3)
	≥2 years post op	48	113.0	159.0	134.2 ± 10.3	1 (2.1)

Abbreviations: CRP, C-reactive protein; F, female; iPTH, intact Parathyroid hormone; M, male.
[a]Analysed if vitamin B12 150–250 pmol/L.

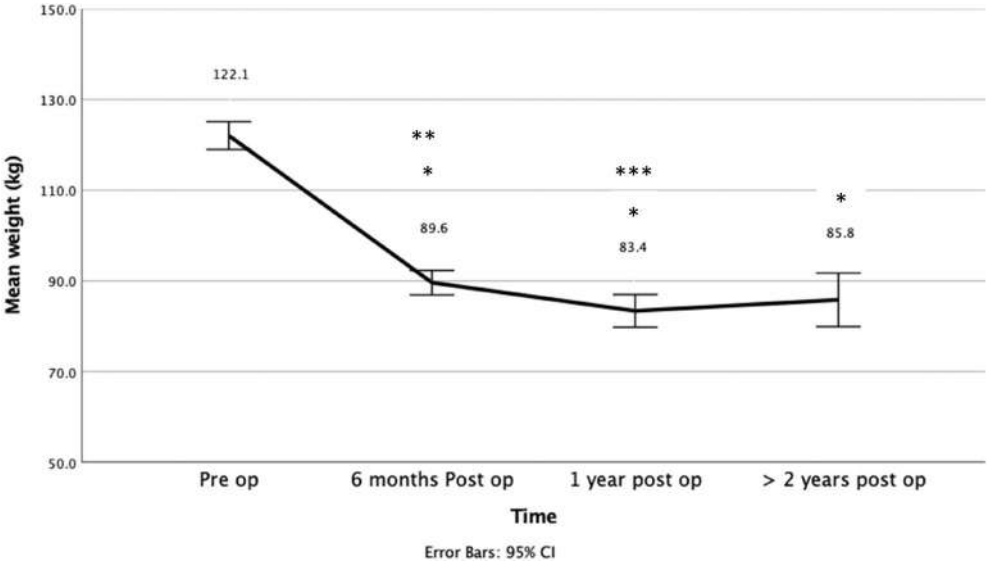


FIGURE 1 Weight loss over time following bariatric surgeries. *Statistically different to pre op weight $p \leq 0.001$. **Statistically different to >2 years post op weight $p = 0.009$. ***No difference between 1 year and > 2 years post op weight.

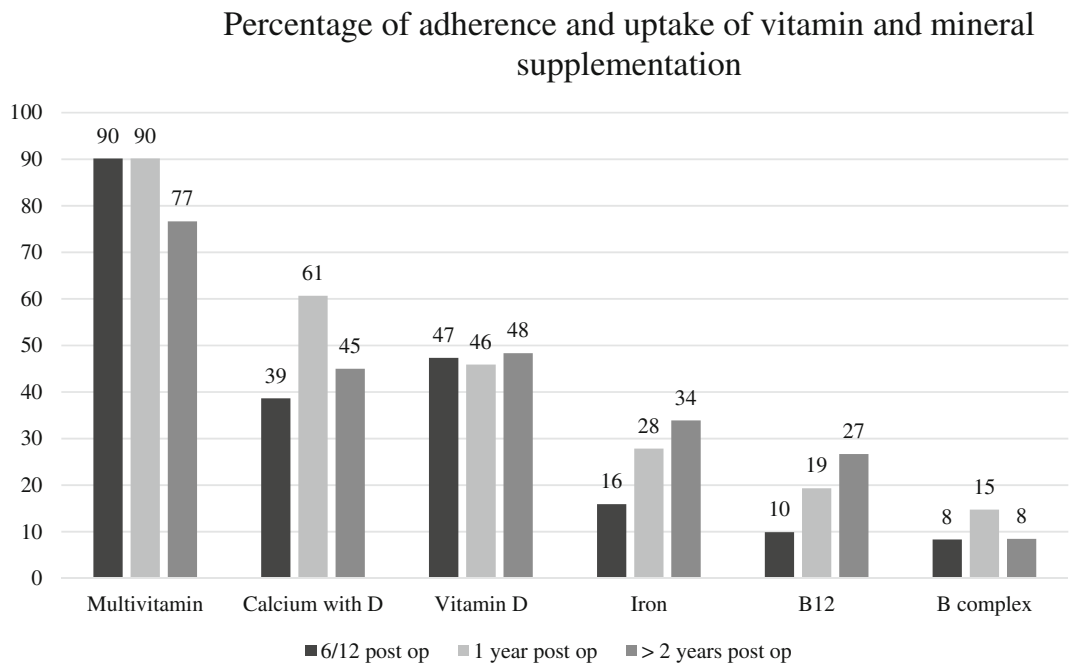
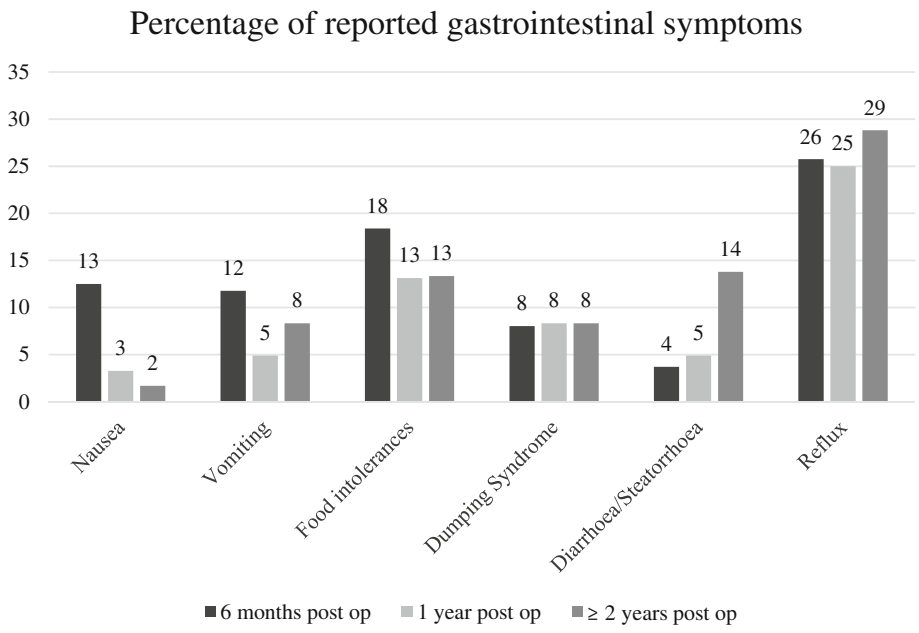


FIGURE 2 Percentage of adherence and uptake of multivitamin and mineral supplements by patients.

FIGURE 3 Percentage of reported gastrointestinal symptoms over time in bariatric patients.



and in some cases, they may have been taken for up to 1 year. Apart from one patient (13 years post laparoscopic adjusted gastric banding), who in addition to the B_6 toxicity, had vitamin D and total protein abnormalities, all others did not exhibit any additional nutritional abnormalities. All B_6 levels were corrected with 3 weeks of stopping the high dose supplements.

Mean vitamin D levels improved over time, with a significant difference at 6 months, 1 year and ≥ 2 years postoperative compared to the preoperative values (Figure S1). iPTH improved at 6 months postoperative, however, no difference was seen beyond that time point (Figure S2, online supplemetary material). Iron levels and C-reactive protein levels both improved over time. However, at 6 months postoperative a significant reduction was observed in mean values of Active B_{12}, folate and total protein with some (total protein) persisting over time (Figures S3–S5, online supplementary material).

The adherence to the multivitamins was higher than other specific additional supplements. Adherence was

90% in the first year following surgery but declined to 77% at 2 years and beyond. In this cohort, 60% of patients were taking additional calcium and vitamin D supplements, with adherence again declining over time. Iron and vitamin B_{12} supplements are generally recommended based on patients' requirements. As the recommendation to take these additional supplements increased over time, so did their uptake (Figure 2).

The most common gastrointestinal symptoms reported by patients are described in Figure 3. Reflux, food intolerances, nausea and vomiting were common. There was improvement in the prevalence of some symptoms, however reflux remained a problem longer term, with 44% of patients at 6 months, 25% at 1 year, and 28% at ≥2 years requiring daily proton pump inhibitors for its management.

From 214 patients, the substantive complication rate was 6.5%, with 12 patients requiring hospital readmissions and 2 endoscopic interventions. Only two patients had thiamin levels assessed during their hospital stay and both did develop thiamin deficiency. One patient with a very complicated medical and mental health history developed refeeding syndrome and required intensive care unit admission, enteral nutrition support, as well psychological support.

4 | DISCUSSION

Consistent with other studies,[21–25] our research shows that bariatric surgery results in significant weight loss (TWL: 37.3 ± 14.1), which then stabilises and is maintained beyond 2 years following surgery. However nutritional abnormalities remain a concern, requiring close monitoring and adjustment based on individual patients. This is even more crucial in the acute stages postoperatively when patients may be at a higher risk of complications related to their surgery; or are still adjusting to their new gastrointestinal system and hence may experience foregut symptoms and its related acute and severe nutritional consequences.

The main preoperative nutritional abnormalities in this cohort were related to vitamin D, hyperparathyroidism, B_{12} and ferritin. The prevalence of hypovitaminosis D (39%), was consistent with other Australian studies in the bariatric surgical population, reported as 32–57%,[8,26,27] and was expectedly higher than in the average population, reported as 23% in the Australian Health Survey.[28] It is important to note that levels of Vitamin D deficiency can widely vary depending on what reference range is used (Table 2 describes the reference values in this study). An inverse relationship between BMI and vitamin D has been suggested in the literature, possibly due to the sequestration of vitamin D, being a fat-soluble vitamin, in the adipose tissue.[29] Vitamin D is essential for the absorption of calcium and hence optimal musculoskeletal and metabolic bone health. Furthermore hyperparathyroidism was evident in 27.6% of patients in this cohort, which is also a common abnormality in the bariatric surgical population and with a similar impact on bone mineral density and metabolic bone health.[10]

Epidemiological studies suggest a protective benefit of obesity against osteoporosis, due to increased bone mineral density as a result of a larger bone size and a higher mechanical loading, but there is more recent evidence of low vitamin D and hyperparathyroidism in this population.[10] A review by Brzozowska et al. suggests a strong inverse relationship between total fat mass and bone mineral density, discussing the consequence of obesity and its related metabolic syndrome in bone formation rate, bone mineral density and increasing fractures.[30] Given the impact of weight loss on metabolic bone health following bariatric surgery, the screening and early management of vitamin D and iPTH has been recommended for this at-risk population.[6,7,10]

In this cohort, 31% of patients had a vitamin B_{12} abnormality. Vitamin B_{12} (or cobalamin) deficiency has been reported in varying degrees in patients seeking bariatric surgery (0–30%), with the higher deficiency rate in those on medications such as proton pump inhibitors, H_2 Blockers, or Metformin, all of which reduce its absorption rate.[6,7,31] As a water-soluble vitamin, B_{12} is stored in substantial amounts in the liver and hence deficiency takes some time to develop. B_{12} deficiency can result in symptoms such as pernicious anaemia, paraesthesia, numbness, changes in reflexes and in extreme cases gait ataxia, dementia, psychosis and neuropathy.[6] Due to resection (in the sleeve gastrectomy and one anastomosis gastric bypass) or the bypass of the gastric fundus (in gastric bypass) and hence reduction in intrinsic factor patients are at risk of developing vitamin B_{12} deficiency following surgery, and hence early detection and correction is essential for optimal outcome.[9] Measurement of serum vitamin B_{12} may not be adequate to detect vitamin B_{12} deficiency and further tests such as Active B_{12}, methylmalonic acid and homocysteine have also been recommended.[6,9] In this study, we also measured Active B_{12} and found very low deficiency rates (1.1%). Folate, iron, Hb, total protein and albumin abnormalities were negligible. Our findings are similar to other studies showing low prevalence of folate deficiency,[8,32] however these results contrast with others who report higher prevalence of folate deficiency of 54%.[7] This contrast could be due to a high level of adherence to the multivitamin supplementation. Iron deficiency was also negligible in this cohort with only one patient experiencing low iron levels. This

is similar to other findings,[8] whilst others report much higher deficiency rates (13–47%) in the bariatric candidate patients.[6,32,33]

The prevalence of thiamin deficiency has not been fully explored in bariatric surgical candidates.[34] In this study we did not identify any thiamin abnormality in those screened preoperatively ($n = 112$), although others have reported a prevalence of deficiency of 5.5%[32] and up to 29%.[6] The difference in studies may be related to preoperative nutritional health, the quality of the diet, and possible food fortification. There is disparity in the recommendation for routine preoperative thiamin screening in the bariatric guidelines, with some endorsing routine screening for all patients[6] and others reporting a lack of evidence to do so.[7] Therefore, it is not surprising to observe inconsistencies in clinical practices. In a survey of Australia and New Zealand bariatric clinicians only 35.7% of the respondents routinely screened for thiamin levels preoperatively.[35] Considering the short half-life of thiamin and its low storage level in the body, ensuring adequate thiamin status through routine preoperative assessment may be helpful in managing high-risk patients in the acute stages following surgery.

After 2 years post surgery, the situation may change. Consistent with the literature,[6,7,9,32,36] in this cohort nutritional disorders such as abnormal vitamins B_{12}, D, hyperparathyroidism and ferritin were present at ≥2 years postoperative. These results emphasise the long-term need for nutritional assessment, and review of the adequacy, adherence and response to supplementation in bariatric patients. Vitamin D and iPTH, calcium and albumin all play an important role in maintaining bone homeostasis, but in the current study there was negligible albumin abnormalities observed. The initial significant improvement in the mean vitamin D and iPTH levels was similar to other studies which also demonstrated an improvement in vitamin D levels (from 81% to 36% deficiency levels) at 1 year following surgery.[32] This has been attributed to the weight loss and the release of vitamin D from adipose tissue[29] as well as better adherence to recommended vitamin D supplementation. However, over time, vitamin D deficiency of 80% -100% and ongoing hyperparathyroidism has been reported in the literature.[6,36] These findings not only reinforce the need for routine screening and long term follow up but also highlight the need for population based and individualised treatment recommendations. This aligns with recommendations from the American Society for Metabolic and Bariatric Surgery which has emphasised the need for long term monitoring of vitamin D, iPTH, calcium, and albumin. as well as using a dual-energy X-ray absorptiometry scan,[10] as a result of the increased risk of fractures in this population.

In contrast to other reports,[6] folate, Active B_{12}, iron and Hb abnormalities were minimal in our cohort. Several reasons may explain this. Firstly, the dietary contribution of these micronutrients may vary amongst different patient populations, however, this was not investigated in the current study. Secondly, adherence to micronutrient supplementation may also vary amongst patient cohorts. Finally, interpopulation differences in nutrient absorption, metabolism and storage needs should also be considered. The level of abnormality of total protein (which measures the combined amount of two types of proteins, albumin and globulin) and albumin, reflecting the overall nutritional status, were negligible, in this cohort. Protein energy malnutrition is not generally expected following the above mentioned bariatric procedures and nor is it seen in patients who do not experience surgical-related complications.[9] Similar to other findings, with the improvement of weight loss and its inflammatory processes, C-reactive protein levels improved over time in the current study.[27]

Thiamin levels postsurgery may be of particular interest in this clinical population. A recent systematic review described the incidence of thiamin deficiency to be higher than previously reported within the bariatric surgical population and additionally reported limited studies in this area.[34] Furthermore, current practices of screening and treatment of thiamin deficiency in clinical settings are inconsistent,[35] potentially leading to severe consequences and irreversible neurological side effects. In the current study, thiamin abnormality was present in 2 patients at ≤6-month postoperative, both of which needed hospital readmission due to foregut symptoms. Only one patient at 1 year following surgery exhibited thiamin abnormality and was clinically symptomatic. These findings are similar to those of Albaugh et al. who found a 3.5% thiamin deficiency in a cohort of 346 patients.[37] However, it is in contrast with others, who have reported a much higher prevalence of thiamin deficiency of up to 29%.[6,32,38] This difference may be attributed to race with Caucasians experiencing less thiamin deficiency than African Americans or Hispanics.[38]

Thiamin deficiency has been reported following all bariatric procedures.[13,15–18] Due to the irreversible and potential life-threatening consequences of untreated thiamin deficiency, early supplementation, detection and adequate treatment is recommended. In this cohort the patients with thiamin deficiency were reportedly adherent to multivitamin supplementation. In a previous study, where thiamin deficiency was prevalent in 25.7% of patients, no difference was found with adherence to multivitamin supplementation between patients who had thiamin deficiency versus those who did not (70.4%, 84.6%, $p = 0.10$).[38] However, African American race

(odds ratio [OR][39] 3.9, $p = 0.019$), higher preoperative BMI (OR 1.13, $p = 0.001$), nausea (OR 3.81, $p = 0.02$) and vomiting (OR 3.49, $p = 0.032$) were found to be independent risk factors of developing thiamin deficiency.[38] In the high-risk group patients, closer monitoring, routine screening of thiamin, and additional thiamin supplementation in the acute postoperative phase may contribute to the prevention, early detection and appropriate treatment of thiamin deficiency.

Another B group vitamin of interest is Vitamin B_6 or pyridoxal phosphate, a water-soluble vitamin with the generic name representing six compounds (vitamers) with vitamin B6 activity. It is a co-factor for over 100 enzymes involved in amino acid metabolism and neurotransmitter synthesis. It naturally occurs in a variety of food groups such as legumes, nuts, wheat bran, as well as animal sources such as meat.[9] Vitamin B_6 has not been well studied in the bariatric population and hence the understanding of its prevalence of deficiency and toxicity remains limited.[9] Recent studies report varying level of vitamin B_6 toxicity prior to surgery (21%) and increasing postoperatively (47.5%).[32] The concern with vitamin B_6 toxicity is that unlike other water-soluble B vitamins, chronic administration of high dose supplements can cause severe and progressive sensory neuropathy characterised by ataxia. The severity of symptoms generally appears to be dose dependent, and usually stop with discontinuation of the excess pyridoxine supplements. The incidence of vitamin B_6 toxicity in the cohort in the current study was much lower and only seen in 5 patients (2.2%). This may be due to the type and the quantity of the additional B6 supplements contributing to the toxicity. The current study's cohort were taking additional supplements with added vitamin B6 whereas others reported the toxicity to be related to consumption of energy drinks.[40]

Given the abnormalities noted with nutrients, vitamin supplementation is routinely provided in this patient cohort. Despite several guidelines and clinician recommendations, the adherence to multivitamin supplementation remains suboptimal and tend to decline over time.[8,36] In this cohort 90% of patients reported to be taking supplements, however this reduced to 77% by 2 years and beyond. The adherence to the additional supplements was even lower with 60% of patients taking the additional recommended calcium and vitamin D supplementation in the current study, and this declined over time. Other studies have shown similar findings with 74.1% of patients taking a vitamin D supplement during the first postoperative year and reducing to only 11.1% after 4 years.[36]

A recent study including 4614 postoperative bariatric surgical patients used a 24-item questionnaire to explore the factors affecting adherence to multivitamin supplements.[41] They overall found a negative attitude towards taking supplements with common reported barriers for inconsistent users identified to be: forgetting daily intake (68.3%), gastro-intestinal side effects (25.6%) and unpleasant taste or smell (22.7%). In contrast those who did not use any multivitamin supplementation reported gastrointestinal side effects (58.5%), high costs (13.5%) and the absence of vitamin deficiencies (20.9%) to be the barriers. Furthermore, they found a total of 28.5% of patients to be dissatisfied with the instructions received on multivitamin supplementation use. Hence to optimise adherence to multivitamin supplementation, closer attention to adherence at each consult, consideration of patients' individual preferences, and implementation of a shared decision–making process by the clinicians was recommended.

Consistent with other literature, common gastrointestinal symptoms reported by patients in the current study were reflux, food intolerances, nausea and vomiting.[27,42] These mostly resolved over time, likely as the gastrointestinal system evolves and also patients cognitively adapt to their new capacity. In this cohort, the complication rate was 6.5% with 14 patients requiring further investigations or interventions. Only two patients with foregut symptoms who needed hospital interventions had their thiamin level tested. Both had thiamin abnormality and one further developed severe malnutrition, refeeding syndrome, requiring intensive care unit admission and enteral nutrition support for its management. Patients with complications were generally presented to their nearest hospital, which may not routinely care for bariatric surgical patients. Hence thiamin was not assessed for all patients, nor was it supplemented during hospital readmissions. Some of the reasons were the expense of the test as well as the duration of time it takes to receive the results (up to 2 weeks). This not only results in underreporting of thiamin deficiency, but highlights the role of the bariatric specialised clinics in education of staff in other hospitals, in caring for bariatric patients.

The limitations of this study were firstly reliance on the retrospective data available for some aspects of the study as well as also relying on reported data. Secondly, patients were not randomly allocated to each surgical group and the majority of patients had sleeve gastrectomy procedure, hence the results do not translate to other bariatric procedures. Thirdly, only a small number of patients had thiamin levels tested, especially during the acute stages postoperatively and hence this may underreport the prevalence of thiamin deficiency. However, with limited studies published on thiamin levels, this study presents a realistic observation of private bariatric clinics

and hence encourages others to reflect on clinical practice, especially given that most bariatric surgery is conducted privately in Australia.[43] Developing a protocol for routine assessment, screening and supplementation of thiamin may also be of benefit for patients presenting with complications leading to foregut symptoms and requiring readmissions.

Bariatric surgery results in durable weight loss, however acute and chronic nutritional concerns remain an issue in the bariatric surgical patient. With weight loss and good adherence to supplementation, some such as vitamin D and iPTH tend to initially improve, however as stores deplete, these become a concern in the longer term. Furthermore, adherence to supplementation tends to reduce over time, increasing the risk of long-term complications. Patients with foregut symptoms and complications develop diet and multivitamin supplement intolerance, increasing their risk of acute nutritional deficiency, especially thiamin and its related consequences. Thiamin deficiency is however underreported, as its not routinely screened. Hence, the need for prompt assessment and supplementation in the symptomatic bariatric patient, with the aim to prevent severe complications. To increase awareness in health settings that may not routinely care for bariatric surgical patients and hence reduce potential risk, a specific protocol in managing the bariatric complicated patient is recommended.

AUTHOR CONTRIBUTIONS

NZ, LCT, EPN and MB contributed to the conception and design of the study. NZ contributed to acquisition, analysis and interpretation of data, and drafted the manuscript. MB contributed to data analysis, LCT, MB, EPN and MLT contributed to data interpretation. All authors critically revised and gave final approval for the manuscript. The authors acknowledge Assoc Prof Garrett-Smith and Dr Steve Leibman for assistance with subject recruitment and Assoc Prof Garrett-Smith for assistance with deidentification of data prior to analyses.

CONFLICT OF INTEREST

Marijka Batterham and Elizabeth Phillipa Neale are on the Editorial Board of Nutrition & Dietetics. They were excluded from the peer review process and all decision-making regarding this article. This manuscript has been managed throughout the review process by the Journal's Editor-in-Chief. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made. The authors declare no other conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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REFERENCES

1. Sjöström L, Lindroos AK, Peltonen M, et al. Lifestyle, diabetes, and cardiovascular risk factors 10 years after bariatric surgery. *N Engl J Med*. 2004;351:2683-2784.
2. Cummings DE, Arterburn DE, Westbrook EO, et al. Gastric bypass surgery vs intensive lifestyle and medical intervention for type 2 diabetes: the CROSSROADS randomised controlled trial. *Diabetologia*. 2016;59:945-953. doi:10.1007/s00125-016-3903-x
3. Buchwald H, Avidor Y, Braunwald E, et al. Bariatric surgery: a systematic review and meta-analysis. *JAMA*. 2004;292:1724-1737. doi:10.1001/jama.292.14.1724
4. NHMRC. National Health and Medical Research Council. Department of Health and Aging. Australian Dietary Guidelines: Eat for Health. https://www.eatforhealth.gov.au/sites/default/files/files/the_guidelines/n55_australian_dietary_guidelines.pdf (2013).
5. Mechanick JI, Apovian C, Brethauer S, et al. Clinical practice guidelines for the perioperative nutrition, metabolic, and nonsurgical support of patients undergoing bariatric procedures: 2019 update—cosponsored by American Association of Clinical Endocrinologists/American college of endocrinology, the Obesity Society, American Society for Metabolic & bariatric surgery, obesity medicine association, and American Society of Anesthesiologists—executive summary. *Endocr Pract*. 2019;25:1346-1359. doi:10.4158/gl-2019-0406
6. Parrott J, Frank L, Rabena R, Craggs-Dino L, Isom KA, Greiman L. American society for metabolic and bariatric surgery integrated health nutritional guidelines for the surgical weight loss patient. *Surg Obes Relat Dis*. 2016;13:727-741. doi:10.1016/j.soard.2016.12.018
7. O'Kane M, Parretti HM, Pinkney J, et al. British obesity and metabolic surgery society guidelines on perioperative and postoperative biochemical monitoring and micronutrient replacement for patients undergoing bariatric surgery: 2020 update. *Obes Rev*. 2020;1-23:e13087. doi:10.1111/obr.13087
8. Zarshenas N, Nacher M, Loi KW, Jorgensen JO. Investigating nutritional deficiencies in a Group of Patients 3 years post laparoscopic sleeve gastrectomy. *Obes Surg*. 2016;26:2936-2943.
9. Aills L, Blankenship J, Buffington C, Furtado M, Parrott J. Bariatric nutrition: suggestions for the surgical weight loss patient. *Surg Obes Relat Dis*. 2008;4:S73-S108. doi:10.1016/j.soard.2008.03.002
10. Kim J, Nimeri A, Khorgami Z, et al. Metabolic bone changes after bariatric surgery: 2020 update, American Society for

Metabolic and Bariatric Surgery Clinical Issues Committee position statement. *Surg Obes Relat Dis*. 2021;12:1-18. doi:10.1016/j.soard.2020.09.031
11. Sechi G, Serra S. Wernicke's encephalopathy: new clinical settings and recent advances in diagnosis and management. *Lancet Neurol*. 2007;6:442-455.
12. Punchai S, Hanipah ZN, Meister KM, Schauer PR, Brethauer SA, Aminian A. Neurologic manifestations of vitamin B deficiency after bariatric surgery. *Obes Surg*. 2017;27:2079-2082. doi:10.1007/s11695-017-2607-8
13. Stroh C, Meyer F, Manger T. Beriberi, a severe complication after metabolic surgery: review of the literature. *Obes Facts*. 2014;7:246-252. doi:10.1159/000366012
14. Kerns JC, Arundel C, Chawla LS. Thiamin deficiency in people with obesity. *Adv Nutr*. 2015;6:147-153. doi:10.3945/an.114.007526
15. Chen BA, Chen LC. Wernicke's encephalopathy after bariatric surgery with atypical magnetic resonance imaging: a case report. *Acta Neurol Taiwan*. 2017;26:29-32.
16. Angstadt JD, Bodziner RA. Peripheral polyneuropathy from thiamine deficiency following laparoscopic Roux-en-Y gastric bypass. *Obes Surg*. 2005;15:890-892. doi:10.1381/0960892054222759
17. Martines G, Musa N, Aquilino F, Capuano P. Severe neurological complication following adjustable gastric banding. *G Chir*. 2018;39:92-96.
18. Makarewicz W, Kaska L, Kobiela J, et al. Wernicke's syndrome after sleeve gastrectomy. *Obes Surg*. 2007;17:704-706.
19. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol*. 2008;61:344-349.
20. Mechanick JI, Youdim A, Jones DB, et al. Clinical practice guidelines for the perioperative nutritional, metabolic, and nonsurgical support of the bariatric surgery patient: 2013 update—cosponsored by American Association of Clinical Endocrinologists, the Obesity Society, and American Society for Metabolic & bariatric surgery. *Endocr Pract*. 2013;19:337-372. doi:10.4158/ep12437.Gl
21. Kessler Y, Adelson D, Mardy-Tilbor L, et al. Nutritional status following one anastomosis gastric bypass. *Clin Nutr*. 2020;39:599-605. doi:10.1016/j.clnu.2019.03.008
22. Aleman R, Lo Menzo E, Szomstein S, Rosenthal R. Efficiency and risks of one-anastomosis gastric bypass. *Trans Med*. 2020;8-(Suppl 1):7.
23. Robert M, Espalieu P, Pelascini E, et al. Efficacy and safety of one anastomosis gastric bypass versus Roux-en-Y gastric bypass for obesity (YOMEGA): a multicentre, randomised, open-label, non-inferiority trial. *Lancet*. 2019;393:1299-1309. doi:10.1016/s0140-6736(19)30475-1
24. Parmar CD, Mahawar KK. One anastomosis (mini) gastric bypass is now an established bariatric procedure: a systematic review of 12,807 patients. *Obes Surg*. 2018;28:2956-2967. doi:10.1007/s11695-018-3382-x
25. Parikh M, Eisenberg D, Johnson J, El-Chaar M. American Society for Metabolic and Bariatric Surgery review of the literature on one-anastomosis gastric bypass. *Surg Obes Relat Dis*. 2018;14:1088-1092. doi:10.1016/j.soard.2018.04.017
26. Toh SY, Zarshenas N, Jorgensen JO. Prevalence of nutrient deficiencies in bariatric patients. *Nutrition*. 2009;25:1150-1156. doi:10.1016/j.nut.2009.03.012
27. Zarshenas N, Tapsell LC, Batterham M, Neale E, Talbot M. Changes in anthropometric measures, nutritional indices and gastrointestinal symptoms following one anastomosis gastric bypass (OAGB) compared with roux-en-y gastric bypass (RYGB). *Obes Surg*. 2021;31:2619-2631. doi:10.1007/s11695-021-05284-2
28. ABS, 2011. Australian Bureau of Statistics. ABS Cat no. 4719.0. Canberra, 2011–2012.
29. Blum M, Dolnikowski G, Seyoum E, et al. Vitamin D(3) in fat tissue. *Endocrine*. 2008;33:90-94. doi:10.1007/s12020-008-9051-4
30. Brzozowska M, Sainsbury A, Eisman A, Baldock P, Center J. Bariatric surgery, bone loss, obesity and possible mechanisms. *Obes Rev*. 2013;14:52-67. doi:10.1111/j.1467-789X.2012.01050.x
31. Frame-Peterson L, Megill R, Carobrese S, Schweitzer M. Nutrient deficiencies are common prior to bariatric surgery. *Nutr Clin Pract*. 2017;32:463-469.
32. van Rutte PJW, Aarts EO, Smulders JF, Nienhuijs SW. Nutrient deficiencies before and after sleeve gastrectomy. *Obes Surg*. 2014;24:1639-1646. doi:10.1007/s11695-014-1225-y
33. Ben-Porat T, Elazary R, Yuval JB, Wieder A, Khalaileh A, Weiss R. Nutritional deficiencies after sleeve gastrectomy: can they be predicted preoperatively? *Surg Obes Relat Dis*. 2015;11:1029-1036. doi:10.1016/j.soard.2015.02.018
34. Aasheim E. Wernicke encephalopathy after bariatric surgery. A Systematic Review. *Ann Surg*. 2008;248:714-720.
35. Zarshenas N, Tapsell L, Batterham M, Neale E, Talbot M. Screening and treatment of thiamine deficiency in a sample of multidisciplinary bariatric surgery clinical teams. *Obes Surg*. 2021;31:4666-4668. doi:10.1007/s11695-021-05614-4
36. Ben-Porat T, Elazary R, Goldenshluger A, Sherf Dagan S, Mintz Y, Weiss R. Nutritional deficiencies four years after laparoscopic sleeve gastrectomy-are supplements required for a lifetime? *Surg Obes Relat Dis*. 2017;13:1138-1144. doi:10.1016/j.soard.2017.02.021
37. Albaugh V, Williams B, MAher C, Spann M, English W. Prevalence of thiamine deficiency is significant in patients undergoing primary bariatric surgery. *Surg Obes Relat Dis*. 2021;17:653-658. doi:10.1016/j.soard.2020.11.032
38. Tang L, Alsulaim HA, Canner JK, Prokopowicz GP, Steele KE. Prevalence and predictors of postoperative thiamine deficiency after vertical sleeve gastrectomy. *Surg Obes Relat Dis*. 2018;14:943-950. doi:10.1016/j.soard.2018.03.024
39. Maessen DE, Hanssen NM, Lips MA, et al. Energy restriction and Roux-en-Y gastric bypass reduce postprandial alpha-dicarbonyl stress in obese women with type 2 diabetes. *Diabetologia*. 2016;59(9):2013-2017. doi:10.1007/s00125-016-4009-1
40. Tynes M, Matthias H, Timper K. Regular intake of energy drinks and multivitamin supplements is associated with elevated plasma vitamin B6 levels in post-bariatric patients. *Sci Rep*. 2021;11:17830. doi:10.1038/s41598-021-97205-7
41. Smelt J, Heusschen L, Theel W, et al. Factors affecting patient adherence to multivitamin intake after bariatric surgery: a multicentre survey study from the patient's perspective. *Obes Surg*. 2021;31:4316-4326. doi:10.1007/s11695-021-05571-y
42. Zarshenas N, Tapsell LC, Neale EP, Batterham M, Talbot ML. The relationship between bariatric surgery and diet quality: a

systematic review. *Obes Surg*. 2020;30:1768-1792. doi:10.1007/s11695-020-04392-9

43. BSR. *Bariatric Surgery Registry Eighth Annual Report: 2019/20*. Monash University; 2019/2020.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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ORIGINAL RESEARCH

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Exploring the diets of mothers and their partners during pregnancy: Findings from the Queensland Family Cohort pilot study

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Abstract

Aim: Modifiable behaviours during the first 1000 days of life influence developmental trajectories of adult chronic diseases. Despite this, sub-optimal dietary intakes during pregnancy and excessive gestational weight gain are common. Very little is known about partners' dietary patterns and the

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influence on women's pregnancy dietary patterns. We aimed to examine dietary intake during pregnancy among women and their partners, and gestational weight gain patterns in the Queensland Family Cohort pilot study.

Methods: The Queensland Family Cohort is a prospective, observational study piloted at a Brisbane (Australia) tertiary maternity hospital from 2018 to 2021. Participant characteristics, weight gain, dietary and nutrient intake were assessed.

Results: Data were available for 194 pregnant women and their partners. Poor alignment with Australian Guide to Healthy Eating recommendations was observed. Highest alignment was for fruit (40% women) and meat/alternatives (38% partners) and lowest for breads/cereals (<1% women) and milk/alternatives (13% partners). Fewer women (4.4%–60.3%) than their partners (5.4%–92.3%) met guidelines for all micronutrient intakes from food alone, particularly folic acid, iodine, and iron. Women were more likely to meet daily recommendations for fruit, vegetables, dairy, bread/cereals, and meat/alternatives when their partners also met recommendations. Women with a higher pre-pregnancy body mass index were more likely to gain above recommended weight gain ranges.

Conclusions: In this contemporary cohort of pregnant women and their partners, sub-optimal dietary patterns and deficits in some nutrients were common. There is an urgent need for evidence-informed public health policy and programs to improve diet quality during pregnancy due to intergenerational effects.

KEYWORDS
birth cohort, dietary intake, dietary guidelines, maternal health, gestational weight gain, pregnancy

1 | INTRODUCTION

The Developmental Origins of Health and Disease paradigm confirms that modifiable lifestyle behaviours during the first 1000 days of life contribute to developmental trajectories of many adult chronic diseases.[1] Antenatal nutrition status, maternal dietary patterns (such as fruit and vegetable intake), and gestational weight gain contribute to both short- and long-term maternal and child health outcomes, including risk of pregnancy and delivery complications, and risk of postpartum obesity, Type 2 diabetes mellitus, and cardiovascular disease.[1–5] Furthermore, there is emerging evidence that paternal risk factors, such as dietary patterns unaligned with those recommended in dietary guidelines and obesity are also associated with adverse metabolic and cardiovascular outcomes in their offspring.[6,7]

Despite this, women commonly report sub-optimal dietary intakes during pregnancy. Only 10%–40% of pregnant women meet current recommendations for fruit and vegetable intake.[8–12] Less than 1% achieve recommenced breads and cereal intakes and extremely low numbers meet pregnancy Nutrient Reference Values for folate, iodine, calcium, zinc, and fibre from food alone.[9–12] Furthermore, only 40%–50% of women consume the recommended nutrient supplements (iodine, folic acid) pre-pregnancy with minimal change once pregnancy is confirmed.[13] It is notable that very few studies with low sample sizes have documented paternal and/or partner dietary patterns during pregnancy and how this potentially influences maternal dietary intake.[14,15] Current evidence is limited in Australia and internationally, but is critical to inform family-based health promotion strategies and targeted interventions.[13]

A recent systematic review and meta-analysis of >1 million pregnant women identified that less than a third gained weight within the Institute of Medicine recommendations[3] with approximately one in two and one in

four women having excessive or suboptimal gestational weight gain respectively in pregnancy.[3] Similar patterns have been observed in Australia.[16–21] In addition to total gestational weight gain, the pattern of weight gain across each trimester can impact pregnancy outcomes, such as the development of gestational diabetes mellitus.[22] However, few studies document these patterns across trimesters during pregnancy.

Substantial changes in demographics and characteristics of pregnant women in Australia have occurred over the last three decades relating to advanced maternal age, obesity, ethnic minority background, and pre-existing medical conditions.[23] Thus, the goal of this study was to describe pregnancy dietary intake and gestational weight gain patterns in a contemporary cohort of women birthing at a tertiary Queensland perinatal centre, and dietary intakes of their partners. We utilised data from women and their families collected as part of the Queensland Family Cohort Pilot Study,[24] which will inform further data collection in the main Queensland Family Cohort study, a large birth cohort study based at the Mater Mothers' Hospitals in Brisbane.[24]

Specific aims of the current analysis were to examine (i) dietary intake during pregnancy of women and their partners, including dietary nutrient and food group intake, how these health behaviours compare with Australian Dietary Guidelines and NRVs, and explore the relationship between women's and partner's dietary intake, and (ii) to describe gestational weight gain of women across pregnancy and alignment with current guidelines.

2 | METHODS

This study was approved by the Human Research Ethics Committee of Mater Research Institute—UQ Human Research Ethics Committee (HREC/16/MHS/113).

Women who were 12–24 weeks pregnant and booked to give birth at the Mater Mothers' Hospitals from 2018 to 2020 were eligible to participate, with their partners also invited to participate. Informed consent was obtained from both the pregnant women and their partners (without the necessity of being a biological parent).

Maternal and partner characteristics were collected at 22 weeks via questionnaire and included socio-demographic (education, income, ethnicity) information, age, parity, and pre-pregnancy height and weight (to calculate body mass index [BMI]). The following pre-existing medical conditions were assessed based on questions about self-reported medical history and crosschecked with medication use at 22 weeks: arthritis, asthma or other breathing conditions, blood pressure or other heart conditions, anticoagulants, cancer, hypercholesterolemia, hormones to aid conception or for medical conditions, depression, anxiety, diabetes mellitus, or epilepsy.

Information about maternal and partner dietary intake over the previous 3–6 months was self-reported at 24 weeks' gestation using the Australian Eating Survey (AES) semi-quantitative food frequency questionnaire (FFQ).[25] The AES is a 120-item semi-quantitative FFQ. The frequency options within the AES ranged from "Never" up to "≥4 times/day", but varied depending on the food, with some drinks items up to "≥7 glasses/day". Standard portion sizes were derived for AES items using data from the National Nutrition Survey.[26] Nutrient intakes were computed using data in the AUSNUT 2011–13 database.[27] A measure of diet quality, the Australian Recommended Food Score (ARFS), was calculated as an AES sub-scale with a maximum score of 73.[25,28] A sub-set of 70 AES food items are used to calculate the ARFS. It comprises eight sub-scales from core food groups of vegetables, fruit, grains, meats, non-meat proteins, dairy with total score ranging from 0 to 73. For most items, AES frequency response options are collapsed into two categories "once per week or more" or "less than once per week or never".[25] Percentage of total energy intake from the five core food groups (nutrient-dense) and from non-core foods (energy-dense, nutrient-poor, discretionary) was calculated. All dietary data were based on food intake, and did not include nutrient supplements, thus supplemental micro-nutrients were not included in analysis.

Participant food group and nutrient intakes were compared to recommendations outlined in the Australian Guide to Healthy Eating (AGHE) with food group intake (serves/day) calculated using the standard AGHE serve sizes[29] and national Nutrient Reference Values, including Estimated Average Requirements; Adequate Intakes; Acceptable macronutrient distribution range,[30] respectively.

Maternal weight was self-reported at 22 weeks' gestation (including self-reported pre-pregnancy weight), and formally measured at 24-, 28- and 36-week gestation, and finally at 6 weeks postpartum. Total gestational weight gain was determined based on self-reported pre-pregnancy weight and measured weight at 36 weeks' gestation.

Participant characteristics, gestational weight gain and dietary intake, and alignment with guidelines, were described as means with standard deviations or as number of participants with percentages. Cumulative gestational weight gain was compared across women's pre-pregnancy BMI categories using one-way analysis of variance. Women's and partner's food group intakes were compared to the AGHE food group servings specifications.[29] Women and partners were said to meet a food group if their intake either met or exceeded the AGHE values, except for the "extras" category, which was reported as the percentage of total energy derived from

AGHE core and discretionary food groups. Nutrient values for each participant were compared to the Nutrient Reference Values. Associations of maternal characteristics and dietary quality with alignment of gestational weight gain to Institute of Medicine guidelines[31] were explored using chi-square tests or analysis of variance. Associations of maternal and partner characteristics with adherence to dietary guidelines were explored using χ^2 tests or *t* tests.

3 | RESULTS

Data from 194 pregnant women and their partners (98.5% male) were available (Table 1 and Figure 1). The mean age of pregnant women was 33.7 (*SD* 4.5) years and 34.5 (*SD* 6.3) years for partners. The mean baseline gestation week was 22.4 (*SD* 2.0) weeks. Approximately 30% of women in the cohort were overweight or obese (17.8% and 13.0%, respectively) with almost 60% of their partners overweight or obese (42.3% and 17.6%, respectively). Twice as many women as men reported a pre-existing chronic condition based on their medication use.

As shown in Table 2, percentage of total energy from macronutrients of carbohydrate, protein, and fat for pregnant women and their partners were similar. Greater than 60% of women and 40% of partners consumed long-chain omega 3 fatty acids (LC n3) at or above the recommended guidelines. Women's mean dietary fibre intake was 24.8 g/day and partner's 28.9 g/day. Low proportions of women met micronutrient intake recommendations, particularly folic acid (4%), iodine (15%), and iron (<1%) from food and beverages. A larger proportion of their partners met micronutrient recommendations; however, calcium (40%) and folic acid (50%) intakes were lower than the proportion meeting iron and zinc recommendations (each 92%).

Poor alignment with the AGHE was observed, with very low proportions of participants meeting the five core food group intake recommendations (Table 2). Furthermore, only 41.4% of women met daily fruit and 28.4% vegetable intake recommendations, while around 31.5% and 15.0% of their partners met these, respectively. Fewer than 1% of women and 20% of partners met the recommended intake of serves for breads, cereals, and grains core food group. Approximately, one-third of kilojoules were consumed from non-core food groups by

TABLE 1 Characteristics of pregnant women ($n = 194$[a]) and their partners ($n = 194$[a]) participating in the Queensland Family Cohort Pilot Study

	Pregnant women		Partners	
Characteristics	***n***	**Value**	***n***	**Value**
Age (years), mean (*SD*)	194	33.7 (4.5)	194	34.5 (6.3)
Gestational age at study entry (weeks), mean (*SD*)	178	22.4 (2.0)	-	-
Born in Australia or New Zealand, *n* (%)	185	115 (62.2)	192	126 (65.6)
Education level, *n* (%)	183		188	
Up to year 12		8 (4.4)		23 (12.2)
Certificate/diploma		138 (75.4)		134 (71.3)
Postgraduate degree		37 (20.2)		31 (16.5)
Total weekly household income after tax, *n* (%)	143		-	
AUD ≤ $1000		23 (16.1)		-
AUD > $1000		120 (83.9)		-
Nulliparous, *n* (%)	115	13 (11.3)		-
BMI (kg/m^2)[b], mean (*SD*)	185	24.4 (5.1)	187	26.7 (4.6)
BMI category[b], *n* (%)	185		187	
Underweight		12 (6.5)		3 (1.6)
Normal weight		116 (62.7)		72 (38.5)
Overweight		33 (17.8)		79 (42.3)
Obesity		24 (13.0)		33 (17.6)
Pre-exsting chronic condition, *n* (%)	183	37 (20.2)	147	16 (10.9)

[a]Number of participants varies due to missing data.
[b]Pre-pregnancy BMI for pregnant women.

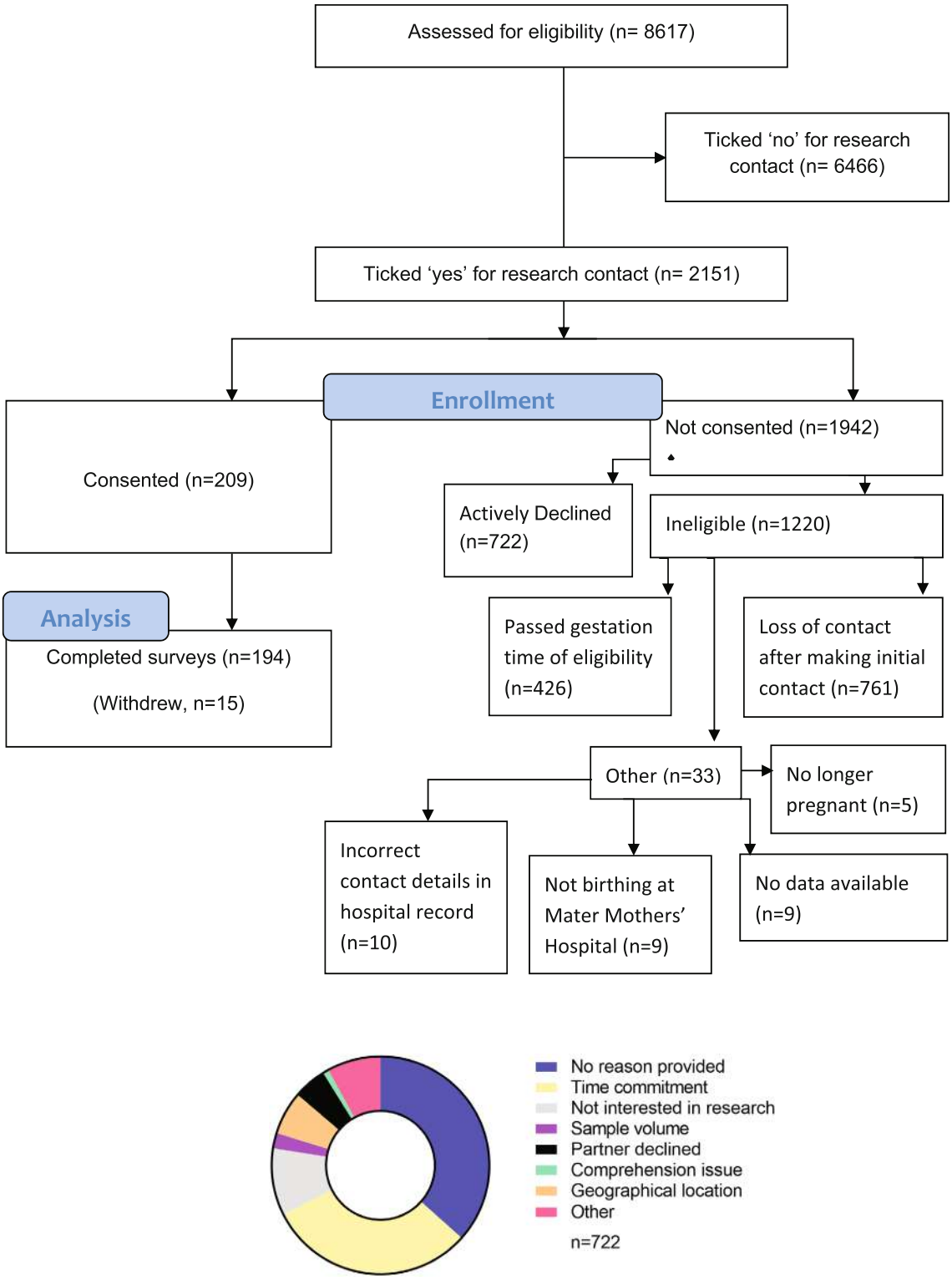

FIGURE 1 STROBE flowchart for participant inclusion in the Queensland Family Cohort study

both women and their partners (31.7% and 35.4%, respectively). Overall mean diet quality as indicated by the ARFS was 30.6 (*SD* 11.3) for women and 29.2 (*SD* 10.9) for their partners, out of a maximum of 73.

Mean total gestational weight gain was 13.0 kg (*SD* 5.5). Table 3 reports cumulative gestational weight gain across pregnancy according to pre-pregnancy BMI. Gestational weight gain from pre-pregnancy to 24, 28, and

TABLE 2 Nutrient and five core food group intake and adherence to guidelines at 24 weeks' gestation among pregnant women and their partners

		Pregnant women $n = 136$		Partners $n = 129$	
	Requirements pregnancy; partners	Daily intake mean (*SD*)	Guideline alignment %	Daily intake mean (*SD*)	Guideline alignment %
Energy (kJ)		7551 (2814)		9992 (4175)	
Macronutrients					
Carbohydrates (g)		203.3 (85.5)		266.3 (118.5)	
Carbohydrates (% energy)	45–65%[a];45–65%[a]	45.7 (6.4)	59.7	45.3 (6.7)	53.1
Protein (g)	≥49[b]; 52	76.2 (29.2)	86.0	100.6 (41.7)	93.8
Protein (% energy)	15–25%[a];15–25%[a]	17.4 (2.7)	87.6	17.4 (2.8)	87.5
Total fat (g)		70.6 (26.7)		91.0 (42.2)	
Total fat (% energy)	20–35%[a];20–35%[a]	36.5 (4.5)	35.7	35.3 (5.2)	53.1
Saturated fat (g)		26.7 (11.1)		33.8 (16.5)	
Saturated fat (% energy)		13.7 (2.4)		13.1 (2.6)	
Polyunsaturated fat (g)		9.4 (3.8)		37.0 (17.6)	
Polyunsaturated fat (% energy)		4.9 (0.9)		4.8 (0.9)	
Monounsaturated fat (g)		28.4 (10.9)		12.5 (6.2)	
Monounsaturated fat (% energy)		14.8 (2.4)		14.4 (2.6)	
n-6 (linoleic) (g)	≥10[c]; ≥13[c]	7.9 (3.2)	25.7	10.6 (5.4)	24.8
n-3 (alpha-linolenic) (g)	≥1.0[c]; ≥1.3[c]	1.0 (0.4)	50.7	1.2 (0.6)	36.4
LC n-3 (DHA + EPA) (mg)	≥115[c]; ≥160[c]	136.8 (124.4)	63.6	209.1 (212.2)	44.2
Dietary fibre (g)	≥28; >30	24.8 (10.9)	38.2	28.9 (13.4)	39.5
Micronutrients, from diet					
Calcium (mg)	≥840; ≥840	708.9 (364.3)	28.7	828.7 (426.0)	39.5
Folate (μg)	≥520; ≥320	303.3 (126.5)	4.4	343.5 (153.9)	52.7
Iodine (μg)	≥160; ≥100	116.3 (56.7)	15.4	141.4 (67.5)	74.4
Iron (mg)	≥22; ≥6	9.3 (4.3)	0.7	11.9 (5.2)	92.3
Sodium (mg)	460–920; 460–920	1577.5 (677.2)	7.4	2077.8 (1062.2)	5.4
Zinc (mg)	≥9; >6.5	9.7 (3.9)	60.3	12.3 (4.9)	92.3
Foods[d]					
Grain (cereal) foods (servings)	≥8.5; ≥6	3.1 (1.5)	0.8	4.2 (2.1)	20.5
Fruit (servings)	≥2; ≥2	1.9 (1.2)	41.4	1.5 (1.1)	31.5
Vegetables and legumes/beans (servings)	≥5; ≥6	3.8 (1.9)	28.4	3.9 (2.1)	15.0
Milk, yoghurt, cheese, and/or alternatives (servings)	≥2.5; ≥2.5	1.3 (1.0)	10.9	1.4 (1.1)	13.3
Lean meat and poultry, fish, eggs, tofu, nuts and seeds, legumes, and beans (servings)	≥3.5; ≥3	2.4 (1.1)	25.4	2.8 (1.2)	38.1
Core foods (kJ)		5416 (1748)		6389 (2223)	
Core foods (% energy)		68.3 (11.5)		64.6 (10.3)	
Non-core foods (kJ)		2545 (1284)		3682 (2455)	
Non-core foods (% energy)		31.7 (11.5)		35.4 (10.3)	

(Continues)

TABLE 2 (Continued)

	Requirements pregnancy; partners	Pregnant women $n = 136$		Partners $n = 129$	
		Daily intake mean (*SD*)	Guideline alignment %	Daily intake mean (*SD*)	Guideline alignment %
Overall diet quality					
ARFS		30.6 (11.3)		29.2 (10.9)	

Abbreviation: ARFS, Australian Recommended Food Score.
[a]Acceptable macronutrient distribution range, AMDR.
[b]2nd and 3rd trimesters only.
[c]AI (adequate intake) not EAR.
[d]Serving size: (a) Breads and cereals: bread 40 g, cereal 30 g, cooked porridge 120 g, muesli 30 g, cooked rice/pasta/noodles/barley/quinoa 70–120 g, dry biscuits 40 g; (b) Fruit: whole fruit (including canned) 150 g, fruit juice 125 ml, dried fruit 30 g; (c) Vegetables: cooked or fresh vegetables 75 g; (d) Dairy and alternatives: milk 250 ml, hard cheese 40 g, soft cheese (ricotta) 120 g, yoghurt 200 g; (e) Meat and alternatives: lean (cooked) beef/ veal/lamb/pork/65 g, poultry (cooked) 80 g, fish (cooked)100 g, eggs 120 g, nuts/seeds/nut butters 30 g, tofu 170 g, cooked or canned legumes 150 g; (f) Extras: sweet biscuit 35 g, sweet pastries/cakes/pies 40 g, savoury pies/pastries 60 g, pizza 60 g, hamburger 60 g, chocolate 35 g, processed meats 110 g, sausage 50–60 g, potato crisps/ corn chips 30 g, jam/honey 45 g, ice-cream 75 g, fat spread 20 g, sugar 40 g, light beer 600 ml, full strength beer 400 ml, wine (including sparkling) 200 ml, spirits/liqueurs 60 ml, fortified wine 60 ml.

TABLE 3 Cumulative gestational weight gain according to pre-pregnancy BMI category, $n = 174$

	24 Weeks' gestation (kg) mean (*SD*)	28 Weeks' gestation (kg) mean (*SD*)	36 Weeks' gestation (kg) mean (*SD*)
Overall	7.3 (4.2)	9.5 (4.5)	13.0 (5.5)
Underweight	7.7 (2.4)	9.4 (2.4)	12.9 (3.5)
Normal weight	7.5 (3.5)	9.7 (3.8)	13.5 (4.8)
Overweight	8.0 (4.0)	10.3 (4.5)	13.6 (4.9)
Obesity	5.2 (7.0)	6.9 (7.6)	9.4 (9.2)
p value	0.06	0.04	0.02

Note: *p* values from analysis of variance comparing gestational weight gain between all pre-pregnancy BMI categories at each time point.

36 week's gestation differed by pre-pregnancy BMI ($p = 0.06$, 0.04 and 0.02, respectively) and was lower among women with obesity (pre-pregnancy BMI >29.9 kg/m^2). Women retained weight at 6-week postpartum, with an average weight of 69.7 kg (*SD* 14.9) compared with a pre-pregnancy weight of 65.4 kg (*SD* 13.9). Average weight retained at 6 weeks postpartum was 4.3 kg (*SD* 7.1).

A significant relationship exists between pre-pregnancy BMI and women's attainment of gestational weight gain guidelines, with a greater proportion of women gaining above their recommended gestational weight gain range among higher ppBMIs (data not shown). There was no significant difference between women with gestational weight gain within range, above Institute of Medicine guidelines or with inadequate gestational weight gain and their consumption of energy-dense, nutrient-poor foods (32%, 33%, and 29%, respectively, $p = 0.17$).

Tables 4 and 5 present associations between participant characteristics and attainment of dietary guidelines. Older women and partners diets were more likely to align with meat/alternatives recommendations ($p = 0.06$), and older partners compared to younger partners were also more likely to meet dairy food group recommendations ($p = 0.07$). Women with a higher level of education and a lower pre-pregnancy BMI were more likely to meet daily vegetable intake recommendations compared with those with lower levels of education ($p = 0.06$) and higher pre-pregnancy BMI ($p = 0.006$). Significant associations were observed between attainment of food group recommendations between women and partners. Women were more likely to meet daily dietary intake recommendations for the following food groups when partners also met these recommendations: fruit ($p = 0.008$); vegetable ($p < 0.0001$), dairy ($p = 0.04$), bread, cereal, and grain ($p < 0.0001$), meat and alternatives group requirements ($p < 0.0001$).

4 | DISCUSSION

This analysis of contemporary Australian pregnant women and partners' dietary intake patterns shows that a

TABLE 4 Associations of maternal characteristics with adherence to food-based dietary guidelines, $n = 136$[a,b]

	Fruit servings/day n (%)			Vegetables servings/day n (%)			Dairy servings/day n (%)			Meat and alternatives servings/day n (%)		
	<2 80 (58.6)	≥2 56 (41.4)	*p* value*	<5 98 (71.7)	≥5 39 (28.4)	*p* value*	<2.5121 (89.2)	≥2.5 15 (10.9)	*p* value*	<3.5101 (74.6)	≥3.5 35 (25.4)	*p* value*
Age (years), mean (*SD*)	33.1 (5.2)	34.0 (5.1)	0.32	33.6 (5.8)	33.6 (5.1)	0.97	33.6 (5.1)	33.5 (6.3)	0.94	33.1 (5.1)	35.3 (6.7)	0.06
Gestational age at study entry (weeks), mean (*SD*)	21.9 (2.4)	22.0 (1.9)	0.84	21.8 (2.3)	22.5 (1.4)	0.12	22.0 (2.2)	21.7 (1.5)	0.70	21.9 (2.2)	22.2 (1.9)	0.53
Born in Australia or New Zealand, *n* (%)	51 (68.0)	36 (67.9)	0.99	59 (67.1)	22 (62.9)	0.66	77 (67.0)	11 (78.6)	0.38	61 (67.0)	19 (61.3)	0.56
Education level, *n* (%)			0.23			0.06			0.21			0.47
Up to year 12	2 (2.7)	1 (1.9)		3 (3.5)	1 (2.9)		1 (0.9)	1 (7.1)		2 (2.3)	1 (3.2)	
Certificate/diploma	58 (78.4)	36 (70.1)		69 (80.2)	22 (62.9)		86 (76.1)	10 (71.4)		70 (78.7)	21 (67.7)	
Postgraduate degree	14 (18.9)	15 (28.0)		14 (16.3)	12 (34.3)		26 (23.0)	3 (21.4)		17 (19.1)	9 (29.0)	
Total weekly household income after tax, *n* (%)			0.28			0.16			0.60			0.51
AUD ≤ $1000	9 (15.0)	3 (7.7)		10 (14.5)	1 (4.0)		10 (11.4)	2 (16.7)		7 (10.5)	4 (15.4)	
AUD > $1000	51 (85.0)	36 (92.3)		59 (85.5)	24 (96.0)		78 (88.6)	10 (83.3)		60 (89.6)	22 (84.6)	
Nulliparous, *n* (%)	5 (10.6)	3 (10.3)	0.97	4 (7.8)	4 (16.7)	0.25	6 (9.0)	2 (20.0)	0.29	4 (7.4)	4 (20.0)	0.12
Pre-pregnancy BMI (kg/m^2), mean (*SD*)	24.7 (5.1)	24.1 (4.4)	0.45	24.8 (5.6)	22.0 (3.4)	0.006	24.4 (4.8)	25.2 (4.9)	0.59	24.0 (5.0)	24.0 (5.9)	0.97
Pre-pregnancy BMI category, *n* (%)			0.87			0.14			0.85			0.79
Underweight	4 (5.3)	2 (3.8)		7 (8.0)	2 (5.7)		6 (5.2)	1 (7.1)		6 (6.6)	3 (9.7)	
Normal weight	48 (64.0)	33 (62.3)		53 (60.2)	28 (80.0)		72 (62.6)	9 (64.3)		59 (64.8)	21 (67.7)	
Overweight	13 (17.3)	12 (22.6)		14 (15.9)	4 (11.4)		22 (19.1)	3 (21.4)		15 (16.5)	3 (9.7)	
Obesity	10 (13.3)	6 (11.3)		14 (15.9)	1 (2.9)		15 (13.0)	1 (7.1)		11 (12.1)	4 (12.9)	
Pre-exsting chronic condition, *n* (%)	15 (20.3)	7 (13.5)	0.32	14 (16.1)	9 (26.5)	0.19	19 (16.8)	3 (21.4)	0.67	17 (18.9)	6 (20.0)	0.89
Partner adhering to guideline for grains, *n* (%)	6 (10.9)	11 (24.4)	0.07	10 (11.0)	16 (44.4)	<0.0001	15 (16.7)	2 (18.2)	0.90	17 (18.1)	9 (28.1)	0.23
Partner adhering to guideline for fruit, *n* (%)	10 (18.2)	19 (42.2)	0.008	18 (19.8)	22 (61.1)	<0.0001	27 (30.0)	2 (18.2)	0.41	30 (31.9)	9 (28.1)	0.69
Partner adhering to guideline for vegetables, *n* (%)	4 (7.3)	8 (17.8)	0.11	1 (1.1)	19 (52.8)	<0.0001	12 (13.3)	1 (9.1)	0.20	14 (14.9)	4 (12.5)	0.74

(Continues)

TABLE 4 (Continued)

	Fruit servings/day n (%)			Vegetables servings/day n (%)			Dairy servings/day n (%)			Meat and alternatives servings/day n (%)		
	<2 80 (58.6)	≥2 56 (41.4)	*p* value*	<5 98 (71.7)	≥5 39 (28.4)	*p* value*	<2.5121 (89.2)	≥2.5 15 (10.9)	*p* value*	<3.5101 (74.6)	≥3.5 35 (25.4)	*p* value*
Partner adhering to guideline for dairy, *n* (%)	8 (14.6)	5 (11.1)	0.61	8 (8.8)	8 (22.2)	0.04	12 (13.3)	1 (9.1)	0.69	12 (12.8)	4 (12.5)	0.97
Partner adhering to guideline for meat and alternatives, *n* (%)	21 (38.2)	13 (28.9)	0.33	36 (39.6)	12 (34.3)	0.59	31 (34.4)	4 (36.4)	0.90	16 (17.0)	32 (100.0)	<0.0001

Note: *p values from χ^2 tests or t tests.
[a]Number of participants varies due to missing data.
[b]Adherence to the guideline for bread and cereals was not included as only 0.8% of women adhered to the guideline.

large proportion of dietary intakes are not aligned with recommendations during pregnancy, with a high proportion also experiencing excessive gestational weight gain. Our findings suggest dietary intake of pregnant women is influenced by age, education levels, and pre-pregnancy BMI. An association exists between womens' and partners' dietary intake and their likelihood of alignment with national food and nutrient recommendations. This was particularly so in regard to fruit, vegetables, and meat and alternatives food groups.

Compared with the broader Australian population over the age of 18, pregnant women in our cohort were less likely to have overweight or obesity (Australian population: 29.6% and 30.1% versus Queensland Family Cohort 17.8% and 13.0%, respectively).[32] The pre-pregnancy BMI of the cohort is also lower than that documented for Queensland women; over 50% of women start pregnancy with a BMI above the healthy weight range.[33] A similar proportion of partners in the cohort had overweight, compared with the wider Australian population, however only a 17.6% had obesity compared with 32.5% of the population.[32]

The proportion of both women and their partners' intakes aligning with recommendations in the AGHE five core food groups for fruit intake per day were lower than the general Australian population's alignment.[34] The inverse was true for proportion meeting daily vegetable recommendations, with about three times as many women and eight times as many partners (males) meeting recommendations compared with the wider Australian population.[34] This pattern of (women's) fruit and vegetable intake is very similar to that recently reported in a study of 534 women surveyed using the same AES FFQ in their third trimester attending the John Hunter Hospital antenatal service (Newcastle, NSW, Australia).[10] The findings from our study are consistent with several other Australian and international studies that demonstrate poor alignment with vegetable, and cereal/grains recommendations.[35] Interestingly, apart from a slightly higher proportion of women meeting meat/alternatives guidelines in the John Hunter Hospital study compared with the Queensland Family Cohort (25.4% vs. 18.9%, respectively), the remainder of the women whose intake aligned with five core food group recommendations were extremely similar, including just ∼1% aligning with the guideline for cereals grains) intake and approximately one-third of energy intake contributed by non-core (junk) foods.[10] This is also reflected in the Queensland Family Cohort's partners' intake and the wider Australian population.[36]

This pattern of food group (core and energy-dense, nutrient-poor) is mirrored in the proportion of Queensland Family Cohort women and partners' alignment with

TABLE 5 Associations of partner characteristics with adherence to food-based dietary guidelines, $n = 129$[a]

	Bread and cereals servings/day *n* (%)			Fruit servings/day *n* (%)			Vegetables servings/day *n* (%)			Dairy servings/day *n* (%)			Meat and alternatives servings/day *n* (%)		
	<6102 (79.5)	≥6 27 (20.5)	*p* value*	<2 88 (68.5)	≥2 41 (31.5)	*p* value*	<6109 (85.0)	≥6 20 (15.0)	*p* value*	<2.5112 (86.7)	≥2.5 17 (13.3)	*p* value*	<3 80 (61.9)	≥3 49 (38.1)	*p* value*
Age (years), mean (*SD*)	33.8 (6.8)	35.1 (4.1)	0.38	33.7 (6.9)	35.0 (4.7)	0.32	34.1 (6.6)	33.9 (4.8)	0.88	33.7 (6.1)	36.6 (7.0)	0.07	33.3 (6.5)	35.5 (5.9)	0.06
Born in Australia or New Zealand, *n* (%)	72 (71.3)	17 (65.4)	0.56	62 (71.3)	27 (67.5)	0.67	73 (67.6)	16 (84.2)	0.15	74 (66.7)	15 (88.2)	0.07	57 (73.1)	31 (64.6)	0.31
Education level, *n* (%)			0.40			0.86			0.09			0.10			0.72
Up to year 12	11 (11.1)	4 (15.4)		11 (12.6)	4 (10.5)		12 (11.3)	3 (15.8)		15 (14.2)	1 (5.9)		8 (10.5)	7 (14.6)	
Certificate/diploma	74 (74.6)	16 (61.5)		63 (72.4)	27 (71.1)		80 (75.5)	10 (52.6)		79 (74.5)	11 (64.7)		57 (75.0)	33 (68.8)	
Postgraduate degree	14 (14.1)	6 (23.1)		13 (14.9)	7 (18.4)		14 (13.2)	6 (31.6)		15 (11.3)	5 (29.4)		11 (14.5)	8 (16.7)	
BMI (kg/m^2), mean (*SD*)	26.4 (3.9)	25.5 (3.4)	0.28	26.7 (4.2)	25.3 (2.8)	0.05	26.6 (3.9)	23.9 (2.5)	0.005	26.4 (3.7)	25.7 (4.4)	0.51	26.2 (3.6)	26.4 (4.2)	0.80
BMI category, *n* (%)			0.69			0.13			0.07			0.74			0.79
Underweight	2 (2.0)	1 (4.4)		3 (3.5)	1 (2.6)		2 (1.9)	1 (5.9)		2 (1.8)	1 (6.3)		2 (2.6)	1 (2.2)	
Normal weight	40 (39.6)	11 (47.8)		32 (37.2)	18 (47.4)		40 (37.4)	10 (58.8)		45 (41.3)	6 (37.5)		30 (39.0)	20 (43.5)	
Overweight	43 (42.6)	9 (39.1)		35 (40.7)	17 (44.7)		47 (43.9)	5 (29.4)		46 (42.2)	7 (43.8)		35 (45.5)	17 (37.0)	
Obesity	16 (15.8)	2 (8.7)		16 (18.6)	2 (5.3)		18 (16.8)	1 (5.9)		16 (14.7)	2 (12.5)		10 (13.0)	8 (17.4)	
Pre-exsting chronic condition, *n* (%)	7 (9.0)	2 (10.0)	0.89	4 (5.7)	5 (17.9)	0.06	7 (8.6)	2 (11.8)	0.69	8 (9.3)	1 (7.7)	0.85	5 (8.5)	3 (7.9)	0.92
Women adhering to guideline for fruit, *n* (%)	34 (41.0)	11 (64.7)	0.07	26 (36.6)	19 (65.5)	0.008	37 (42.1)	8 (66.7)	0.11	40 (46.0)	5 (38.5)	0.61	32 (48.5)	13 (38.2)	0.33
Women adhering to guideline for vegetables, *n* (%)	20 (19.8)	16 (61.5)	<0.0001	14 (16.1)	22 (55.0)	<0.0001	17 (15.7)	19 (100.0)	<0.0001	28 (25.2)	8 (50.0)	0.04	23 (29.5)	12 (25.0)	0.59
Women adhering to guideline for dairy, *n* (%)	9 (10.7)	2 (11.8)	0.90	9 (12.5)	2 (6.9)	0.41	11 (12.4)	1 (8.3)	0.20	10 (11.4)	1 (7.7)	0.69	7 (10.6)	4 (11.4)	0.90
Women adhering to guideline for meat and alternatives, *n* (%)	23 (23.0)	9 (34.6)	0.23	23 (26.4)	9 (23.1)	0.69	28 (25.9)	4 (22.2)	0.74	28 (25.5)	4 (25.0)	0.97	1 (1.3)	32 (66.7)	<0.0001

Note: *p values from χ^2 tests or t tests.

[a]Number of participants varies due to missing data.

acceptable micronutrient distribution range for macronutrients which is at the very lower end of the range for carbohydrates (45%–65%) and at or above the high end of the range for total fat (20%–35%).[30] Very similar macronutrients distributions were reported in the John Hunter Hospital cohort.[10] These intakes are slightly higher than those of the general Australian population for carbohydrate (~43%) and substantially lower for fat (~39%).[37] Fibre intakes of women and their partners were lower than recommendations (24.8 g/d and 28.8 g/d compared with recommendations of 28 g/d and 30 g/d, respectively),[30] with women's intake similar to the John Hunter Hospital cohort.[10] Further, the sub-optimal intake of foods aligned with the ADG is reflected in the low proportion of women meeting estimated average requirements, particularly for calcium, iodine, folic acid, and iron. The John Hunter Hospital cohort reported similar proportions for calcium and iron, but higher for folic acid (53.7%) and iodine (23.7%) and other Australian and international studies have reported similar patterns of insufficient intake.[10,35] Comparing partners' intakes with the broader population, proportions of calcium were similar; however, lower (but still high) intakes of iron, zinc, and folic acid intake were documented.[38]

Reinforcing the pattern of inadequate intake, the ARFS scores around 30 for women and their partners were lower than those recently documented in a from a survey of 93 252 Australians (76% female) which reported a mean ARFS score of 34.1 ± 9.7 (females 34.5 ± 9.3; males 33.1 ± 10.6)[39] and substantially lower than the maximum score of 73.[40]

Relationships between intake, BMI, and education in this cohort are expected, with higher vegetable intakes regularly documented to be associated with lower pre-pregnancy BMI and higher education levels.[35,41–43] While it has been documented that demographic characteristics of education, income, and BMI influences an individual's intake, less has been recorded regarding influences within a relationship, particularly during pregnancy.[41–43] However, it is known that spousal support influences other health behaviours, for example the initiation and maintenance of regular exercise.[44] Furthermore, the influences on family, particularly of children's eating patterns is also well known.[45] Understanding the mediators and moderators of dietary intake relationships observed in the current study, particularly the direction of influence within the dyad could be a powerful health promotion strategy. This is particularly salient due to the pregnancy public health strategy of folic acid and iodine supplementation in bread since 2009[46] and the contribution of these food groups to sufficient fibre intake.

Consistent with previous research, this study has again highlighted the high prevalence of gestational weight gain above recommendations across all pre-pregnancy BMI categories in Australian women.[47] This is concerning given this study cohort appears to have a lower representation of women with a pre-pregnancy BMI above the healthy range than the broader Queensland pregnant population[33] and therefore is likely an underestimate of the extent of excess gestational weight gain. These findings reinforce the need to ensure multilevel strategies are implemented to support healthy gestational weight gain with mechanisms to identify deviations from a healthy trajectory and provide early intervention.

This study has a number of strengths. Recruitment of pregnant woman-partner dyads provides a unique opportunity enabling investigation of associations between dietary behaviours, gestational weight gain, and participant characteristics. Further work is required to examine mediators and moderators of relationships observed in this study.

A limitation of this study included the dietary assessment as part of a larger cohort study utilising a battery of questionnaires and assessments,[24] hence contributing to a lower completion of the FFQ from within the wider cohort. Further, the FFQ was not repeated across pregnancy to reduce participant burden so changes to macro and micronutrient intake was not captured. Despite some studies suggesting stability of dietary intake across pregnancy,[48] lack of multiple data collection points across pregnancy and the postnatal period precludes potential analyses regarding associations between dietary patterns, biological measures, and outcomes within and beyond pregnancy as is the goal of the wider cohort study.[24] Repeated dietary intake assessment, at a minimum, at the end of each trimester and within the postnatal period would be recommended to account for impact of morning sickness (early), satiety (late), development of conditions that change dietary intake (gestational diabetes mellitus), and/or educational interventions. An additional study limitation is the use of the AES FFQ and ARFS tool. Despite being previously used in pregnant women in Australia,[10,48–50] it has not been validated in these populations. Furthermore, the dietary analysis only considered intakes of foods and not supplements which may result in under-reporting of various nutrients, particularly folic acid, iodine, and iron. It is suggested that dietary intake assessment in the larger study is achieved through administration of the AES online (~15 min) and/or a blended assessment with a smart-phone-image-based dietary assessment method (validated for use with pregnant women).[51,52] Self-reported pre-pregnancy weight was used to calculate pre-pregnancy BMI. While this method is common in studies examining relationships with pre-pregnancy weight and BMI,[16,53] with a

high correlation with measured weight prior to pregnancy,[54] under and overreporting that results in misclassification cannot be eliminated.

Despite recruitment being designed to ensure the cohort was representative of the Queensland population, with efforts made to invite all eligible individuals, including those from non-English speaking backgrounds, <18 years of age, with special needs and First Nation community members, and participants with underlying serious or chronic health conditions, the sample had a lower BMI, was older and more educated than the wider pregnant and non-pregnant Australian population. A further limitation of this study is the small sample size and lack of power, particularly to examine subgroup analysis such as gestational weight gain adherence. However, it should be recognised this was a pilot study with the aim to inform the methodologies for a larger study.

In addition to the potential adaptations to the larger cohort study methodology, the findings of this study suggest the translation of antenatal-nutrition science evidence into clinical and public health policy and practice remains inadequate. Strong calls have been made for Australian nutrition practice guidelines for maternal health.[55,56]

In the current cohort of pregnant women and their partners, we have documented sub-optimal intakes of all foods and nutrients, reflecting the wider Australian population and comparable pregnant populations. A relationship exists between pre-pregnancy BMI and women's attainment of gestational weight gain guidelines. Future research should investigate mediators and moderators of dietary intake between women and their partners. There is an urgent need for evidence-informed public health policy and programs to improve diet quality during pregnancy due to its intergenerational effects.

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CONFLICTS OF INTEREST

Shelley Wilkinson and Helen Truby are Associate Editors of Nutrition & Dietetics. They were excluded from the peer review process and all decision-making regarding this article. This manuscript has been managed throughout the review process by the Journal's Editor-in-Chief. The Journal operates a blinded peer review process and the peer reviewers for this manuscript were unaware of the authors of the manuscript. This process prevents authors who also hold an editorial role to influence the editorial decisions made. The other authors declare no other conflicts of interest. No funding was received for undertaking the preparation, analysis, or writing of this study; funders did not influence the plan, analysis, or content of this paper. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

AUTHOR CONTRIBUTIONS

All authors are members of the QFC research collaborative and contributed to study variables that were collected and discussions regarding study design. All authors contributed to planning of the paper, data interpretation, critical manuscript review, and writing. SAW led the writing of the paper, with significant inputs from DAJMS, SdJ, and CEC. DAJMS undertook data analysis.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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REFERENCES

1. Heindel J, Vandenberg L. Developmental origins of health and disease: a paradigm for understanding disease cause and prevention. *Curr Opin Pediatr*. 2015;27:248-253.
2. Callaway LK, Prins JB, Chang AM, McIntyre HD. The prevalence and impact of overweight and obesity in an Australian obstetric population. *Med J Austral*. 2006;184(2):56-59.
3. Goldstein RF, Abell SK, Ranasinha S, et al. Association of gestational weight gain with maternal and infant outcomes: a systematic review and meta-analysis. *JAMA*. 2017;317(21):2207-2225.
4. Fleming T, Watkins A, Velazquez M, et al. Origins of lifetime health around the time of conception: causes and consequences. *Lancet*. 2018;391:1842-1852.
5. Nassan F, Chavarro J, Tanrikut C. Diet and men's fertility: does diet affect sperm quality? *Fertil Steril*. 2018;110:570-577.
6. Murugappan G, Li S, Leonard S, Winnm V, Druzin M, Eisenberg M. Association of preconception paternal health and adverse maternal outcomes among healthy mothers. *AJOG*. 2021;3:100384. 10.1016/j.ajogmf.2021.100384
7. Eberle C, Kirchner M, Herden R, Stichling S. Paternal metabolic and cardiovascular programming of their offspring: a systematic scoping review. *PLoS ONE*. 2020;15(12):e0244826.
8. de Jersey SJ, Nicholson JM, Callaway LK, Daniels LA. An observational study of nutrition and physical activity behaviours, knowledge, and advice in pregnancy. *BMC Pregnancy Childbirth*. 2013;13:115.
9. Mishra G, Schoenaker D, Mihrshahi S, Dobson A. How do women's diets compare with the new Australian dietary guidelines? *Public Health Nutr*. 2015;18(2):218-225.
10. Slater K, Rollo M, Szewczyk Z, Ashton L, Schumacher T, Collins C. Do the dietary intakes of pregnant women attending

public hospital antenatal clinics align with Australian guide to healthy eating recommendations? *Nutrients*. 2020;12(8):2438.
11. Blumfield M, Hure A, Macdonald-Wicks L, Patterson A, Smith R, Collins C. Disparities exist between national food group recommendations and the dietary intakes of women. *BMC Womens Health*. 2011;11:37.
12. Blumfield M, Hure A, Macdonald-Wicks L, et al. The association between the macronutrient content of maternal diet and the adequacy of micronutrients during pregnancy in the women and their children's health (watch) study. *Nutrients*. 2012;4:1958-1976.
13. McKenna E, Hure A, Perkins A, Gresham E. Dietary supplement use during preconception: the Australian longitudinal study on Women's health. *Nutrients*. 2017;9:1119.
14. Nguyen P, Frongillo E, Sanghvi T, et al. Engagement of husbands in a maternal nutrition program substantially contributed to greater intake of micronutrient supplements and dietary diversity during pregnancy: results of a cluster-randomized program evaluation in Bangladesh. *J Nutr*. 2018;148(8):1352-1363.
15. Fowles E, Murphey C, Ruiz R. Exploring relationships among psychosocial status, dietary quality, and measures of placental development during the first trimester in low-income women biological research for. *Nursing*. 2011;13(1):70-79.
16. de Jersey SJ, Nicholson JM, Callaway LK, Daniels LA. A prospective study of pregnancy weight gain in Australian women. *Austral New Zealand J Obstetr Gynaecol*. 2012;52:545-551.
17. Wilkinson S, Donaldson E, McCray S. Re-evaluating the nutritional awareness, knowledge and eating behaviours of women attending a tertiary maternity hospital following iterative service design. *Nutr Diet*. 2018;75(4):372-380.
18. Schumacher T, Weatherall L, Keogh L, et al. Reprint of characterizing gestational weight gain in a cohort of Indigenous Australian women. *Midwifery*. 2019;74:148-156.
19. Blumfield M, Schreurs M, Rollo M, MacDonald-Wicks L, Kokavec A, Collins C. The association between portion size, nutrient intake and gestational weight gain: a secondary analysis in the WATCH study 2006/7. *J Hum Nutr Diet*. 2015;29(3):271-280.
20. Barnes R, Wong T, Ross G, et al. Excessive weight gain before and during gestational diabetes mellitus management: what is the impact? *Diabetes Care*. 2019;43:74-81.
21. Fealy S, Attia J, Leigh L, et al. Demographic and social-cognitive factors associated with gestational weight gain in an Australian pregnancy cohort. *Eating Behav*. 2020;39:101430.
22. Schoenaker D, de Jersey S, Willcox J, Francois M, Wilkinson S. Prevention of gestational diabetes: the role of dietary intake, physical activity and weight before, during and between pregnancies. *Semin Reprod Med*. 2021;38:352-365. doi:10.1055/s-0041-1723779
23. Kingsbury A, Gibbons K, McIntyre H, et al. How have the lives of pregnant women changed in the last 30 years? *Women Birth*. 2017;30(4):342-349.
24. Borg D, Rae K, Fiveash C, et al. Queensland Family Cohort: a study protocol. *BMJ Open*. 2021;11:e044463. doi:10.1136/bmjopen-2020-044463
25. Collins C, Burrows T, Rollo M, 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.
26. Australian Bureau of Statistics. National Nutrition Survey: Nutrient Intakes and Physical Measurements. Australian Bureau of Statistics; Canberra, Australia, 1998.
27. Food Standards Australia and New Zealand. Ausnut 2011–13–- Australian Food Composition Database Kingston, ACT, Australia FSANZ; 2014. http://foodstandards.gov.au/
28. Ashton L, Williams R, Wood L, et al. Comparison of Australian recommended food score (ARFS) and plasma carotenoid concentrations: a validation study in adults. *Nutrients*. 2017;9(8):888.
29. National Health and Medical Research Council. *Australian Dietary Guidelines: Eat for Health*. National Health and Medical Research Council; 2013.
30. National Health and Medical Research Council, Ministry of Health. Nutrient Reference Values 2020. Accessed June 1, 2021. https://www.nrv.gov.au.
31. Institute of Medicine. *Weight Gain During Pregnancy: Reexamining the Guidelines*. The National Academies Press; 2009.
32. Australian Bureau of Statistics. Health conditions and risks Canberra: ABS; 2018. Accessed June 29, 2021. https://www.abs.gov.au/statistics/health/health-conditions-and-risks.
33. Queensland Health. Perinatal Data Collection Queensland: Queensland Health; 2020. Accessed June 29, 2021. https://www.health.qld.gov.au/hsu/collections/pdc.
34. Australian Bureau of Statistics. Dietary Behaviour Canberra: ABS; 2018. Accessed June 29, 2021. https://www.abs.gov.au/statistics/health/health-conditions-and-risks/dietary-behaviour/2017-18.
35. Caut C, Leach M, Steel A. Dietary guideline adherence during preconception and pregnancy: a systematic review. *Matern Child Nutr*. 2020;16(2):e12916.
36. Australian Bureau of Statistics. Australian Health Survey: Nutrition First Results - Foods and Nutrients Canberra ABS; 2014. Accessed June 29, 2021. https://www.abs.gov.au/statistics/health/health-conditions-and-risks/australian-health-survey-nutrition-first-results-foods-and-nutrients/latest-release#discretionary-foods.
37. Australian Bureau of Statistics. Apparent Consumption of Selected Foodstuffs, Australia Canberra: ABS; 2020. Accessed June 29, 2021. https://www.abs.gov.au/statistics/health/health-conditions-and-risks/apparent-consumption-selected-foodstuffs-australia/2019-20#dietary-energy.
38. Australian Bureau of Statistics. Australian Health Survey: Usual Nutrient Intakes Canberra: ABS; 2015. Accessed June 29, 2021. https://www.abs.gov.au/statistics/health/health-conditions-and-risks/australian-health-survey-usual-nutrient-intakes/latest-release#essential-minerals.
39. Williams R, Rollo M, Schumacher T, Collins C. Diet quality scores of Australian adults who have completed the healthy eating quiz. *Nutrients*. 2017;9(8):880.
40. Collins C, Young A, Hodge A. Diet quality is associated with higher nutrient intake and self-rated health in mid-aged women. *J Am Coll Nutr*. 2008;27(1):146-157.
41. te Velde S, Twisk J, Brug J. Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight. *The Brit J Nutr*. 2007;98(2):431-438.
42. Giskes K, Turrell G, Patterson C, Newman B. Socio- economic differences in fruit and vegetable consumption among Australia adolescents and adults. *Public Health Nutr*. 2002;5(5):663-669.

43. Nour M, Lutze S, Grech A, Allman-Farinelli M. The relationship between vegetable intake and weight outcomes: a systematic review of cohort studies. *Nutrients*. 2018;10(11):1626.
44. Miller Y, Trost S, Brown W. Mediators of physical activity behavior change among women with young children. *Am J Prev Med*. 2002;23:98-103.
45. Kirby S, Baranowski T, Reynolds K, Taylor G, Binkley D. Children's fruit and vegetable intake: socioeconomic, adult-child, regional, and urban-rural influences. *J Nutr Educ Behav*. 1995; 27(5):261-271.
46. Australian Institute of Health and Welfare. Folic Acid and Iodine Fortification. 2016. Accessed June 29, 2021. https://www.aihw.gov.au/reports/food-nutrition/folic-acid-iodine-fortification/contents/summary.
47. Cheney K, Berkemeier S, Sim K, Gordon A, Black K. Prevalence and predictors of early gestational weight gain associated with obesity risk in a diverse Australian antenatal population: a cross-sectional study. *BMC Pregnancy Childbirth*. 2017;17:296.
48. Lee Y, Collins C, Schumacher T, et al. Disparities exist between the dietary intake of Indigenous Australian women during pregnancy and the Australian dietary guidelines: the *Gomeroi gaaynggal* study. *J Hum Nutr Diet*. 2019;32(4):473-485.
49. Lee Y, Lumbers E, Schumacher T, Collins C, Rae K, Pringle K. Maternal diet influences fetal growth but not fetal kidney volume in an Australian indigenous pregnancy cohort. *Nutrients*. 2021;13(2):569.
50. Ashman A, Collins C, Weatherall L, et al. A cohort of indigenous Australian women and their children through pregnancy and beyond: the *Gomeroi gaaynggal* study. *J Develop Origins Health Disease*. 2016;7(4):357-368.
51. Ashman A, Collins C, Brown L, Rae K, Rollo M. A brief tool to assess image-based dietary records and guide nutrition counselling among pregnant women: an evaluation. *JMIR Mhealth Uhealth*. 2016;4(4):e123.
52. Ashman A, Collins C, Brown L, Rae K, Rollo M. Validation of a smartphone image-based dietary assessment method for pregnant women. *Nutrients*. 2017;9(1):73. doi:10.3390/nu9010073
53. Headen I, Cohen A, Mujahid M, Abrams B. The accuracy of self-reported pregnancy-related weight: a systematic review. *Obes Rev*. 2017;18(3):350-369.
54. Oken E, Taveras E, Kleinman K, Rich-Edwards J, Gillman M. Gestational weight gain and child adiposity at age 3 years. *Am J Obstet Gynecol*. 2007;196(322):e1-e8.
55. Miller M, Hearn L, van der Pligt P, Willcox J, Campbell K. Preventing maternal and early childhood obesity: the fetal flaw in Australian perinatal care. *Aust J Prim Health*. 2014;20:123-127.
56. Wilkinson S, Donaldson E, Willcox J. Nutrition and maternal health: a mapping of Australian dietetic services. *BMC Health Serv Res*. 2020;20:660.

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ORIGINAL RESEARCH

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Patterns of discretionary food intake among Australian children and their association with socio-demographic, lifestyle, and adiposity measures

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Abstract

Aim: Australian children consume 35% of energy from discretionary food and beverages which increases their risk of non-communicable diseases like type 2 diabetes. Despite this concerning statistic, broad analysis of the profile of discretionary food intake has not been fully undertaken. This study asks: what is the discretionary food and beverage intake profile, contribution to nutrient intakes, and associations with demographic and health characteristics?

Methods: Cross-sectional data from the 2011–12 National Nutrition and Physical Activity Survey ($n = 2812$, 2–18 years) were used to profile discretionary food consumption. Dietary intake was assessed by 24-h recall. General linear models tested the difference in respondent characteristics by age group, sex, and quartiles of discretionary food energy contribution.

Results: Ninety-nine percent of respondents consumed discretionary foods, 74% exceeded the maximum discretionary food recommended serves. Among 10 eating occasions available to select: snack, dinner, lunch and morning tea appeared to contribute 76% of discretionary food energy, with snack and dinner contributing 24% each. Age and frequency of discretionary food consumption were positively associated with energy intake from discretionary foods ($p < 0.001$); while sex, socio-economic status, physical activity and body composition had no association. High discretionary food consumers chose specific discretionary food items in a large quantity (1.0–3.5-serves/discretionary food) compared to low discretionary food consumers (0.4–1.4-serves/discretionary food).

Conclusions: Nearly all Australian children and adolescents consumed discretionary food daily. No demographic or anthropometric characteristics beyond increasing age were associated with higher discretionary food.

Targeted public health policy and community interventions are required to focus on addressing the largest contributors to discretionary food intake in terms of equivalent serve sizes, popularity, and eating occasion.

KEYWORDS
adolescent, children, diet, nutrient intake, population health

1 | INTRODUCTION

Poor diet quality is one of the leading contributors to the rise of non-communicable diseases in children and adolescents globally.[1] In Australia, 400 children and adolescents are diagnosed with type 2 diabetes each year and one in ten have elevated blood pressure.[2,3] Of concern, non-communicable diseases which are prevalent in children adversely affect growth, development, and maturation leading to compromised health in adulthood and reduced life expectancy.[4,5]

The Australian Dietary Guidelines provide recommendations for food and beverage intake to ensure the optimal growth and development of Australians, including children and adolescents.[6] The Australian Dietary Guidelines encourage eating from the five core food groups, where non-core foods and beverages, referred to as discretionary foods and beverages, are not required to provide essential nutrition and are high in saturated fat, added sugars, added salt, or alcohol, and low in dietary fibre.[6] The Australian Dietary Guidelines acknowledge discretionary foods and beverages may contribute to the enjoyment of eating, but should be limited. For children or inactive adolescents the recommended maximum discretionary foods and beverages serves are 0–½-serves/day; and 0–2½-serves/day for highly active boys older than 4 years, girls older than 9 years, and adolescents.[6] A serve of discretionary foods and beverages is defined as contributing 600 kJ; e.g., 2 scoops of ice-cream, one tablespoon of honey or butter, one can of soft-drink, or 12 hot chips. Consumption beyond the recommended maximum discretionary foods and beverages serves not only contributes to excessive energy intake but also displaces core foods and therefore essential nutrients.[7]

Due to complex socio-economic, historical, environmental, and political factors which affect the Australian food supply and culture, in 2011–12 Australian children and adolescents consumed approximately 35% of their energy intake from discretionary foods and beverages.[8–11] Brief health surveys conducted in 2012, 2015, and 2018 revealed a slight increase in the number of children aged 2–18 years meeting recommendations for fruit and vegetables (4.8, 5.1 and 6.0% respectively), but the numbers remained low. Similarly, only a minimal drop in the proportion of children consuming sugar-sweetened drinks (2.2% decrease) was observed.[12] Despite these concerning statistics, a broad analysis of discretionary foods and beverages intake profile of Australian children and adolescents has not been undertaken. A deeper understanding of discretionary foods and beverages intakes and their associations with sociodemographics and non-communicable disease risk factors may provide an opportunity for more relevant and targeted public health policy and community- or school-level interventions, as well as opportunities to intervene at the individual level.

In the latest nationally-representative sample of Australian children and adolescents diets (2011–2012), this study asks: what are the discretionary foods and beverages intake profile, contribution to nutrient intakes, and associations with sociodemographic and health characteristics? While an analysis of children and adolescents' discretionary food intake using national-level data has been previously reported,[13] the current study expands on the earlier findings by reporting the contribution of eating occasions to discretionary foods and beverages consumption and comparing results with the Australian recommendations. Further, associations between discretionary foods and beverages consumption with sociodemographic and health characteristics are examined.

2 | METHODS

This cross-sectional study has been reported according to the Strengthening the Reporting of Observational Studies in Epidemiology checklist for cross-sectional studies.[14] Data were collected under the Census and Statistics Act 1905; thus, ethical approval was not required.

The 2011–12 National Nutrition and Physical Activity Survey was conducted by the Australian Bureau of Statistics on a nationally-representative sample of 12 153 Australians aged 2 years and over.[15] Trained interviewers used the Automated Multiple-Pass Method to capture all foods and beverages consumed by respondents (either the children/adolescents or their primary caregiver) within the 24-hours prior to the interview day. The majority of recalls (84%) were collected from primary caregivers depending on child's age. Children aged

15–17 years were interviewed directly. Total energy and nutrient intakes were derived from the Food Standards Australia New Zealand customised nutrient composition database (AUSNUT).[16] Data from the first 24-h recall among 2812 respondents aged 2–18 years were utilised.

The Australian Bureau of Statistics categorised food groups in the survey as discretionary foods and beverages or non- discretionary foods and beverages based on Australian Dietary Guidelines' definitions.[6] Foods were primarily classified at the minor food group level (5-digit), and where it was not possible to determine if it was discretionary at this level, the unique food code level (8-digit) was used along with the nutrient profiling cut-offs used in the Australian Dietary Guidelines modelling document.[17] Discretionary food and beverage groups in this study were reported at the sub-major food group level (3-digit). There were a total of 132 sub-major food groups in the AUSNUT database, and 60 of these food groups contained a discretionary foods and beverages (hereon in described as discretionary foods and beverages group). The sub-group name is used to refer to foods in those food groups that are discretionary. For example, 'potatoes' only refers to discretionary potatoes, e.g., hot chips.

For the top 20 discretionary foods and beverages groups, the prevalence, mean serves, and mean grams consumed among consumers of the food group (99% of respondents), percent contribution of the food group to total discretionary foods and beverages energy, and the per capita percent contribution of each discretionary foods and beverages group to total sugars (naturally occurring sugars and added sugars combined), saturated fat, and sodium were calculated. Mean daily energy intake, energy intake from discretionary foods and beverages, the proportion of total energy intake from discretionary foods and beverages, and the mean serves of discretionary foods and beverages per day (1-serve = 600 kJ) were calculated. The proportion of energy intake from discretionary foods and beverages was calculated by using total daily energy intake. The quartiles of the percent energy contribution from discretionary foods and beverages were calculated and used to define low consumers as quartile one and high consumers as quartile four.

As part of the survey, respondents were asked to identify the name of their reported eating occasion as well as the time they began consuming each food or beverage. The available eating occasion options in the survey were: breakfast, morning tea, brunch, lunch, afternoon tea, dinner, supper, snack, beverage/drink, extended consumption, or other, and were chosen by participants, and were irrespective of time of day. An eating occasion was further defined as the consumption of one or more foods or beverages at the same time. The proportion of eating occasions at which a discretionary foods and beverages was consumed and the percent contribution of each eating occasion to total discretionary foods and beverages energy were calculated. Among the top four eating occasions that contributed the most to daily discretionary foods and beverages energy, the top five sub-major food groups, the percent of total discretionary foods and beverages energy that it contributed at the eating occasion, and the mean energy intake among consumers of the food group were calculated.

Respondents were classified by age group (2–3, 4–8, 9–13, and 14–18 years), sex, socio-economic status, physical activity level, adiposity measures, and usual fruit and vegetable serves. The Socio-Economic Indexes for Areas (SEIFA),[18] that ranks areas in Australia into quintiles according to relative socio-economic advantage or disadvantage using postcode, was used to define socio-economic status. Physical activity was the amount of physical activity each respondent reported that they undertook in the week prior to the survey. For children aged 2-4-years, physical activity included any active play or movement such as free play in a playground or tidying up. The total number of minutes of physical activity was recorded, with one session equivalent to 30-minutes of moderate-intensity physical activity. The amount of time spent sitting or lying down for school, transport, and leisure during the week prior to the survey was also self-reported by respondents. Respondents were classified based on the duration and number of sessions of physical activity into three categories: inactive, insufficiently active, or sufficiently active for health.[19]

Physical measurements including weight, height, and waist circumference were measured for all respondents by trained interviewers. Body mass index (BMI) z-score, also known as BMI standard deviation (SD) score, is a measure of relative weight adjusted for age and sex. The BMI z-score was calculated using the respondents' age, sex, height, and weight; and the World Health Organization growth reference standards for 2–4 and 5–19-year-old children.[20] The standard normal distribution was then calculated for all respondents' BMI z- scores. This was used to categorise children into three BMI percentile categories: <85% (recommended BMI), ≥85% to <95%, or ≥95%. Each respondent's waist circumference to height ratio was calculated and categorised as <0.5 (recommended ratio) or ≥0.5, reflecting cardiometabolic risk.[21] Respondents were asked to specify the usual number of fruit and vegetable serves consumed per day from the following options: do not eat fruit/vegetables, ≤1-serve, 1-serve, 2-serves, 3-serves, 4-serves, 5-serves, or ≥6-serves. To determine the mean number of serves, 'don't eat fruit/vegetables' was defined as 0, '≤1 serve' as 0.5, and '≥ 6-serves' as 6.

This study used energy intake (EI) to basal metabolic rate (BMR) ratio (EI:BMR) to calculate under-reporters as respondents with implausibly low intakes. Respondents were classified as under-reporters or not under-reporters based on the Goldberg[22] cut-off limit of 0.9 for EI:BMR, which is the lower 95% confidence limit for a single day of data for a single individual, allowing for day-to-day variation in energy intakes, and errors in calculation of EI:BMR.

The statistical package IBM SPSS, version 23.0[23] (IBM Corp.,) was used for all analyses. Due to the large sample size and the number of tests, p-values <0.001 were treated as significant. The data were weighted using proportional weights so that the sum of the weights was the same as the overall sample size; all results presented in this paper are based on weighted analyses. Descriptive summaries were calculated for all variables of interest. General linear models were used to investigate the difference in respondent characteristics by age group, sex, and quartiles of discretionary foods and beverages energy contribution, and post hoc pairwise comparisons using the Bonferroni correction were performed to show pairwise significance between quartiles of discretionary foods and beverages energy contribution. The main effects of the factors were included, together with the interaction of age and sex. To compare group differences for categorical variables, the Pearson chi-square test was carried out.

3 | RESULTS

Almost all of the 2812 children and adolescents consumed discretionary foods and beverages on the day of the survey (99%) and 74% of the respondents exceeded the discretionary foods and beverages serve recommendations (Table 1). Between 70% and 80% of all sex and age groups exceeded the serving recommendation, except for the sex and age group females 4-8-years (88%) and males 14–18-years (54%). The mean intake was 5.1 discretionary foods and beverages serves per day. For all respondents aged ≥4-years, males had a higher discretionary foods and beverages intake and a higher proportion of energy from discretionary foods and beverages for several age groups; however, more females exceeded discretionary foods and beverages serves across all age groups than males (Table 1).

More than a third of daily energy intake came from discretionary foods and beverages for all age and sex groups with the exception of children aged 2-3-years, where it was just under 30% (27.6 ± 1.4% for males, 29.5% ± 1.6% for females). For each age group, the number of total eating occasions and the proportion of eating occasions at which a discretionary foods and beverages was consumed were similar between males and females. Overall, more than half of all eating occasions contained discretionary foods and beverages (55.6 ± 0.4%).

Among discretionary foods and beverages consumers, the top five discretionary foods and beverages food groups ranked by their contribution to daily discretionary foods and beverages energy intake were: cakes, muffins, scones, cake-type desserts (9.4%); sweet biscuits (7.2%); pastries (6.6%); potatoes (6.2%); and frozen milk products (5.8%). The lowest ranked were butters (1.5%); fish and seafood products (1.6%), and other confectionary (1.8%) (Table S1, supplementary material). Three discretionary foods and beverages food groups (mixed dishes where cereal is the major ingredient e.g. pizzas, burgers, sushi; cakes, muffins, scones, cake-type desserts; and pastries) were consumed in large quantities (3.5, 3.0 and 2.6 discretionary foods and beverages serves, respectively) but were not among the top five food groups when ranked by popularity. In contrast, sweet biscuits and frozen milk products were consumed in relatively small quantities (1.1 and 1.4 discretionary foods and beverages serves, respectively) but were both among the five most popular discretionary foods and beverages food groups.

The top five food groups ranked by popularity (sweet biscuits; soft-drinks, and flavoured mineral waters; sugar, honey and syrups; processed meat; frozen milk products) had between 20.5% and 31.0% consumers, with a mean quantity of around ≤1-serves per consumer (Table S1, supplementary material). Of the top 20 discretionary food groups; soft-drinks and flavoured mineral waters contributed the most to free sugars; sweet biscuits the most to saturated fat; and processed meat the most to sodium (Table S1, supplementary material).

The top four eating occasions by contribution to total discretionary energy were: snack, dinner, lunch, and morning tea; together they contributed 76% of discretionary foods and beverages energy with snack and dinner contributing 24% each (Table 2). The top food groups at snack, dinner, lunch, and morning tea were: chocolate and chocolate-based confectionary (14%), potatoes (12%), pastries (13%), and cakes, muffins, scones, cake-type desserts (21%), respectively.

As well as being the top contributor to morning tea discretionary foods and beverages intake, cakes, muffins, scones, cake-type desserts was among the top five contributors to snack (3rd) and to lunch (5th). Other food groups that were top discretionary foods and beverages contributors in two different eating occasions were sweet biscuits (2nd-highest contributor to snack and morning tea), potatoes (highest contributor to dinner and 2nd-highest to lunch), mixed dishes where cereal is the major

TABLE 1 Discretionary food and beverage intake characteristics of 2812 children and adolescents 2–18 years from the 2011–12 National Nutrition and Physical Activity Survey

	2–3 y				4–8 y				9–11 y				12–13 y				14–18 y				All respondents 2–18 y	
	M		F		M		F		M		F		M		F		M		F			
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Exceeded DF servings[a]	135	78.0	125	79.1	306	73.2	343	87.9	194	75.5	201	79.1	145	73.2	141	73.4	208	53.5	281	73.4	2079	73.9
Prevalence of consumers by DF servings																						
Non-consumers	5	2.9	5	3.0	1	0.3	7	1.8	1	0.4	0	0.0	4	2.0	5	2.6	4	1.1	8	2.0	40	1.4
>0–1[b]	33	19.4	29	18.4	39	9.3	43	10.9	14	5.4	13	5.1	11	5.6	12	6.2	22	5.8	34	8.9	249	8.9
>1–3	61	35.1	70	44.2	102	24.3	119	30.5	50	19.5	40	15.8	38	19.2	48	24.9	69	17.8	85	22.3	682	24.3
>3–5	45	26.0	21	13.4	115	27.5	119	30.6	74	28.8	70	27.7	37	18.7	54	28.0	86	22.2	88	23.0	710	25.3
>5	29	16.5	33	20.9	162	38.7	102	26.2	118	45.9	130	51.4	108	54.5	74	38.3	207	53.2	167	43.7	1130	40.2
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
DF servings	2.9	0.2	3.1	0.2	4.9	0.2	3.9	0.1	5.7	0.2	5.6	0.2	6.2	0.3	5.0	0.3	6.9	0.3	5.5	0.2	5.1	0.1
Energy intake (MJ)	6.0	0.2	5.9	0.2	7.6	0.1	6.4	0.1	8.9	0.2	8.1	0.2	9.6	0.3	7.8	0.2	10.2	0.2	8.1	0.2	8.0	0.1
Energy from DF (%)	27.6	1.4	29.5	1.6	37.3	1.0	34.8	0.9	37.9	1.3	40.0	1.2	37.8	1.4	37.6	1.5	38.8	1.1	38.1	1.1	36.6	0.4
EO	7.5	0.2	7.8	0.2	7.1	0.1	7.1	0.1	7.3	0.1	7.1	0.1	6.8	0.1	6.8	0.2	6.2	0.1	6.2	0.1	6.9	0.0
EO with DF	3.4	0.1	3.3	0.1	3.9	0.1	3.8	0.1	4.3	0.1	4.2	0.1	3.9	0.1	3.6	0.1	3.6	0.1	3.4	0.1	3.8	0.0
EO with DF (%)	46.5	1.6	44.3	1.7	55.5	1.0	55.3	1.1	58.6	1.1	59.3	1.1	57.9	1.5	54.1	1.6	59.0	1.1	56.3	1.1	55.6	0.4

Abbreviations: DF, discretionary foods and beverages; EO, eating occasion; F, females; M, males; MJ, mega joules; SE, standard error; y, years.

[a]Maximum recommended DF serves: 2–3y boys 1 serving, 2–3y girls 1 serving, 4–8y boys 2.5 servings, 4–8y girls 1 servings, 9-11y boys 3 servings, 9-11y girls 3 servings, 12-13y boys 3 servings, 12-13y girls 2.5 servings, 14–18y boys 5 servings, 14–18y girls 2.5 servings.

[b]Includes those who consumed discretionary foods or beverages that do not contain energy, such as diet or zero calorie soft drinks.

TABLE 2 Top four reported eating occasions[a] that contributed the most to total discretionary food and beverage energy intake and the top five sub-major food groups by per cent contribution to discretionary energy at each reported eating occasion among 2812 children and adolescents aged 2–18 years from the 2011–12 National Nutrition and Physical Activity Survey

	Snack 23.9% of total DF energy			Dinner 23.8% of total DF energy			Lunch 19.6% of total DF energy			Morning tea 8.8% of total DF energy		
Rank	Sub-major food group[b]	Contribution to total DF energy at the EO (%)	kJ among consumers of the food group (mean)	Sub-major food group	Contribution to total DF energy at the EO (%)	kJ among consumers of the food group (mean)	Top sub-major food group	Contribution to total DF energy at the EO (%)	kJ among consumers of the food group (mean)	Sub-major food group	Contribution to total DF energy at the EO (%)	kJ among consumers of the food group (mean)
1	Chocolate and chocolate-based confectionery	13.9%	811	Potatoes	12.2%	868	Pastries	13.3%	1475	Cakes, muffins, scones, cake-type desserts	20.5%	1651
2	Sweet biscuits	12.9%	600	Sausages, Frankfurts and saveloys	11.6%	1373	Potatoes	10.6%	1123	Sweet biscuits	18.1%	564
3	Cakes, muffins, scones, cake-type desserts	12.2%	1648	Mixed dishes where cereal is the major ingredient[c]	11.0%	2350	Mixed dishes where cereal is the major ingredient	7.4%	2025	Muesli or cereal style bars	13.0%	532
4	Frozen milk products	10.5%	786	Pastries	9.8%	1442	Cakes, muffins, scones, cake-type desserts	7.4%	1690	Potato snacks	8.4%	608
5	Potato snacks	8.1%	744	Frozen milk products	8.7%	787	Processed meat	6.7%	220	Savoury biscuits	7.6%	770

Abbreviations: DF, discretionary foods and beverages; EO, eating occasion.

[a]The remaining 23.8% of DF consumption came from breakfast 7.4%, brunch 0.5%, afternoon tea 7.4%, supper 2.0%, beverage/drink 4.5%, extended consumption 1.7%, and other 0.3%.

[b]The sub-group name is used to refer to foods in those food groups that are discretionary. For example, 'potatoes' only refers to discretionary potatoes, e.g., hot chips.

[c]Includes foods such as sandwiches, burgers, wraps, sushi, pizzas.

ingredient (3rd-highest contributor to dinner and lunch), and pastries (4th-highest contributor to dinner and highest contributor to lunch) (Table 2).

The contribution of discretionary foods and beverages to total daily energy in quartile 1 (low consumers) ranged between 0–21% and between 50–100% in quartile 4 (high consumers) (Table 3). High consumers of discretionary foods and beverages were older; 6.7% of those aged 2–3-years were high consumers compared to 66.2% of those aged 9–18-years ($p < 0.001$). There were no significant differences between sex, socio-economic status, physical activity, BMI z-score, or waist-to-height ratio groups and quartiles of energy intake from discretionary foods and beverages. There was also no significant association between prevalence of under-reporting and quartile of discretionary foods and beverages intake.

Based on general linear models adjusted for age, sex, and their interaction, total daily energy and discretionary foods and beverages energy intake increased with increasing quartile of discretionary foods and beverages intake ($p < 0.001$) (Table 4). The number of daily eating occasions did not differ by quartile of discretionary foods and beverages intake, but high discretionary foods and beverages consumers had almost double the number of eating occasions that contained discretionary foods and beverages compared to low consumers ($p < 0.001$). Similarly, the proportion of eating occasions at which discretionary foods and beverages was consumed increased from 37.4% among low consumers to 66.9% among high consumers ($p < 0.001$).

Self-reported usual daily fruit serves were higher among low (2.2 ± 0.0 serves) compared to high (1.8 ± 0.0 serves) discretionary foods and beverages consumers ($p < 0.001$) but were not significantly different to consumption by children from quartile 2 or quartile 3. Self-reported usual daily vegetable serves were higher among low consumers (2.1 ± 0.0 serves) compared to children in all other quartiles (1.8 ± 0.0 serves) ($p < 0.001$).

All but one food group in the top five discretionary foods and beverages groups ranked by their contribution to discretionary foods and beverages energy among low consumers were different to those among high consumers (Table 5). Soft-drinks and flavoured mineral waters was the second-top contributor among low consumers and fifth-top among high consumers. The top five discretionary foods and beverages groups among low consumers were all among the top five most popular discretionary foods and beverages groups among all children, and were consumed in smaller quantity (≤2-serves), whereas the top five discretionary foods and beverages groups among high consumers were not as popular (apart from soft-drinks and flavoured mineral waters) but were characterised by larger quantities (mostly >2-serves) (Table 2).

4 | DISCUSSION

The results of this study demonstrate that nearly all Australian children and adolescents consumed discretionary foods and beverages, with 70%–80% of respondents exceeding national recommendations for discretionary foods and beverages intake.[24] Sweet biscuits, cake and cake-like desserts, potatoes, frozen milk products, and soft-drinks and flavoured mineral waters may have the largest public health impact on Australian children and adolescents as they were both the most frequently consumed discretionary foods and beverages and contributed the most to energy intake. The type of discretionary foods and beverages consumed differed by type of eating occasion with savoury discretionary foods and beverages groups such as potatoes, processed meats, and pastries the largest contributors at lunch and dinner; and sweet discretionary foods and beverages food groups such as chocolate, cake and cake-like desserts, and sweet biscuits the largest contributors to morning tea and snack. However, although discretionary foods and beverages consumed during meals and mid-meals may differ in their characteristics, this study found all eating occasions are contributors to discretionary foods and beverages intake in Australian children and adolescents.

This study found that the discretionary foods and beverages intake of Australian children and adolescents had similarities with the discretionary foods and beverages intake of Australian adults, where cake and cake-like desserts were the largest contributor to discretionary foods and beverages energy intake to both groups; and pastries, soft-drinks and flavoured mineral waters, and sweet biscuits all in the top five contributors if alcohol was excluded.[25] However, unlike Australian adults, with whom higher discretionary foods and beverages intake was associated with lower socio-economic status and higher waist circumference,[25] no demographic nor anthropometric characteristics beyond increasing age were associated with higher discretionary foods and beverages intake in Australian children and adolescents. Although females and males had similar discretionary foods and beverages intake, more females than males exceeded the recommended maximum discretionary foods and beverages serves, as females have a lower maximum discretionary foods and beverages serves target. Any intervention which aims to address this phenomenon in females should be carefully designed so as not to promote disordered eating habits.[26]

Whilst the most consumed discretionary foods and beverages foods (sweet biscuits; soft-drinks and flavoured mineral waters; sugar, honey, and syrups; frozen milk products; and chocolate and chocolate-based confectionary) are relevant for public health initiatives; they do not necessarily have the largest public health impact due to

TABLE 3 Associations between quartiles of energy contribution from discretionary foods and beverages and demographic and adiposity-related measures and lifestyle characteristics among 2812 children and adolescents 2–18 years from the 2011–12 National Nutrition and Physical Activity Survey

Characteristic	Q1 (low consumer)	Q2	Q3	Q4 (high consumer)	*p* value from Pearson's chi-square test
Range of % energy from DF	0–21.4	21.4–35.5	35.5–50.4	50.4–100	
	%	%	%	%	
Sex (within quartile)					0.278
Female	48.1	48.1	52.1	47.4	
Male	51.9	51.9	47.9	52.6	
Age groups (within quartile)					< 0.001
2–3 y	19.2	12.0	9.2	6.7	
4–8 y	27.8	29.9	30.2	27.1	
9–11 y	14.5	17.9	19.9	20.3	
12–13 y	12.4	13.2	14.7	15.1	
14–18 y	26.1	26.9	26.0	30.8	
Age and sex groups (within quartile)					
Females					< 0.001
2–3 y	18.9	11.2	8.4	7.8	
4–8 y	29.5	29.3	30.5	23.9	
9–11 y	12.1	17.8	21.3	22.4	
12–13 y	13.9	12.1	13.4	16.4	
14–18 y	25.7	29.6	26.4	29.6	
Males					< 0.001
2–3 y	19.5	12.4	10.1	5.7	
4–8 y	26.3	30.8	29.8	30.1	
9–11 y	16.7	17.9	18.5	18.4	
12–13 y	11.0	14.6	16.1	13.8	
14–18 y	26.6	24.5	25.6	32.0	
Quintiles SEIFA[a] (within quartile)					0.020
Lowest 20%	25.0	23.2	27.5	24.4	
Highest 20%	24.5	24.4	29.2	21.9	
Met physical activity guidelines[e] (within quartile)					
2–4 y	71.3	79.2	76.8	80.9	0.273
5–17 y	18.6	20.6	18.7	19.8	0.824
18 y	54.8	26.4	30.7	41.3	0.002
zBMI group[b] (within quartile)					0.032
<85%	66.2	68.1	67.8	71.8	
≥ 85% to <95%,	11.9	13.2	15.8	10.4	
≥ 95%	22.0	18.8	16.4	17.9	

TABLE 3 (Continued)

Characteristic	Q1 (low consumer)	Q2	Q3	Q4 (high consumer)	*p* value from Pearson's chi-square test
Waist: height ratio group[c] (within quartile)					0.004
No risk of chronic disease	63.8	66.0	69.9	73.1	
Increased risk of chronic disease	36.2	34.0	30.1	26.9	
Under-reporters[d] (within quartile)	24.9	17.6	13.6	14.1	0.001

Abbreviations: Q, quartile; DF, discretionary foods and beverages; y, years; SEIFA, Socio-Economic Indexes for Areas; zBMI, body mass index-for-age-z-score; EO, eating occasion.
[a]SEIFA was developed by the ABS and ranks areas in Australia according to their relative socio-economic advantage (20).
[b]Calculated using the standard normal distribution of BMI z-scores: < 85%, ≥ 85% to <95%, and (≥ 95%) (22).
[c]In children a waist circumference to height ratio of <0.5 is associated with a low risk of chronic disease, whereas a ratio of >0.5 is associated with a higher risk (23). Therefore, a waist circumference to height ratio of 0.5 was used as a cut-off for waist circumference and risk of metabolic complications.
[d]Among children aged 10 years and over. Participants were classified as under-reporters based on the Goldberg cut-off limit of an energy intake to basal metabolic rate ratio of 0.9 (24).
[e]For children 2–4 years old at least three hours of physical activity every day is recommended; for children 5–17 years old at least 60 minutes of moderate to vigorous physical activity every day is recommended; for 18-year-olds at least 150 minutes of physical activity over five or more sessions per week is recommended (17).

TABLE 4 The estimated effect of quartiles of energy contribution from discretionary foods and beverages on diet, lifestyle, and adiposity-related characteristics among 2812 children and adolescents 2–18 years from the 2011–12 National Nutrition and Physical Activity Survey

	Q1 (low consumer)		Q2		Q3		Q4 (high consumer)		
Characteristic[a]	Mean	SE	Mean	SE	Mean	SE	Mean	SE	*P* value[b]
Energy intake (MJ)[f]	6.8[g]	0.1	7.4[g]	0.1	8.1[h]	0.1	8.4[h]	0.1	< 0.001
Discretionary energy intake (MJ)[d]	0.8[g]	0.1	2.1[h]	0.1	3.5[i]	0.1	5.5[j]	0.1	< 0.001
Non-discretionary energy intake (MJ)[f]	6.0[g]	0.1	5.4[h]	0.1	4.6[i]	0.1	2.9[j]	0.1	< 0.001
Proportion of energy from discretionary (%)[c]	11.8[g]	0.3	28.1[h]	0.3	42.6[i]	0.3	63.2[j]	0.3	< 0.001
DF serves[d]	1.4[g]	0.1	3.5[h]	0.1	5.9[i]	0.1	9.2[j]	0.1	< 0.001
Total EO[c]	6.7	0.1	7.1	0.1	7.0	0.1	7.1	0.1	0.001
EO with DF[c]	2.4[g]	0.1	3.7[h]	0.1	4.1[i]	0.1	4.6[j]	0.1	< 0.001
Proportion of EO with DF (%)[c]	37.4[g]	0.7	53.7[h]	0.7	60.1[i]	0.7	66.9[j]	0.7	< 0.001
zBMI[c]	0.70	0.05	0.64	0.05	0.67	0.05	0.54	0.05	0.151
Waist: height ratio[c]	0.49	0.00	0.49	0.00	0.49	0.00	0.49	0.00	0.037
Self-reported fruit serves[c]	2.2[g]	0.0	2.0[g,h]	0.0	2.0[g,h,c]	0.0	1.8[i]	0.0	< 0.001
Self-reported vegetable serves[e]	2.1[g]	0.0	1.8[h]	0.0	1.8[h]	0.0	1.8[h]	0.0	< 0.001

Abbreviations: Q, quartile; SE, standard error; DF, discretionary foods and beverages; EO, eating occasion; zBMI, body mass index-for-age-z-score.
[a]Adjusted for quartile of per cent energy from DF, age group, sex, and their interaction using univariate ANOVA.
[b]*p* values denote the effect of quartiles of per cent energy from DF.
[c]Age group was significant ($p < 0.001$, univariate ANOVA).
[d]Age group and sex were significant ($p < 0.001$) but not their interaction (univariate ANOVA).
[e]Age group and the interaction was age group and sex were significant ($p < 0.001$) but not sex (univariate ANOVA).
[f]Age group, sex, and their interaction were all significant ($p < 0.001$, univariate ANOVA).
[g,h,i,j]Different superscripts denotes significant difference ($p < 0.001$ post hoc, Bonferroni).

variations in average serve sizes. For example, although sweet biscuits were the most highly consumed discretionary foods and beverages, the average serves size was 1.1. Although cake and cake-like desserts and mixed dishes where cereal is the major ingredient were not as commonly consumed; when they were consumed, the average

TABLE 5 The top five sub-major food groups by quartiles of energy contribution from discretionary foods and beverages among children 2–18 years from the 2011–12 National Nutrition and Physical Activity Survey

	Q1 (low consumer)		Q2		Q3		Q4 (high consumer)	
Rank	Sub-major food group[a]	Contribution to total energy intake (%)	Sub-major food group	Contribution to total energy intake (%)	Sub-major food group	Contribution to total energy intake (%)	Sub-major food group	Contribution to total energy intake (%)
1	Sweet biscuits	1.2	Sweet biscuits	2.6	Cakes, muffins, scones, cake-type desserts	4.6	Cakes, muffins, scones, cake-type desserts	6.8
2	Soft drinks, and flavoured mineral waters	0.7	Frozen milk products	1.8	Sweet biscuits	3.2	Pastries	6.0
3	Sugar, honey and syrups	0.6	Cakes, muffins, scones, cake-type desserts	1.5	Frozen milk products	2.8	Potatoes	5.2
4	Frozen milk products	0.6	Soft drinks, and flavoured mineral waters	1.5	Soft drinks, and flavoured mineral waters	2.4	Mixed dishes where cereal is the major ingredient	5.0
5	Chocolate and chocolate-based confectionery	0.6	Potatoes	1.5	Pastries	2.3	Soft drinks, and flavoured mineral waters	3.5

Abbreviation: Q, quartile.

[a]The sub-group name is used to refer to foods in those food groups that are discretionary. For example, 'potatoes' only refers to discretionary potatoes, e.g., hot chips.

serve sizes were 3.0 and 3.5 discretionary foods and beverages serves, respectively. This study found that the top discretionary foods and beverages consumers were those who more commonly chose discretionary foods and beverages foods which had larger average serve sizes, thus contributing to the large 1600 kJ total daily energy intake gap between the lowest and highest discretionary foods and beverages consumers. Soft-drinks and flavoured mineral waters was the only discretionary foods and beverages group which was one of the top discretionary foods and beverages consumed by both low and high consumers, suggesting that although the average serve size was 1.0, this discretionary foods and beverages group may be one of the most important for public health.

The findings of this study also provide a basis for public health policy and interventions to target high discretionary foods and beverages eating occasions, such as snacks, lunch, and dinner, with the provision of core foods such as vegetables.[27,28] Interventions which have shown efficacy at increasing consumption of vegetables and/or decreasing discretionary foods include serving vegetables first at main meals[29]; repeated exposure to vegetables[30]; and for the Australian setting, using a non-institutionalised multidisciplinary and community-based program which increases familiarity with food, cooking, and mindfulness.[31] Substitution of discretionary foods and beverages with foods from the Five Food groups has similarly been suggested by a previous study that examined the contribution of discretionary foods and beverages to the energy, saturated fat and added sugars intakes of Australian children.[13] Further, a study that used a simulation model showed that the substitution of discretionary foods and beverages with foods from the Five Food groups such as fruit and vegetables reduced energy, saturated fat and added sugars intakes.[32] From a policy perspective; research has found that healthy food and drink policies at school significantly improved the food environment for Australian pupils.[33] Although this study found discretionary foods and beverages groups contributed differently to free sugars, saturated fat, and sodium intake; public health and health care providers are moving away from nutrient-focused recommendations and towards those which are food based and address overall diet quality.[34] Introducing health policies at the population level such as regulating marketing tactics and introducing taxes to discretionary foods and beverages have also been suggested based on an ecological framework.[35] Further, a recent study conducted in Australia supports that restricting the merchandising of discretionary foods and beverages is beneficial in reducing discretionary foods and beverages consumption,[36] this, in particular, can be beneficial for children and adolescents as they are susceptible to marketing activity.[37,38]

In Australia, the intake of discretionary foods and beverages decreased from 1995–2007 with a corresponding decrease from 40% to 35% of daily energy intake being derived from discretionary foods and beverages.[39] The current study revealed that this trend has not continued, finding that 36.6% of energy was derived from discretionary foods and beverages in 2011–2012. There is no more recent population-level and nationally representative data for Australia and trends since then are unknown. Although food groups are classified differently, data from the US National Health and Nutrition Examination Survey reported that children and adolescents decreased intakes of solid fats, added sugars, and alcoholic beverages from 1994 to 2010,[40] but trends since then are unknown. Similarly to Australia, intakes of core foods in the USA differed by demographic characteristics but not for the intake of discretionary foods and beverages.[41] This finding suggests that excessive consumption of discretionary foods and beverages is a national public health concern and is not limited to certain population groups.

Qualitative research with Australian children and adolescents has suggested that the maintained excessive intake of discretionary foods and beverages may be partly due to misinterpretation of the Australian Dietary Guidelines. Velardo and Drummond reported that whilst Australian children agreed that discretionary foods and beverages should be consumed only sometimes and in small amounts, they still interpreted this to represent regular intake.[42] Australian children and adolescents may also not recognise discretionary foods and beverages intake; for example children recognised a cream bun as discretionary foods and beverages only if the cream tasted sweet.[42] This suggests that not all of the savoury discretionary foods and beverages intake at lunch and dinner, reported by respondents in this study, may have been recognised as discretionary foods and beverages intake. Such a phenomenon is likely, considering this has been found to occur in Australian adults, where adults mostly recognised discretionary foods and beverages intake when it was consumed between main meals and defined them as snacks.[43] This is also evident in the current findings where respondents selected 'snack' as one of the top two eating occasions where discretionary foods and beverages was consumed. Thus, interventions that increase knowledge, such as educating parents and messages delivered in schools, may have a beneficial impact on children and adolescents' discretionary foods and beverages consumption.[27]

The strength of this study is the use of a large, nationally-representative sample of Australian children and adolescents. Data are limited by being cross-sectional and from a single day of 24-hour recall. Findings do not reflect causal relationships between dietary intake and health, and dietary intakes are not indicative of usual

intakes. Further, despite being the latest available data, data were collected 10 years ago (2011–2012) and may not accurately reflect the current eating patterns of children. Thus, there is a need for a more recent national nutrition survey to investigate the most recent trends in discretionary foods and beverages consumption. Evidence of under reporting of energy intake in the survey was not found to impact results.

Nearly all Australian children and adolescents consumed discretionary foods and beverages daily, across all meals and snacks, with the highest intakes among 4–8-year olds and adolescents at snack, lunch, or dinner. The profile of discretionary foods and beverages intake was characterised by age, average numbers of serves consumed, and frequency of consumption but not body composition, physical activity, socio-economic status, or sex. Broad public health strategies and community- and school-based interventions relevant to the Australian setting are both needed to address the diet quality and health of Australian children and adolescents.

AUTHOR CONTRIBUTIONS

All authors have reviewed and approved the final version of this manuscript prior to submission and declare this work has not been submitted for publication elsewhere. FFM and SM led the drafting of the manuscript. AM conducted the data analysis. All authors contributed to the revision of the manuscript and study concept.

CONFLICT OF INTEREST

FFM, AM, TC, KT, HRA, MB and SM independently work for Nutrition Research Australia, which is funded by government, not-for-profits, community, and industry organisations. FFM, AM, TC, KT, HRA, MB and SM declare no conflicts of interest. The funding body, Nestlé Australia Ltd had no contribution to the analysis plan, the data analysis, drafting of the manuscript, nor interpretation of the findings.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available from the Australian Bureau of Statistics.

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REFERENCES

1. Green R, Sutherland J, Dangour AD, Shankar B, Webb P. Global dietary quality, undernutrition and non-communicable disease: a longitudinal modelling study. *BMJ Open*. 2016;6(1): e009331. doi:10.1136/bmjopen-2015-009331
2. Larkins NG, Teixeira-Pinto A, Craig JC. The prevalence and predictors of hypertension in a National Survey of Australian children. *Blood Press*. 2018;27(1):41-47.
3. Diabetes Australia. Type 2 diabetes in younger people: small but significant 2015 Available from: https://www.diabetesaustralia.com.au/news/14153?type=articles accessed 06/06/2018.
4. Michaud P-A, Suris JC, Viner R. *The Adolescent with a Chronic Condition: Epidemiology, Developmental Issues and Health Care Provision*. World Health Organization; 2007.
5. World Health Organization. New global estimates of child and adolescent obesity released on World Obesity Day 2017 Available from: http://www.who.int/end-childhood-obesity/news/new-estimate-child-adolescent-obesity/en/ accessed June 9 2018.
6. Australian Dietary Guidelines. 2013.
7. Rangan AM, Schindeler S, Hector DJ, Gill TP, Webb KL. Consumption of 'extra' foods by Australian adults: types, quantities and contribution to energy and nutrient intakes. *Eur J Clin Nutr*. 2009;63(7):865-871. doi:10.1038/ejcn.2008.51
8. Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med*. 1999;29(6):563-570.
9. Gracey M. Historical, cultural, political, and social influences on dietary patterns and nutrition in Australian aboriginal children. *Am J Clin Nutr*. 2000;72(5):1361s-1367s.
10. Foresight. *Tackling obesities: future choices - building the obesity system map*. Science Government Office for Science, Department of Innovation Universities and Skills; 2007.
11. 4364.0.55.007 - Australian Health Survey: Nutrition First Results - Food and Nutrients, 2011–12. Statistics ABo abs.gov.au: Commonwealth of Australia, 2014.
12. *Australian Bureau of Statistics. National Health Survey: First Results, Reference Period 2017–18 Financial Year*. 2018. Commonwealth of Australia.
13. Johnson BJ, Bell LK, Zarnowiecki D, et al. Contribution of discretionary foods and drinks to Australian children's intake of energy, saturated fat, added sugars and salt. *Children (Basel)*. 2017;4(12):14. doi:10.3390/children4120104
14. Von Elm E, Altman DG, Egger M, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Prev Med*. 2007;45(4):247-251.
15. Australian Health Survey: Users'Guide, 2011–13. In: Statistics ABo, ed. Canberra: Australian Bureau of Statistics, 2013.
16. Food Standards Australia New Zealand. NUTTAB 2010 Online Searchable Database 2010 Available from: http://www.foodstandards.gov.au/science/monitoringnutrients/nutrientables/nuttab/Pages/default.aspx accessed May 2017.
17. National Health and Medical Research Council and Department of Health and Aging *A Modelling System to Inform the Revision of the Australian Guide to Healthy Eating*. 2011. Commonwealth of Australia.
18. Australian Bureau of Statistics (ABS). Perspectives on Education and Training: Social Inclusion, Cat. no. 4250.0.55.001. 2009.
19. Australian Bureau of Statistics. Australian Health Survey: Users' Guide, 2011–13, Cat. no. 4363.0.55.001. 2013.

20. Organization WH. Global Database on Child Growth and Malnutrition: Growth Reference Data for 5–19 Years. http://www.who.int/growthref/en/ 2007.
21. Yan W, Bingxian H, Hua Y, et al. Waist-to-height ratio is an accurate and easier index for evaluating obesity in children and adolescents. *Obesity*. 2007;15(3):748-752.
22. Goldberg GR, Black AE, Jebb SA, et al. Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *Eur J Clin Nutr*. 1991;45:569-581.
23. *SPSS Statistics for Windows, Version 23 [Program]*. IBM Corp; 2016.
24. National Health and Medical Research Council. Educator Guide. 2013.
25. Fayet-Moore F, McConnell A, Cassettari T, Tuck K, Petocz P, Kim J. Discretionary intake among Australian adults: prevalence of intake, top food groups, time of consumption and its association with sociodemographic, lifestyle and adiposity measures. *Public Health Nutr*. 2019;22(9):1576-1589.
26. Carey RN, Donaghue N, Broderick P. Peer culture and body image concern among Australian adolescent girls: a hierarchical linear modelling analysis. *Sex Roles*. 2013;69(5–6):250-263.
27. Grieger JA, Wycherley TP, Johnson BJ, Golley RK. Discrete strategies to reduce intake of discretionary food choices: a scoping review. *Int J Behav Nutr Phys Act*. 2016;13(1):57. doi:10.1186/s12966-016-0380-z
28. Fayet-Moore F, McConnell A, Cassettari T, Tuck K, Petocz P, Kim J. Vegetable intake in Australian children and adolescents: the importance of consumption frequency, eating occasion and its association with dietary and sociodemographic factors. *Public Health Nutr*. 2020;23(3):474-487.
29. Elsbernd S, Reicks MM, Mann TL, et al. Serving vegetables first: a strategy to increase vegetable consumption in elementary school cafeterias. *Appetite*. 2016;96:111-115.
30. Ahern SM, Caton SJ, Blundell-Birtill P, Hetherington MM. The effects of repeated exposure and variety on vegetable intake in pre-school children. *Appetite*. 2019;132:37-43.
31. Mayr HL, Cohen F, Isenring E, et al. Multidisciplinary lifestyle intervention in children and adolescents-results of the project GRIT (growth, resilience, insights, thrive) pilot study. *BMC Pediatr*. 2020;20:1-16.
32. Grieger JA, Johnson BJ, Wycherley TP, et al. Comparing the nutritional impact of dietary strategies to reduce discretionary choice intake in the Australian adult population: a simulation modelling study. *Nutrients*. 2017;9(5). doi:10.3390/nu9050442
33. Pettigrew S, Pescud M, Donovan RJ. Stakeholder perceptions of a comprehensive school food policy in Western Australia. *Health Policy*. 2012;108(1):100-104.
34. Tapsell LC, Neale EP, Satija A, Hu FB. Foods, nutrients, and dietary patterns: interconnections and implications for dietary guidelines. *Adv Nutr*. 2016;7(3):445-454.
35. Johnson BJ, Hendrie GA, Golley RK. Reducing discretionary food and beverage intake in early childhood: a systematic review within an ecological framework. *Public Health Nutr*. 2016;19(9):1684-1695. doi:10.1017/s1368980015002992
36. Brimblecombe J, McMahon E, Ferguson M, et al. Effect of restricted retail merchandising of discretionary food and beverages on population diet: a pragmatic randomised controlled trial. *Lancet Planet Health*. 2020;4(10):e463-e473. doi:10.1016/S2542-5196(20)30202-3
37. Cairns G, Angus K, Hastings G, Caraher M. Systematic reviews of the evidence on the nature, extent and effects of food marketing to children. A Retrospective Summary. *Appetite*. 2013;62:209-215. doi:10.1016/j.appet.2012.04.017
38. Cairns G, Angus K, Hastings G, et al. *The Extent, Nature and Effects of Food Promotion to Children: a Review of the Evidence to December 2008*. World Health Organization; 2009.
39. Rangan AM, Kwan J, Flood VM, Louie JCY, Gill TP. Changes in 'extra'food intake among Australian children between 1995 and 2007. *Obes Res Clin Pract*. 2011;5(1):e55-e63.
40. Slining MM, Popkin BM. Trends in intakes and sources of solid fats and added sugars among US children and adolescents: 1994–2010. *Pediatr Obes*. 2013;8(4):307-324.
41. Kirkpatrick SI, Dodd KW, Reedy J, Krebs-Smith SM. Income and race/ethnicity are associated with adherence to food-based dietary guidance among US adults and children. *J Acad Nutr Diet*. 2012;112(5):624-635.e6.
42. Velardo S, Drummond M. Australian children's perceptions of discretionary foods. *Appetite*. 2018;120:43-48.
43. Fayet-Moore F, McConnell A, Cassettari T, et al. The role of snacking in the diet of Australian adults: a comparison of objective and subjective definitions of snacking on prevalence, top snack foods, contribution to discretionary energy intake, and association with anthropometric measures. Unpublished Work 2020

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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ORIGINAL RESEARCH

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Is there enough behaviour change science in nutrition and dietetics curricula in Australia and New Zealand? A descriptive study

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Abstract

Aim: The application of behaviour change science is fundamental to the role of dietitians. This study aimed to describe how behaviour change science is embedded within the curricula of accredited/registered dietetics programs in Australia and New Zealand.

Methods: A descriptive study triangulated quantitative document analysis of curricula content from university websites (Part 1) with qualitative, structured interviews with dietetics academics (Part 2). Part 2 verified and advanced upon information captured in Part 1 and was analysed using thematic content analysis.

Results: Twenty-five courses from 18 university programs (15 Australia and 3 New Zealand) were synthesised. Fifteen interviews (12 Australia, 3 New Zealand) were conducted. Behaviour change science was taught and assessed at varying levels across all programs. It was taught primarily within lectures or workshops where students apply skills learnt in practical case-based activities, and assessed through small group education planning or demonstrating communication and counselling skills. Five themes were identified from the interviews: (1) *behaviour change science should be foundational*; (2) *integrate and scaffold within curricula*; (3) *structural limitations within curricula*; (4) *challenging for students* and (5) *recommendations for competencies*.

Conclusion: Behaviour change science is clearly of value to the dietetics profession. Core content appears to be embedded across all university programs; however, the level and depth of the content varied. The knowledge gained from this study provides direction for curricular improvements.

KEYWORDS

behaviour change, curricula, curriculum, dietetics, qualitative research, transtheoretical model, universities

1 | INTRODUCTION

Behaviour change science is a component of health psychology and behavioural medicine that focuses on the mechanisms and processes that explain how individuals and groups deliberately change their behaviours.[1,2] Behaviour change science encompasses behaviour change theories, models, and techniques and strategies that can be used to support changes in behaviour.[1,2] Dietitians provide nutrition care to individuals and groups to enable dietary behaviour changes that lead to improved health outcomes.[3,4] A recent systematic review demonstrated the usefulness of behaviour change theories and techniques in underpinning dietary interventions to enhance health-related outcomes.[5] The review identified a general lack of reporting of behaviour change theories and techniques used in nutrition interventions, suggesting dietitians may implement behaviour change science in practice without recognising or reporting such practices.[5]

A cross-sectional survey of 394 UK dietitians found that they recognised the importance of behaviour change in their role but reported receiving inadequate training in behaviour change during their dietetics education.[6] New Zealand dietitians interviewed reported using behaviour modification and motivational interviewing techniques frequently in practice; however, they reported that most of these skills were developed after their university training.[7] In a 2018 Australian dietetics workforce report, almost 60% of the dietitians reported counselling to be a key component of their practice, yet perceived their skills to be lacking in this area.[8] It appears that practising dietitians in the field could have benefited from a stronger behaviour change science curriculum component within dietetics education programs.

Tertiary education for dietitians in Australia is designed according to Program Accreditation Standards,[9] where graduates need to demonstrate entry-level competence against the National Competency Standards for Dietitians.[3] New Zealand registration of dietitians and programs need to comply with the Dietitians Board standards.[4] The New Zealand competency standards specify that dietitians should be able to "apply principles of behavioural psychology, counselling and learning" (Standard 2.2.1)[4] whereas the current Australian standards include behavioural counselling in examples of strategies to support competence development.[3] Research examining behaviour change science in physiotherapy programs has demonstrated that theoretical and practical learning is essential, and theories of health psychology should ideally be covered and reinforced throughout the degree.[10] However, no studies have examined whether this need is also true for dietetics. This study aimed to understand the way in which behaviour change science had been taught and assessed within Australian and New Zealand dietetics education programs.

2 | METHODS

A relativist philosophical positioning and subjectivist epistemology guided this research, whereby reality is interpreted subjective to the researchers' and participants' experiences.[11] A descriptive methodology through an iterative process of document review of publicly available course outlines (Part 1) and structured interview with Program Directors or an academic representative (Part 2) was used to describe and understand dietetics academics' perspectives of teaching and assessing behaviour change science.[11] An adaptation to a methodological approach, used by Rohwer[12] in a study exploring evidence-based competencies within allied health curricula, guided this study and interview guide. Figure 1 illustrates a flow diagram for the methods of Part 1 and Part 2.

Terminology used to define degrees and the unit of teachable work varies across universities. For consistency, this study used "program" to refer to the dietetics university degree and "course" for the subject/unit of learning within each teaching period (semester/trimester). The term "course outline" refers to any information regarding a course and its requirements that are taught within the curriculum (ie, learning objectives, curriculum outline and assessment).

First, the dietetics programs accredited in Australia and registered in New Zealand at the time (2020) were identified through the relevant professional association websites. Next, the research team developed a list of key terms using search terms previously applied in a recently published systematic review,[5] and accreditation standards of dietetics education programs[9,14] (Supplementary Table A1). Next, the lead researcher screened the publicly available course outlines for behaviour change science concepts using the key terms. Courses related to human biosciences and food science (ie, biochemistry, human biology, physiology)[9] were excluded from the screening as they were not expected to contain behaviour change science content. Professional placement courses (ie, learning experiences conducted outside the university environment) were also excluded as our focus was to explore how behaviour change science is taught within the university coursework context in a consistent way for all students within the program. The courses that explicitly included any of the primary key terms in the course outline were included for further analysis.

Data were extracted into a purpose-developed Microsoft Excel file. A coding system anonymised identifying information. The course categorisation was developed and cross-checked by the research team for consistency. Extracted data were collated to describe the topics related to behaviour change science. Topics directly related to behaviour change theories/models/techniques were categorised according to whether they were covered by most

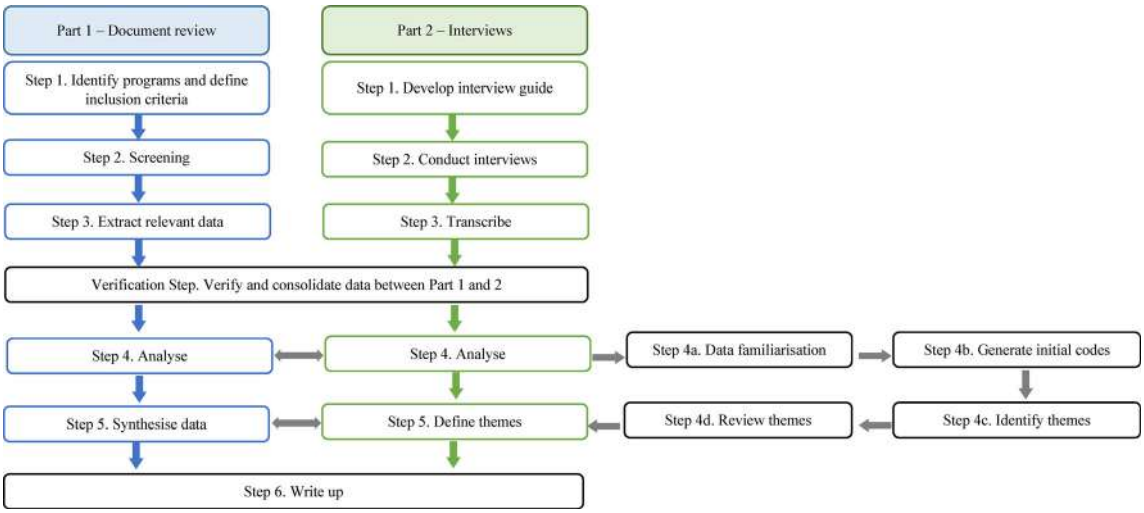

FIGURE 1 Flow diagram for a descriptive study of behaviour change science in Australian and New Zealand dietetics education programs (Source: Part 1 adapted from Rohwer and colleagues[12] and Part 2 included structured interviews and thematic analysis with program directors[13])

of the 18 universities (n = 12-18), moderate (n = 5-11) or minimal (n ≤ 4) number. Topics of communication and counselling skills were categorised as "secondary" as they assist in applying knowledge in behaviour change science. Learning outcomes addressing behaviour change science were reviewed against Bloom's taxonomy of cognitive learning objectives to assess the different complexities of cognitive processes required to demonstrate certain skills and abilities.[15]

In Part 2, qualitative research methods were used to interview university Program Directors or their representatives. The lead researcher who conducted the interviews is a female PhD candidate and Accredited Practising Dietitian with post-graduate experience in qualitative research, whose current research is in behavioural science in dietetics, which may have influenced the interpretation of results. She had no prior relationships with the participants except with the university's program director through which the study was conducted. The Consolidated criteria for Reporting Qualitative research checklist[16] and the APA Journal Article Reporting Standards for qualitative research[17] guided Part 2 (see Supplementary Table B1). Part 2 was approved by the Griffith University Human Research Ethics Committee (reference 2020/341).

Contact details of the Program Directors were obtained through the university websites and researcher contacts. They were emailed to invite participation, including the information and consent form detailing their requirements for the study. Program Directors were invited to participate or nominate an appropriate academic member who could best address behaviour change science content. The interview questions and summary of information found in Part 1 were sent in subsequent emails to prepare the participant for the interview. Data were collected from August 2020 to November 2020. Interviews were conducted through Microsoft Teams, Zoom or telephone. Audio data were transcribed verbatim by the lead researcher into a Word document and an automatic transcription platform,[18] and were extracted to an Excel file for analysis. Field notes were made throughout the interview process. The recruitment and interview process were pilot tested with one university to improve the interview process and guide.

The interview guide (Supplementary Table C1) was designed for the Program Directors to verify and extend findings from Part 1. Individualised questions addressed gaps in this data to describe the teaching methods and assessments available to students and the behaviour change science content of those activities. All participants were provided with the study definition of behaviour change science and invited to comment: "Behaviour change science encompasses the facilitating and influential factors that lead to a change in behaviour. This encompasses behaviour change theories and models, and the techniques and strategies that we use on a more everyday basis to support people to make changes".[1,2] The four areas of inquiry adapted from Rohwer[12] that guided the interview were (1) importance/value/role of behaviour change science to dietetics education and practice; (2) what is taught; (3) what is assessed and (4) future directions. No repeat interviews were required. The transcripts were returned to participants for comment and corrections which were incorporated into a finalised transcript.

The thematic analysis involved data familiarisation, generation of codes, then to identify, review and define

themes suggested by the data[13] (Figure 1), also ensuring the themes fit within the main areas of inquiry adapted from Rohwer.[12] Coding and thematic analysis were performed in Microsoft Excel by the lead researcher and cross-checked by two other research members who were senior academic dietitians, which may have deepened and influenced the interpretation of results. Variances were discussed and conclusions made together. All authors were involved in the interpretation of the results—the two others were a senior academic dietitian (with a long history of dietetics curriculum development) and a senior behavioural scientist. After each interview transcript was finalised, the lead researcher conducted another verification process to consolidate the data from Part 1 and 2 into a cohesive table in Microsoft Excel.

3 | RESULTS

In 2020, a total of 20 dietetics education programs (14 Master and 6 Bachelor) from 18 universities held full accreditation (Australia; n = 15) or registration (New Zealand; n = 3) and were included in this study (see Table 1). Within these programs, 25 courses were identified that taught behaviour change science, and 22 of these were verified through interviews. Interviews were conducted with representatives of 15 universities (12 in Australia; 3 in New Zealand). Three Australian universities did not respond to repeated recruitment efforts. Participants were all academics responsible for planning and creating course content and delivery. Interviews lasted between 23 and 56 minutes (mean 36 minutes).

TABLE 1 Characteristics of reviewed dietetics degrees, types of courses and interviews conducted in a study exploring behaviour change science within education programs across Australia and New Zealand

	n
University dietetics program[a]	
Masters	14
Bachelor	6
University academic interviews	
Interview conducted	15
Did not respond	3
Courses with BCS	25
Dietetics practice	19
Nutrition education	3
Public health nutrition	2
Interpersonal skills	1
Teaching method	
Workshops/simulations	15
Lectures	14
Student-led clinic	4

Abbreviation: BCS, behaviour change science.
[a]Some universities offered both bachelor and master level programs.

Behaviour change science was primarily taught in courses relating to *Dietetics Practice* (ie, communication and counselling or dietetics professional skills). Some behaviour change science was integrated across other courses, such as *Nutrition Education* and *Public Health Nutrition*, with one course on *Interpersonal Skills*. The textbooks most used included Bauer and Liou, *Nutrition counselling and education skill development*, and Holli and Beto, *Nutrition counseling and education skills: A guide for professionals* (see Supplementary Table D1 for a complete list of textbooks).

Relevant behaviour change science topics addressed in the courses are detailed in Table 2. Topics related to behaviour change theories/models and how to implement them, counselling therapies, dietetics consultation and group nutrition education. Other topics considered secondary to behaviour change science yet still important to the application of behaviour change science included communication and counselling skills.

Most universities (n = 12-18) covered the trans-theoretical model, or "stages of change", motivational interviewing, communication and counselling skills and small group education. Between 5 and 11 universities taught adult learning and education theories, the health belief model and social cognitive theory. Some universities covered counselling therapy such as cognitive behaviour therapy and the nutrition care process, and cultural awareness/competence. The least taught (n ≤ 4) were theory of planned behaviour and self-determination theory. Other behavioural-related theories/models included the behaviour change wheel, COM-B model and process of change. Few universities addressed specific counselling therapies and communication tools such as acceptance and commitment therapy and DIET-COMMS.[19] Only two courses addressed behaviour change theory at a group, public health or policy level, and these were within *Public Health Nutrition*-related courses identified.

Most universities (n = 12-18) addressed behaviour change science topics within workshops, which focused on drawing on behaviour change theories/models/techniques and applying them to case studies (Table 2). Other examples included identifying appropriate behaviour modification techniques for clients. Between 5 and 11 universities used roleplaying to facilitate learning, including practical and simulated patients, where students played a dietitian and patients. Some roleplay included motivational interviewing, cognitive behaviour therapy and counselling simulations for various health conditions or

TABLE 2 Summary of the behaviour change science content and teaching methods in the courses that primarily teach behaviour change science within dietetics education programs across Australia and New Zealand

	Covered mostly (12-18 universities)	Covered moderately (5-11 universities)	Covered minimally (4 or less universities)
Topics and content			
Behaviour change theory/models and how to implement them	TTM, stages of change.	Adult learning and education theory; health belief model; social cognitive theory.	COM-B; control theory; dialect behavioural therapy; Michie's behaviour change wheel; operant classic and operant conditioning; process of change; psychodynamic theory; SDT; sociology and human behaviour; TPB.
Counselling therapies	Motivational interviewing.	CBT.	ACT; mindfulness; HAES; solution-focused therapy.
Dietetics consultation	Communication and counselling skills.	NCP; Cultural awareness/ competence.	AIDET, ISBAR, DIET-COMMS; Behaviour change technique taxonomy.
Group nutrition education	Small group education, facilitating education and learning for groups.		Behaviour change theories/ frameworks at a group, community, public health and policy level; group development theory; socio-ecological model for public health/ environment.
Teaching methods			
	Lectures Case studies: motivational interviewing; using COM-B to understand behavioural problems; TTM; cases utilising different stages of change/motivation levels.	Role-plays/ simulations: practice dietetics consultations using: theories; motivational interviewing; OARS, CBT, goal setting, negotiating with client; for specific health conditions.	Small group education planning workshops: plan small group education program, use theories and relate strategy to theory, share to class (not assessed); group education programs for specific health conditions. Student clinic: behaviour change technique taxonomy embedded; develop communication skills and individualised care plans.

Abbreviations: ACT, acceptance and commitment therapy; AIDET, acknowledge, introduce, duration, explanation and thank you; CBT, cognitive behaviour therapy; COM-B, capability, opportunity, motivation, behaviour; DIET-COMMS, tool for measuring communication skills in patient consultations; HAES, health at every size; ISBAR, introduction, situation, background, assessment and recommendation; NCP, nutrition care process; OARS, open questions, affirmations, reflective listening, summary reflections; SDT, self-determination theory; TPB, theory of planned behaviour; TTM, trans-theoretical model.

focused on communication and counselling skills. Few universities ($n \leq 4$) integrated a student-led clinic where students developed communication skills. One university had specifically embedded a behaviour change technique taxonomy within the clinic, where students had to connect to the techniques they used.

Table 3 lists the types of assessment directly or indirectly assessing behaviour change science content in the relevant courses (see Supplementary Table E1 for further assessment details). Most universities ($n = 12$-18) directly and indirectly assessed behaviour change science. Direct assessments meant the data made direct links with behaviour change science and assessments. Indirect meant the data did not explicitly state the link between behaviour change science and assessment; however, the use was implied or expected. A moderate number of universities ($n = 5$-11) directly assessed behaviour change science by creating and delivering small group education sessions where students were asked to specify the behaviour change techniques and theories used or develop education plans using behaviour change theory. Other assessments included observing how well students use behaviour change techniques in student clinics. A moderate number of universities indirectly assessed behaviour change science through dietetics counselling consultations where students were required to video record a consultation, apply interpersonal skills and reflect on how to improve.

Few universities ($n \leq 4$) reported assessing theoretical knowledge of behaviour change theories/models and

TABLE 3 List of the assessment types where behaviour change science is assessed directly or indirectly in the courses that teach behaviour change science within dietetics education programs across Australia and New Zealand

Assessment	Examples of how BCS is assessed	Directly[a]	Indirectly[b]
Create/deliver small group education		10	1[c]
Test/Quizzes/exam on theoretical knowledge		4	0
Simulated patients			
	OSCE/simulation exam	4	5
	In-class consultations	1	3
Case study			
	Nutrition education resource	1	2
	Final exam	1	0
Dietetics consultation			
	Video record a consultation	1	4
Other assessments/ assignments			
	Student clinic performance using techniques	1	0
	Creative assessment	1	0
	Personally follow a prescribed diet	1	0
Total universities		15[d]	15
Total universities with direct only		3	n/a[e]
Total universities with indirect only		n/a	3

[a]Directly: publicly available content and participants made direct links with behaviour change science and assessments.
[b]Indirectly: publicly available content and participants did not explicitly state the link between behaviour change science and assessment, however, the use is implied or expected.
[c]One university reported insufficient information available online to conclude whether the small group education assessment makes direct links to behaviour change theories/models and techniques.
[d]Some universities had more than one directly related assessment.
[e]n/a, not applicable for that row.
BCS, behaviour change science; OSCE, objective structured clinical examination

motivational interviewing. Assessment of this theory included multiple-choice questions, end of trimester exams or weekly quizzes. While Objective Structured Clinical Examinations (OSCE) were conducted, few directly addressed behaviour change science through assessing behaviour change counselling, using readiness to change, goal setting, confidence scales or stages of change. In most OSCEs, the assessment of behaviour change science was implied rather than explicitly making links to theories/models, as students were marked on patient-centredness or their communication and counselling skills. Few universities used assessments through in-class simulated patient consultations where students conducted a consultation using communication and counselling strategies or demonstrated counselling or communication skills.

There were 141 publicly available learning objectives across the 25 courses (Table 4). The learning objectives that directly related to behaviour change science accounted for 16.3% of all objectives. They were mostly at the "apply" cognitive level of Bloom's taxonomy, with a few at higher levels related to creating nutrition group education plans. Almost half of the learning objectives related to communication and counselling skills (47.6%).

The behaviour change science definition provided in the interview (see Methods) was perceived by some participants to be broad yet comprehensive, with additional suggestions offered. One participant mentioned, "I see it as much more about the application of those [behaviour change theories/models] more so than just understanding others" (P09), and another mentioned, "educational theories" (P13) being important as well. One participant said it might be context-specific, "how we might incorporate that into dietetics may mean a different thing in the context of dietetics versus as if it was in the context of a psychology degree" (P07), illustrating the importance of understanding and defining behaviour change science in the context of the dietetics profession.

Five themes were identified from the 15 interviews with dietetics academics, describing their perspectives on

TABLE 4 A total number of universities with learning objectives directly related to behaviour change and level of Bloom's Taxonomy in the courses that teach behaviour change science within dietetics education programs across Australia and New Zealand

	Total university	
Learning objectives directly related to behaviour change theories/ models/ techniques[a]		14
Example learning objectives		
Remember	*Describe* behaviour change and counselling techniques that relate to the dietetics consultation	3
Understand	n/a	0
Apply	*Employ* principles of behaviour change, counselling and learning in the provision of nutrition care for individuals and groups	11
Analyse	*Critically analyse* behaviour change theory in food and nutrition contexts	3
Evaluate	Describe and *compare* individual and environmental models explaining health behaviour	1
Create	*Develop* group education programs centred on behaviour change theory	3
Learning objectives related to communication and counselling skills[b]		18
Example learning objectives		
Remember	*Describe* the principles and styles of communication, including elementary counselling with individuals, groups, populations and other professionals.	2
Understand	*Communicate* specialist knowledge effectively with a diverse range of clients and colleagues	3
Apply	*Display* effective active listening, interviewing and interpersonal skills.	15
Analyse	*Assess* the effectiveness of communication and counselling approaches.	1
Evaluate	*Evaluate* varying nutritional needs, growth and development and human behaviour across the lifespan consistent with the best available evidence.	3
Create	*Create* individualised nutrition care plans for a diverse range of individuals.	8

[a]Exact key terms extracted from the learning objectives related to behaviour change theories/ models/ techniques: adult learning/education theory, behaviour change theory, behaviour change and counselling techniques, counselling strategies, health promotion theoretical frameworks, individual and environmental models explaining health behaviour, motivational models of counselling, nutrition counselling strategies and techniques grounded in learning and behaviour change theories, nutritional counselling theory, nutrition education program development and behaviour change management.
[b]Exact key terms extracted from the learning objectives related to communication and counselling skills: client-centred communication and counselling, client-centred oral and written communication strategies, communication skills, counselling skills, translate technique scientific information.

behaviour change science and dietetics. In theme 1, *behaviour change science should be foundational*, all participants strongly advocated the importance of behaviour change science to the dietetics profession, saying it is fundamental to education and that "it should be foundational" (P10). Some academics discussed patient-centredness and the role of dietitians in providing individualised care. These participants said students need to learn the skills to understand patients and see that behaviour change science is embedded within that interaction. One mentioned, "It's not emphasised enough as a role as a dietitian and not taught enough within the degree" (P12). One aspect that stood out was the common understanding that behaviour change science extends beyond working with individual clients and is an essential skill that is "applicable to every human engagement that you have as a professional" (P01). One participant said, "It's not just about being told what to eat, and it's not just about nutrition. It has a very strong place in dietetics practice because that's a skill that we can actually offer to the community" (P04). Several participants mentioned that dietitians might intuitively use behaviour change strategies, but understanding the science behind it might be lacking, or that "we as dietitians don't delve enough into the science of it" (P12).

In theme 2, *integrate and scaffold within curricula*, participants most consistently reported the need for scaffolding behaviour change science teaching from the beginning to the end of the degree. The university programs that scaffolded the content did so by introducing basic concepts and theories, which were then expanded on in subsequent courses and used in different contexts (ie, individual or groups, individual case management or public health). Some mentioned wanting to assess behaviour change science more directly by adjusting marking guides for simulations or assessments to include more self-recorded interviews with accompanying reflections on performance. One participant suggested integrating dietetics learning with psychology, where students could complete a short certificate qualification additional to their dietetics degree.

Theme 3 was *structural limitations within curricula*. There was a consensus that participants wanted to do more with curricula teaching of behaviour change science but mentioned experiencing limitations or barriers. The

most prominent barrier discussed was time constraints of the program, especially in Master level degrees, stating the curricula are "overloaded", "tight" and that "there isn't room in the curriculum to add it in" (P08). Some participants described how adding more content is limited by the structure of the university or only having room for one course, "I think it is something that could definitely be expanded if we had more time and if we didn't have to do everything else" (P03). The knowledge of the academics/educators was also mentioned as a barrier to confidently teaching behaviour change science. Others emphasised the need for a global appreciation for behaviour change science amongst colleagues and the profession to continue conversations on these topics. Some participants discussed financial barriers to including simulated patient activities. A couple mentioned there was already sufficient emphasis due to behaviour change science content and assessment being integrated and scaffolded across the years and not dedicated to one course. A common opinion discussed was the sense of limited control to make curricula changes which they felt stemmed from needing to meet accreditation standards. However, the specifics of these challenges were not further discussed, "We are really tied to meeting the guidelines that the DAA [sic] accreditation board mandates from us" (P12).

In theme 4, *challenging for students*, most of the perceived challenges described by participants involved placement. Participants discussed the limited exposure students have on clinical placements, which are primarily conducted in acute care settings where there were few opportunities for behaviour change counselling compared with private practice or outpatient settings. Another challenge involved the ability of academic staff to ensure that supervisors reinforce behaviour change science to the students: "How much are students going to be able to practise the skills they've learnt and be prompted to as well, and reinforced around it, it is going to depend a lot on supervisors that they have" (P14). Finally, a few participants talked about how students' focus and emphasis on the nutrition assessment process (ie, anthropometry, biochemistry, social history) means less focus on communication and counselling.

One participant mentioned that students do not see the application and importance of what they have learnt until placement, "I think the challenge is teaching it in a way that's going to engage the students where they really see that relevance" (P02). Another wanted to provide students with more personal experiences at university; however, large classes limited their ability to do so. The university setting was seen as being most appropriate to practise and assess the skills before placements, "It's easier for us to assess whether or not they are actually using this stuff they learned the year before in the clinic setting because then we can observe that more closely" (P15).

Theme 5 involved *recommendations for competencies*. Participants mentioned that dietetics competencies are "broad", and the role of dietitians is complex. All the participants agreed that behaviour change science should be part of the competencies, either explicitly stated or integrated somehow. Some participants discussed that students demonstrate competence within assessments; therefore, having behaviour change science within competencies could allow assessments to be more explicit or direct. One participant discussed the importance of students self-reflecting in the final stages of their degree to solidify the behaviour change science learning in their foundational years and demonstrate how they have applied it in practice. However, specific strategies to increase behaviour change science or address gaps within the current competencies were not raised by participants.

4 | DISCUSSION

This paper adds to the literature on behaviour change science in allied health professional curricula[10] and broadens the evidence base by exploring all Australian and New Zealand dietetics education programs. The curricula reviewed in this study showed the range of behaviour change science topics and teaching methods across all university programs, including the wide variety of assessment types. The interviews highlighted potential areas in curricula where behaviour change science can be enhanced; however, the participants discussed barriers to embedding more content.

Participants advocated behaviour change science as being relevant beyond individual dietetics care. While behaviour change science was primarily addressed in courses related to *Dietetics Practice*, it also appeared in public health nutrition. Many participants discussed the need to "scaffold" the content earlier and integrate it across several courses. As dietetics is focused on demonstrated competence,[3,4] there are uncertainties as to whether behaviour change science concepts must be taught before students demonstrate application and are assessed. Integrating behaviour change science content across curricula is possible, having been achieved in the context of physiotherapy[10] and evidence-based medicine for medical schools.[20] Behavioural medicine competencies and content were successfully scaffolded within the physiotherapy curricula by focusing on foundational knowledge (first year), assessment of clients (second year), then treatment and evaluation (third year).[10] Some of the dietetics programs in this study seemed to be teaching and assessing more content than others. Those universities with less content could follow a similar format, where students learn behaviour change science

concepts across multiple courses in their degree and apply that knowledge to various contexts to consolidate learning.

Most of the learning activities regarding behaviour change science took place within workshops using roleplays and simulated patients. The majority of learning objectives related to behaviour change science was at the level of *apply* or higher in Bloom's taxonomy (rather than requiring a level of *remembering* or *understanding*), which encourages demonstrated learning and practical-based tasks[15] and is reflective of the competency standards.[3,4] An observational study of third-year dietetics students found that repeated simulated patient engagements resulted in modest improvements in student communication skills.[21] However, the cost and resources involved in hiring simulated patients may challenge the ability to provide frequent practice opportunities.[21] Participants discussed financial barriers, particularly associated with reduced course budgets due to the COVID-19 pandemic. Therefore, including more peer-assisted and roleplay learning may be a cost-effective alternative allowing students to learn and apply these skills.

The predominant theories and counselling approaches of the transtheoretical model and motivational interviewing were taught in most of the included programs. In contrast, social cognitive theory and self-determination theory were not covered extensively. The systematic review of theory-based dietetic randomised controlled trials by Rigby and colleagues' published in 2020 identified that social cognitive theory underpinned 79% of included study interventions[5]; compared with a review a decade earlier, where only two of 89 included studies were informed by social cognitive theory.[22] Rigby and colleagues found a fair grade of evidence for social cognitive theory to underpin intervention design by dietitians, with 73% of studies showing positive intervention effects.[5] Social cognition models lend themselves well to group settings.[23] Dietetics academics may wish to consider incorporating social cognitive-type theories into the curricula as the assessments for small-group education identified in this study required students to draw on theories learnt in class. Teaching theories on volitional phases (ie, Health Action Process Approach) or implicit processes (ie, habit theory) are beneficial as they extend common motivational theories.[24] Learning theories have also been found to be important in underpinning simulated-based learning in dietetics education.[25] These results suggest that academics need to remain current with developments in behaviour change science theory in order to teach models that are at the cutting edge of practice. Liaising with psychology academics who are familiar with the latest behaviour change science literature could assist in this process.

Behaviour change science was viewed as fundamental to dietetics with some participants reporting they wanted to add behaviour change science content but felt their curriculum was already overloaded. The use of concept-based approaches, which are "mental constructs of one or two-word nouns, or short phrases",[26(p2)] would allow behaviour change science content to be added without overloading curricula. Some participants expressed a lack of confidence in teaching behaviour change science. One way to enhance confidence may be to add expertise from psychology and human behaviour. The few participants who already had the input of psychologists reported they valued their expertise, again suggesting there is an opportunity to liaise with psychology/behavioural science academics for dietetics curricula development. Another means to increase educator confidence and currency of models would be the use of a resource such as the 2020 'Handbook of Behavior Change'.[27]

Participants described behaviour change science as important to dietetics education and practice and felt that it should be reflected in the dietetics competency standards, but views on how this could be best achieved varied. Competency standards were seen as broad and aimed at capturing demonstrated learning.[3,4] The New Zealand dietetics competency standards address behaviour change science in the statement "apply principles of behavioural psychology, counselling and learning" (Standard 2.2.1).[4] Other allied health professions, such as exercise physiology,[28] and social work,[29] have incorporated behaviour change science-related terms into their practice or professional standards. There is the opportunity to embed behaviour change or psychology practices into the dietetics National Competency Standards more explicitly to influence curricula development. The next revision of the Australian National Competency Standards will be released in 2021.[3]

The document review of 18 university curricula and 15 interviews with dietetics academics enabled a detailed overview of behaviour change science in dietetics education programs. However, it is acknowledged that the results are a description of the content taught within the 25 specific courses where the foundational knowledge of behaviour change science was identified to be taught and is not reflective of all dietetics content. Data from three of the 25 identified courses could not be verified due to non-participation in interviews. There was the possibility of response bias, as all participants were involved with teaching the courses and strongly advocated for behaviour change science, resulting in favourable answers. Not all components of Rohwer's triangulation[12] were completed, as interviews with students were not conducted. Future research needs to explore how students practise on placement or whether student and graduate dietitians take the initiative to upskill in behaviour change counselling during or after their dietetics degree. An interpretive study grounded in social

constructivism could explore how behaviour change science has been constructed within university curricula from academics' perspectives. We suggest such a study be conducted from people with a more independent positioning on dietetics curricula.

This study has provided a comprehensive picture of how behaviour change science is currently addressed within the curricula of dietetics education programs in Australia and New Zealand. It is apparent that behaviour change science is valued by academic professionals and seen as playing an essential role in dietetics education and practice. Further opportunities to strengthen curricula have been identified. Ensuring that students have an adequate understanding of behaviour change science through teaching, learning and assessment within their dietetics education programs can generate graduates with the confidence to approach patients to help facilitate behaviour change for a range of health-related conditions.

CONFLICT OF INTEREST

Lauren Williams is a member of the Australian Dietetic Council responsible for accrediting dietetics programs in Australia.

AUTHOR CONTRIBUTIONS

Roshan Rigby contributed to the conception and design of the research, the collection and analysis of the data and created the original draft and reviewed and edited subsequent versions. All authors contributed to the design of the research, to the analysis and interpretation of the data and to writing, reviewing and editing. All authors agree with the final manuscript being submitted.

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REFERENCES

1. Michie S, Johnston M. Theories and techniques of behaviour change: developing a cumulative science of behaviour change. *Health Psychol Rev*. 2012;6(1):1-6.
2. Michie S, West R, Campbell R, Brown J, Gainforth H. *ABC of Behaviour Change Theories*. Sutton: Silverback Publishing; 2014.
3. Dietitians Australia. National Competency Standards for Dietitians in Australia: Dietitians Australia; 2015. https://dietitiansaustralia.org.au/wp-content/uploads/2020/11/NCS-Dietitians-Australia-with-guide-1.0.pdf.
4. Dietitians Board. Professional Competencies & Standards for Dietitians Wellington: Dietitians Board; 2017. https://www.dietitiansboard.org.nz/Portals/12/Professional%20Standards%20and%20Competencies%20for%20Dietitians%20Web%20Version.pdf.
5. Rigby RR, Mitchell L, Hamilton K, Williams LT. The use of behavior change theories in dietetic practice in primary health care: a systematic review of randomized controlled trials. *J Acad Nutr Diet*. 2020;120(7):1172-1197.
6. Rapoport L, Perry KN. Do dietitians feel that they have had adequate training in behaviour change methods? *J Hum Nutr Diet*. 2008;13(4):287-298.
7. Zinn C, Schofield G, Hopkins WG. Management of adult overweight and obesity: consultation characteristics and treatment approaches of private practice dietitians. *Nutr Diet*. 2012;70(2):113-119.
8. Victorian Department of Health and Human Services. *Dietetics Workforce Report*. Melbourne; 2018.
9. Dietitians Association of Australia. *Accreditation Standards for Dietetics Education Programs Version 2.0*. Deakin, Australia: Dietitians Association of Australia; 2017. https://daa.asn.au/wp-content/uploads/2016/06/DAA-Accredition-Standards-2017-1.pdf.
10. Sandborgh M, Dean E, Denison E, et al. Integration of behavioral medicine competencies into physiotherapy curriculum in an exemplary Swedish program: rationale, process, and review. *Physiother Theory Pract*. 2018;36(3):365-377.
11. Bradshaw C, Atkinson S, Doody O. Employing a qualitative description approach in health care research. *Global Qual Nurs Res*. 2017;4:1-8.
12. Rohwer A, Schoonees A, Young T. Methods used and lessons learnt in conducting document reviews of medical and allied health curricula—a key step in curriculum evaluation. *BMC Med Educ*. 2014;14(1):236.
13. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. 2006;3(2):77-101.
14. Dietitians Board. *Accrediation Standards for New Zealand Dietetic Education Programmes*: Wellington, New Zealand: Dietitians Board; 2018. https://www.dietitiansboard.org.nz/wp-content/uploads/2019/04/NZDB-Accred-Standards-Online.pdf.
15. Krathwohl DR, Anderson LW. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York, NY: Longman; 2009.
16. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*. 2007;19(6):349-357.
17. Levitt HM, Bamberg M, Creswell JW, Frost DM, Josselson R, Suarez-Orozco C. Journal article reporting standards for qualitative primary, qualitative meta-analytic, and mixed methods research in psychology: the APA publications and communications board task force report. *Am Psychol*. 2018;73(1):26-46.
18. Otter.ai. *My Conversations*. California (US); 2021. https://otter.ai/.
19. Whitehead KA, Langley-Evans SC, Tischler VA, Swift JA. Assessing communication skills in dietetic consultations:the development of the reliable and valid DIET-COMMS tool. *J Hum Nutr Diet*. 2014;27:321-332.
20. Blanco MA, Capello CF, Dorsch JL, Perry GJ, Zanetti ML. A survey study of evidence-based medicine training in US and Canadian medical schools. *J Med Libr Assoc*. 2014;102(3):160-168.
21. Gibson S, Davidson Z. An observational study investigating the impact of simulated patients in teaching communication skills in preclinical dietetic students. *J Hum Nutr Diet*. 2016;29(4):529-536.

22. Spahn JM, Reeves RS, Keim KS, et al. State of the evidence regarding behavior change theories and strategies in nutrition counseling to facilitate health and food behavior change. *J Am Diet Assoc*. 2010;110(6):879-891.
23. Bandura A. *Social foundations of thought and action. The Health Psychology Reader*. Englewood Cliffs, NJ: Prentice Hall; 1986:94-106.
24. Schwarzer R, Hamilton K. Changing behavior using the health action process approach. In: Hamilton K, Cameron LD, Hagger MS, Hankonen N, Lintunen T, eds. *The Handbook of Behavior Change. Cambridge Handbooks in Psychology*. Cambridge: Cambridge University Press; 2020:89-103.
25. O'Shea MC, Williams LT, Rogers G, Palermo C, Cardell E. It's time to link theory to practice in simulation-based learning: lessons from learning theories. *J Acad Nutr Diet*. 2021. https://doi.org/10.1016/j.jand.2021.06.011
26. Tweedie J, Wright HH, Palermo C, Pelly FE. Key concepts for dietetic curriculum: an observational study of Australian dietitians' perceptions. *Nutr Diet*. 2021;1-9.
27. Hagger MS, Cameron LD, Hamilton K, Hankonen N, Lintunen T. *Handbook of Behavior Change*. New York, NY: Cambridge University Press; 2020.
28. ESSA. Accredited Exercise Physiologist Professional Standards 2015. https://www.essa.org.au/wp-content/uploads/2016/12/AEP-Professional-Standards-with-coverpage_approved.pdf.
29. Australian Association of Social Workers. *Practice Standards. 4 Knowledge for Practice*. Canberra: Australian Association of Social Workers; 2013.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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