The Indigenous Australian Malnutrition Project: Comparing the burden and impact of malnutrition in Indigenous and non-Indigenous Australian patients, and validation of a malnutrition screening tool

Natasha Frances Franklin

MNUR (Ed) CCRN BN

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Monash University in September 2018

School of Public Health and Preventive Medicine
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The Indigenous Australian Malnutrition Project

ABSTRACT

Background: Protein-energy malnutrition is a significant health problem in adult patients admitted into acute care settings. Although the prevalence of malnutrition and associated health outcomes are relatively well-understood from previous studies, the burden and impact of malnutrition in Aboriginal Australian and/or Torres Strait Islander people is not well understood. Furthermore, although several malnutrition screening tools are available to screen patients for malnutrition risk, a screening tool has not yet been validated for use in Indigenous Australians. Therefore, the objectives of this thesis were to measure and compare the burden and impact of malnutrition among Indigenous Australians versus non-Indigenous Australians, and to validate a malnutrition screening tool that can be used for both adult Indigenous and non-Indigenous Australian patients.

Methods: This thesis includes three studies that were conducted in three regional hospitals in the Northern Territory and Far North Queensland in Australia. The first study is a cross-sectional survey comparing the burden and nature of malnutrition in adult Indigenous and non-Indigenous Australian patients admitted into medical inpatient settings. The second study is a cohort study comparing 30-day and six-month health outcomes, including length of hospital stay, hospital readmission rates, and survival rates. The third and final study includes a validation study using the widely accepted Malnutrition Screening Tool (MST) and the newly developed, Adult Nutrition Tool (ANT), developed as part of this thesis. All participants were screened for malnutrition using the MST and ANT and then assessed for malnutrition using the Subjective Global Assessment
(SGA) tool. Participants with an SGA of B or C were classified as malnourished. Anthropometry data and acute and chronic disease severity indexes were collected to predict markers associated with malnutrition.

**Results:** A total of 608 participants were recruited to the study and of which, 271 (44.6%) were Indigenous Australians. A total of 250 (41.7%, 95% CI 40.1–52.3%) participants were found to be malnourished. Significantly higher rates of malnutrition were observed among Indigenous Australian participants compared to non-Indigenous participants (125/250, 46.1%, 95% CI 40.1–52.3% versus 125/250, 37.1%, 95% CI 31.9–42.5%, \( p = 0.024 \)). Health outcomes were significantly poorer among Indigenous participants who were malnourished than Indigenous participants who were nourished. Malnourished Indigenous participants were more likely to be readmitted into hospital at 30-days (RR 1.53, 95% CI 1.19–1.97, \( p = 0.002 \)) and six months (RR 1.40, 95% CI 1.05–1.88, \( p = 0.018 \)); and less likely to be alive at six-months (RR 1.63, 95% CI 1.20–2.21, \( p = 0.015 \)) than Indigenous participants who were well-nourished. The area under the curve (AUC) when utilising the ANT was significantly higher in Indigenous and non-Indigenous participants compared to the MST (AUC 0.90, 95% CI 0.88–0.92 versus AUC 0.81, 95% CI 0.77–0.84, \( p < 0.001 \)). An ANT ≥ 2 demonstrated superior sensitivity for detection of malnutrition in Indigenous and non-Indigenous participants (96.0%, 95% CI 92.8–98.7%) compared with the MST (84.0%, 95% CI 78.9–88.3%) but inferior specificity (59.5%, 95% CI 54.2–64.6% versus 70.7%, 95% CI 65.7–75.3%).

**Conclusion:** This thesis describes the Indigenous Australian Malnutrition Project which is the first body of research to measure and compare the burden
and impact of malnutrition in Indigenous and non-Indigenous Australians patients. This is also the first body of research to specifically measure the burden and impact of malnutrition in adult Indigenous Australian patients admitted into an acute care health setting as well as validate a malnutrition screening tool that can be used for both Indigenous and non-Indigenous Australians. The findings reported in this thesis highlight the burden of malnutrition in patients residing in regional areas is higher than reported elsewhere in Australia. In addition to higher rates of malnutrition among all study participants, the findings in this thesis reports significantly higher rates of malnutrition in Indigenous participants when compared to non-Indigenous Australian participants, and that the health outcomes are poorer for Indigenous patients who are malnourished compared to Indigenous patients who are well-nourished. From the findings of the validation study, ANT is a new malnutrition screening tool that is validated for use in both adult Indigenous and non-Indigenous patients admitted into medical inpatient settings. In addition to early referral to nutrition and dietetic services for patients identified at-risk of malnutrition, a longer-term cohort study (i.e., greater than six months) is required to understand the true impact of malnutrition. Furthermore, health economic studies are also required to measure the burden of malnutrition to health care services and aide in more nutrition and dietetic services. In implementing the ANT into clinical practice, the reliability of ANT needs to be established and the use of ANT in other clinical settings is also required.
DECLARATION FOR THESIS BASED ON PUBLISHED OR UNPUBLISHED WORK

Publications during enrolment

This thesis contains three published works, one manuscript accepted for publication, and one paper submitted for peer-review publication, including:


Conferences attended during PhD enrolment


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Thesis including published works declaration

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes three original papers published in peer reviewed journals and two unpublished publications. The core theme of the thesis is “understanding the burden and impact of malnutrition among Indigenous Australians and validation of a malnutrition screening tool”. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the student, working within the Department of Epidemiology and Preventive Medicine in the School of Health Sciences under the supervision of Professor Graeme Maguire, Professor Simon Stewart and Dr Malcolm Riley.

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research. In the case of published and planned publications included in this thesis, my contribution to the work involved the following:
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<th>Co-author name(s), nature and percentage of contribution</th>
<th>Co-author/ s Monash student (Y/N)</th>
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| Two            | The burden of protein-energy malnutrition among adult Indigenous Australians: A scoping review | Submitted for peer review publication | Conception, design and review methodology; search; reporting results; drafting of manuscript, including revision and final approval (70%). | Prof Graeme Maguire, review and final approval (10%).  
Prof Simon Stewart, review and final approval (10%).  
Dr Malcolm Riley, review and final approval (10%). | No |
| Three          | 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 | Published                    | Conception, study design; drafting of manuscript, including revisions and final approval (65%).                  | Prof Graeme Maguire, review and final approval (15%).  
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Dr Malcolm Riley, review and final approval (10%). | No |
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<td>Accepted for publication</td>
<td>Conception and design (including development of screening</td>
<td>Prof Graeme Maguire, review and final</td>
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tools in acute medical inpatients and validation of a screening tool among adult Indigenous Australian patients.

- data collection; data entry, coding and cleaning; data analysis and interpretation of data; drafting of manuscript, including revisions and final approval (70%).
- approval (10%).
- Prof Simon Stewart, review and final approval (10%).
- Dr Malcolm Riley, review and final approval (10%).

No

No

I have renumbered sections of submitted or published papers to generate a consistent presentation within the thesis, although the original page numbers are also included as PDF copies.

Student signature: [Redacted] Date: 09 September 2018

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student’s and co-authors’ contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor signature: [Redacted] Date: 09 September 2018
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I also wish to record my acknowledgement and gratitude to the following people:

The traditional owners of lands where this project was conducted and the Indigenous Australian people who participated in this study. I am deeply grateful for their time and sharing their stories about their nutritional health and well-being. As a non-Aboriginal nurse and researcher, I hope that the outcomes of this project provide a way forward to reducing the burden and impact of malnutrition among both Indigenous and non-Indigenous Australians.

I would like to thank my supervisors – Professor Graeme Maguire, Professor Simon Stewart and Dr Malcolm Riley. I considered myself extremely privileged to have such knowledgeable and experienced supervisors and I have enjoyed the diversity of skills and insights that each have offered. Heartfelt thanks for your guidance, mentorship and support throughout this journey.
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Angelina, I dedicate this PhD to you. You are the constant star that shines in my life and I am so very proud of the person who you are.
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<tbody>
<tr>
<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<td>ACSQHC</td>
<td>Australian Commission on Safety and Quality in Health Care</td>
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<td>AIWH</td>
<td>Australian Institute of Health and Welfare</td>
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<td>ANT</td>
<td>Adult Nutrition Tool</td>
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<td>ANZICS</td>
<td>Australian and New Zealand Intensive Care Society</td>
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<td>APACHE</td>
<td>Acute Physiology and Chronic Health Evaluation</td>
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<td>ASH</td>
<td>Alice Springs Hospital</td>
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<td>ASPEN</td>
<td>American Society of Parental Nutrition and Enteral Nutrition</td>
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<td>AUC</td>
<td>Area Under the Curve</td>
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<td>BMI</td>
<td>Body Mass Index</td>
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<td>CBH</td>
<td>Cairns Base Hospital</td>
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<td>CCI</td>
<td>Charlson Comorbidity Index</td>
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<tr>
<td>CI</td>
<td>Confidence Interval</td>
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<td>CINAHL</td>
<td>Cumulative Index to Nursing and Allied Health Literature</td>
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<td>DAA</td>
<td>Dietitians Association of Australia</td>
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<td>ESPEN</td>
<td>European Society of Parental Nutrition and Enteral Nutrition</td>
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<td>FFMI</td>
<td>Fat Free Mass Index</td>
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<td>FNQ</td>
<td>Far North Queensland</td>
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<td>HGS</td>
<td>Hand Grip Strength</td>
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<td>HR</td>
<td>Hazards Ratio</td>
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<td>HREC</td>
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<td>IAM</td>
<td>Indigenous Australian Malnutrition</td>
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<td>ICD 10-AM</td>
<td>International Classification of Diseases 10-Australian Modified</td>
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<td>ICGC</td>
<td>International Consensus Guideline Committee</td>
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<td>IQR</td>
<td>Interquartile Range</td>
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<td>JBI</td>
<td>Johanna Briggs Institute</td>
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<td>LoS</td>
<td>Length of stay</td>
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<td>MNA</td>
<td>Mini Nutritional Assessment</td>
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<td>MST</td>
<td>Malnutrition Screening Tool</td>
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<td>Mid Upper Arm Circumference</td>
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<td>NPV</td>
<td>Negative Predictive Value</td>
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<td>Northern Territory</td>
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<td>OCED</td>
<td>Organisation of Economic Cooperation and Development</td>
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<tr>
<td>OR</td>
<td>Odds Ratio</td>
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<td>PEM</td>
<td>Protein Energy Malnutrition</td>
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<td>PG SGA</td>
<td>Patient Generated Subjective Global Assessment</td>
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<td>PPV</td>
<td>Positive Predictive Value</td>
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<td>QLD</td>
<td>Queensland</td>
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<td>Royal Darwin Hospital</td>
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<td>ROC</td>
<td>Receiver Operator Curve</td>
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<td>RR</td>
<td>Relative Risk</td>
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<td>South Australia</td>
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<td>SAPS</td>
<td>Simplified Acute Physiology Score</td>
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SD Standard Deviation
SGA Subjective Global Assessment
VIC Victoria
WHO World Health Organization
WHR Waist-Hip-Ratio
CHAPTER 1
THESIS INTRODUCTION, BACKGROUND AND THESIS PLAN

Introduction

Malnutrition is a global public health problem with 88 per cent of the world’s countries experiencing two main types of malnutrition, under-nutrition or over-nutrition (Development Initiatives, 2017). While the prevalence over-nutrition (obesity-related malnutrition) is increasing globally, undernutrition due to food insecurity and chronic disease is a public health priority including Australia, especially among Indigenous Australians (Commonwealth of Australia, 2018; Lee & Ride, 2018). The United Nations General Assembly released the 2017 Global Nutrition Report proclaiming a Decade of Action on Nutrition from 2016 to 2025 with the need to eradicate starvation and all other forms of malnutrition (Development Initiatives, 2017). Therefore, the concepts described in this chapter an overview of malnutrition in the form of under-nutrition and the impact to individual’s health and well-being, particularly for Indigenous Australians, what is already known about the burden and impact of malnutrition in Australian acute healthcare care settings, and the role of malnutrition screening tools and their use in patients admitted into acute care settings. Finally, an outline of the thesis structure is provided.

Background

In Australia, the burden of malnutrition in the form of over-nutrition is a major health problem and several health strategies or programs exist aiming to reduce the incidence of nutrition-related conditions including cardiovascular
The Indigenous Australian Malnutrition Project: Chapter 1

disease, diabetes and chronic kidney disease (Commonwealth of Australia, 2009; Lee & Ride, 2018; Menzies School of Health Research, 2018; National Health and Medical Research Council, 2013). However, despite Australia being listed as a high-income country with a ‘Better Life Index’ when compared to many other countries (The Organisation of Economic Cooperation and Development [OECD], 2017), under-nutrition due to economic disadvantage and subsequent food insecurity is a problem especially for Australia’s First Nation people, Indigenous Australians (Lee & Ride, 2018). Indigenous Australians are vulnerable to food insecurity and diets of poor nutritional quality (for example, high energy but poor nutrient diets) and Indigenous Australians are more likely to experience nutrition-related diseases than non-Indigenous Australians (Australian Institute of Health and Welfare [AIHW], 2017a).

To address malnutrition and close the health-disparity gap between the Indigenous and non-Indigenous Australian people, it is important that the true burden and impact of malnutrition among Indigenous people is understood. Although several studies report the prevalence and health outcomes of malnutrition among adults in Australian hospitals (Agarwal et al., 2013; Holyday et al., 2012; Isenring 2010; Sharma et al., 2017), currently there are no studies specifically measuring the burden and impact of malnutrition in adult Indigenous Australians in healthcare settings. For example, in 2010, although a large survey was undertaken across 42 Australian hospitals, of the 3122 patients enrolled into the study, only 61 (2%) of the survey’s participants were identified as Indigenous Australians (Agarwal et al., 2012).
The Indigenous Australian Malnutrition Project: Chapter 1

Protein-energy malnutrition

Malnutrition broadly refers to under-nutrition that results from insufficient nutrient intake or from alterations in digestion and/or impaired absorption (Saunier et al., 2010). Inadequate nutrition intake or any disruption to the gastrointestinal system may cause protein-energy malnutrition as well as other macro and micro nutrients.

Protein-energy malnutrition (PEM) includes two sub-types: Marasmus and Kwashiorker (Mattson Porth, 2015). Marasmus PEM represents progressive loss of muscle mass and fat stores due to inadequate food intake and in adults, is typically caused by prolonged periods of starvation (Mattson Porth, 2015). Loss of muscle mass and subcutaneous fat are common signs of Marasmus PEM, including poor skin integrity, impaired immunity, alterations in cardiovascular and metabolic function, and gastrointestinal symptoms such as diarrhoea (Mattson Porth, 2015). Kwashiorkor PEM is commonly associated with children and results from protein deficiency and diets that are high in nutrient poor carbohydrates (Mattson Porth, 2015). In severe cases of Kwashiorkor PEM, severe loss of proteins in the visceral components of the body, namely the liver, hypoalbuminemia can occur with subsequent oedema (Mattson Porth, 2015). In developed countries, PEM can occur in adults due to acute illness, trauma or non-communicable diseases (Mattson Porth, 2015). Marasmus PEM typically results from chronic diseases including chronic respiratory, cardiovascular, gastrointestinal or kidney diseases and cancers, while Kwashiorkor PEM is typically associated with acute hypermetabolic states such as trauma, burns and sepsis (Mattson Porth, 2015).
Protein homeostasis is critical to individuals’ health and well-being. In healthy adults, protein haemostasis is maintained by a cycle in which net loss of protein in the post-absorptive state is matched by a new postprandial gain of protein. In individuals with acute illness or chronic disease, net protein breakdown is accelerated, and protein rebuilding disrupted. Protein mass is lost from the body’s organs including the liver, gastrointestinal tract, kidneys and heart. As protein is lost from the liver, hepatic synthesis of proteins declines, and plasma protein levels decrease and there is also a decrease in immune cells. Consequently, there are systemic complications as shown in figure 1, including poor wound healing; impaired immunity; atrophy of the gastrointestinal tract (namely the small intestine); loss of cardiac muscle; and weakened respiratory muscles.
The Indigenous Australian Malnutrition Project: Chapter 1

Figure 1: Systemic consequences of protein-energy malnutrition in adults due to acute illness, trauma or chronic disease (adapted from Saunder et al., 2010).

Subsequently, malnutrition results in increased healthcare utilisation, including increased hospital presentations and admissions; longer length of hospital stay; increased morbidity including decreased quality of life; and increased risk of mortality when compared to adults who are well-nourished (Barker, Gout & Crowe, 2011). Consequently, malnutrition is associated with significant healthcare cost in Australia, with malnutrition being associated with approximately $44,176 in extra costs per patient per year (AIHW, n.d.).

Malnutrition in the Australian healthcare context

Approximately 40 per cent of adult patients admitted to Australian hospitals each year are malnourished and the rate of hospital-acquired
Malnutrition in 2015-16 was 12 per 10,000 hospitalisations (Australian Commission on Safety and Quality in Health Care, 2018). However, rates of malnutrition are frequently under-reported due to the lack of a single agreed standardised diagnostic method (Agarwal et al., 2015). In healthcare settings, tools such as the Subjective Global Assessment, the Patient-Generated Subjective Global Assessment, and the Mini-Nutritional Assessment (MNA) are used by dietitians to assess patients’ nutritional status (for example, well-nourished or malnourished) (Detsky et al., 1987; Guerra et al., 2017; Vellas et al., 2006). However, classification and case-based funding for malnutrition is based on the International Classification of Diseases 10-Australian Modification (ICD 10-M) criteria of a Body Mass Index (BMI) of less than 18.5 kg/m², or unintentional weight loss equal or greater than 5 per cent resulting in subcutaneous fat loss and/or muscle wasting (National Centre for Classification in Health, 2010). The use of the ICD 10-AM criteria to diagnose malnutrition is problematic especially in individuals who are overweight (BMI 25.0 – 29.9 kg/m²) or obese (BMI: equal or greater than 30.0 kg/m²), or who suffer from PEM due to chronic disease where weight loss often occurs over a longer period of time, and therefore, acute weight loss or BMI may not be a sensitive marker of malnutrition among individuals with complex and/or severe chronic disease. These different methods used to diagnose malnutrition make it difficult to determine the true prevalence of malnutrition in both hospital and community settings.

**Malnutrition screening**

Screening patients for malnutrition risk is now standard practice across Australian healthcare services. Clinicians, usually nurses, are required to screen
patients for malnutrition on admission to hospital and at-regular periods throughout patients' hospital admission (Australian Commission on Safety and Quality in Health Care, 2018). Several malnutrition screening tools are used in Australian hospital practice with the Malnutrition Screening Tool (MST) being a widely used tool throughout many inpatient and outpatient settings (Ferguson et al., 1999). Malnutrition screening is designed to be a rapid and simple process to detect malnourished patients so early referral to dietetic services is made for nutrition assessment and subsequent management (van Bokhorst-de van der Schueren, et al., 2014). However, it is important that any screening tool is validated for patients, including patients from culturally and linguistically diverse backgrounds, including Indigenous Australians (Frew, Sequeira & Cant, 2010). To date, despite screening being standard clinical practice, a screening tool has not yet been validated specifically among Indigenous Australian patients in an Australian hospital inpatient setting. Anecdotally, the MST is unlikely to be a valid or reliable screening tool for Indigenous Australian patients due to language barriers. For example, Indigenous Australians residing in remote or very remote regions, English is often a fourth or five language and questions asking patient to quantify their weight loss may not be understood or culturally appropriate (ref). At the time of this thesis, the MST is used as the screening tool in all three regional hospitals despite not being validated for use in Indigenous Australian patients who are potentially at increased risk of malnutrition due the higher number of chronic diseases they experience compared to non-Indigenous Australians.

Nutritional health and well-being of Indigenous Australians
As well as using different diagnostic criteria to diagnose malnutrition, the prevalence of malnutrition varies depending on individuals’ demographics and health characteristics. For example, Indigenous Australians who experience economic disadvantage are at increased risk of both over and undernutrition due to food insecurity (Lee & Ride, 2018). Indigenous Australians continue to experience economic disadvantage for many complex reasons, including colonisation associated with racism and separation from land and families by British settlers in the late 1700s (Sherwood & Ceia, 2014).

The burden of nutrition-related chronic diseases in Indigenous Australian adults is greater than non-Indigenous Australians, including cardiovascular disease (27% versus 21% respectively); diabetes (18% versus 5% respectively); and chronic kidney disease (22% versus 10% respectively) (AIHW, 2017a). Indigenous Australians experience chronic disease at a younger age than non-Indigenous Australians (for example, the rate of chronic kidney is four times higher in Indigenous Australians between the ages of 45-54 than non-Indigenous Australians); have higher rates of hospital admissions (for example, the proportion of hospitalisation is almost twice in Indigenous adults when compared to non-Indigenous adults); and survival rates are greater in Indigenous compared with non-Indigenous adults and Indigenous adults who are also more likely to die at a younger age (69.1 years compared with 79.7 years for males, and 73.7 years compared with 83.1 years for females) (AIHW, 2017a; AIHW, 2017b). Furthermore, the prevalence of chronic diseases is higher in Indigenous Australians living in remote areas (AIHW, 2017a). For example, Indigenous people living in remote areas are six times more likely to have diabetes mellitus.
and five times more likely to have chronic kidney disease than non-Indigenous people living in remote areas (AIHW, 2017a).

While over-nutrition and other forms of malnutrition including micronutrient malnutrition, such as iron and folate deficiency, has been studied in Indigenous Australians (Australian Bureau of Statistics, 2014), the issue of PEM in adult Indigenous Australians has, by comparison, been a clinical problem that is still relatively unexplored. Indigenous Australians are more likely to experience higher rates of malnutrition due to food insecurity combined with the burden of chronic disease they experience compared to other Australian populations (AIHW, 2017a; AIHW, 2017b). National reports, including the Australian Prime Minister’s ‘Closing the Gap’ report in 2018, highlight that despite Australian being a high-income country, Indigenous Australians continue to experience food insecurity due to financial hardship (Commonwealth of Australia, 2018). For many Indigenous Australian people living in regional and remote areas of Australia, food insecurity is compounded by land dispossession and inability to access traditional foods; financial hardship; larger families and overcrowded households; and vast distances to large supermarkets and public services (Commonwealth of Australia, 2018; Lee & Ride, 2018). Furthermore, Indigenous Australian people living in regional and remote regions rely on access to community stores where nutritious food is more expensive than in non-remote stores or supermarkets and be limited in supply (Lee & Ride, 2018).

**Thesis aims**

While there are several studies reporting food insecurity and the burden of chronic disease in adult Indigenous Australians (Ferguson et al., 2017;
Wycherley et al., 2017; Spurway & Soldatic, 2016), there have been no studies measuring both the burden and impact of malnutrition among Indigenous Australians. Furthermore, a malnutrition screening tool has not yet been validated for use in Indigenous Australians. Therefore, the aims of this thesis are to:

1. Address the current knowledge gap regarding the burden and impact of malnutrition among Indigenous and non-Indigenous patients admitted into regional Australian hospitals in the Northern Territory and Far North Queensland; and

2. Validate a malnutrition screening tool for use in both Indigenous Australian and non-Indigenous patients to aide in the early detection of malnutrition and facilitate earlier dietitian referral and subsequent nutrition assessment and management.

**Chapter plan**

Chapters in this thesis include a scoping review of the literature to determine what is known about protein-energy malnutrition in adult Indigenous Australians, before including papers that outlines the study protocol for the ‘Indigenous Australian Malnutrition Project’, and three outcome papers including results of a cross-sectional survey, cohort study, and validation of a newly developed malnutrition screening tool (the Adult Nutrition Tool) for adult Indigenous Australian patients. The final chapter in this thesis includes a discussion providing recommendations for future clinical practice as well as recommendations for future research.
Conclusions

Malnutrition is both a globally and nationally recognised problem. The impact and consequences of malnutrition are well recognised and reflected by the requirement to have policies and procedures in place to screen and management patients in hospital who are malnourished. Despite the awareness of the impact of malnutrition, the burden and impact of malnutrition for adult Indigenous Australians is not well known. This thesis includes a suite of chapters that outline the findings of studies undertaken to address this knowledge gap. In addition, this thesis provides validation of a new malnutrition screening tool for both Indigenous and non-Indigenous patients. This thesis contributes to the global strategy to address malnutrition with a particular focus on Indigenous Australian patients residing in regional Australia. In turn it is hoped the findings presented here help close the health disparity gap that continues to exist between Indigenous and non-Indigenous Australians by informing future healthcare responses to malnutrition.
References


The Indigenous Australian Malnutrition Project: Chapter 1


Isenring, E., Cross, G., Kellet, E., Koczwara, B., & Daniels, L. (2010). Nutritional status and information needs to medical oncology patients receiving treatment


CHAPTER 2

THE BURDEN OF PROTEIN-ENERGY MALNUTRITION AMONG ADULT INDIGENOUS PEOPLE IN THE AUSTRALIAN HEALTHCARE CONTEXT

Introduction

This chapter includes a scoping review of the literature to understand the burden of malnutrition among adult Indigenous Australians in the Australian healthcare context and to understand the reporting of malnutrition in this group of people. A scoping review methodology was used to map the reporting of malnutrition in different healthcare contexts, different study designs, and different nutrition assessment methods (Joanna Briggs Institute, 2015). This review reports the prevalence of malnutrition in Indigenous and non-Indigenous Australians and the different tools used to assess malnutrition in Australian healthcare facilities, including acute care (both public and private); subacute and rehabilitation settings; geriatric settings; cancer care services; renal services; and residential aged care between the periods 1999 and 2018.

This scoping review was undertaken following submission and publication of chapters 3 and 4 due to the limited studies published in this specific topic. The rationale for undertaking the review following the dissemination of the results described in chapter 4 was that prior to the study protocol outlined in chapter 3, a search of the library databases, web-searches and hospital-based reports yielded no results regarding the prevalence of malnutrition among Indigenous Australians. Due to absence of relevant studies a systematic review could not be undertaken. With the release and publication of the Johanna Briggs Institute Scoping Review guidelines (2015), a scoping review was undertaken to as
outlined above. As this scoping review was conducted after the publication of papers presented in chapters 3 and 4, the results reported in chapter 4 are included in this review for the purpose of publication.

The Indigenous Australian Malnutrition Project: Chapter 2

The burden of protein-energy malnutrition among Indigenous Australians: A scoping review

Abstract

Aims: This aims of this review are to explore studies undertaken in Australian healthcare settings to understand the diagnostic tools used to detect malnutrition and to compare the differences in reporting rates between Indigenous and non-Indigenous Australian patients.

Methods: This scoping review uses the Johanna Briggs Institute’s scoping review guidelines. A three-step search strategy was used in this review, PubMed, CINAHL and the Aboriginal Australian & Torres Strait Islander combined Informit Indexes databases were searched. Data were extracted using a charted table, which was developed to record key information relevant to the review’s objectives. Studies were included if they were conducted in an Australian healthcare setting, if they used a validated method of detecting malnutrition, and were published between 1999 and 2018.

Findings: A total of 54 studies were included in the review. Most studies were conducted in Queensland, Victoria, New South Wales and South Australia. The SGA and PG-SGA were the most common tools used to detect malnutrition. Only three study reports identified where study participants were Indigenous Australian (n = 357/20,064, 1.8%). A total of 5,409 (27.0%) of the review’s participants were malnourished. Of the two studies that identified Indigenous and non-Indigenous Australians, only one study reported the prevalence of malnutrition among Indigenous Australian patients where 134/296 (45.3%) were found to be malnourished.
Conclusions: There is insufficient evidence to understand the burden of malnutrition among adult Indigenous Australians in the Australian healthcare context. Further research is required to address this problem and to inform nutrition policies and clinical guidelines tailored for Indigenous Australian people.

Keywords: Indigenous Australians, malnutrition, undernutrition
Background

Protein-energy malnutrition (hereafter referred to as malnutrition) is defined as a state of undernourishment characterised by muscle wasting and subcutaneous fat loss. Malnutrition in adults is commonly associated with co-existing chronic disease and studies clearly demonstrate a relationship between malnutrition and subsequent healthcare utilisation. In Australia, the prevalence of malnutrition in various healthcare settings has been widely reported, including a large survey conducted in Australian hospitals in 2010 where the prevalence of malnutrition was reported as 32%. However, establishing the exact prevalence of malnutrition is not possible due to varying patient characteristics including patients with advanced age and nature of different chronic diseases (for example, cardiovascular disease versus cancer). As well as different patient characteristics, the true prevalence of malnutrition cannot be established due to a lack of a gold-standard diagnostic tool and varying methods to assess malnutrition.

For example, diagnostic methods commonly used in hospital inpatient and outpatient settings include the Subjective Global Assessment (SGA), the Patient-Generated SGA (PG-SGA), the Mini Nutritional Assessment (MNA), the Malnutrition Universal Screening Tool (MUST), and the International Classification of Diseases 10-Australian Modified (ICD-10AM) criteria.

While many studies have reported the prevalence of malnutrition using varying assessment methods in different healthcare settings and in specific patient populations (for example, patients with cancer), there is a large gap of evidence regarding the burden of malnutrition among adult Aboriginal Australian and/or Torres Strait Islander people (hereafter referred to as Indigenous
Indigenous Australians represent three per cent of Australia’s population and experience poorer levels of health and wellbeing compared to non-Indigenous Australians. Due to the ongoing effects of invasion by British Settlers in the late 1700’s, Indigenous Australians are more likely to suffer higher rates of communicable and non-communicable diseases, increased disease severity, are more likely to experience a lower quality of life, and more likely to die younger than non-Indigenous people. As well as poorer health, Indigenous Australians are also more likely to experience barriers to accessing health services and specialist services increasing their likely risk for disease-related malnutrition.

Poor nutrition and factors such as food insecurity are also a major risk factor for malnutrition and nutritional health among Indigenous Australians is a well-established health priority due to several critical issues. Indigenous Australians are more likely to face food insecurity than non-Indigenous Australians due to income differences and Indigenous people are more likely to live in rural or remote regions than non-Indigenous people where access to nutritious and affordable food is a major problem. While there are several nutrition intervention programs at a community level, the prevalence of
malnutrition among adult Indigenous Australians has not been well-established and is not well understood.

**Objectives**

The objectives of this scoping review were to:

1. Explore studies undertaken in Australian healthcare settings to understand the diagnostic tools used to detect malnutrition; and
2. Compare the differences in rates of reporting malnutrition in both Indigenous and non-Indigenous Australian patients.

**Research question**

What is the prevalence of protein-energy malnutrition among adult Indigenous Australian people utilising Australian healthcare services?

**Inclusion criteria**

This review included any studies reporting the prevalence of malnutrition in adults utilising Australian healthcare services. In the absence of a gold-standard diagnostic tool, the concepts of interest in this review were studies that reported malnutrition using validated nutrition assessment methods including the SGA (A = well nourished; B or C = malnourished);\(^{10}\) PG-SGA (A = well nourished; B or C = malnourished);\(^{11}\) MUST (score ≥ 2);\(^{12}\) MNA (score < 17);\(^{13}\) and the ICD-10AM criteria (Body Mass Index [BMI] of less than 18.5 kg/m\(^2\), or unintentional weight loss equal or greater than 5% resulting in subcutaneous fat loss and/or muscle wasting).\(^{14}\) Studies were also included if they also reported malnutrition using the World Health Organization (WHO) underweight criteria of a BMI < 18.5
kg/m²,¹⁹ or studies that used a BMI cut-off point of < 22.0 kg/m² for patients aged 65 years and over.²¹

Studies were included if they reported the prevalence of malnutrition in community health care settings (for example, dialysis centres); residential aged-care; or acute health care settings, including outpatient settings. Studies excluded from this review were: studies reporting malnutrition in pregnant or lactating women; studies reporting malnutrition in mental health conditions such as anorexia nervosa and bulimia; studies that used malnutrition risk screening tools as the reference standard; and studies that reported over-nutrition (such as overweight or obesity) and studies reporting micronutrient deficiencies (including anaemia and vitamin and mineral deficiencies).

Studies of different quantitative study designs were eligible for this review including cross-sectional survey, cohort studies, randomised clinical trials, and systematic reviews that met this review's inclusion criteria for participants, concept and context.

**Methods**

The search strategy was developed by the first author (NM) and the review methodology was based on the Joanna Briggs Institute (JBI) scoping review methodology.²¹ A scoping review methodology was selected for this study to map key concepts and understand the reporting of malnutrition in the wider Australian healthcare contexts and to examine studies' participant population to determine what is known about the burden of malnutrition among Indigenous Australians. Using the JBI scoping review methodology, an initial search was undertaken by
the first author using the following two databases: Medline and CINHAL. The
initial search was then analysed by screening articles' titles and abstracts for
keywords by the first author and a second reviewer (a librarian). A second search
was then undertaken using all identified keywords using CINAHL, PubMed, the
Aboriginal Australian & Torres Strait Islander combined Informit Indexes, and
Google Scholar by the first author and the second reviewer. The reference lists
of all identified articles were then analysed by the first author (NM) and the
second reviewer for any additional studies. Full-length studies published in
English were included in this review and no time periods were applied to the
search to gain a wider appreciation of the concept and context of malnutrition in
Australian healthcare settings. The final search terms used in the second search
were: protein energy malnutrition OR malnutrition OR undernourished OR
underweight OR nutritional status OR subjective global assessment AND
Australia OR Australian OR Australasian. Databases were searched from April
25th to May 12th 2018. Two reviewers were involved in the selection of studies.

Data were extracted from the included studies using an instrument
developed according to the proposed review protocol. A table of charted data
included: Author(s); year of publication; study healthcare setting and location
(where reported); aims or objectives of the study; study population and size
(including distinguishing Indigenous Australian study participants); study design;
malnutrition reference standard; and malnutrition outcomes for study participants
and Indigenous Australian participants (see Table 1).

Results
As seen in Figure 1, the search strategy identified a total of 596 studies. After excluding 95 duplicates and 431 studies that did not meet this review’s inclusion criteria, 70 were selected for full-text review to further determine the relevance of studies to our inclusion criteria of which, a further 24 studies were excluded. Another nine studies were included through hand searching the reference lists of the full-text articles included in this review. Finally, 54 studies were included in this review.6,22-74

Figure 1: Search strategy using databases CINAHL, PubMed, the Aboriginal & Torres Strait Islander combined Informit Indexes and Goggle Scholar.
Study designs, location and settings

The study designs and settings of included studies are summarised in Table 1. Studies were published from 1999 to 2018. Of the 55 studies included in this review, 30 were cross-sectional (either prospective or retrospective audits); 15 were cohort studies; seven were validation of a malnutrition screening tool; and two were randomised controlled trials.

Sixteen studies were conducted in Queensland; 12 studies in South Australia; 11 studies in New South Wales; 11 studies in Victoria; and one study in the Northern Territory. Three studies did not specify study locations and one study was conducted throughout 44 Australian acute healthcare services although the locations of these services were not specified.

Twenty-four studies were conducted in acute care inpatient and outpatient settings (including public and private hospitals); 14 studies were cancer care services; six studies in rehabilitation or sub-acute healthcare services; five studies in geriatric evaluation and management services; three studies in renal dialysis services; two studies in residential and aged care services; and one study that was a mixed setting, geriatric and renal services.
Study participants

A total of 20,003 participants were included in this review. Of this total, 357 participants were identified as either Aboriginal, Aboriginal Australian, Torres Strait Islander, or Indigenous Australian representing less than two per cent of this review's study population.6,61,72 One study specifically excluded Indigenous Australians; citing a lack of funding for interpreter services and the other study not providing any rationale for excluding Indigenous patients.64

Tools used to detect malnutrition

As outlined in Table 1, 25 studies used an SGA B or C (mild-moderate or severe malnutrition respectively);6,23,28,31,32,38,42,45,49,54,56,60,61,66,67,72,74 17 studies used the PG-SGA B or C (mild-moderate or severe malnutrition respectively);22,34,35,43,47,48,50-52,59,64,69,71 eight studies used the MNA;33,36,37,44,53,57,58,73 four studies used a BMI cut off point of <18.5 kg/m²;6,23,46,63 one study used a BMI cut off point < 22.0 kg/m² in adults aged 65 years and over;68 two studies used the ICD 10-AM criteria;29,30 one study used a MNA-SF (score < 7);65 one study used a BMI < 18.5 kg/m² and Fat Free Mass Index;46 one study used the SGA and a BMI < 18.5 kg/m²;63 one study used a SGA or MNA;55 and one study used a PG-SGA or MNA.62

Prevalence of malnutrition

As outlined in Table 1, a total of 5409/20,003 (27.0%) of studies’ participants were malnourished. The prevalence of malnutrition ranged from 4.2–97.1%. Only two studies reported the prevalence of malnutrition among Indigenous Australian patients.61,71 Of the 296 Indigenous Australian participants
included in these two studies, 134/296 (45.2%) were malnourished according the SGA or the PG-SGA.\textsuperscript{61,71}

\textbf{Discussion}

This scoping review included 54 studies reporting malnutrition in adult patients in different Australian healthcare contexts. Although many studies have been conducted in South Australia, Victoria, Queensland and New South Wales, this review found a lack of evidence in other states and territories, including Australia Capital Territory, Western Australia, Tasmania and the Northern Territory. The lack of published studies particularly in Western Australia and the Northern Territory potentially contributes to the knowledge gap regarding the burden of malnutrition among Indigenous Australians due to proportion of Indigenous peoples residing in these two geographical regions when compared to other states and territories.\textsuperscript{75} Although Indigenous Australian people represent only 3 per cent of the total Australian population, Indigenous Australians are often over-represented in healthcare settings due to the burden of disease they experience.\textsuperscript{76} With less than two per cent of the study population identified as Indigenous Australian in this review, our findings have highlighted that there is insufficient data to properly understand the true burden of malnutrition among adult Indigenous Australians in healthcare settings and therefore, there is insufficient evidence to inform clinical practice guidelines among this particularly vulnerable group of patients.

This review highlights a major gap in what is known about the burden and impact of malnutrition among Indigenous Australians admitted into different
healthcare settings. While several studies have reported the prevalence and negative health outcomes associated with malnutrition in different healthcare settings, it is likely the burden and impact of malnutrition is greater among Indigenous Australians.

The burden of malnutrition needs to be considered in context with inpatient hospital separation rates. In 2016-17, 4.7% of hospital separations were Indigenous Australians, and 90% of separations for Indigenous Australians were from public hospitals compared with 58% of separations for non-Indigenous patients. Furthermore, in geographical jurisdictions such as the Northern Territory (that has the highest proportion of Indigenous residents compared to other states and territories), there is a lack of studies regarding the burden of malnutrition among Indigenous Australians in different clinical settings such as renal or cancer care settings. Furthermore, this lack of knowledge extends to inpatient malnutrition burden where, in the Northern Territory, Indigenous patients are even more over represented and account for 70 per cent of public hospital separations.

Our review also highlights varying methods to detect malnutrition. While the SGA and PG-SGA are widely used tools there is a need to validate these tools and appropriate malnutrition screening tools among Indigenous Australian people. In Australia, healthcare standards recommend screening patients using a validated tool upon or within 24 hours of admission to a healthcare service. Although there are many screening tools used in Australian healthcare services (for example, the Malnutrition Screening Tool, the Mini Nutrition Assessment –
Short Form, the MUST), validation of these screening tools is required in adult Indigenous Australian inpatients to aid in the early detection of malnutrition among this group of patients who are likely to be vulnerable to malnutrition.

The limitations of this review include only including studies in the healthcare context and the focus on protein-energy malnutrition. While a review of Indigenous Australians nutrition status including vitamin and mineral deficiency may provide a better overview of their nutritional health and wellbeing, it was not within the scope of this review. Given the lack of studies in the healthcare context reporting the burden of malnutrition in adult Indigenous Australians, other studies reporting malnutrition in pregnant women and young adolescents may also provide more insight into this problem given the importance of nutrition across the lifespan.

Conclusions

This review found a significant lack of published studies describing the prevalence of malnutrition among Indigenous Australians and this review was unable to gain a better appreciation and understanding of the different methods to detect malnutrition among this group of people. Due to the lack of evidence found in this scoping review, it is imperative that further research is undertaken to understand both the burden and impact of malnutrition among Indigenous Australians to better inform nutrition policies and clinical guidelines. Furthermore, due to the nature of malnutrition it is important that validated screening and assessment tools are used to detect malnutrition among Indigenous Australians to facilitate in early dietetic referral and subsequent nutrition management.
References


6. Agarwal E, Ferguson M, Banks M, Batterham M, Bauer J, Capra S, Isenring E. Nutritional status and dietary intake of acute care patients: Results from the


41. Garth AK, Newsome CM, Simmance N, Crowe TC. (2010). Nutritional status, nutrition practices and post-operative complications in patients with


Table 1: Study demographics and characteristics, malnutrition reference standard and prevalence of malnutrition among Indigenous and non-Indigenous Australian patients.

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Study setting, location</th>
<th>Study design</th>
<th>Study aims</th>
<th>Total number of participants (n = 20,064)</th>
<th>Total number of Indigenous Australian participants (n = 357) (1.8%)</th>
<th>Malnutrition reference standard</th>
<th>Total patients malnourished (n = 5,418) (27.0%)</th>
<th>Total number of Indigenous Australian patients malnourished (n = 134/296) (45.3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott et al. (2014)(^{22})</td>
<td>Public hospital; chemotherapy outpatients, Victoria</td>
<td>Cross-sectional (prospective)</td>
<td>Assess the validity of the PG-SGA in patients receiving chemotherapy</td>
<td>300</td>
<td>Not stated</td>
<td>PG-SGA (B/C)</td>
<td>51 (17)</td>
<td>-</td>
</tr>
<tr>
<td>Agarwal et al. (2012)(^{6})</td>
<td>Public hospital; 42 medical/surgical inpatient wards, location not specified</td>
<td>Cross-sectional (prospective)</td>
<td>Determine the nutritional status and dietary intake of patients in hospital</td>
<td>3122</td>
<td>61</td>
<td>SGA (B/C): BMI &lt;18.5 kg/m(^2)</td>
<td>993 (32)</td>
<td>-</td>
</tr>
<tr>
<td>Banks et al. (2010)(^{23})</td>
<td>Multicentre public healthcare facilities, including 16 acute care facilities and 5</td>
<td>Cross-sectional (prospective)</td>
<td>Determine the effect of nutritional status on the presence and severity of pressure ulcers</td>
<td>3122</td>
<td>61</td>
<td>SGA (B/C): BMI &lt; 18.5 kg/m(^2)</td>
<td>993 (32)</td>
<td>-</td>
</tr>
<tr>
<td>Study Authors and Year</td>
<td>Setting</td>
<td>Design</td>
<td>Objectives</td>
<td>Sample Size</td>
<td>Nutritional Assessment</td>
<td>Malnourished Patients</td>
<td>Sensitivity (%)</td>
<td></td>
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<tr>
<td>Bauer et al. (2011)</td>
<td>Private hospital, Queensland</td>
<td>Cross-sectional (prospective)</td>
<td>Assess the nutritional status in an acute care setting and examine factors associated with an increased risk of being malnourished</td>
<td>147</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>29 (19.7)</td>
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<tr>
<td>Bauer et al. (2007)</td>
<td>Private hospital, Queensland</td>
<td>Cross-sectional (prospective)</td>
<td>Assess the nutritional status in an acute care setting and examine factors associated with an increased risk of being malnourished</td>
<td>49</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>22 (44.9)</td>
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<tr>
<td>Bauer et al. (2003)</td>
<td>Private hospital; oncology ward, Queensland</td>
<td>Validation study</td>
<td>Determine the sensitivity and specificity of the MST against the SGA in hospital</td>
<td>65</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>49 (75)</td>
<td></td>
</tr>
<tr>
<td>Study Authors (Year)</td>
<td>Setting</td>
<td>Study Design</td>
<td>Purpose</td>
<td>Sample Size</td>
<td>Methodology</td>
<td>Nutritional screener</td>
<td>Malnutrition Prevalence</td>
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<tr>
<td>Bauer et al. (2002)²⁷</td>
<td>Private hospital; oncology ward, Queensland</td>
<td>Cross-sectional (prospective)</td>
<td>Assess the nutritional status in an acute care setting and examine factors associated with an increased risk of being malnourished</td>
<td>71</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>54 (76.1)</td>
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<tr>
<td>Beck et al. (2001)²⁸</td>
<td>Public hospitals, New South Wales</td>
<td>Cross-sectional (prospective)</td>
<td>Describe nutritional screening and assessment practices by dietitians</td>
<td>5149</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>634 (12.3)</td>
<td></td>
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<tr>
<td>Bell et al. (2013)²⁹</td>
<td>Public hospital; orthopaedic ward, Queensland</td>
<td>Cross-sectional (prospective)</td>
<td>Determine whether the MST or anthropometric parameters adequately detect malnutrition in patients with hip fracture</td>
<td>92</td>
<td>Not stated</td>
<td>ICD 10-AM</td>
<td>35 (37.5)</td>
<td></td>
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<tr>
<td>Bolton et al. (2013)³⁰</td>
<td>Cancer care hospital, Victoria</td>
<td>Cross-sectional (retrospective audit)</td>
<td>Determine the prevalence of malnutrition risk and</td>
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<td>Not stated</td>
<td>ICD 10-AM</td>
<td>50 (51.5)</td>
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<td>Study</td>
<td>Setting</td>
<td>Study Design</td>
<td>Purpose</td>
<td>Sample Size</td>
<td>Nutritional Assessment</td>
<td>Malnutrition Rate</td>
<td>Region</td>
<td></td>
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<td>Chan et al. (2012)&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Public hospital; renal inpatient ward, New South Wales</td>
<td>Cohort (retrospective)</td>
<td>Describe the nutritional status of patients with end-stage kidney disease on renal replacement therapy</td>
<td>163</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td></td>
<td></td>
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<td>Chan et al. (2014)&lt;sup&gt;32&lt;/sup&gt;</td>
<td>Pre-dialysis clinic, New South Wales</td>
<td>Cross sectional (retrospective audit)</td>
<td>Describe the nutritional characteristics of patients with end-stage kidney disease</td>
<td>210</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td></td>
<td></td>
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<tr>
<td>Charlton et al. (2010)&lt;sup&gt;33&lt;/sup&gt;</td>
<td>Two rehabilitation hospitals, New South Wales</td>
<td>Cross sectional (retrospective audit)</td>
<td>Describe the nutritional status of older patients admitted to rehabilitation hospitals</td>
<td>2076</td>
<td>Not stated</td>
<td>MNA (score &lt; 17)</td>
<td></td>
<td></td>
</tr>
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<td>Creaser (2010)&lt;sup&gt;34&lt;/sup&gt;</td>
<td>Chemotherapy day unit, Victoria</td>
<td>Cross-sectional (prospective)</td>
<td>Examine the nutritional status of oncology patients</td>
<td>85</td>
<td>Not stated</td>
<td>PG SGA (B/C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First author et al. (year)</td>
<td>Setting</td>
<td>Study type</td>
<td>Objective</td>
<td>Sample size</td>
<td>Nutritional screening tool</td>
<td>Prevalence</td>
<td>Additional notes</td>
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<td>Davidson et al. (2012)</td>
<td>Chemotherapy ambulatory care unit, Queensland</td>
<td>Cross-sectional (prospective)</td>
<td>Determine the prevalence of malnutrition in patients receiving chemotherapy</td>
<td>121</td>
<td>Not stated</td>
<td>PG SGA (B/C)</td>
<td>31 (25.6)</td>
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<tr>
<td>Dent et al. (2012)</td>
<td>Public hospital; geriatric evaluation and management unit, South Australia</td>
<td>Cross-sectional (prospective)</td>
<td>Determine the prevalence in hospitalised patients ≥ 70 years</td>
<td>100</td>
<td>Not stated</td>
<td>MNA (score &lt; 17)</td>
<td>84 (84.0)</td>
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<tr>
<td>Dent et al. (2011)</td>
<td>Public hospital; geriatric evaluation and management unit, South Australia</td>
<td>Validation study</td>
<td>Determine the predictive ability and accuracy of nutrition screening tools</td>
<td>172</td>
<td>Not stated</td>
<td>MNA (score &lt; 17)</td>
<td>53 (31.0)</td>
<td></td>
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<tr>
<td>Ferguson et al. (1999)</td>
<td>Two cancer care hospitals, Queensland</td>
<td>Validation study</td>
<td>Validate the newly developed Malnutrition Screening Tool in cancer patients undergoing radiotherapy</td>
<td>106</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>12 (11.0)</td>
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<tr>
<td>Ferguson et al. (1999)</td>
<td>Private hospital, Queensland</td>
<td>Validation study</td>
<td>Validate the MST that could be used in acutely ill</td>
<td>408</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>69 (16.9)</td>
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<td>Design</td>
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<td>Sample Size</td>
<td>Malnutrition Screening Tool</td>
<td>Prevalence</td>
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<tr>
<td>Frew et al. (2010)(^{40})</td>
<td>Public hospital, Victoria</td>
<td>Cross-sectional (prospective)</td>
<td>Develop a malnutrition screening process for adult inpatients from culturally diverse backgrounds</td>
<td>95</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>55 (58.0)</td>
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<tr>
<td>Garth et al. (2010)(^{41})</td>
<td>Public hospital, Victoria</td>
<td>Cohort study</td>
<td>Determine whether specific perioperative nutritional practices and protocols are associated with improved patient outcomes in surgical patients with upper gastrointestinal and colorectal cancer</td>
<td>25</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>12 (48.0)</td>
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<tr>
<td>Gout et al. (2009)(^{42})</td>
<td>Public hospital, Victoria</td>
<td>Cross-sectional (prospective and)</td>
<td>Determine the prevalence and diagnosis, documentation</td>
<td>275</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>62 (22.5)</td>
<td></td>
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<tr>
<td>Study</td>
<td>Setting</td>
<td>Methodology</td>
<td>Objective</td>
<td>n</td>
<td>SGA Score</td>
<td>% Malnourished</td>
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<tr>
<td>Hill et al. (2011)(^43)</td>
<td>Cancer care hospital, Victoria</td>
<td>Cross-sectional</td>
<td>Determine the nutritional status of patients with GI cancers receiving radiotherapy</td>
<td>73</td>
<td>Not stated</td>
<td>11 (36.4)</td>
<td></td>
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<tr>
<td>Holyday et al. (2012)(^44)</td>
<td>Public hospital; acute geriatric wards, New South Wales</td>
<td>Randomised controlled trial</td>
<td>Assess the impact of nutrition screening and intervention and patient outcomes and costs</td>
<td>143</td>
<td>Not stated</td>
<td>32 (22.0)</td>
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<tr>
<td>Hoong et al. (2017)(^45)</td>
<td>Public hospital, Queensland</td>
<td>Cohort study</td>
<td>Measure the association with all-cause mortality, emergency hospitalisation and healthcare costs in patients with COPD</td>
<td>286</td>
<td>Not stated</td>
<td>47 (16.4)</td>
<td></td>
<td></td>
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<tr>
<td>Study</td>
<td>Setting</td>
<td>Study Type</td>
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<td>Results</td>
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<tr>
<td>Humphreys et al. (2008)</td>
<td>Two public hospitals; pulmonary clinics, South Australia</td>
<td>Cross-sectional (prospective)</td>
<td>Determine in patients with COPD the prevalence of nutritional depletion, adequacy of dietary intake and relationship between nutritional depletion and clinical indicators</td>
<td>66</td>
<td>Not stated</td>
<td>BMI (&lt; 20.0 kg/m²) Fat Free Mass Index (&lt; 16.6 kg/m² men; &lt; 14.5 kg/m² women)</td>
<td>20 (30.0)</td>
<td>-</td>
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<tr>
<td>Hung et al. (2013)</td>
<td>Public hospital; transplant centre, Queensland</td>
<td>Pilot cohort study</td>
<td>Describe the changes in nutritional status, body composition, quality of life, and physical activity levels of cancer patients</td>
<td>66</td>
<td>Not stated</td>
<td>PG SGA (B/C)</td>
<td>1 (4.2)</td>
<td>-</td>
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<tr>
<td>Isenring et al. (2010)</td>
<td>Outpatient clinic; chemotherapy day unit, Queensland</td>
<td>Cross-sectional (prospective)</td>
<td>Determine the prevalence of malnutrition in patients with cancer</td>
<td>191</td>
<td>Not stated</td>
<td>PG SGA (B/C)</td>
<td>94 (49.0)</td>
<td>-</td>
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<tr>
<td>Isenring et al. (2009)</td>
<td>Eight residential aged care</td>
<td>Validation study</td>
<td>Determine the validity of the MST against SGA (B/C)</td>
<td>346</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>122 (42.8)</td>
<td>-</td>
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<tr>
<td>Study (Year)</td>
<td>Setting/Environment</td>
<td>Study Design</td>
<td>Objectives</td>
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<td>Findings</td>
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<tr>
<td>Isenring et al. (2006)</td>
<td>Public hospital; chemotherapy day unit, Queensland</td>
<td>Validation study</td>
<td>Determine the relative validity of the MST compared with a full nutrition assessment by the scored PG SGA and to assess the MST inter-rater reliability in outpatients receiving chemotherapy</td>
<td>50</td>
<td>Not stated</td>
<td>PG SGA (B/C) 13 (26.0)</td>
<td></td>
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<tr>
<td>Isenring et al. (2004)</td>
<td>Private outpatients department, Queensland</td>
<td>Randomised controlled trial</td>
<td>Determine the impact of early and intensive nutrition intervention on body weight, body composition, nutritional status, global quality of life</td>
<td>60</td>
<td>NR</td>
<td>PG SGA (B/C) 21 (35)</td>
<td></td>
<td></td>
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<tr>
<td>Study: Isenring et al. (2003)</td>
<td>Two radiation oncology centres, Queensland</td>
<td>Cohort study</td>
<td>Evaluate the scored PG SGA tool as an outcome measure in clinical nutrition practice and determine its association with quality of life</td>
<td>60</td>
<td>Not stated</td>
<td>PG SGA (B/C)</td>
<td>21 (35.0)</td>
<td>-</td>
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<tr>
<td>Study: Kaur et al. (2008)</td>
<td>Ambulatory rehabilitation service, South Australia</td>
<td>Cross-sectional (prospective)</td>
<td>Assess the nutritional status of older adults in ambulatory rehabilitation</td>
<td>229</td>
<td>Not stated</td>
<td>MNA (score &lt; 17)</td>
<td>11 (5.0)</td>
<td>-</td>
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<td>Study: Klemm et al. (2008)</td>
<td>Public hospital, Victoria</td>
<td>Cross-sectional (prospective)</td>
<td>Evaluate a clinical nutritional guideline for patients with a hip fracture to determine whether an</td>
<td>113</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
<td>42 (37.2)</td>
<td>-</td>
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<tr>
<td>Study</td>
<td>Setting</td>
<td>Study Design</td>
<td>Purpose</td>
<td>Patient Characteristics</td>
<td>Malnutrition Tool(s)</td>
<td>Results</td>
<td>Other Notes</td>
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<tr>
<td>Lambert et al. (2014)</td>
<td>Public hospital; geriatric and renal wards, location not stated</td>
<td>Cohort study</td>
<td>Evaluate the use of Nutrition as Medication as a dietary intervention strategy in malnourished renal and geriatric hospital inpatients</td>
<td>18, Not stated</td>
<td>SGA (B/C) MNA (score &lt; 17)</td>
<td>15 (83.3)</td>
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<td>Lazarus &amp; Hamlyn (2005)</td>
<td>Private hospital, New South Wales</td>
<td>Cross-sectional (prospective)</td>
<td>Determine the prevalence of malnutrition and whether malnourished participants were identified and documented as malnourished</td>
<td>324, Not stated</td>
<td>SGA (B/C)</td>
<td>127 (42.3)</td>
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<tr>
<td>McDougall et al. (2015)</td>
<td>Three rehabilitation and geriatric</td>
<td>Cohort study</td>
<td>Determine whether the MNA and</td>
<td>114, Not stated</td>
<td>MNA (score &lt; 17)</td>
<td>37 (32.0)</td>
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<td>Reference</td>
<td>Setting Description</td>
<td>Study Type</td>
<td>Objective</td>
<td>Methods</td>
<td>Study Population</td>
<td>Nutritional Status</td>
<td>Prevalence</td>
<td>Mortality Rate</td>
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<td>Marshall et al. (2016)</td>
<td>Two rural rehabilitation units, New South Wales</td>
<td>Cohort study</td>
<td>Determine the prevalence of malnutrition, health aged care use, and mortality of older malnourished patients</td>
<td>MNA-SF</td>
<td>57</td>
<td>Not stated</td>
<td>16 (28.0)</td>
<td>-</td>
</tr>
<tr>
<td>Martineau (2005)</td>
<td>Public hospital; acute stroke unit, location not stated</td>
<td>Cohort study</td>
<td>Determine the nutritional status of patients with acute stroke and measure the association between nutritional status and health outcomes</td>
<td>PG SGA (B/C)</td>
<td>73</td>
<td>Not stated</td>
<td>14 (19.2)</td>
<td>-</td>
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<tr>
<td>Middleton et al. (2001)</td>
<td>Two public hospitals, New South Wales</td>
<td>Cohort study</td>
<td>Determine the prevalence of malnutrition using the</td>
<td>SGA (B/C)</td>
<td>819</td>
<td>Not stated</td>
<td>293 (35.8)</td>
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The Indigenous Australian Malnutrition Project: Chapter 2

<table>
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<tr>
<th>Study</th>
<th>Setting</th>
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<th>Other Findings</th>
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<tr>
<td>Morris et al. (2016)</td>
<td>Three regional hospitals, Northern Territory and Queensland</td>
<td>Cross-sectional</td>
<td>Determine the burden and nature of malnutrition in Indigenous and non-Indigenous medical inpatients</td>
<td>608</td>
<td>271</td>
<td>SGA (B/C) 250 (41.1) 271 (46.1)</td>
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<tr>
<td>Read et al. (2005)</td>
<td>Two public hospital; medical oncology day centres, New South Wales</td>
<td>Validation study</td>
<td>Compare the MNA and PG SGA as a nutrition assessment tool in patients with cancer</td>
<td>157</td>
<td>Not stated</td>
<td>MNA (score &lt; 17) PG SGA (B/C) 15 (10.0) -</td>
</tr>
<tr>
<td>Shalit et al. (2016)</td>
<td>Pulmonary rehabilitation setting, Victoria</td>
<td>Cohort study</td>
<td>Identify factors that influence dietary intake patterns in</td>
<td>30</td>
<td>Not stated</td>
<td>BMI &lt;18.5 kg/m² 4 (13.0) -</td>
</tr>
<tr>
<td>Authors (Year)</td>
<td>Setting</td>
<td>Study Design</td>
<td>Objectives</td>
<td>Number of Indigenous Patients</td>
<td>Screening Tool</td>
<td>Excluded</td>
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<td>Sharma et al. (2016)</td>
<td>Public hospital, South Australia</td>
<td>Cohort study</td>
<td>Assess nutrition screening adequacy and investigated factors associated with missed opportunity to diagnose malnutrition</td>
<td>178</td>
<td>Indigenous patients excluded</td>
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<tr>
<td>Slattery et al. (2015)</td>
<td>Rehabilitation unit, South Australia</td>
<td>Cross-sectional (retrospective audit)</td>
<td>Assess whether the MNA-SF can predict clinical outcomes in older rehabilitation patients and to investigate the relationship between admission diagnosis and nutritional status</td>
<td>181</td>
<td>Not stated</td>
<td>MNA-SF (≤ 7)</td>
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<tr>
<td>Smith et al. (2009)</td>
<td>Public hospital; upper gastrointestinal unit, New South Wales</td>
<td>Cross-sectional (prospective)</td>
<td>Determine whether the MRCS is predictive of complicated</td>
<td>31</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
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<td>Study</td>
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<td>Objective</td>
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<tr>
<td>Smith et al. (2009)&lt;sup&gt;67&lt;/sup&gt;</td>
<td>Public hospital: surgical inpatient setting, New South Wales</td>
<td>Cohort study</td>
<td>Determine whether the MRCS is predictive of MRCs</td>
<td>143</td>
<td>SGA (B/C)</td>
<td>31 (21.7)</td>
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<tr>
<td>Stolz (2002)&lt;sup&gt;68&lt;/sup&gt;</td>
<td>Public hospital; falls clinic, South Australia</td>
<td>Cross-sectional (prospective)</td>
<td>Describe the nutritional health and current nutritional management of patients attending a falls clinic</td>
<td>90</td>
<td>BMI &lt;22.0 kg/m²</td>
<td>11 (12.2)</td>
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<tr>
<td>Tan et al. (2015)&lt;sup&gt;69&lt;/sup&gt;</td>
<td>Cancer centre, New South Wales</td>
<td>Cohort study</td>
<td>Measure the association between nutritional status, inflammatory markers and overall survival in patients with</td>
<td>114</td>
<td>PG SGA (B/C)</td>
<td>66 (57.9)</td>
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<tr>
<td>Reference</td>
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<td>Thomas et al. (2007)</td>
<td>Public hospital; acute assessment unit, South Australia</td>
<td>Cohort study</td>
<td>Compare the MNA and PG SGA as a nutrition assessment tool in patients with advanced cancer</td>
<td>64</td>
<td>Not stated</td>
<td>PG SGA (B/C)</td>
</tr>
<tr>
<td>Todd et al. (2013)</td>
<td>Two dialysis centres, South Australia</td>
<td>Cross-sectional (prospective)</td>
<td>Determine the nutritional status of Aboriginal and non-Aboriginal haemodialysis patients</td>
<td>76</td>
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<td>PG SGA (B/C)</td>
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<tr>
<td>Vidot et al. (2016)</td>
<td>Public hospital; transplant ward, South Australia</td>
<td>Cross-sectional (prospective)</td>
<td>Investigate the prevalence and duration of preprocedural medically ordered fasting in patients with hepatic cirrhosis or post liver transplantatio</td>
<td>34</td>
<td>Not stated</td>
<td>SGA (B/C)</td>
</tr>
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</table>
Visvanathan et al. (2004)\textsuperscript{73} | Sub-acute facility, South Australia | Cross-sectional (prospective) | Determine the prevalence of malnutrition using brief screening methods and to determine the relationship between these results and those of a more standard nutritional assessment and discharge outcomes | 65 | Not stated | MNA (score < 17) | 28 (43.1) | -

Whitley et al. (2017)\textsuperscript{74} | Two geriatric evaluation and management units, Victoria | Cross-sectional (prospective) | Examine changes in nutritional status, function and mobility in patients admitted to a geriatric unit | 59 | Not stated | SGA (B/C) | 32 (54.0) | -

Abbreviations: PG SGA = Patient Generated Subjective Global Assessment; SGA = Subjective Global Assessment; BMIT = Body Mass Index; ICD 10-AM – International Classification of Disease 10-Australian Modification; MNA = Mini Nutritional Assessment; MNA-SF = Mini Nutritional Assessment Short Form
Conclusions

Chapter 2 of this thesis includes a scoping review of the literature aiming to understand the reporting of malnutrition among adult Indigenous Australians and tools used to detect malnutrition. This chapter highlights that there is a large gap of evidence, and that despite numerous studies reporting malnutrition in different healthcare contexts, studies reporting the burden of malnutrition among Indigenous Australian patients is significantly lacking despite their increased risk of chronic disease-related malnutrition (Glover & Freeman, 2011).

The findings from this review that also includes the findings reported in chapter 4 highlight that further research is required to understand the true burden and impact of malnutrition among Indigenous Australians. This includes measuring the prevalence of malnutrition in Indigenous Australian patients with chronic health conditions such as diabetes mellitus, kidney disease and cancer. Furthermore, as demonstrated in this review, various methods are used to detect malnutrition and there is a need to reach a consensus which is the most valid method to diagnose malnutrition among Indigenous and non-Indigenous patients.
The Indigenous Australian Malnutrition Project: Chapter 2

References


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CHAPTER 3

THE INDIGENOUS AUSTRALIAN MALNUTRITION PROJECT – STUDY PROTOCOL

Introduction

Prior to implementation of the Indigenous Australian Malnutrition Project, there have been no regional hospital studies that have specifically measured the burden and impact of malnutrition specifically among Aboriginal Australian and/or Torres Strait Islander people (Indigenous Australians). Furthermore, the findings in the review in Chapter 2 of this thesis demonstrates that there is also a paucity of studies specifically measuring the burden and impact of malnutrition among adult Indigenous Australians in any setting, whether remote, regional or urban. Despite several malnutrition screening tools being used in clinical practice (Platek & Nicholson, 2015), a screening tool has also not yet been validated for adult Indigenous Australian patients. This chapter outlines the study protocol for the Indigenous Australian Malnutrition Project, which was undertaken in two large regional hospitals in the Northern Territory and one large regional hospital in Far North Queensland in Australia.

This chapter includes the following peer-reviewed and published paper:

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

Natasha F. Morris¹,², Simon Stewart¹,³, Malcolm D. Riley⁴ and Graeme P. Maguire¹,²,⁵,⁶

Abstract

Background: Malnutrition is associated with adverse outcomes for hospital inpatients and is a significant economic burden on hospitals. Malnutrition is frequently under-recognised in this setting and valid screening and early diagnosis are important for timely nutritional management. Aboriginal Australian and/or Torres Strait Islander peoples (Indigenous Australians) are likely to be at increased risk of malnutrition due to their disproportionate burden, pattern and age-distribution of chronic diseases. Despite this increased risk, the burden and impact of malnutrition in Indigenous Australians is poorly understood. Furthermore, a suitable screening tool has not been validated for this vulnerable patient group. The aim of this study is to determine the burden of malnutrition, understand its impact, and validate a malnutrition screening tool for Indigenous Australian inpatients.

Methods: This project involves cross-sectional, prospective cohort and diagnostic validation methodologies to assess the burden and impact of malnutrition and to validate a malnutrition screening tool. A target of 752 adult Indigenous and non-Indigenous Australian inpatients will be recruited across three different public hospitals in the Northern Territory and far north Queensland of Australia. Cross-sectional data collection will be used to determine the prevalence of malnutrition using the Subjective Global Assessment and to stratify participants based on the International Consensus Guideline Committee mainnutrition aetiology-diagnostic framework. Subjects will then be followed prospectively to measure short and long-term health outcomes such as length of hospital stay, in-hospital mortality, 30-day and 6-month readmission rates. Finally, the utility of a new screening tool, the Australian Nutrition Tool, will be assessed against an existing screening tool, the malnutrition screening tool, used in these settings and the malnutrition reference standard, the Subjective Global Assessment.

Discussion: Indigenous Australians continue to experience poorer levels of health than non-Indigenous Australians and issues such as food insecurity, poor diet, and a disproportionate burden of chronic disease play a key contributing role for malnutrition in Indigenous Australians. To improve the health and hospital outcomes of Indigenous and non-Indigenous Australians, it is important that patients are routinely screened using a validated screening tool. It is also

*Correspondence: natashamorris@bakerid.redu.edu
² Baker IDI Heart and Diabetes Institute, FO Box 1294, Alice Springs, NT 0871, Australia
Full lists of author information is available at the end of the article

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The Indigenous Australian Malnutrition Project: Chapter 3

Background

Defining malnutrition

Malnutrition is defined by the American Society of Parenteral and Enteral Nutrition (A.S.P.E.N.) as any “any nutritional imbalance” (White et al. 2012, p. 730). More specifically, malnutrition can refer to a state of under-nutrition (from insufficient intake or impaired utilisation), or over-nutrition (from excessive caloric intake and/or inadequate physical activity) (Escott-Stump 2012). Either state leads to altered body composition and function (Saundra et al. 2010). It is important however, that the term ‘under-nutrition’ is not confused with being underweight (e.g. often represented by Body Mass Index [BMI] <18.5 kg/m²). Under-nutrition is a term used synonymously with protein-energy deficiency, where there is a loss of body cell mass with signs of subcutaneous fat loss and skeletal muscle wasting and therefore (Escott-Stump 2012; Saundra et al. 2010); under-nutrition can occur irrespective of individuals’ BMI (Saundra et al. 2010). Malnutrition, in this study protocol, refers to ‘under-nutrition’, meaning protein-energy malnutrition (PEM) (Escott-Stump 2012).

Causes of malnutrition

PEM is a condition caused by a number of inter-related factors. These factors include issues such as food insecurity due to poor social determinants of health; high-energy but nutrient deficient diets; risk factors such as alcohol and illicit substance abuse; acute or chronic disease including mental health disorders or acute injury such as burns and trauma (White et al. 2012; Escott-Stump 2012; Saundra et al. 2010; Jensen et al. 2009). Individuals at highest risk for malnutrition include the elderly, especially those with dementia; individuals suffering from chronic disease/s where they are not meeting their protein-energy requirements (Escott-Stump 2012); or individuals from vulnerable population groups such as Aboriginal Australian and/or Torres Strait Islander peoples (Indigenous Australians) (Brownio et al. 2014; Clifford et al. 2010).

Burden and impact of protein-energy malnutrition

Rates of hospital inpatient PEM vary greatly between surveys depending on the patient population and the methods used to diagnose malnutrition. In recent hospital-based surveys in Canada and Australia, using the Subjective Global Assessment (SGA), the prevalence of PEM in adult inpatients has been reported as ranging from 17 to 58% (Allard et al. 2015; Ulna et al. 2012; Gibson et al. 2012). Compared to well-nourished patients, surveys also demonstrated that malnourished patients had an increased length of hospital stay, higher rates of in-hospital mortality, more frequent hospital readmissions, and overall poorer longer-term survival rates (Allard et al. 2015; Agarwal et al. 2013; Lim et al. 2012; Norman et al. 2008; National Collaborating Centre for Acute Care [NICE] 2006). These adverse outcomes are likely to be related to the systemic effects of malnutrition (see Fig. 1). Some of the main adverse and costly events associated with PEM include: increased risk of hospital-acquired infections; delayed wound healing; increased risk of falls; and increased risk of pressure injuries (Escott-Stump 2012; Barker et al. 2010; Banks et al. 2010; Saundra et al. 2010; Norman et al. 2008).

The financial impact of malnutrition is frequently underestimated and often underestimated. Due to the lack of recognition, diagnosis and poor documentation, it is likely that malnourished patients are often not identified and coded correctly against ICD-10-AM criteria, which can result in a loss of hospital activity-based funding (Agarwal et al. 2013; Rowell and Jackson 2011; Banks et al. 2010). As a follow-up from the Australasian Nutrition Care Day Survey, malnourished patients’ medical records were audited (Agarwal et al. 2012). The results showed that only 16% of malnourished patients had a separation code for malnutrition notated. Furthermore, out of 52 hospitals participating in the survey, 40% of the hospitals failed to identify and code any malnourished patients (Agarwal et al. 2012).

The loss of activity-based funding associated with under-recognition and reporting of malnutrition was demonstrated in a public hospital in Victoria, Australia where malnutrition was estimated to add an additional annual cost of AUD $1.5 million (US $10.5 million) at 2015 valuations (Rowell and Jackson 2011). However, this cost was likely to represent a significant underestimate with only 1.9% of inpatients being coded as malnourished compared to nearly one-third of adult inpatients being assessed as malnourished in more recent Australian surveys (Agarwal et al. 2012).

Malnutrition screening

Systems to detect PEM or malnutrition risk in hospital inpatients has been shown to be variably implemented. Screening for malnutrition typically focuses on unintentional weight loss and sub-optimal oral intake in the last
6 months (Elia 2015). Due to a significant proportion of inpatients being at-risk of malnutrition, identifying at-risk or malnourished patients early in the admission process using a validated Malnutrition Screening Tool is best practice (Elia 2015; Dietitians Association of Australia [DAA] 2009; NICE 2006). It is advocated that early detection will facilitate early and comprehensive nutritional assessment and management by trained health providers, such as a dietitian (Elia 2015; Rowell and Jackson 2011; NICE 2006). The Malnutrition Screening Tool (MST) (see Table 1), developed in Australia, is a widely used malnutrition screening tool validated for the general adult inpatient population (van Bakhorst-de van der Schueren et al. 2014; Ferguson et al. 1999). Although the MST has demonstrated high sensitivity and specificity in different hospital inpatient populations (i.e. medical, surgical, and
oncology inpatients) (van Bekhorst-de van der Schueren et al. 2014), the MST has not been validated for the Indigenous Australian population. The MST poses potential cultural and linguistic barriers that may potentially influence the reliability and validity of the tool (Shaw et al. 2015; Gibson et al. 2012; Clifford et al. 2010; Frew et al. 2010). Those include patients needing to understand, and being able to recall, questions related to changes in appetite and/or weight loss in the last 6 months (Fang et al. 2013; Ferguson et al. 1999). Furthermore, depending on local hospital protocols, a patient who is ‘unsure’ about recent unintentional weight loss may still prompt an, often unnecessary, referral to dietetic services.

Due to these potential cultural and linguistic barriers, and the need for a reliable malnutrition screening tool for Indigenous Australians, the Australian Nutrition Tool (ANT, shown in Table 2) has been designed specifically for this project (Morris et al. 2015). The main differences between the MST and ANT are that patients are questioned about food intake rather than decreased appetite; weight loss is measured as a categorical variable rather than numerical; and ANT contains a third criterion where the health provider makes an assessment whether the patient looks undernourished (i.e. assessing for signs of subcutaneous fat loss, muscle wasting and/or poor skin integrity).

### Diagnosing malnutrition

The diagnosis of malnutrition in hospital inpatients is further limited by the lack of an accepted gold-standard diagnostic definition (White et al. 2012; Jensen et al. 2009; Jensen and Wheeler 2012). According to the International Classification of Diseases-10-AM (ICD-10-AM), adult malnutrition is classified according to a BMI of <18.5 kg/m²; or a certain percentage of weight loss, sub-optimal oral intake, and evidence of subcutaneous fat loss and/or muscle wasting (Australian Consortium for Classification Development 2015). It has been argued that the diagnosis of PEM is more complex than these ICD-10-AM criteria and a more global and systemic assessment of at-risk patients is required (White et al. 2012; Jensen et al. 2009, 2010).

A more comprehensive system for malnutrition assessment and diagnosis would incorporate the patients’ clinical diagnosis; past medical history (including communicable and non-communicable diseases); clinical assessment of weight history (i.e. loss of weight); changes to food intake (i.e. a sub-optimal intake); gastrointestinal signs and symptoms (i.e. nausea, vomiting, diarrhoea and/or anorexia); functional capacity (i.e. ability to complete day-to-day activities); a physical assessment for signs of subcutaneous fat loss and skeletal muscle wasting; anthropometric measures such as BMI; hand-grip strength; and blood chemistry data (Malone and Hamilton 2013; Jensen et al. 2010; Lochs et al. 2006). One such assessment tool is the SGA (Detsky et al. 1987). The SGA remains a superior nutritional assessment tool for detecting malnutrition in acute care settings (da Silva Fink et al. 2015; Steensom et al. 2013). A recent systematic review concluded that this tool had higher reliability and superiority than other nutrition assessment tools to detect malnutrition (da Silva Fink et al. 2015). Furthermore, and more recently, central to the diagnosis of malnutrition and evaluation of blood chemistry data, are inflammatory markers (such as C-Reactive Protein) due to the utilisation of proteins from the skeletal muscle in malnourished states (Jensen et al. 2010; Malone and Hamilton 2013; Lochs et al. 2006). Elevated inflammatory markers in malnutrition relate, in part, to the process of skeletal muscle proteins being utilised to meet metabolic requirements with resulting cytokine-mediated inflammation (White et al. 2012; Jensen et al. 2009, 2010; Malone and Hamilton 2013; Lochs et al. 2006).

### Nutritional health determinants of Indigenous Australians

Indigenous Australians experience well documented poorer health and lower life expectancy compared with non-Indigenous Australians (Australian Institute of Health and Welfare [AIHW] 2015; Browne et al. 2014; Clifford et al. 2010). Indigenous Australians experience a disproportionate burden of nutrition-related disorders and risk-factors (Browne et al. 2014; Clifford et al. 2010). For example, in 2013–2014, Indigenous Australian adults were 3.7 times more likely to have chronic renal disease; 3.3 times more likely to have diabetes; and 1.2 times more likely to have cardiovascular disease than non-Indigenous Australians.
The Indigenous Australian Malnutrition Project: Chapter 3

Table 2 The Australian Nutrition Tool (ANT) (Morris et al. 2015)

<table>
<thead>
<tr>
<th>Question 1</th>
<th>Score 1</th>
<th>Score 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think you have been eating enough food (or tucker) lately?</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>A little bit or not sure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you think you have lost weight recently without trying?</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, how much weight do you think you have lost?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A little bit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A lot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health provider assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the patient look undernourished?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A bit or not sure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANT score (Q1 + Q2 + Q3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition Screening Scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score 0–1</td>
<td>Weigh patient and rescreen in 7 days</td>
<td></td>
</tr>
<tr>
<td>Score 2</td>
<td>Weigh patient, refer to hospital malnutrition action plan or policy, rescreen in 7 days</td>
<td></td>
</tr>
<tr>
<td>Score ≥ 3</td>
<td>Weigh patient and refer to a dietitian</td>
<td></td>
</tr>
</tbody>
</table>

Australians (AIHW 2015). These conditions in turn, increase patients’ risk for malnutrition, which adversely affect clinical outcomes (AIHW 2015; Norman et al. 2008). Furthermore, Indigenous Australians also experience disproportionate nutrition-related risk-factors for chronic disease(s), and are more likely to be overweight (BMI ≥ 25.0 kg/m²) or obese (BMI ≥ 30.0 kg/m²) compared to non-Indigenous Australians (Australian Bureau of Statistics [ABS] 2012–2013).

Poor nutrition (i.e. poor fruit and vegetable intake and high consumption of high-energy but nutrient poor foods) is a factor in the prevention and management of chronic disease for Indigenous Australians (Pettrigrew et al. 2015; Browne et al. 2014; Clifford et al. 2010). Given the disproportionate burden of nutrition-related diseases in the Indigenous Australians population, early and reliable malnutrition screening leading to earlier diagnosis, referral and management is an important and often ignored strategy for improved health outcomes. Although the burden and impact of malnutrition in a range of adult hospital inpatient populations has been widely reported elsewhere (Allard et al. 2015; Corkins et al. 2014; Houngh et al. 2014; Fang et al. 2013; Agarwal et al. 2012; Álvarez-Hermández et al. 2012; Lamb et al. 2009; Meijers et al. 2009; Westergren et al. 2009), the prevalence, burden and impact of malnutrition in adult Indigenous Australians has not been previously reported and is poorly understood. Therefore, the aims of this research project are to:

1. Determine the prevalence of malnutrition in adult Indigenous Australians and assess the different types of malnutrition Indigenous Australians may experience according to a malnutrition aetiology-diagnostic framework;
2. Assess the health and health care impact of malnutrition in adult Indigenous Australians compared to non-Indigenous Australians by assessing length of hospital stay, in-hospital survival, 30 day and 6 month readmission and survival; and
3. Assess the validity of a culturally appropriate screening tool for Indigenous Australians as well as other patients with linguistic barriers where English may not be a first language.

Methods

The Indigenous Australian Malnutrition study incorporates cross-sectional, prospective cohort and diagnostic validation studies to assess the prevalence and impact of PEM and to validate a malnutrition screening tool (see Fig. 2). The project will be conducted in two public hospitals (Alice Springs Hospital and the Royal Darwin Hospital) in the Northern Territory and one public hospital (Cairns Base Hospital) in the far north of Queensland, Australia. The project sampling frame will include all non-elective community and residential-care based admissions to adult internal medicine units (including medical sub-specialties). Indigenous (people identified
by patient registration data or who self-identify as Aboriginal Australian and/or Torres Strait Islander) and non-Indigenous Australians aged 18 years and over who are able to provide informed consent (or who have a carer who is able to consent) will be invited to participate. Patients excluded from the study will include those under the age of 18 years, medical patients admitted directly to an intensive care unit, inter-hospital transfers, patients (or where appropriate, carers) unwilling or unable to provide informed consent, pregnant or lactating women, and non-medical admissions (i.e. surgical, orthopaedic, paediatric, routine renal dialysis and mental health admissions).

**Cross-sectional study of the prevalence of inpatient malnutrition**

All consenting participants will be screened for malnutrition risk (by NM and an independent dietitian) using the MST and ANT. The ANT was developed with the involvement of dietitian experts from each of the three study sites, Indigenous and non-Indigenous health providers (including Aboriginal Liaison Officers), and academic experts.

Following screening, all participants, irrespective of MST and ANT scoring, will have a diagnostic assessment for malnutrition using the SGA (Jensen et al. 2009). The prevalence of PEM will be determined using the SGA and stratified using existing SGA criteria: well-nourished (SGA A); mild-to-moderate malnutrition (SGA B); and severe malnutrition (SGA C). Participants who are assessed as well-nourished (SGA A) will be assessed for malnutrition risk based on SGA risk-factors including (i.e. unintentional weight loss within the last 6 months and suboptimal food intake). All participants will undergo further nutritional assessment using the World Health Organisation (WHO) BMI classification (WHO 2016); WHO waist-hip ratio (WHO 2006); mid-upper arm circumference, and hand-grip strength measurement using standard measurement techniques (Stewart 2015). Malnourished patients will be stratified into malnutrition categories based on the A.S.P.E.N. and European Parenteral and Enteral Nutrition (ESPEN) International Consensus Guideline Committee (ICGC) malnutrition aetiology-diagnostic framework (see Fig. 3) (White et al. 2012; Jensen et al. 2010). The ICGC classifies malnutrition into three main types: starvation-related...

Prospective cohort study to assess the impact of malnutrition

The second component of this study will be to assess the impact of PEM on hospital inpatients and the hospital health care system. This will be assessed by evaluating the influence of PEM (including stratification by severity and aetiology) on length of hospital stay, in-hospital mortality, discharge destination, and 30 days and 6 months readmission and survival using hospital and jurisdictional death registry data.

Comorbidities, the severity of the presenting illness and other contributors to health outcome will be controlled for using the Charlson Comorbidity Index (Charlson et al. 1987), the Australian New Zealand Intensive Care Society (ANZICS) score calculator and multivariate techniques. The Charlson Comorbidity Index particularly focuses on patient age and existing comorbidities that have been previously shown to influence survival (Charlson et al. 1994). The ANZICS score calculator focuses on acute illness severity and include the Acute Physiology and Chronic Health Evaluation (APACHE) II score; APACHE II risk of death; Simplified Acute Physiology Score (SAPS) II score; and SAPS II risk of death (ANZICS Research Centre 2010).

Diagnostic validation study of screening tools

The final component of this study will be an assessment of the validity of the screening tools in this setting to detect PEM in inpatients. Results for the existing MST and new ANT will be compared to the SGA. Standard diagnostic validation techniques will be utilised (see statistical analysis below) to identify suitable scoring cut-offs and to determine overall utility as a screening tool in this setting.

Sample size analysis

The sample size required to detect a 10 % absolute difference in the prevalence of malnutrition in Indigenous as compared with non-Indigenous Australians (based on 2 equal sized groups, an assumed prevalence of malnutrition of 30 % in Australian adult inpatients (Agarwal et al. 2013), power of 80 % and two-sided alpha of 0.05) is 752 (i.e. 376 in each group).

Statistical analysis

Data will be analysed using Stata® 14 (StataCorp College Station, TX, USA). Descriptive analysis of participants
will utilise standard univariate techniques and will be reported as percentages with 95% confidence intervals (95% CI), means with standard deviations (SD) or medians with interquartile range depending on the data format and distribution. Comparisons between Indigenous and non-Indigenous participants will be undertaken using \( \chi^2 \) for categorical data and Student’s t Test or Mann–Whitney U test for continuous normally distributed data or non-normally distributed data respectively. A \( p \) value <0.05 will be taken to indicate statistical significance and all tests will be two-sided. The utility of the MST and ANT to detect PEM as measured by the SGA will be investigated using diagnostic test analysis including determining sensitivity and specificity, and positive and negative predictive values. Optimal scoring cut-offs for the MST and ANT will be determined using receiver operator characteristic (ROC) analysis.

The impact of PEM on the outcomes listed above will be first assessed using bivariate analysis for length of hospital stay, in-hospital mortality, discharge destination, 30 days and 3 months readmission. Survival to 6 months post-discharge will be presented using Kaplan–Meir curves and analyses using the log rank test to compare survival in patients with and without PEM, and in Indigenous and non-Indigenous Australians.

Multivariable linear, logistic and Cox proportional hazard models will be developed to identify independent factors associated with outcome measures. These will use a backwards stepwise approach including in the first model all factors associated with a particular outcome variable using bivariate analysis with a \( p \) value <0.1. Factors with a \( p \) value \( \geq 0.05 \) will be progressively removed from the models starting with those variables with a regression coefficient closest to 0 or an odds or hazard ratio closest to 1. Final models will be limited to predictive factors with significant coefficients (\( p < 0.05 \)).

Diagnostic validation analysis will first involve the assessment of concordance between the MST and ANT by the technique of Lin (1989) that assesses the agreement between two different continuous measures. Mean difference (bias) and limits of agreement will be determined using the techniques of Bland and Altman (1999). Cut-offs for scores for both screening tools for excluding and diagnosing malnutrition will be determined from receiver operating characteristics (ROC) curve analysis with multivariate regression analysis used to determine whether patient factors affect the relationship between the screening tool score and SGA assessment.

**Ethics approval**

This project has been approved by the Central Australian, Menzies, Far North Queensland, and Monash University Human Research Ethics Committees.

**Discussion**

The study outlined in this paper aims to provide a new and detailed perspective on the burden, impact and diagnosis of PEM in a high income country setting and in an underserved population, in this instance, Indigenous Australians. The prevalence of PEM and those at-risk of malnutrition is significant in hospital inpatients (Allard et al. 2015; Agarwal et al. 2012, 2013; Ulfang et al. 2012; Gibson et al. 2012). PEM, in turn, has been associated with a number of adverse clinical outcomes (Allard et al. 2015; Agarwal et al. 2012, 2013; Escott-Stump 2012; Lim et al. 2012; Rowell and Jackson 2011; Saundar et al. 2010). Whilst the cost of PEM is substantial for both patients and the health care system (Agarwal et al. 2013; Lim et al. 2012; Barker et al. 2010; Rowell and Jackson 2011; Norman et al. 2008), understanding of its burden and impact remains limited, particularly in underserved populations such as Indigenous Australians. We hypothesise that the burden and impact of malnutrition in Indigenous Australians is likely to be greater and more severe than for non-Indigenous Australian inpatients. We also anticipate that the type of PEM that Indigenous Australian inpatients present with is more likely to be chronic disease-related. Such stratification of malnutrition into different aetiology types is important to allow a tailored response to management. Whilst documenting the burden and impact of malnutrition is important this information must also, where appropriate, be utilised to enhance health care practice. While the Dietitians Association of Australia recommend that all hospital patients are screened within 24 h of hospital admission (DAA 2009), this is variably implemented (Green and James 2013). In addition, whilst such screening does necessarily use a reliable malnutrition screening tool that has been validated for a specific patient population this is not possible for Indigenous Australians where no such validated tool currently exists. By validating a new malnutrition screening tool (ANT), we hope to enhance and inform the detection and management of PEM in Australia in general and for Indigenous Australians. In summary, the Indigenous Australian Malnutrition project will provide new insights into PEM in adult Indigenous and non-Indigenous Australians in the acute care setting and seek to improve and simplify diagnosis with the validation of a new malnutrition screening tool (ANT) for the detection of PEM in Indigenous Australians.

**Abbreviations**

The Indigenous Australian Malnutrition Project: Chapter 3

Committee: LoS: Length of stay; MST: malnutrition screening tool; PEM: protein energy malnutrition; SAPS: Simplified Acute Physiology Score; SCA: Subjective Global Assessment.

**Authors’ contributions**
NM was responsible for the conception and design of this project and paper, planning the projects methods, design and statistical analysis, drafting the paper, giving final approval and agrees to be accountable for all aspects of this paper’s contents. SS was responsible for the conception of the project, project planning, reviewing the draft protocol paper, giving final approval and agrees to be accountable for all aspects of this paper’s contents. MDR was responsible for the design of the project, study methods and designs, reviewing the protocol paper, giving final approval and agrees to be accountable for all aspects of this paper’s contents. GFM was responsible for the conception and design of this project and paper, planning the projects methods, design and statistical analysis, drafting the paper, giving final approval and agrees to be accountable for all aspects of this paper’s contents. All authors read and approved the final manuscript.

**Authors’ information**
NM is a PhD candidate at Baker IDI Heart and Diabetes Institute and Monash University in Australia. NM is a recipient of a Bellberry Limited Aboriginal and Torres Strait Islander Health scholarship and a National Health Medical Research Council (NHMRC) Public Health postgraduate scholarship. SS is supported by the NHMRC of Australia. MDR is a senior research scientist at CSIRO Food, Nutrition and Bioscience Products. GFM is supported by an NHMRC Practitioner Fellowship.

**Author details**
1. Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, VIC, Australia.
2. Baker Heart and Diabetes Institute, PO Box 1294, Alice Springs, NT 0871, Australia.
3. NHMRC Centre for Research Excellence to Reduce Inequality in Heart Disease, Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia.
4. CSIRO Food, Nutrition and Bio-Products, PO Box 10041, Adelaide BC, SA 5000, Australia.
5. James Cook University, School of Medicine and Dentistry, Townsville, Qld, Australia.
6. Baker Heart and Diabetes Institute, 75 Commercial Road, Melbourne, VIC 3084, Australia.

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**Competing interests**
The Indigenous Australian Malnutrition study protocol has been peer-reviewed and the project has received external funding from the National Health Medical Research Council. The external funding included research stipends as part of the Public Health postgraduate scholarship NFM received. The authors declare they have no other competing interests.

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Chapter 3


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Conclusions

This chapter has detailed the methods used to conduct a combined cross-sectional, prospective cohort and screening tool validation study which includes Indigenous and non-Indigenous Australian adults in three regional hospitals in the Northern Territory and Far North Queensland. The Indigenous Australian Malnutrition Project included a cross-sectional survey measuring the burden of malnutrition; a cohort study measuring the impact of malnutrition at 30-days and six-months; and a screening tool validation study of the Malnutrition Screening Tool (Ferguson et al., 1999) and the newly developed Adult Nutrition Tool.¹ Study findings for the cross-sectional survey, cohort study, and validation study are reported in Chapters 4, 5 and 6, respectively.

Appendices supporting this chapter include:

- Appendix A – The Adult Nutrition Tool (ANT)©
- Appendix B to E – Human Research Ethics Committees’ letters of approval
- Appendix F – Participant information brochure
- Appendix G – Participant informed consent form
- Appendix H – The Malnutrition Screening Tool (MST)
- Appendix I – The Subjective Global Assessment (SGA) tool
- Appendix J – The IAM project data collection tool

¹ The title of the Australian Nutrition Tool was changed to the Adult Nutrition Tool after the study protocol was published to capture an international audience.
As of 19\textsuperscript{th} August 2018, the study protocol has been downloaded over 1,500 times from Springer\textit{Plus} and has been cited twelve times in peer-reviewed publications, including a review of nutrition among Indigenous Australian people (Lee & Ride, 2018).
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References


CHAPTER 4

THE INDIGENOUS AUSTRALIAN MALNUTRITION PROJECT: THE BURDEN AND NATURE OF MALNUTRITION AMONG MEDICAL INPATIENTS IN REGIONAL HOSPITALS

Introduction

Chapter 4 reports the findings of the cross-sectional study described in chapter 3 of this thesis, measuring the burden and nature of malnutrition in adult medical inpatients in two regional hospitals in the Northern Territory and one regional hospital in Far North Queensland of Australia. This study reports the total prevalence of malnutrition for Indigenous and non-Indigenous participants and the burden of malnutrition by hospital region. Comparisons are made between participants’ socio-economic status and health-related characteristics according to their nutrition status (nourished or malnourished) and their Indigenous status (Indigenous Australian or non-Indigenous Australian). This paper also reports factors that independently predict malnutrition among all study participants as well as by their Indigenous status.

This chapter includes the following peer-reviewed and published paper:


Review

The burden and nature of malnutrition among patients in regional hospital settings: A cross-sectional survey

Natasha F. Morris a, b, c, Simon Stewart a, b, d, Malcolm D. Riley e, Graeme P. Maguire a, b, *

a Baker Heart and Diabetes Institute, 75 Commercial Road, Melbourne, VIC 3084, Australia
b Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, VIC, Australia
c The University of Melbourne, Department of Nursing, Melbourne, Australia
d Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia
e CSIRO Health and Biosecurity, PO Box 10041, Adelaide, SA 5000, Australia

Summary

Background/Aims: Indigenous people experience a higher burden of nutrition-related conditions and are more likely to experience food insecurity compared to non-Indigenous people. Consequently, they remain at increased risk of malnutrition; particularly when residing in regional or remote areas. This study aims to compare and characterise the burden and nature of malnutrition among a representative cohort of Indigenous and non-Indigenous Australians admitted to regional hospitals for medical inpatient care.

Methods: This was a cross-sectional survey conducted in three regional hospitals in the Northern Territory and Far North Queensland of Australia from February 2015 to September 2015. A total of 1006 adult medical inpatients were screened for eligibility. Of these, 608 eligible patients were screened for malnutrition using the validated Malnutrition Screening Tool and assessed for malnutrition using the Subjective Global Assessment. Socio-economic and health-related variables and anthropometric measurements were collected to identify the correlates of malnutrition.

Results: Of the 271 Indigenous patients and 337 non-Indigenous patients screened and assessed for malnutrition, 250/608 (41.7%, 95% CI 40.1–52.3%) were found to be malnourished. Significantly higher rates of malnutrition (46.1%, 95% CI 40.1–52.3% versus 37.1%, 95% CI 31.9–42.5%) were found in Indigenous patients compared to non-Indigenous patients (P = 0.024). Higher rates of malnutrition were observed in Indigenous patients residing in Central Australia (36.7%, 95% CI 46.7–56.4%) than in the Top End of the Northern Territory (40.7%, 95% CI 31.7–50.1%) and in Far North Queensland (36.7, 95% CI 23.4–51.7%). Factors independently predictive of malnutrition for both Indigenous and non-Indigenous participants included residence in Central Australia (OR 4.31, 95% CI 2.63–7.90, P < 0.001); an increased Charlson Comorbidity Index prognostic score (OR 1.37 [per incremental score], 95% CI 1.19–1.59, P < 0.001); and an underweight Body Mass Index (OR 29.97, 95% CI 3.68–244.0, P < 0.001). Of the 250/608 patients who were malnourished, the positive predictor value (PPV) for malnourished patients who were underweight was 96.6% (95% CI 88.3–99.6%); for Indigenous Australians who were malnourished and underweight, the PPV was 90%. A mid-upper arm circumference of less than 23 cm demonstrated a strong PPV for all patients who were malnourished (96.1%, 95% CI 89.0–99.2%).

Conclusion: This is the first study to characterise malnutrition in adult Indigenous Australians in a hospital inpatient setting. Compared to non-Indigenous patients the burden and pattern of malnutrition was both higher and markedly different among Indigenous patients. These data highlight the critical importance for actively screening for and responding to malnutrition in this vulnerable patient population in regional and remote settings.

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1. Background

Malnutrition in hospital inpatients is a well-recognized and reported problem [1–4]. Although malnutrition refers to both a state of over-nutrition or under-nutrition, in the context of this study, malnutrition is defined according to The European Society of Clinical Nutrition and Metabolism (ESPEN) as either a body mass index (BMI) of <18.5 kg/m², or unintentional weight loss and either reduced BMI or low fat free mass index [5]. Malnutrition in hospital patients is a global problem, however, rates of malnutrition vary between different studies due to the heterogeneous nature of different study participants and their socio-demographic, economic and health status, as well as different health settings [6].

In Australia, the prevalence of malnutrition in hospital patients was reported in 2010 as 32 percent [7]. This cross-sectional survey is the largest point-prevalence audit to date that was conducted across 56 hospitals in Australian and New Zealand measuring both malnutrition risk and malnutrition in hospital inpatients [7]. However, some noted limitations of this study included: the exclusion of hospitals in regional areas such as the Northern Territory (NT) and Far North Queensland (FNQ); and only two percent of the study’s population identified as Aboriginal Australian and/or Torres Strait Islander [7]. Furthermore, to date, no study has specifically aimed to measure the prevalence of malnutrition in Aboriginal and/or Torres Strait Islanders (hereafter referred to as Indigenous Australians), who may be at greater risk of malnutrition due to their current burden of chronic diseases and socioeconomic factors [8–12].

Similar to other Indigenous populations worldwide, health disparities between Indigenous and non-Indigenous populations continue to exist due to ongoing socioeconomic disadvantage, burden of chronic diseases, poor nutrition, and difficulties accessing health services [11]. Today, this health disparity gap between Indigenous and non-Indigenous people in Australia is evident by the life-expectancy gap with a lower life-expectancy of 10.6 years for Indigenous males and 9.5 years for Indigenous females [13]. While there are global problems related to diet-related diseases, such as cardiovascular disease, type 2 diabetes mellitus and chronic kidney disease [8], diets high in saturated fat and sugars are attributable to the overweight and obesity epidemic [14]. However, while Indigenous people are more likely to be overweight or obese compared to non-Indigenous populations [15], Indigenous Australians are also more likely to be underweight or suffering from protein-energy malnutrition due to food insecurity, poor or limited food choices, socioeconomic disadvantage, which when combined with chronic disease, creates a ‘perfect storm’ for malnutrition. However, despite these risk factors, the prevalence of malnutrition in Indigenous Australians is not clearly understood and not fully appreciated by health care providers and policy decision-makers.

1.1. Study objectives

Using a combination of socio-demographic, health-characteristic, anthropometry and other assessment data, the study objectives were to: (1) determine the burden and nature of malnutrition among adult Indigenous and non-Indigenous Australian medical inpatients in three different regional hospitals in Australia; and (2) identify nutrition-related factors to facilitate screening patients for malnutrition and the early detection and diagnosis of malnutrition.

2. Methods

This was a prospective observational study using a cross-sectional survey to screen eligible medical inpatients for malnutrition risk and malnutrition, and malnutrition-related risk-factors in three regional hospitals in Northern Territory (NT) and Far North Queensland (FNQ) in Australia (see Fig. 1). Royal Darwin Hospital is a 300-bed public hospital located in the Top End of the NT which services approximately 140,000 patients per year; Alice Springs
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Hospital is a 186-bed public hospital in Central Australia in the NT, servicing approximately 60,000 patients per year; and Cairns Hospital is a 251-bed public hospital in FNQ that services approximately 259,000 patients per year [10].

Fig. 2 illustrates the procedure for participant recruitment into The Indigenous Australian Malnutrition Project [17]. Participants recruited included both Indigenous Australian (identified as Aboriginal Australian and/or Torres Strait Islander) and non-Indigenous Australian patients admitted into medical inpatient wards between February 2015 and September 2015. Patients admitted into a medical inpatient unit within three hospitals were screened for study eligibility within 72 h of admission to hospital. Medical patients were identified from hospitals’ electronic databases and screened for study eligibility, the details of which is published elsewhere [17]. Briefly, eligible patients included Indigenous and non-Indigenous patients, aged 18 years and over who were able to provide written informed consent (or had a carer who was able to provide consent) admitted as non-elective admissions from the community, including residential care settings. Patients excluded from the study were those under the age of 18 years, medical inpatients admitted directly to critical care units, patients who were assessed by the research team as pregnant or lactating women, patients with end-stage renal failure receiving dialysis, and parents or carers who were unwilling or unable to provide informed consent.

The primary outcome analysed in this study were participants’ nutritional status (nourished versus malnourished) using the validated Subjective Global Assessment (SGA) [18]. Secondary outcome measures included in the analysis were health-related characteristics including reason for hospital admission, co-existing chronic diseases, number of discharge medications, and Charlson Comorbidity Index (CCI) [19]; and anthropometric data including body mass index (BMI), World Health Organization BMI classification [20], mid-upper arm circumference (MUAC) [21] and hand-grip strength (HGS) [22].

Patients enrolled in the study were first screened for malnutrition risk by a trained registered nurse or accredited dietitian using the validated Malnutrition Screening Tool (MST) developed by Ferguson et al. (1999) [22]. The MST is a two-item tool designed to detect (1) unintentional weight loss and quantity of weight loss, and (2) suboptimal dietary intake due to a decreased appetite [22]. Following screening all patients, irrespective of MST score, were assessed for malnutrition using the SGA [18]. The SGA is an 8-item tool assessing unintentional weight loss, changes in dietary intake; gastrointestinal symptoms; functional capacity; and a physical assessment [18]. Patients with an SGA A were classified as ‘nourished’ and patients with an SGA B (mildly or moderately malnourished) or SGAC (severely malnourished) were classified as ‘malnourished’ [18]. At the end of each study day, participants’ MST and SGA results were discussed and confirmed by the two researchers. Where disagreement occurred between the two researchers’ nutritional status was confirmed by the hospital’s dietitian.

Following SGA assessment, patients’ height, weight, waist-and-hip circumference, mid-arm circumference and hand-grip strength were measured. Patients’ height, weight and waist and hip circumference were measured using a Seca 213 Stadiometer, Seca 856 digital scale and Seca 203 measuring tape (Seca, Hamburg, Germany) by the researchers as being able to safely stand (i.e., not identified as a high fall risk). All measurements were undertaken with patients being bare-footed and wearing hospital issued clothing. Height and weight was used to calculate patients’ BMI, and waist and hip circumference to calculate Waist-to-Hip Ratio (WHR). These were then classified according to World Health Organisation (WHO) BMI and WHR categories [20,23]

MUAC was assessed using a SECA 203 measuring tape using the technique described by Stewart (2015) [20]. Patients’ bare right mid-upper arm is reported unless the arm was not available (i.e., patient declined measurement or covered by a wound dressing). HGS was assessed using the Jamar Plus + Hand Dymamometer (Patterson Medical, Warrenville, US). The average of three dominant hand measures is reported unless the dominant hand was not available (e.g., intravenous device in situ or patient declined due to pain or discomfort), in which case, non-dominant hand measures were used where possible.

Socio-demographic variables included ethnicity (Indigenous or non-Indigenous Australian) date of birth, gender (female or male), employment (paid employment or not in paid employment), partner status (relying with a partner), and area of residence (postcode) were collected from patients’ medical records at the time of study enrolment and confirmed by hospitals’ electronic databases six-months after study enrolment. Age was calculated from patients’ date of birth to the date of study enrolment and area of remoteness classified according the Australian Standard Geographic Classification Remoteness Structure Digital Boundaries [24].

Health-related variables including diagnosis at time of hospital separation, number and type of chronic diseases, number of prescribed medications at time of hospital separation were collected at the time of screening or six-months later. The number of prescribed medication at time of hospital separation were calculated to classify polypharmacy (defined as equal or greater than five medications) [25], and patients’ CCI was calculated using the health-related variables described above at six-months.

All significant variables in the bivariate analyses were included in the regression analysis to identify independent predictors of malnutrition. These variables included socio-demographic data (age, gender, partner, area of remoteness), health-related data (separation diagnosis, chronic disease, polypharmacy, CCI), and anthropometric data (BMI classification, MUAC, HGS).

A sample size of 752 patients, assuming power of 80% and two-sided alpha of 0.05, was required to detect a 10% absolute difference in the prevalence of malnutrition in Indigenous compared with non-Indigenous patients, based on two equal size groups (i.e., 276 patients in each group) and an assumed prevalence of malnutrition of 30% in non-Indigenous Australian adult inpatients [7].

2.1. Statistical methods

Data version 14.2 was used to analyse data (StataCorp College Station, TX, USA). Descriptive analysis utilizing standard univariate techniques is reported as percentages with 95% confidence intervals (95% CI), means with standard deviations (SD) or medians with interquartile ranges (IQR) depending on the data format and distribution. Comparisons between Indigenous and non-Indigenous Australians and socio-demographic and health-related characteristics were undertaken using $\chi^2$ for categorical data and Student’s t Test or Mann–Whitney U test depending on the data distribution. Comparisons were made between SGA and socio-demographic, health-related characteristics and malnutrition risk using the same statistical methods and tests. A P value of <0.05 was taken to indicate statistical significance and all tests were two-sided.

Logistic regression analyses were undertaken to identify factors independently associated with malnutrition (SGA B and C) for all study participants, and for Indigenous Australian and non-Indigenous Australian patients. A backwards stepwise approach was used which included all variables associated with malnutrition.
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Fig. 2. The Indigenous Australian Malnutrition Project: Study selection and patient recruitment.
3.2. Health-related characteristics

The health characteristics of participants is outlined in Table 2. The clinical profile of Indigenous and non-Indigenous participants was similar in many respects; however, non-Indigenous participants were more likely to be admitted with a ‘musculoskeletal’ condition (OR 5.20, 95% CI 1.96–17.36, P = 0.001), a weaker association was observed with Indigenous participants being more likely admitted with a sepsis-related condition (OR 2.15, 95% CI 1.00–4.53, P = 0.036). However, notably, only a small amount of musculoskeletal and septic cases were observed in both participant groups as seen in Table 2. 

Whilst the level of chronic cardiovascular and respiratory disease was not significantly different between the two participant groups, Indigenous participants were more likely to have pre-existing diabetes mellitus (OR 3.58, 95% CI 2.50–5.13, P < 0.001), or chronic kidney disease (OR 5.43, 95% CI 1.47–8.80 P < 0.001) and non-Indigenous participants were more likely to have a pre-existing musculoskeletal condition (OR 3.50, 95% CI 2.28–5.43, P < 0.001). A history of cancer within the last five years (OR 2.61, 95% CI 1.41–4.03, P < 0.001), or a mental health condition (OR 2.83, 95% CI 1.63–5.08, P = 0.001). Indigenous participants’ (CRS) prognostic score was higher than non-Indigenous participants (mean difference 0.76) reflecting greater multi-morbidity and higher mortality risk. Indigenous patients were also more likely to meet criteria for polypharmacy (defined as ≥ five medications) at time of discharge from hospital (OR 1.72, 95% CI 1.11–2.70, P = 0.011).

3.3. Nutrition status

A summary of participants’ nutrition status (defined by the SGA) is outlined in Table 3. Of the 608 participants, 250 (41.1%) were malnourished. Two hundred and sixteen (216) (36.4%, 95% CI 31.5–40.4%) were classified as SGA B and 34 (11.6%, 95% CI 9.6–18.8%) were classified as SGA C. Due to the small number of participants with an SGA C, subsequent analysis of malnourished patients is dichotomised as SGA A (nourished) and SGA B or C (malnourished).

Across all three hospitals, Indigenous participants were more likely to be malnourished than non-Indigenous Australian

| Table 1 | Socio-economic characteristics according to Indigenous Australian status. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Age (years) | 61.6 | 54.5 | 68.3 | <0.001 |
| n = 608, mean (SD) | 40.1–77.6 | 41.1–81.3 | 40.6–80.3 | |
| Gender (male) | 204/508 (40.4) | 161/254 (63.5) | 144/354 (40.0) | 0.104 |
| n (%) (95% CI) | 44.9–92.0 | 45.0–92.1 | 44.5–91.6 | |
| Current partner | 290/605 (48.2) | 118/272 (42.9) | 171/325 (51.8) | 0.021 |
| n (%) (95% CI) | 42.9–50.0 | 42.9–50.1 | 42.9–50.0 | |
| Employment | 117/508 (23.1) | 43/254 (16.9) | 94/354 (26.6) | <0.001 |
| n (%) (95% CI) | 23.1–27.0 | 16.9–22.9 | 26.6–30.4 | |
| Regional hospital n (%) (95% CI) | 245/608 (40.5) | 110/272 (41.1) | 134/325 (41.1) | 0.165 |
| Top End (NT) | 18/508 (3.5) | 14/254 (5.5) | 20/354 (5.7) | <0.001 |
| Central Australia (NT) | 0/508 (0.0) | 1/254 (0.4) | 1/354 (0.3) | <0.001 |
| Far North QLD | 175/608 (28.6) | 60/272 (22.2) | 115/325 (35.4) | 0.001 |
| Demographic region n (%) (95% CI) | 14/254 (2.9) | 3/161 (1.9) | 11/272 (4.0) | 0.078 |
| Major city & inner-regional | 117/608 (19.4) | 40/254 (15.7) | 77/354 (21.9) | <0.001 |
| Outer-regional | 48/608 (7.9) | 16/254 (6.3) | 32/354 (9.1) | <0.001 |
| Remote/very remote | 27/608 (4.5) | 19/254 (7.5) | 8/354 (2.3) | <0.001 |
| n (%) (95% CI) | 4.5–8.9 | 7.5–12.0 | 2.3–3.8 | |
participants (OR 1.45, 95% CI 1.03–2.04, P = 0.024). As seen in Fig. 3, although no significant difference was observed between indigenous and non-indigenous participants in the Top End and Far North Qld, Indigenous Australian participants were more likely to be malnourished in Central Australia than non-Indigenous participants (OR 2.72, 95% CI 1.43–5.20, P = 0.001).

3.4 Anthropometric characteristics

Differences in anthropometric measures are outlined in Table 3. Overall, no significant difference was found between Indigenous and non-Indigenous Australian patients’ median BMI and the WHO BMI classification [20]. Indigenous patients did however, have a marginally higher waist:hip ratio (median difference 0.02 cm), smaller MUAC (median difference 1.9 cm) and weaker HGS (median difference 3.8 kg) compared with non-Indigenous patients.

3.5 Independent factors associated with malnutrition

Factors independently associated with malnutrition are outlined in Table 4. Factors that predicted malnutrition for all participants included residing in Central Australia; an increased CCI prognostic
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Table 4

<table>
<thead>
<tr>
<th>Variable</th>
<th>All (OR 95% CI)</th>
<th>P value</th>
<th>Indigenous Australians (OR 95% CI)</th>
<th>P value</th>
<th>Non-Indigenous Australians (OR 95% CI)</th>
<th>P value</th>
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<tr>
<td>Socio-demographic</td>
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<td>characteristics</td>
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<tr>
<td>Age (years)</td>
<td>0.30 (0.15–0.58)</td>
<td>&lt;0.001</td>
<td>1.04 (1.01–1.07)</td>
<td>0.012</td>
<td>0.20 (0.07–0.55)</td>
<td>0.002</td>
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<td>characteristics</td>
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<tr>
<td>Underweight (BMI &lt; 18.5 kg/m²)</td>
<td>20.07 (3.68–244.03)</td>
<td>0.001</td>
<td>1</td>
<td></td>
<td>2.72 (2.02–3.70)</td>
<td>0.005</td>
</tr>
<tr>
<td>Overweight (BMI 25.00–29.50 kg/m²)</td>
<td>0.20 (0.10–0.41)</td>
<td>&lt;0.001</td>
<td>0.24 (0.10–0.58)</td>
<td>0.001</td>
<td>0.07 (0.02–0.23)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Obesity (BMI ≥ 30.00 kg/m²)</td>
<td>0.19 (0.08–0.49)</td>
<td>&lt;0.001</td>
<td>0.27 (0.08–0.90)</td>
<td>0.033</td>
<td>0.07 (0.02–0.21)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MUAC (≥ 85 cm)</td>
<td>0.07 (0.07–0.95)</td>
<td>0.002</td>
<td>0.17 (0.06–0.58)</td>
<td>0.003</td>
<td>0.06 (0.04–0.85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>MCS (≥ 80 cm)</td>
<td>0.95 (0.82–0.98)</td>
<td>0.002</td>
<td>0.94 (0.86–0.98)</td>
<td>0.008</td>
<td>0.74 (0.60–0.98)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

4. Discussion

Although poor nutrition and diet-related chronic diseases are well-known risk factors for malnutrition, this is the first study that specifically characterises malnutrition in medical patients admitted into regional Australian hospitals. We found that Indigenous Australian patients participating in this study were younger and more likely to be residing in remote and very remote regions than non-Indigenous patients who were more likely to be living in outer-regions of Australia. Indigenous patients were also more likely to have a chronic disease including diabetes mellitus and chronic kidney disease; had a higher CCI prognostic score indicating higher morbidity and risk of mortality; and were more likely to be discharged from hospital with five or more medications. Our study found that just over 41% of patients were malnourished and a notable finding was the high rate of malnutrition in both Indigenous and non-Indigenous participants with over 37% of non-Indigenous and over 40% of Indigenous Australian participants malnourished. One particular striking finding, was that we also found that nearly 60% of Indigenous patients in Central Australia were malnourished, which was much higher than all other study sub-groups including patients residing in the Top End or Far North Queensland of Australia.

While there a number of studies describing the prevalence of malnutrition in hospital inpatients [16,27], it is difficult to make comparisons between these studies and our findings This is in part due to the nature of malnutrition, which varies depending on patient demographics and their health characteristics, including the severity or acuteness of the reason for hospital admission. However, this study has found much higher rates of malnutrition than that which has been reported in other Australian hospital settings [7]. As well as overall higher rates of malnutrition risk and malnutrition in our study cohort, the rate of malnutrition for Indigenous patients residing in Central Australia were almost double the rate reported by Agarwal et al. (2012) [7]. One explanation for this finding is that the survey by Agarwal et al. did not include outer-regional hospitals including the Northern Territory and Far North Queensland, and of the patients included in the survey, only approximately 26% comprised of patients identified as Aboriginal Australian and/or Torres Strait Islanders.

While malnutrition assessment using the SGA relies on subjective data or is potentially biased to patient recall, this study found that anthropometric measurements such as a BMI < 18.5 kg/m², a smaller mid-upper arm circumference, and weaker hand-grip strength were all strong predictors of malnutrition for both Indigenous and non-Indigenous patients.

Socio-economic disadvantage and other health determinants are likely to be significant contributors to the higher burden of malnutrition seen in Indigenous Australians. This highlights the need for health care providers to have a greater understanding and awareness of malnutrition in such vulnerable populations in both detect and respond to malnutrition. While Indigenous Australians account for 3% of the Australian population, in the Northern Territory and Far North Queensland, Aboriginal Australian and/or Torres Strait Islander peoples represent over a third of the population and Indigenous people in these regions experience some of the poorest levels of health compared to Indigenous and non-Indigenous people living in metropolitan and inner-regional settings [28]. Despite the number of nutritional interventions in regional and remote settings, Indigenous people living in these regions are vulnerable to socio-economic and health disadvantages due to not being able to access or afford nutritious food; experiencing barriers accessing health care services due to geographical distances; and not being able to access health care specialists such as dietitians [29]. Prior to this study it has been difficult to determine or appreciate the burden and nature of malnutrition in regional settings such as the Northern Territory and Far North Queensland.

It is important for health care providers to consider potential factors that may predict malnutrition when screening and assessing patients. For example, as well being more aware of patients residing in regional or remote settings risk for malnutrition, health care providers need to be aware of socio-demographic and health-related risk factors. These risk-factors include living in regions such as Central Australia where access to health care services can be particularly difficult; limited access to and the high cost of nutritious food; and the burden of multiple chronic diseases.

To facilitate reliable malnutrition screening and early detection of malnutrition, health care providers should consider adult patients who are underweight, i.e., a BMI < 18.5 kg/m² [PPV 98.6%, 95% CI
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4.1. Limitations

Two key limitations should be considered when interpreting the findings of this study. First, some patients were unable or did not consent to anthropometric measurements being taken due to the nature of the hospital inpatient setting where measurements such as BMI cannot be calculated as patients are frequently unable to stand due to weakness or falls risk. The utility of other assessments, such as MUAC, as a simple screening tool for malnutrition in such patients should be explored. Secondly, this study only measured malnutrition in medical inpatients and therefore the results of this study may not be generalizable to patients in the broader hospital inpatient settings. Further study of these other patient groups should be a priority for future studies particularly to determine whether similar or differing factors drive malnutrition burden.

5. Conclusion

This is the first study to characterise the burden and nature of malnutrition in regional hospitals in the Northern Territory and Far North Queensland of Australia. We have demonstrated a higher rate of malnutrition than previously reported elsewhere in predominantly urban indigenous and non-Indigenous Australians. Furthermore, we have highlighted regional variations in risk, particularly for indigenous patients, and differing factors associated with malnutrition. In light of the challenges facing health care delivery in regional and remote settings, these findings provide an important first step in potentially more reliable screening and diagnostic practices to reflect the relatively unique nature of malnutrition seen in these hospital settings.

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Statement of authorship

All authors have made substantial contributions including reviewing and approving the final version of this manuscript. NM, SS, MR GM participated in the design of the study; NM carried out data collection; NM reviewed and drafted the study data CM performed statistical analysis. NM and CM drafted the manuscript and NM, GM, SS and MR all reviewed the manuscript.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.nesp.2017.12.010.

References


The Indigenous Australian Malnutrition Project: Chapter 4
Conclusions

This chapter and the associated publication offer new insights into the burden of malnutrition in both Indigenous and non-Indigenous patients living in and accessing health care in remote and regional Australia. While this chapter reports a higher prevalence of malnutrition in both Indigenous and non-Indigenous patients in regional hospital settings, one important finding is the burden of malnutrition among Indigenous Australians residing in Central Australia. The rate of malnutrition among Indigenous patients residing in Central Australia is almost double the national average reported in the Nutrition Care Day Survey in 2010. These finding highlights that this chronic disease-related problem needs to be urgently addressed to fully understand the impact of malnutrition in this vulnerable population of people. The following chapter of this thesis measures the impact of malnutrition by assessing both short and longer-term health outcomes in participants enrolled in this project.
References


CHAPTER 5

MEASURING THE DIFFERENTIAL IMPACT OF MALNUTRITION AMONG
INDIGENOUS AND NON-INDIGENOUS ADULTS ADMITTED TO HOSPITAL IN
REGIONAL AUSTRALIA

Introduction

This chapter reports the findings of the prospective cohort study described in
the study protocol in Chapter 3. This cohort study included participants from the cross-
sectional survey, measuring health outcomes included length of index hospital
admission, discharge destination, 30-day and six-month hospital readmissions and
survival. Health outcome comparisons were made between participants’ nutrition
status as well as their Indigenous status. Furthermore, health outcomes comparisons
were also made between Indigenous Australian participants and their nutrition status
to determine the impact of malnutrition among this group of patients.

This chapter includes the following peer-reviewed and published paper:

malnutrition among Indigenous and non-Indigenous adults admitted to hospital in
doi:10.3390/nu10050644
Differential Impact of Malnutrition on Health Outcomes Among Indigenous and Non-Indigenous Adults Admitted to Hospital in Regional Australia—A Prospective Cohort Study

Natasha Morris 1,2,*, Simon Stewart 3, Malcolm Riley 4 and Graeme Maguire 5,6,*

1 Monash University, Department of Epidemiology and Preventive Medicine; Baker Heart and Diabetes Institute; Melbourne 3004, Australia
2 The University of Melbourne, Department of Nursing, Melbourne 3052, Australia
3 The Queen Elizabeth Hospital, Cardiology Unit, Adelaide 5012, Australia; simon.stewart64@gmail.com
4 CSIRO Health and Biosecurity, Adelaide 5000, Australia; malcolm.riley@csiro.au
5 Western Health, General Internal Medicine, Melbourne 3001, Australia
* Correspondence: natasha.morris@unimelb.edu.au (N.M.); graeme.maguire@wh.org.au (G.M.); Tel.: +61-3-8345-6666 (G.M.)

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Abstract: The burden of malnutrition in Indigenous people is a major health priority and this study’s aims are to understand health outcomes among Indigenous and non-Indigenous patients. This cohort study includes 608 medical inpatients in three regional hospitals. Participants were screened for malnutrition using the Subjective Global Assessment tool. Hospital length of stay, discharge destination, 30-day and six-month hospital readmission and survival were measured. Although no significant difference was observed between Indigenous participants who were malnourished or nourished (p = 0.120), malnourished Indigenous participants were more likely to be readmitted back into hospital within 30 days (Relative Risk (RR) 1.53, 95% CI 1.19–1.97, p = 0.002) and six months (RR 1.40, 95% Confidence Interval (CI) 1.05–1.88, p = 0.018), and less likely to be alive at six months (RR 1.63, 95% CI 1.20–2.21, p = 0.015) than non-Indigenous participants. Malnutrition was associated with higher mortality (Hazard Ratio (HR) 3.32, 95% CI 1.87–5.89, p < 0.001) for all participants, and independent predictors for six-month mortality included being malnourished (HR 2.16, 95% CI 1.16–3.79, p = 0.014), advanced age (HR 1.04, 95% CI 1.02–1.06, p = 0.001), increased acute disease severity (Acute Physiology and Chronic Health Evaluation score; HR 1.03, 95% CI 1.01–1.05, p = 0.002) and higher chronic disease index (Charlson Comorbidity Index, HR 1.36, 95% CI 1.16–3.79, p = 0.014). Malnutrition in regional Australia is associated with increased healthcare utilization and decreased survival. New approaches to malnutrition-risk screening, increased dietetic resourcing and nutrition programs to proactively identify and address malnutrition in this context are urgently required.

Keywords: malnutrition; Indigenous Australians; subjective global assessment; Australia; survival

1. Introduction

Malnutrition is a highly prevalent problem in adult hospital patients in both low and high-income countries [1–3]. This is of clinical and public health significance given that recent cohort studies demonstrate a direct relationship between malnutrition and adverse health outcomes [2,4,5]. This includes increased healthcare utilization through longer lengths of hospital stay, frequent hospital admissions, and increased mortality when compared with nourished patients. In Australia, nearly a one-third of adult patients are reported to be malnourished [2]. However, given the diverse and
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dispersed Australian population and presence of high-risk/vulnerable communities beyond major population centers [6,7], we recently examined the pattern and prevalence of malnutrition among a representative cohort of 608 inpatients admitted to three hospitals located in regional Australia [8]. Overall, we found a higher than expected prevalence of malnutrition (41.7%), which was largely driven by a higher prevalence of malnutrition among Indigenous compared to non-Indigenous Australians [8]. This key differential was most evident amongst Indigenous Australians residing in Central Australia where 57 per cent of Indigenous versus 33% of non-Indigenous Australians were found to be malnourished [8]. Our initial findings of a higher prevalence of malnutrition among Indigenous people confirmed the potential role of malnutrition in contributing to persistent disparities in health outcomes; even among those who have accessed hospital care [8]. In a follow-up of our study cohort, we sought to determine the subsequent impact of malnourishment on short-to-medium health outcomes in the same cohort; hypothesizing that malnourishment would have a greater negative impact among Indigenous Australian people.

2. Materials and Methods

2.1. Study Design, Setting and Participants

The study rationale and design and initial findings of the Indigenous Australian Malnutrition Project have been reported previously [8,9]. This prospective cohort study used convenience sampling and was conducted in two regional hospitals in the Northern Territory and one regional hospital in Far North Queensland. Figure 1 outlines the recruitment of 608 participants enrolled into this study between February 2015 and September 2015.

Figure 1. Study recruitment pathway and data available for final outcome analysis.
2.2. Nutrition Status and Disease Severity Outcomes

As shown in Figure 1, all participants were assessed for malnutrition using the validated Subjective Global Assessment (SGA) tool within 72 h of admission by two study investigators (a Registered Nurse or an Accredited Dietitian). As per the SGA criteria, participants with an SGA of “A” were classified as “nourished” and participants with an SGA of B (mild-moderate malnutrition) or C (severe malnutrition) were classified as “malnourished” [10]. Acute and chronic disease severity (Acute Physiology and Chronic Health Evaluation (APACHE) III and Charlson Comorbidity Index (CCI)) were calculated in all study participants [11,12]. We used the APACHE III calculator in this study as the APACHE tools are the only prognostic calculator that assess acute physiologic distress including serum biochemistry and hematology [11]. To gain a better understanding of participants nutritional status, body mass index (BMI) was calculated in 579/608 (95.2%) of study participants.

2.3. Health Outcomes

Several short and medium-term health outcomes were examined according to participants nutritional status (nourished or malnourished) or their Indigenous status (Indigenous Australian or non-Indigenous Australian). Selected outcomes of interest as shown in Figure 1 included length of hospital index admission (date and time of admission to date and time of hospital separation); inpatient survival (alive or dead); hospital discharge destination (usual residential address); 30-day and six-month hospital readmission; and all-cause survival status from the point of time of hospital separation of the index admission. Length of hospital stay and discharge destination were calculated and determined in all study participants and data for 30-day and six-month hospital readmission were available as outlined in Figure 1.

Outcome data were collected and correlated with each hospitals’ medical record electronic databases by the study’s investigators during the February 2015 to September 2015 study period and cross-checked at the point of six months (March 2016) following the last participant enrolment in Far North Queensland (September 2015). Participant survival data were independently collected by hospitals’ medical record reporting officers and then confirmed by the first author (NM) using each Territory and State’s Births, Deaths and Marriages registrars [13,14].

2.4. Statistical Analysis

Data analysis was undertaken using Stata Release 15.1 (StataCorp, College Station, TX, USA). Descriptive data summarizing participants’ characteristics and health outcomes were summarized using standard univariate techniques and reported as frequencies and percentages with 95 per cent confidence intervals (95% CI), medians with first and third interquartile ranges (IQR) after assessing the format and distribution of data. Unadjusted comparisons between nutrition status and Indigenous status were undertaken using chi-square tests ($X^2$) for categorical data, and Mann-Whitney U test for continuous non-parametric data. Further unadjusted comparisons measuring Indigenous versus non-Indigenous participants’ health outcomes and nutrition status were undertaken by using Wilcoxon rank-sum test. A $p$ value $< 0.05$ was taken to indicate statistical significant and all tests were two-sided.

Survival analyses for mortality are presented as Kaplan–Meir curves and analyzed using the log-rank test. Multivariable linear, logistic and Cox proportional hazard modelling were utilized using a back stepwise approach to identify independent factors associated with health outcome measures (length of hospital index admission, six-month hospital readmission, and six-month mortality) that were identified as significantly different in the univariate analyses. These factors included age (years); nutrition status (nourished or malnourished); APACHE III and CCI scores. All factors were included in the first model using bivariate analysis with a $p$ value $< 0.1$. Factors with a $p$ value $\geq 0.05$ were progressively removed from the models starting with variables that contributed least to predictive modelling. Final models were limited to predictive factors with significant coefficients ($p < 0.05$).
2.5. Ethics Approval

Approval for this study was granted by Monash University (CF14/3350 2014001787); Central Australia (HREC-14-256); Menzies School of Health Research (HREC 2014-2282); and Far North Queensland (HREC/141QCH/86-927) Human Research Ethics Committees.

3. Results

3.1. Participant Characteristics

The characteristics of study participants according to their nutrition status are summarized in Table 1. The overall prevalence of malnutrition in this study cohort was (41.1%, 95% CI 37.2–45.1). Indigenous participants were more likely to be malnourished than non-Indigenous participants (Odds Ratio (OR) 1.45, 95% CI 1.03–2.04, \( p = 0.024 \)) and malnourished participants were significantly older than nourished patients by 4.2 years. Malnourished participants had a significantly lower median BMI than nourished patients (21.6 kg/m^2 versus 28.8 kg/m^2, respectively), and when compared to nourished participants, malnourished participants had a higher median APACHE III score (34 versus 27, respectively) and higher mean CCI score (2.7 versus 2.0, respectively) than nourished participants. No significant different differences were observed between participants gender and nutrition status.

Table 1. Characteristics of study participants according to their nutrition status (nourished or malnourished).

<table>
<thead>
<tr>
<th></th>
<th>All n = 608</th>
<th>Nourished (SGA A) n (%) = 338 (55.9)</th>
<th>Malnourished (SGA B or C) n (%) = 250 (41.1)</th>
<th>( p ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (IQR)</td>
<td>61.6 (49.1–72.2)</td>
<td>59.2 (48.0–70.5)</td>
<td>63.4 (50.9–73.3)</td>
<td>0.009</td>
</tr>
<tr>
<td>Gender (female), n (%) 95% CI</td>
<td>294 (48.4) 44.3–52.4</td>
<td>179 (50.0) 44.7–55.3</td>
<td>115 (46.0) 39.7–52.4</td>
<td>0.331</td>
</tr>
<tr>
<td>Indigenous status (Indigenous Australian) n (%) 95% CI</td>
<td>271 (44.6) 40.6–48.8</td>
<td>146 (53.9) 47.7–59.9</td>
<td>125 (46.1) 40.1–52.3</td>
<td>0.024</td>
</tr>
<tr>
<td>BMI (kg/m^2), median (IQR)</td>
<td>26.3 (21.6–31.2)</td>
<td>28.8 (25.4–34.2)</td>
<td>21.6 (18.8–25.4)</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>APACHE III, median (IQR)</td>
<td>30 (20–30)</td>
<td>27 (19–36)</td>
<td>34 (24–44)</td>
<td>(&lt;0.001)</td>
</tr>
<tr>
<td>CCI, median (IQR)</td>
<td>2 (1–3)</td>
<td>2 (1–3)</td>
<td>2 (1–4)</td>
<td>(&lt;0.001)</td>
</tr>
</tbody>
</table>

3.2. Health Outcomes for Nourished and Malnourished Participants

Health outcomes according to each participant’s nutritional status at baseline are summarized in Table 2. Although there was no difference was observed in respect to discharge destination at the time of hospital separation, length of hospital stay among malnourished participants was nearly two days longer than nourished participants. Likewise, although no significant difference was observed in the total number of hospital readmissions at six months, malnourished participants were more likely to be readmitted into hospital at 30-day (RR 1.51, 95% CI 1.25–1.82) and at six months (RR 1.48, 95% CI 1.21–1.81). While in-hospital mortality did not vary by nutritional status, mortality at 30 days (RR 1.68, 95% CI 1.24–2.27) and at six months (RR 1.78, 95% CI 1.45–2.19) were significantly higher in malnourished than nourished participants.
Table 2. Health outcomes according to participants nutrition status (nourished or malnourished).

<table>
<thead>
<tr>
<th></th>
<th>All n = 608</th>
<th>Nourished (SGA A)</th>
<th>Malnourished (SGA B or C)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(\pi (%) = 358 (59.9))</td>
<td>(\pi (%) = 250 (41.1))</td>
<td></td>
</tr>
<tr>
<td>Length of stay median (IQR)</td>
<td>4.7 (2.6–9.1)</td>
<td>4.1 (2.2–7.7)</td>
<td>5.9 (2.9–11.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Discharge destination n (%), 95% CI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usual residential address</td>
<td>503 (827) 79.5–85.7</td>
<td>291 (81.3) 76.9–85.2</td>
<td>212 (84.8) 79.7–89.0</td>
<td>0.259</td>
</tr>
<tr>
<td>Hospital readmissions n (%), 95% CI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>145/591 (24.6) 20.9–8.0</td>
<td>64/346 (18.4) 14.5–22.9</td>
<td>81/245 (32.6) 26.9–38.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>6 months</td>
<td>323/591 (54.2) 50.1–58.2</td>
<td>165/346 (47.4) 42.1–52.8</td>
<td>158/245 (63.7) 57.4–69.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mortality n (%), 95% CI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>22/591 (3.7) 2.3–5.5</td>
<td>4/346 (1.2) 0.3–2.9</td>
<td>12/245 (4.9) 2.6–8.4</td>
<td>0.006</td>
</tr>
<tr>
<td>6 months</td>
<td>55/591 (9.2) 7.0–11.8</td>
<td>11/346 (4.0) 2.2–6.7</td>
<td>35/245 (14.3) 10.2–19.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

3.3. Health Outcomes Among Indigenous and Non-Indigenous Australian Participants

As summarized in Table 3, no significant differences were observed between Indigenous and non-Indigenous participants and their length of hospital index stay, participants discharge destination, 30-day hospital readmissions and six-month survival. Overall however, Indigenous Australians were more likely to be readmitted to hospital within six months (RR 1.39, 95% CI 1.15–1.68) and have a higher total number of hospital readmissions at six months and in contrast, non-Indigenous participants were less likely to survive at 30 days (RR 1.52, 95% CI 1.18–1.94).

Table 3. Health outcomes according to participants Indigenous status.

<table>
<thead>
<tr>
<th></th>
<th>Indigenous Australian n (%) = 271 (44.6)</th>
<th>Non-Indigenous Australian n (%) = 337 (55.4)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of stay, median (IQR)</td>
<td>5.0 (2.3–9.0)</td>
<td>4.6 (2.5–9.1)</td>
<td>0.186</td>
</tr>
<tr>
<td>Discharge destination n (%), 95% CI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Usual residential address</td>
<td>217 (80.1) 74.5–84.7</td>
<td>286 (84.9) 80.6–88.5</td>
<td>0.120</td>
</tr>
<tr>
<td>Hospital readmissions n (%), 95% CI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>73 (27.0) 21.8–32.8</td>
<td>72 (22.1) 17.7–27.1</td>
<td>0.195</td>
</tr>
<tr>
<td>6 months</td>
<td>169 (62.6) 55.5–68.4</td>
<td>154 (48.0) 42.4–53.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mortality n (%), 95% CI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 days</td>
<td>3 (1.1) 0.2–3.2</td>
<td>13 (4.0) 2.2–6.8</td>
<td>0.028</td>
</tr>
<tr>
<td>6 months</td>
<td>21 (7.8) 4.9–11.5</td>
<td>28 (8.7) 5.9–12.4</td>
<td>0.878</td>
</tr>
</tbody>
</table>

A summarized in Table 4, nutritional status appeared to modulate some of these key differentials in health outcomes. For example, Indigenous Australians who were malfnourished were more likely to be readmitted back into hospital within 30-day (RR 1.53, 95% CI 1.19–1.97) and six months (RR 1.40, 95% CI 1.05–1.88) and were less likely to be alive at six months than nourished Indigenous participants (RR 1.63, 95% CI 1.20–2.21). Likewise, non-Indigenous Australians who were malnourished were also likely to be readmitted back into hospital at 30 days (RR 1.46, 95% CI 1.10–1.95) and six months (RR 1.53, 95% CI 1.15–2.05) and were less likely to survive at six months (RR 2.07, 95% CI 1.56–2.75). In addition, non-Indigenous participants who were malnourished were also likely to have longer length of hospital index stay, more frequent six-month hospital readmissions and less likely to survive at 30 days than non-Indigenous participants who were nourished (RR 2.13, 95% CI 1.53–3.00).
Table 4. Health outcomes according to participants Indigenous and nutrition status.

<table>
<thead>
<tr>
<th></th>
<th>Indigenous Australians n (%) = 271 (44.6)</th>
<th>p Value</th>
<th>Non-Indigenous Australians n (%) = 337 (55.4)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of stay median (IQR)</td>
<td>4.8 (2.8-8.3)</td>
<td>0.120</td>
<td>5.8 (2.8-13.7)</td>
<td>0.001</td>
</tr>
<tr>
<td>Discharge destination usual address n (%), 95% CI</td>
<td>66.8-81.5</td>
<td>75.1-91.9</td>
<td>80.4-90.2</td>
<td>75.8-88.3</td>
</tr>
<tr>
<td>Hospital readmissions n (%), 95% CI</td>
<td>30 days</td>
<td>28 (19.2)</td>
<td>45 (36.5)</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>30 days</td>
<td>13.1-25.5</td>
<td>27.8-45.4</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>6 months</td>
<td>47.7-64.4</td>
<td>61.3-78.0</td>
<td>0.018</td>
</tr>
<tr>
<td>Mortality n (%), 95% CI</td>
<td>20 days</td>
<td>1.07</td>
<td>2.16</td>
<td>0.469</td>
</tr>
<tr>
<td></td>
<td>6 months</td>
<td>1.3-87</td>
<td>6.9-12.2</td>
<td>0.015</td>
</tr>
</tbody>
</table>

3.4. Independent Factors Associated with Healthcare Utilisation and Decreased Survival

Factors independently associated with index length of hospital admission, six-month subsequent hospital readmission and six-month mortality are presented in Table 5. We tested the hypothesis that malnutrition would be an independent predictor of increased risk of all-cause readmission and decreased survival in Indigenous and non-Indigenous participants at six-month follow-up. We found that being malnourished conveys the same negative impact for six-month hospital readmission for both Indigenous and non-Indigenous participants, but for Indigenous Australian participants, being malnourished was an independent predictor for mortality at six months. Similarly, for both Indigenous and non-Indigenous participants, increased acute disease severity score (APACHE III) was an independent predictor for increased length of hospital stay; and an increased acute disease severity score (APACHE III) and chronic comorbidity score (CCI) were both predictors for six-month hospital readmission and mortality at six months.

Table 5. Independent predictors of increased length of stay, and 6-month hospital readmission & mortality.

<table>
<thead>
<tr>
<th></th>
<th>All n = 688</th>
<th>Indigenous Australian n = 271 (44.6%)</th>
<th>Non-Indigenous Australian n = 337 (55.4%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APACHE III</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coef</td>
<td>15.0</td>
<td>7.8-22.3</td>
<td>121</td>
</tr>
<tr>
<td>95% CI</td>
<td>15.0</td>
<td>7.8-22.3</td>
<td>121</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pseudo R² (%)</td>
<td>2.7</td>
<td>2.1</td>
<td>3.0</td>
</tr>
<tr>
<td>Six-month readmission</td>
<td>OR</td>
<td>98% CI</td>
<td>98% CI</td>
</tr>
<tr>
<td>p value</td>
<td>2.1</td>
<td>2.1</td>
<td>3.0</td>
</tr>
<tr>
<td>malnourished (SGA B/C)</td>
<td>normal</td>
<td>1.62</td>
<td>1.75</td>
</tr>
<tr>
<td>p value</td>
<td>0.008</td>
<td>0.008</td>
<td>0.008</td>
</tr>
<tr>
<td>Indigenous Australian</td>
<td>1.60</td>
<td>1.12-2.27</td>
<td>1.71</td>
</tr>
<tr>
<td>(yes)</td>
<td>95% CI</td>
<td>98% CI</td>
<td>95% CI</td>
</tr>
<tr>
<td>p value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>APACHE III</td>
<td>1.01</td>
<td>1.00-1.03</td>
<td>1.71</td>
</tr>
<tr>
<td>CCI</td>
<td>1.23</td>
<td>1.16-1.37</td>
<td>1.71</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pseudo R² (%)</td>
<td>6.8</td>
<td>5.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Six-month mortality</td>
<td>HR</td>
<td>95% CI</td>
<td>98% CI</td>
</tr>
<tr>
<td>p value</td>
<td>2.10</td>
<td>1.16-3.79</td>
<td>1.04-7.10</td>
</tr>
<tr>
<td>malnourished (SGA B/C)</td>
<td>normal</td>
<td>2.10</td>
<td>1.04-7.10</td>
</tr>
<tr>
<td>p value</td>
<td>0.014</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td>Age (years)</td>
<td>1.04</td>
<td>1.02-1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>APACHE III</td>
<td>1.03</td>
<td>1.01-1.08</td>
<td>1.03</td>
</tr>
<tr>
<td>CCI</td>
<td>1.03</td>
<td>1.01-1.08</td>
<td>1.03</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pseudo R² (%)</td>
<td>24.1</td>
<td>16.5</td>
<td>35.2</td>
</tr>
</tbody>
</table>

Unadjusted mortality to six months illustrate higher mortality in malnourished patients when stratified by nutrition status (see Figure 2). Likewise, unadjusted mortality to six months was significantly higher in both Indigenous and non-Indigenous Australians who were malnourished (see Figure 3).
Figure 2. Unadjusted survival for Indigenous and non-Indigenous participants to six months stratified by nutritional status (nourished or malnourished), (Log rank, \( p < 0.001; HR 3.32, 95\% CI 1.87–5.89\)).

Figure 3. Unadjusted survival for Indigenous participants to six months stratified by nutritional status (Log rank, \( p = 0.013; HR 3.12, 95\% CI 1.21–8.04\)), and unadjusted survival for non-Indigenous participants to six months stratified by nutritional status (Log rank, \( p = 0.001; HR 3.64, 95\% CI 1.76–7.50\)).

4. Discussion

This cohort study is the first to examine the subsequent impact of malnutrition and measure health outcome differences between hospitalized Indigenous and non-Indigenous people. Overall, we found that malnutrition was a key driver of increased health care utilization and increased risk of mortality for both Indigenous and non-Indigenous participants, highlighting a need for increased dietitian resourcing and urgent community and hospital-based nutrition programs. For example, for every 100 patients who are malnourished, 64.5% will be readmitted back into hospital within six months compared to 47.7% of nourished patients and 14.3% of malnourished patients will die at six months compared to 4.0% of patients who are nourished. Likewise, for every 100 Indigenous patients who
are malnourished 70.2% will be readmitted back into hospital within six months compared to 58.7% malnourished non-Indigenous patients. However, 16.8% of non-Indigenous malnourished patients will die within six months compared to 12.1% of malnourished Indigenous patients. The higher attributable risk for six-month mortality in malnourished non-Indigenous patients compared to Indigenous patients is likely due to our early study finding that non-Indigenous patients were significantly older than non-Indigenous patients by nearly 12 years ($p < 0.001$) [7], highlighting the need for early nutrition assessment in all patients with advanced age. However, we did find that malnutrition was also an independent predictor for six-month mortality for Indigenous Australians confirming that malnutrition is a significant problem for Indigenous Australian patients.

Furthermore, we found that readmission rates for Indigenous Australian participants were significantly higher than non-Indigenous participants at 30 days (27.0% versus 22.1%, respectively) and at six months (62.6% versus 48.0%, respectively). This finding is comparable to other studies differentiating health care utilization in Indigenous and non-Indigenous Australians. Whyatt et al. conducted a longitudinal cohort study from 2002 to 2014 comparing rates of hospital utilization in Indigenous and non-Indigenous Australians with chronic diseases [15]. Whyatt et al. found that while inpatient length of stay in Indigenous Australian patients were similar to non-Indigenous patients (as we found in our study), Indigenous Australians had much higher rates of Emergency Department presentations, were more likely to be admitted as an inpatient, and were also younger than non-Indigenous Australians [15]. Common factors found in our study and other studies predicting increased healthcare utilization for Indigenous and non-Indigenous Australian patients include the presence of chronic disease and more telling, severity of disease. Indigenous Australian patients residing in remote regions like Central Australia or people residing in very remote regions up to 1000 km from the nearest hospital, are more likely to be admitted to hospital than non-Indigenous Australians who are more likely to live in inner or outer regional areas with closer access to community and hospital health services [16].

Given the high proportion of malnutrition we found particularly amongst Indigenous participants, and the subsequent impact of malnutrition for both Indigenous and non-Indigenous participants, these data identify malnutrition as a high priority target for addressing these adverse health outcomes. For example, the national average cost of an overnight stay in an Australian acute care hospital bed is $2074 [17], and in our study, this represented just over $3700 for every patient who was malnourished. We found that rates of hospital readmission were much higher when compared to other longitudinal studies in Australian hospitals. For example, in a large retrospective study measuring hospital readmission rates over a 5-year period in a large general medicine tertiary hospital in South Australia, the 28-day readmission rate was 10.8 per cent [18]. In our study, the total readmission rate at 30 days for all study participants was higher at 24.3% and as high as 32.6% for malnourished participants demonstrating increased healthcare utilization in regional settings and malnutrition being a significant contributing factor.

Although there are several important community-based nutrition intervention programs [19], there is an urgent need to explore strategies for nutrition management for people with chronic disease. This requires a more considered and strategic approach to detecting malnutrition in patients who are admitted to hospital. While screening patients for malnutrition within 24 hours is recommended practice [20], the reliability of malnutrition screening varies greatly depending on the tool being used and how screening is being conducted [21]. Detecting malnutrition early in a patient’s hospital admission is imperative to avoid adverse health outcomes. Further studies are required to consider using acute disease severity scores such as an adapted APACHE scoring system for medical inpatients as our study found that increased healthcare utilization for patients who were malnourished as well as Indigenous patients is attributable to increased acute and chronic disease physiologic scores. Likewise, due to the chronic nature of malnutrition in adults, community-based screening in community health centers should be implemented as part of routine health checks in patients with a chronic disease.
Subsequently, there is an urgent need for increased dietetic resources both in the community and in hospitals.

One of the major limitations of our study includes the relatively short follow-up time at six months from patients' index hospital admission. Lim et al. measured mortality in malnourished and nourished patients at three years from their initial index admission found that nearly half (48.5%) of the patients with malnutrition had died compared to just under 10 per cent of nourished patients (RR 4.8, 95% CI 3.7–6.5, <0.001) [4]. This finding highlights the necessity for long-term follow-up studies to measure the true long-term impact of malnutrition especially for Indigenous Australian patients where the rate of malnutrition is higher and disease severity higher. This study is generalizable to other high-income countries where health disparities between Indigenous and non-Indigenous populations exist but when comparing our study’s findings with other malnutrition-related health outcome studies, caution should be exercised due to the unique geographical location and health services where our study was conducted.

5. Conclusions

This study has confirmed that malnutrition for both Indigenous and non-Indigenous patients admitted into regional hospital settings results in greater healthcare utilization and increased risk of mortality than patients who are nourished. In our study, malnutrition is not only associated with increased hospital readmission and decreased survival, but acute and chronic disease severity in our study’s participants were predictors for increased length of hospital stay and/or hospital readmission and mortality. As an adjunct to malnutrition screening, further research is required to explore the use of acute physiologic scores (i.e., a modified APACHE scoring system) for medical inpatients to aid in detecting malnutrition in patients with an acute illness or with severe chronic disease. Further research is also required to understand the financial burden of malnutrition on health care services through increased length of hospital stays and hospital readmissions. It is also important that future research focuses on chronic-disease related malnutrition in adults residing in the community and the evaluation of nutritional intervention strategies as part of secondary and tertiary prevention management.

Author Contributions: N.M., S.S., M.R. and G.M. designed the research; N.M. conducted the research; N.M. and C.M. analyzed the data; N.M., S.S., M.R. and G.M. wrote and revised the paper. N.M. and G.M. had primary responsibility for final content. All authors read and approved the final manuscript.

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Acknowledgments: The authors would like to thank and acknowledge the Nutrition and Dietetic Departments at each study site, and the study’s research dietitians, Emma Ferrari and Elvio Chan. The authors would also like to acknowledge Marc Remond for assistance with statistical analysis.

Conflicts of Interest: The authors declare no conflict of interest.

References
The Indigenous Australian Malnutrition Project: Chapter 5


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Conclusions

This thesis so far has highlighted the greater burden and impact of malnutrition in Indigenous as compared with non-Indigenous Australian hospital inpatients. Malnutrition is a shared problem among both Indigenous and non-Indigenous Australian patients admitted into hospitals and the findings from chapters 4 and 5 highlight the increased burden and impact of malnutrition among Indigenous Australians. Key differentiating factors highlighted from preceding chapters is that although the prevalence of malnutrition is much higher in Indigenous Australians when compared to non-Indigenous patients, the impact of malnutrition is not seemingly worse among Indigenous patients. However, due to the burden of chronic disease among Indigenous Australians longer cohort studies are required to better understand and appreciate the impact of malnutrition in patients with complex chronic diseases. Furthermore, screening patients with a validated tool is essential for the early detection of malnutrition and subsequent nutrition management. The following chapter describes the development and validation of the Adult Nutrition Tool (ANT), a malnutrition screening tool developed for culturally and linguistically diverse Indigenous and non-Indigenous Australian patients.
CHAPTER 6

THE DEVELOPMENT AND VALIDATION OF THE ADULT NUTRITION TOOL

Introduction

This chapter reports the findings of the malnutrition screen tool validation study. In particular, this study validates the Malnutrition Screening Tool (MST), a tool used widely throughout Australian healthcare services, including the three regional hospitals included in the Indigenous Australian Malnutrition (IAM) project. Despite its widespread use, the MST has not been validated among Indigenous Australians. Due to language barriers and cultural considerations, it was hypothesised that the MST may not be an appropriate screening tool for this group of people. Therefore, the IAM project also included the development and validation of the Adult Nutrition Tool (ANT), a screening tool developed in collaboration with key stakeholders, including members of the Indigenous Australian community.

This chapter includes the following paper which is ‘under review’ by the Asia Pacific Journal of Clinical Nutrition.

A comparison of two malnutrition screening tools in acute medical inpatients and validation of a screening tool among adult Indigenous Australian patients.

Short running title: Comparison of two malnutrition screening tools

Natasha F Morris MNUR\textsuperscript{1,2,3}, Simon Stewart PhD\textsuperscript{1}, Malcom D Riley PhD\textsuperscript{4}, Graeme P Maguire PhD\textsuperscript{1,5}

\textsuperscript{1}. Monash University, Department of Epidemiology and Preventive Medicine

\textsuperscript{2}. Baker Heart and Diabetes Institute

\textsuperscript{3}. The University of Melbourne, Department of Nursing

\textsuperscript{4}. CSIRO Health and Biosecurity

\textsuperscript{5}. Western Health, General Internal Medicine

Correspondence to: Natasha Morris, The University of Melbourne, Tel: 

Authors’ contributions

N.M., S.S., M.R. and G.M. designed the research; N.M. conducted the research; N.M. and G.M. analysed the data; and N.M., S.S., M.R. and G.M. wrote and revised the paper. N.M. and G.M. had primary responsibility for final content. All authors read and approved the final manuscript.
The Indigenous Australian Malnutrition Project: Chapter 6

Abstract

Objectives: The objectives of this study were to identify and validate a screening tool to detect malnutrition among Indigenous and non-Indigenous patients.

Methods and study design: This study included medical patients admitted into three regional hospitals in Australia. A literature review was undertaken of current screening tools before the Malnutrition Screening Tool (MST) and the newly developed Adult Nutrition Tool (ANT) were used to validate a screening tool for use among participants against the Subjective Global Assessment (SGA) tool. The sensitivity and specificity of both the MST and ANT were determined for all study participants as well as according to participants' Indigenous status.

Results: A total of 608 participants were enrolled into the study, of whom 271 (44.6%) were Indigenous. The area under the curve (AUC) when utilising ANT was higher in all participants compared to the MST (0.90, 95% CI 0.88–0.92 versus 0.81, 95% CI 0.77–0.84, p < 0.001). The AUC was also significantly higher for Indigenous participants when utilising ANT compared to the MST (0.88, 95% CI 0.84–0.92 versus 0.78, 95% CI 0.73–0.83, p < 0.001). An ANT ≥ 2 demonstrated superior sensitivity for both Indigenous and non-Indigenous participants (96.0%, 95% CI 92.8–98.7%) than the MST (84.0%, 95% CI 78.9–88.3) but with inferior specificity (59.5%, 95% CI 54.2–64.6) than the MST (70.7%, 95% CI 65.7–75.3).

Conclusion: The ANT is both a valid and accurate tool for Indigenous and non-Indigenous Australian patients. Further research is required to validate ANT to aide in the detection of malnutrition in other clinical settings.

Keywords Adult Nutrition Tool, Indigenous Australian patients, Malnutrition Screening Tool, Subjective Global Assessment, validation
Introduction

Malnutrition is a highly prevalent among hospital patients and is associated with many adverse health outcomes.¹⁻⁵ These outcomes include: increased healthcare utilisation; decreased quality of life; and increased risk of patient morbidity and mortality.¹⁻⁴ Subsequently, screening patients for malnutrition risk upon admission into a healthcare service is best practice so patients identified at risk of malnutrition are referred to dietetic services for nutritional assessment and management.⁶⁻⁷ Screening patients for malnutrition risk, should be simple and rapid and is usually based on the detection of key features related to malnutrition such as decreased oral intake and unintentional weight loss.⁸⁻¹⁰

We recently reported the burden of malnutrition among Indigenous Australians in regional hospital settings, demonstrating higher rates of malnutrition among Indigenous patients when compared to non-Indigenous patients.² In this study, the rate of malnutrition among Indigenous patients was nine per cent higher than non-Indigenous patients (46.1% versus 37.1% respectively) and furthermore, the rate of malnutrition among Indigenous Australian patients residing in Central Australia was much higher when compared to the Top End of the Northern Territory and Far North Queensland (56.7%, 40.7% and 36.7% respectively).² The burden of malnutrition in these regional hospital settings highlight the clinical importance of screening patients for malnutrition risk early during their admission for subsequent management and therefore it is imperative that a valid screening tool is used for patients who are particularly vulnerable to malnutrition risk.

In many other healthcare services throughout Australia, the Malnutrition Screening Tool (MST)¹⁰ is utilised as the risk screening tool. Despite the number of studies validating the MST in a variety of clinical settings and contexts,¹⁰⁻¹⁷ the MST has not been validated for use among Indigenous patients and there are potentially key features of the MST that may erode its capacity to detect malnutrition risk in this vulnerable population.
The Indigenous Australian Malnutrition Project: Chapter 6

The MST is a two-question tool that screens patients for unintentional weight loss, including the amount of recent weight loss, and patients’ loss of appetite.\textsuperscript{10} Patients are scored from 0 to 5 and patients with an MST score $\geq 2$ are categorised at risk of malnutrition resulting in a subsequent referral to a dietitian. However, Indigenous Australian people may not understand or be able to contextualise the MST questions as many Indigenous people are multilingual where English is not their most common or frequent spoken language.\textsuperscript{18} This issue may particularly apply to Indigenous people residing in outer regional, rural or remote regions where English may be their four or fifth spoken language.\textsuperscript{18} It is therefore of upmost urgency to identify and validate a malnutrition screening tool to detect malnutrition among a group of patients who are vulnerable to malnutrition.

The objectives of this study were to validate the MST and a new malnutrition screening tool, the Adult Nutrition Tool\texttrademark{} (ANT), for use among Indigenous Australian patients. We hypothesise that the MST may not be a valid screening tool for Indigenous Australians and therefore may not accurately detect malnutrition among this group of patients. We also hypothesise that the ANT will be a valid tool in detecting malnutrition among both Indigenous and non-Indigenous patients.

**Materials and Methods**

This is a prospective validation study conducted in three large regional hospitals including Alice Springs Hospital and Royal Darwin Hospital in the Northern Territory, and Cairns Hospital in Far North Queensland of Australia. These three hospitals are unique due to their geographical location and the relatively low-density population they service but higher proportion of Indigenous Australian patients compared to non-Indigenous patients.\textsuperscript{19} This study included a convenience sample of adult Indigenous and non-Indigenous Australians admitted into medical inpatient settings during February 2015 and September 2015.\textsuperscript{2} The eligibility criteria for this validation has been published elsewhere.\textsuperscript{20} Briefly
however, participant inclusion criteria were patients who were 18 years and over, who were admitted into a medical inpatient setting and were able to provide informed consent. As seen in Figure 1, study recruitment involved identifying eligible patients from respective hospitals’ electronic medical databases and patient eligibility was screened against the study’s inclusion and exclusion criteria by two study investigators at the beginning of each study day. Where disagreement or uncertainty occurred (for example, reason for medical admission), patients’ eligibility criteria were reassessed by the two study investigators by reviewing patients’ hard-copy medical records and confirmed by patients’ treating doctor or nurse-in-charge.

Following study enrolment, participants were screened for malnutrition risk by a trained registered nurse or accredited dietitian using the MST and the ANT. As described earlier and shown in Box 1 below, the MST is a two-item tool using a 5-point scoring system. Participants who scored between 0 and 1 were classified as ‘no risk’ and participants who scored equal or greater than 2 were classified as ‘at risk’.

As seen in Box 2 below, the ANT is a three-item screening tool with a scoring range of 0 to 7. The development and content validation of the ANT include four phases which are provided in more detail in Appendix A. In Phase 1, a search and review of existing malnutrition screening tools was undertaken by the first author (NM). This review included searching for screening tools that had been validated for use among Indigenous patients or patients from culturally diverse populations. Only one screening tool was identified that was a modified MST and included a third criterion requiring the clinician to use their clinical judgement whether the patient appeared undernourished.

Phase 2 included the development of the ANT modified from the MST. In collaboration with dietitians (including the first author of the MST and dietitian managers from each participating hospital), health language experts and Aboriginal Liaison Officers
from Alice Springs Hospital, questions one and two from the MST were modified to form two items of the ANT that relate to decreased food intake (item one) and weight loss (item two). A key difference between the MST and the ANT relates to item two regarding the amount of recent weight loss is quantified. Instead of asking patients to quantify their weight loss in kilograms, the ANT asks patients to quantify their using three categories: a lot; a little bit; or not sure. This categorisation was based on a pain scale rating that nurses may use to measure Indigenous patients level of pain when the numerical pain scale (pain score 0 to 10) is not understood by the patient. The third and final item in the ANT, asks the clinical to make an assessment whether the patient looks ‘undernourished’ using the prompts: loss of muscle mass; subcutaneous fat loss; or hollow or sunken eyes. This third item was based on the modified MST by Frew et al. and the findings of Green et al. who found that nurses’ professional judgement overrides screening tools.

Phase three included content validation by pilot testing the ANT in acute medical inpatients during November and December 2014. Testing of the ANT was undertaken using the SGA tool and modifications to the scoring of ANT and final content validation was undertaken by the first author (NM) and the dietitian managers from hospitals included in this study.

Phase four included index testing of the ANT and was undertaken between February 2015 to September 2015. Participants were screened separately either by a trained registered nurse or an accredited dietitian. Participants were screened either firstly using the MST followed by the ANT or vice versa (ANT followed by the MST). Immediately after screening, participants were assessed for malnutrition using the SGA tool. At the end of each study day, participants’ MST, ANT and SGA results were discussed and agreed upon between the two study investigators. Where disagreement or uncertainty occurred in respect to screening or SGA results, confirmation and agreement were sought from participants’ respective medical ward dietitian.
Although there are no current studies that have validated the SGA specifically among Indigenous patients, we used the SGA as the reference standard in this study. The SGA is a validated nutrition assessment among medical patients that incorporates both subjective and objective data. These data include: history of recent weight loss; oral intake; gastrointestinal symptoms; functional capacity; subcutaneous fat loss; muscle wasting; and signs of oedema or ascites. As per the SGA criteria, participants with an SGA of ‘A’ were classified as ‘nourished’ and participants with an SGA of ‘B’ or ‘C’ were classified as ‘malnourished’.

A cut-off point of an MST equal or greater than two (≥ 2) was used to classify participants’ ‘at risk’ of malnutrition according to the MST’s original validation study. A cut-off point using the ANT was determined where the sensitivity was equal or greater than 81% (very good) and specificity equal or greater than 41% (moderate) when referenced against the standard of an SGA of B or C (malnourished).

Data were entered and coded in Microsoft Excel for Windows, 2016 (Microsoft Office 2016®) and data analyses performed in Stata Release 15.1 (StataCorp LP, Texas, USA). Data for all 608 study participants were included in the data analyses and receiver operator characteristic (ROC) curves were developed and the area under the curve (AUC) were determined for the MST and the ANT using the SGA as the reference standard. In addition, the AUC for the MST and the ANT was determined after categorisation by participants’ Indigenous status (Indigenous Australian or non-Indigenous Australian). Utilising the predetermined (MST ≥ 2) or yet to be determined ANT cut-off points; sensitivity, specificity, positive predictive value and negative predictive value were determined for all study participants and for subgroups categorised according to participants Indigenous status. A p <0.05 was taken to indicate statistical significance and all tests were two-sided. The sample
size for this study was determined by the sample size required for the cross-sectional survey published elsewhere.\textsuperscript{20}

Approval for this study was granted by Monash University (CF14/3350 2014001787); Central Australia (HREC-14-256); Northern Territory Department of Health Menzies School of Health Research (HREC 2014-2282); and Far North Queensland (HREC/141QCH/86-927) Human Research Ethics Committees.

Results

Baseline demographic and clinical characteristics of study participants are described elsewhere.\textsuperscript{2} As seen in Figure 1, a total of 608 participants were included in this validation study of which 271 (44.6\%) were Indigenous Australian. According to the SGA, 250 (41.1\%, 95\% CI 37.2–45.1\%) of participants were malnourished and of the 250 malnourished participants, 125/271 (46.1\%, 95\% CI 40.1–52.3\%) Indigenous Australians were malnourished versus 125/337 (37.1\%, 31.9–42.5\%) non-Indigenous participants classified as malnourished.\textsuperscript{2}

As seen in Figure 2, the unadjusted AUC utilising the ANT was significantly greater than the MST to predict malnutrition using the reference standard SGA for both Indigenous and non-Indigenous participants (\(p<0.001\)). As seen in Figures 3 and 4, the unadjusted AUC utilising the ANT was also significantly higher compared to the MST when comparing screening tools stratified by participants Indigenous and non-Indigenous status (\(p<0.001\) and \(p<0.001\) respectively). No significant difference was observed however when predicting malnutrition using the MST between Indigenous and non-Indigenous participants (\(p< 0.05\)) and likewise; no significant difference was observed when predicting malnutrition using the ANT between Indigenous and non-Indigenous participants (\(p< 0.05\)).
As summarised in Table 1, an ANT ≥ 2 demonstrated superior sensitivity to a MST ≥ 2 but with inferior specificity in Indigenous and non-Indigenous participants. Only 10 (10/250, 4.0%, 95% CI 1.9–7.2%) malnourished participants tested false negative for malnutrition with an ANT ≥ 2 compared to 40 (40/250, 16.0%, 95% CI 11.7–21.1%) malnourished patients testing false negative with a MST score ≥ 2. Similarly, an ANT ≥ 2 demonstrated superior sensitivity for Indigenous malnourished patients but with overall inferior specificity. Five (5/125, 4.0%, 95% CI 0.13–0.91%) malnourished Indigenous participants tested false negative utilising an ANT ≥ 2 compared to 15 malnourished Indigenous participants (15/125, 12.0%, 95% CI 6.9–19.0%) testing false negative with a MST ≥ 2. For non-Indigenous Australian participants, an ANT ≥ 2 also demonstrated superior sensitivity compared to a MST ≥ 2 or ANT ≥ 3 but with inferior specificity. For non-Indigenous participants who were malnourished, five (5/125, 4.0%, 95% CI 0.10–0.90%) tested false negative with an ANT ≥ 2 compared to 25 (25/125, 20%, 95% CI 13.4–28.1%) who tested false negative with a MST ≥ 2.

Discussion

This study represents a cohort of Indigenous and non-Indigenous medical inpatients admitted into three regional Australian hospitals. We found that although the MST is a validated tool in a variety of different clinical contexts, the newly developed ANT is a valid screening tool for Indigenous and non-Indigenous Australian patients. In our study, we found that the MST had limited sensitivity and specificity for predicting malnutrition risk in Indigenous and non-Indigenous patients when referenced against the SGA. In practical terms, in this study’s context, for every 100 patients screened, the MST will miss 16 patients who should be referred for further nutritional assessment and management compared to an ANT score ≥ 2 which will miss a total of four patients who are malnourished. The greater sensitivity of an ANT ≥ 2 was offset by a lower specificity than the MST. For every 100
patients screened with an ANT ≥ 2, nearly 41 patients will test false-positive for malnutrition, compared to nearly 30 nourished patients using the MST.

To facilitate malnutrition screening by clinicians and engage nurses in screening, it is important that screening tools permit clinicians to exercise their clinical expertise and judgements when screening patients for malnutrition. In Green et al.’s study, screening tools that do not facilitate nurses to apply their clinical knowledge when screening patients for malnutrition resulted in the reduced uptake of screening. Overriding or not affording clinicians to use their clinical expertise, may result in misclassification of patients and potentially contributing to adverse health outcomes due to untreated malnutrition. Therefore, screening tools (like ANT) that incorporate nurses (or other clinicians) to make an assessment and clinical decision that a patient is undernourished may enable and increase the uptake of patient screening.

While some screening tools like the Malnutrition Universal Screening Tool (MUST) include objective data into their screening tool (for example, BMI), many screening tools rely on subjective data and their validity threatened by patient recall. In our study setting, acute or recent changes in weight may not easily be noticed by Indigenous Australian people due to the number and severity of chronic disease they experience. This is compounded in rural and remote settings, where potentially access to weighing scales may be restricted when compared to Indigenous people residing in outer-regional or metropolitan settings. However, our study is not the first validation study to modify the MST that incorporated clinicians’ clinical expertise. As described earlier, Frew et al. validated a modified MST against the SGA for patients with advanced age and for patients from culturally diverse backgrounds with limited English language skills with the addition of a third criterion “Does the patient look obviously frail/underweight” (p. 72) with a binary ‘yes’ or ‘no’ response. The modified MST included a cut-off point ≥ 2 and the sensitivity and specificity of the
modified MST was 77% and 83% respectively.\textsuperscript{21} In our study, ANT demonstrated superior sensitivity (96.0%) but with inferior specificity (59.5%) than the modified MST. Furthermore, in consultation with Aboriginal Liaison Officers language such as ‘underweight’ or reference to being ‘skinny’ was not culturally appropriate terms and in ANT, the word ‘under-nourished’ was used to avoid reference to body size and to also consider patients who may have a high BMI (\( \geq 25.0 \text{ kg/m}^2 \)) who may have protein-energy malnutrition.

While utilising an ANT \( \geq 2 \) is likely to generate greater referral of adequately nourished patients to dietetic services, in our study cohort, utilising an ANT \( \geq 2 \) resulted in identifying 30 patients who were malnourished that may have otherwise not been identified. While an ANT \( \geq 2 \) has overall lower specificity than the MST, we argue that the costs associated with unnecessary dietetic referrals reduces potential harm to patients. A small increase in referral of patients eventually assessed to be adequately nourished is likely to be outweighed by the additional costs associated with not detecting and treating patients with malnutrition.\textsuperscript{28}

In our study context, the ANT is a superior screening tool to the MST for both Indigenous and non-Indigenous patients as the ultimate intention for screening is to detect malnourished patients. While the ANT with a cut-off point \( \geq 2 \) may result in a small increase in unnecessary referrals when compared to the MST, it is more likely to detect malnutrition among Indigenous and non-Indigenous patients and facilitate early nutritional assessment and intervention. Moving forward however, further research is required to explore new approaches to malnutrition screening in addition to subjective patient history such as weight loss and food intake. For example, in our earlier study, we found that acute and chronic disease severity indices were independent predictors for malnutrition among Indigenous and non-Indigenous patients and therefore future studies exploring the use of disease severity indices should be explored to determine their use in detecting malnutrition.\textsuperscript{2} Furthermore, clinicians responsible for screening should receive education and training on how to assess
for protein-energy malnutrition in the context of acute care settings in patients who are often admitted with several chronic and complex diseases and further research is required to identify enablers of malnutrition screening by clinicians.

In addition to our study’s research aim to validate a malnutrition screening tool for use among Indigenous Australian participants, this is the first known study to use the SGA specifically among Indigenous patients. In Australia, only one published study has measured the burden of malnutrition among Indigenous patients with end stage kidney disease using the Patient Generated Subjective Global Assessment (PG-SGA). In this study, only 25 patients were identified as Aboriginal Australian and/or Torres Strait Islander and nine (35%) were found to be malnourished. The SGA has been validated among patients admitted into acute healthcare services and we recommend the SGA as a validated tool for use among Indigenous patients.

One of the major limitations of this study is that the ANT has only been validated among medical inpatients and thus its generalisability to other inpatient groups is therefore limited. Although this tool has been validated as a screening tool for Indigenous and non-Indigenous patients, further validations studies are required in other patient populations such as surgical, renal and oncology patients. Another main limitation of this study, that although the study investigators reviewed and confirmed each study participants’ screening and SGA results at the end of each study day, the investigators were not blinded to participants nutrition status therefore potentially introducing research bias. This study did not test the inter-rater reliability of the ANT and future studies should be undertaken to establish the performance of this tool by healthcare providers responsible for screening patients for malnutrition.
Conclusion

This is the first study to validate a new malnutrition screening tool designed specifically for Indigenous Australian patients and the first study to utilise the SGA specifically among Indigenous Australian patients. We found that the Adult Nutrition Tool – ANT is a validated tool for screening Indigenous and non-Indigenous Australian medical inpatients for malnutrition. Overall, utilising an ANT ≥ 2 is highly sensitive for predicting malnutrition in both Indigenous and non-Indigenous patients but may result in an increase in unnecessary dietetic referrals. We argue, given the impact of malnutrition on both patients and healthcare services, including dietetic resources, the benefits of utilising an ANT ≥ 2 are likely to outweigh any potential additional costs associated with a small increase in ultimately unnecessary dietetic referrals for nourished patients. Further research will be required to ensure the utility of the ANT remains robust when used in routine clinical care as a screening tool to detect malnutrition in adult Indigenous and non-Indigenous Australian hospital patients.
Acknowledgements

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Conflicts of interest and funding disclosure

The authors have no conflicts of interest to declare. This research received project support from the National Health and Medical Research Council Centre for Research Excellence to Reduce Inequality on Heart Disease (NHMRC Grant ID:1044897).
References


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### Table 1: Predicting malnutrition risk as defined by SGA and the (MST) and the ANT

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity % (95% CI)</th>
<th>Specificity % (95% CI)</th>
<th>Positive Predictive Value % (95% CI)</th>
<th>Negative Predictive Value % (95% CI)</th>
<th>Area Under the Curve % (95% CI)</th>
<th>Correct classification rate %</th>
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<td></td>
<td></td>
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<tr>
<td>All participants</td>
<td>84.0 (78.9 – 88.3)</td>
<td>70.7 (65.7 – 75.3)</td>
<td>66.7 (61.2 – 71.9)</td>
<td>86.3 (81.9 – 90.1)</td>
<td>0.81 (0.77 – 0.84)</td>
<td>76.2</td>
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<td>Indigenous Australian</td>
<td>88.0 (81.0 – 93.1)</td>
<td>63.7 (55.3 – 71.5)</td>
<td>67.5 (59.7 – 74.6)</td>
<td>86.1 (78.1 – 92.0)</td>
<td>0.78 (0.73 – 0.83)</td>
<td>74.9</td>
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<td>non-Indigenous Australian</td>
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<td>75.5 (69.1 – 81.1)</td>
<td>65.8 (57.7 – 73.3)</td>
<td>86.5 (80.7 – 91.1)</td>
<td>0.82 (0.77 – 0.86.5)</td>
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<td><strong>ANT ≥ 2</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>All participants</td>
<td>96.0 (92.8 – 98.7)</td>
<td>59.5 (54.2 – 64.6)</td>
<td>62.3 (57.3 – 67.2)</td>
<td>95.5 (91.9 – 97.8)</td>
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<td>Indigenous Australians</td>
<td>96.0 (90.9 - 98.7)</td>
<td>58.9 (50.5 - 67.0)</td>
<td>66.7 (59.3 - 73.5)</td>
<td>94.5 (87.6 - 98.2)</td>
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<td>non-Indigenous Australian</td>
<td>96.0 (90.9 – 98.7)</td>
<td>59.9 (53.0 – 66.6)</td>
<td>58.5 (51.5 – 65.4)</td>
<td>96.2 (91.4 – 98.8)</td>
<td>0.78 (0.74 – 0.82)</td>
<td>73.3</td>
</tr>
</tbody>
</table>
Box 1 - The Malnutrition Screening Tool (MST).10

1. Have you/the patient lost weight recently without trying?  
   - No: 0  
   - Unsure: 2  
   - Yes, how much (kg):  
     - 1 – 5 kg: 1  
     - 6 – 10: 2  
     - 5 – 11: 3  
     - > 15: 4  
     - Unsure: 2

2. Have you/the patient been eating poorly because of a decreased appetite?  
   - No: 0  
   - Yes: 1

Box 2 - The Adult Nutrition Tool (ANT).  

1. Do you think you have been eating enough food lately?  
   - Yes: 0  
   - A little bit less or not sure: 1  
   - No: 3

2. Do you think you have lost weight without trying?  
   (prompt: ask the patient if they have been feeling weak or if their clothes have become loose recently)  
   - No: 0  
   - Not sure: 1  
   - Yes: 2  
   - If yes, how much weight do you think you have lost?  
     - A little bit: 1  
     - A lot: 2

3. Does the patient look frail or undernourished?  
   (assess the patient for signs of muscle wasting, poor skin integrity and/or loss of subcutaneous fat (i.e. hollow sunken eyes)).  
   - No: 0  
   - Somewhat (a little bit): 2  
   - Yes: 3
Figure 2: Study recruitment and index and reference standard testing
Figure 2: Area Under the Curve (AUC) for the Malnutrition Screening Tool (MST score range = 0 to 5) and the Adult Nutrition Tool (ANT score range = 0 to 7) according the reference standard, Subjective Global Assessment (SGA B or C = malnourished) among both Indigenous and non-Indigenous participants.
Figure 3: Area Under the Curve (AUC) for the Malnutrition Screening Tool (MST score range = 0 to 5) and the Adult Nutrition Tool (ANT score range = 0 to 7) for Indigenous Australian participants according to the reference standard, the Subjective Global Assessment (SGA B or C = malnourished).
Figure 4: Area Under the Curve (AUC) for the Malnutrition Screening Tool (MST score range = 0 to 5) and the Adult Nutrition Tool (ANT score range = 0 to 7) for non-Indigenous Australian participants according to the reference standard, Subjective Global Assessment (SGA B or C = malnourished).
Figure legends

Box 1 - The Malnutrition Screening Tool (MST)
Box 2 – The Adult Nutrition Tool (ANT)

Figure 3: Study recruitment and index and reference standard testing
Figure 2: Area Under the Curve (AUC) for the Malnutrition Screening Tool (MST score range = 0 to 5) and the Adult Nutrition Tool (ANT score range = 0 to 7) according the reference standard, Subjective Global Assessment (SGA B or C = malnourished) among both Indigenous and non-Indigenous participants.

Figure 3: Area Under the Curve (AUC) for the Malnutrition Screening Tool (MST score range = 0 to 5) and the Adult Nutrition Tool (ANT score range = 0 to 7) for Indigenous Australian participants according to the reference standard, the Subjective Global Assessment (SGA B or C = malnourished).

Figure 4: Area Under the Curve (AUC) for the Malnutrition Screening Tool (MST score range = 0 to 5) and the Adult Nutrition Tool (ANT score range = 0 to 7) for non-Indigenous Australian participants according to the reference standard, Subjective Global Assessment (SGA B or C = malnourished).
Appendix A: Development, and content and construct validation of the Adult Nutrition Tool (ANT)

**Phase one: Review of malnutrition screening and nutrition assessment tools (July-August 2014)**
1. Review of validated malnutrition screening tools and nutrition assessment tools for adult medical inpatients
2. Review of malnutrition screening tools for adult Indigenous peoples or for individuals from culturally or linguistically diverse backgrounds
3. Review of rapid, simple and reliable malnutrition screening tools predominately used by nurses

**Phase two: Development of ANT based on a modified MST, including face and content validity, including feasibility of screening tool (September-October 2014)**
1. Development of ANT with three hospital dietitian and nutrition managers
2. Review and modification of ANT questions and criteria by the author of the MST
3. Review and modification of ANT by an Indigenous communication in health care expert
4. Review and discussion of ANT with hospital Aboriginal Liaison Officers
5. Review of ANT by the Central Australian Aboriginal Congress Nursing Manager
6. Review of ANT by hospital Nurse Unit Managers and Clinical Nurse Educators for feasibility of screening tool by nurses

**Phase three: Pilot-testing of ANT (November-December 2014)**
1. Pilot-testing of ANT at a regional hospital in Central Australia
2. Modification of ANT scoring and re-testing
3. Final face and content validation of ANT by hospital dietitian and nutrition managers

**Phase four: Prospective Index Testing (February-September 2015)**
1. Malnutrition risk screening of 608 medical inpatients in three regional hospitals
2. All patients screened using the MST and ANT by two study investigators (registered nurse and registered dietitian)
3. Nutrition assessment of all patients using the Subjective Global Assessment by the study's investigators
4. At the end of each study day, malnutrition-risk and nutrition assessment findings were discussed and validated by the study's investigators.
Conclusions

Two distinct topics are outlined in this chapter; identifying a malnutrition screening tool for use among both Indigenous and non-Indigenous adult patients, and the development and validation of a new tool, the Adult Nutrition Tool (ANT). As described in this chapter, malnutrition screening is used to facilitate early detection of malnutrition and it is therefore important that tools used to screen patients are both culturally and linguistically appropriate. Furthermore, the findings from chapters 4 and 5, highlight the importance of using an appropriate malnutrition screening tool that is tailored and validated to a given setting and population and avoiding a ‘one size fits all’ approach.

In addition to the validation of ANT in the Indigenous Australian Malnutrition project, further studies are required to validate the ANT in other patient populations such as patients living with cancer or chronic kidney disease, and validation of ANT in urban settings. In addition to future validation studies, it is important that the inter-rater reliability of ANT is tested amongst clinicians as one of the major barriers of malnutrition screening outcomes, is the variability of screening by clinicians in different healthcare contexts.

This study is published in the Asia Pacific Journal of Clinical Nutrition. Since publication, the Nutrition and Dietetic Department in Central Australia is implementing the ANT into clinical practice both in acute and community healthcare settings; this includes healthcare settings in both Alice Springs and Tennant Creek. The dietitian departments at Royal Darwin Hospital and Cairns Hospital have also expressed interest in introducing the ANT into clinical practice.

In addition to the implementation of ANT into clinical practice, ANT will be used as a screening tool in the project titled ‘Malnutrition in diabetic foot complications and lower limb amputation’. This research project is being led by Dr Natasha Bertschi and the primary aim of this project is to measure the prevalence of malnutrition in patients who have lower limb
amputation as treatment of a complication of diabetic foot disease (Bertschi et al., 2018). This project will be conducted at Royal Darwin Hospital. As a study co-investigator, the author of this thesis will replicate the study at Alice Springs Hospital in collaboration with the hospital’s Nutrition and Dietetic department and with Indigenous Australian key stakeholders.
Reference

CHAPTER 7
DISCUSSION

Introduction

This chapter is a synthesis of previous chapters and includes a summary of the main findings of this thesis, comparisons with similar studies, the methodological limitations of the Indigenous Australian Malnutrition project, translation to practice, implications for practice, and recommendations for future research, policy and practice. This chapter also includes a personal reflection of the thesis author as a non-Indigenous healthcare professional undertaking research focusing on Indigenous Australian health.

Discussion

Until now, there has been a lack of published studies measuring the burden and impact of malnutrition among Indigenous Australians. In this thesis’ scoping review, only one published study reported the rate of malnutrition among Indigenous Australians with end-stage kidney disease (Todd et al., 2013). One of the major limitations of Todd et al., (2013) study includes a small cohort of Indigenous Australian people and therefore almost no generalisations can be drawn from this study. The Indigenous Australian Malnutrition (IAM) project, includes original and landmark studies reporting the burden and impact of malnutrition among Indigenous and non-Indigenous Australians. This is first study to report the burden and impact of malnutrition in regional hospitals in the Northern Territory (NT) and Far North Queensland (FNQ) of Australia; the first study to understand malnutrition among Indigenous Australians admitted into acute healthcare settings; and the first study to validate a malnutrition screening tool for use among both Indigenous and non-Indigenous patients.

In the studies included in the IAM project, a higher prevalence of malnutrition was found among Indigenous and non-Indigenous Australian patients in regional hospitals when compared to the large Nutrition Care Day Survey in 2010 (Agarwal et al., 2012; Morris et al.,
2018a). We found that the rate of malnutrition among non-Indigenous Australian was five per cent higher in regional settings than the national reported prevalence of 32.1% (Agarwal et al., 2012). Of particular significance, is that we found that the burden of malnutrition was significantly greater among Indigenous Australian compared to non-Indigenous patients (Morris et al., 2018a). In addition to the higher proportion of malnutrition among all Indigenous Australians who participated, the burden of malnutrition among Indigenous Australian patients residing in Central Australia was particularly high. The rate of malnutrition among Indigenous patients residing in Central Australia was nearly 57 per cent compared to 33 per cent of non-Indigenous Australians residing in the same region.

Further studies will be required to explain the greater burden of malnutrition in regional areas of Australia overall, particularly among Indigenous Australians and in especially among Indigenous Australians residing in Central Australia. In the interim, several possible reasons may be hypothesised. Hospitals in the NT and FNQ service large geographical regions as outlined in chapter 3 of this thesis. Access to healthcare services (including community healthcare services) are spread over vast distances and for many residing in rural and remote regions, access to major healthcare services is often difficult due to transport and financial issues (Australian Bureau of Statistics [ABS], 2017; Australian Institute of Health and Welfare [AIHW], 2015). Furthermore, for people residing in very remote regions, the burden of disease is 1.7 times higher than for people residing in metropolitan regions (AIHW, 2018a). Coupled with remoteness and restricted access to healthcare services and specialists, the burden of disease is 2.3 times higher among Indigenous Australians compared with non-Indigenous Australians and the proportion of people seeking acute healthcare services is higher than non-Indigenous people especially in regional settings where our study was conducted (AIWH, 2018a; AIHW, 2018b). These factors, driving the greater burden of malnutrition among Indigenous Australian inpatients,
are likely to be amplified in Central Australia where remoteness and disadvantage are even greater.

In this study, we also found that malnutrition was associated with adverse health outcomes including increased length of hospital stay; increased hospital readmission rates; and decreased survival rates among malnourished patients (Morris et al., 2018b). Median length of stay among patients who were malnourished was nearly two days longer than nourished patients and for Indigenous Australians who were malnourished, length of hospital stay was one day longer compared to Indigenous Australians who were nourished. However, length of hospital stay was significantly longer in non-Indigenous patients who were malnourished by nearly two and half days compared to non-Indigenous patients who were found to be nourished (Morris et al., 2018b). Similarly, we also found that hospital readmission rates among patients who were malnourished were significantly higher compared to nourished patients with nearly one third of patients who were malnourished readmitted back into hospital within 30 days and nearly 64 per cent of malnourished patients readmitted within 60 days. Hospital readmission rates were also higher when stratified by participants Indigenous and nutritional status. For Indigenous Australians who were malnourished, hospital readmission was as high as 36 per cent within 30-days and 70 per cent within six months. Hospital readmission rates were also significantly higher among non-Indigenous patients who were malnourished compared to nourished non-Indigenous patients with nearly 30 per cent of malnourished patients readmitted at 30-days and nearly 60 per cent readmitted within six months (Morris et al., 2018b).

As well the impact of longer length of hospital stays, increased risk of hospital readmission within six-months and, by extension, patients’ quality of life, this burden of malnutrition represents a significant cost for the healthcare system. In our study, if the average length of hospital stay is two days longer than nourished patients, this represents
an average extra cost of AUD$1,504 for each patient who was malnourished and
AUD$376,000 overall for the patients involved in this study (Victoria Government Health
Information, 2018).

Patients who were malnourished were also more likely to die within 30-days and six
months and differences in survival rates were also found according to participants’
Indigenous Australian status. At six months, participants who were malnourished were 1.8
times more likely to have died. This association was seen for both Indigenous and non-
Indigenous patients with malnourished Indigenous Australians being 1.5 times more likely
to die and non-Indigenous Australians 2.0 times more likely to die within six-months. The
difference in the association between malnutrition and survival seen in Indigenous as
compared with non-Indigenous participants was largely attributable to non-Indigenous
patients being nearly 12 years older.

While globally there is a lack of studies measuring the impact of malnutrition among
Indigenous populations in the healthcare context, the findings from our study are consistent
with the results of the Nutrition Care Day Survey conducted in 2010 but with notable key
differences (Agarwal et al., 2013). Although Agarwal et al., (2013) also found adverse health
outcomes among patients who were malnourished, the additional length of hospital stay and
readmission rates seen in our study were far greater than in the Nutrition Care Day Survey.
Inferences between survival rates cannot be drawn from the Nutrition Care Day Survey and
our study as Agarwal et al. only measured in-hospital mortality (Agarwal et al., 2013) and
not longer-term survival.

An additional and important key feature we highlighted in our study was the increased
healthcare utilisation by Indigenous Australians compared to non-Indigenous patients
(Morris et al., 2018). Rates of hospital readmission within six months were significantly
higher among Indigenous Australians who were nourished and malnourished compared to
non-Indigenous Australians. In part this may be explained by our addition finding that while Indigenous Australians were significantly younger they were less likely to be in paid employment; more likely to be living in remote or very remote regions; had a significantly higher number of chronic diseases and higher disease severity index; were more likely to be admitted with a diagnosis of sepsis; were more likely to have diabetes mellitus and/or chronic kidney disease; and were more likely to be taking five or more medications (Morris et al., 2018a).

Factors that independently predicated malnutrition among Indigenous and non-Indigenous Australian patients included being female; residing in Central Australia; being diagnosed with a mental health condition; being underweight (body mass index < 18.5 kg/m²); and an increased chronic disease severity index (Morris et al., 2018a). There were also many factors, apart from malnutrition, that were associated with adverse health outcomes. For six-month hospital readmission these included: being Indigenous Australian; and increased acute and chronic disease severity indices (Morris et al., 2018b). Similarly, for six-month mortality these included: increasing age; and again, increased acute and chronic disease severity indices (Morris et al., 2018b). These predictors of malnutrition and adverse health outcomes were shared features among Indigenous and non-Indigenous Australians highlighting the need for early detection of malnutrition and the greater risk of adverse health outcomes in older and more acutely unwell patients with pre-existing comorbidities admitted into a regional healthcare setting.

The findings discussed above, also highlight that Indigenous Australians in this study’s context are more likely to utilise acute healthcare services than non-Indigenous patients and Indigenous patients are at increased risk of malnutrition due to these multiple factors. Therefore, malnutrition screening upon admission to hospital using a validated screening tool for use among Indigenous and non-Indigenous Australian patients is
imperative. Since 1999 and particularly within the last decade, screening patients for malnutrition upon admission into a healthcare setting in Australian has been accepted as best practice. However, internationally there are several different methods of screening, including several different screening tools available for use in the absence of a gold-standard screening tool (van Bokhorst-de van der Schuere et al., 2014). The results of a systematic review of screening tools measuring both sensitivity and specificity demonstrated wide variability amongst 16 malnutrition screening tools (Platek & Nicholson, 2015). This variability is largely attributed to different patient demographics and characteristics, including the nature and severity of both acute and chronic diseases. In our study, while the Malnutrition Screening Tool (MST) is a widely used tool in different clinical settings (van Bokhorst-de van der Schueren, et al., 2014), prior to the IAM project, the MST had not been validated for use among Indigenous Australian patients despite being used in the three regional hospitals included in this study.

The findings from our validation study comparing the MST and the newly developed Adult Nutrition Tool (ANT) demonstrated that the ANT is a valid tool to use in both Indigenous and non-Indigenous patients. The ANT in our study context demonstrated superior sensitivity but with slightly inferior specificity in comparison with the MST. Thus for every 100 patients with confirmed malnutrition, the ANT detected 96 patients compared to 84 patients utilising the MST. Nonetheless this superior sensitivity of the ANT was at the slight expense of specificity. In this case for every 100 patients screened for malnutrition the ANT would incorrectly classify 41 nourished patients as malnourished while the MST would incorrectly classify 30 nourished patients as malnourished. It is nonetheless argued that these findings favour the use of the ANT in this setting with the small additional cost of referring a nourished patient to a dietitian being minimal compared to the impact of failing to identify a patient with malnutrition.
One of the major limitations of the studies nested in the IAM project include the length of follow-up of study participants. To understand and appreciate the full impact of malnutrition in regional healthcare settings further longitudinal studies are required to measure the frequency and nature of hospital readmissions, longer term survival and to estimate direct and indirect costs associated with malnutrition. In addition to longitudinal studies, further studies measuring the burden of malnutrition in other clinical settings are required, including studies in patients with end stage kidney disease, in patients with complication associated with diabetes mellitus, and patients with complex and severe chronic disease such as cancer. One of the limitations of the validation study of the ANT is that the inter-rater reliability of the ANT was not measured and further the reliability of ANT when utilised by clinicians such as nurses needs to be established.

This project has highlighted the burden and impact of malnutrition in regional healthcare settings and specifically among Indigenous Australians. The findings of the studies included in this thesis highlight that there is an urgent need to increase health care capacity to recognise and respond to malnutrition in residents of remote and regional Australia including in Indigenous Australians. They have also highlighted priority area for future research to address this health issue. Malnutrition in this project’s context has also been demonstrated to be inextricably linked to the associated burden and epidemic of chronic non-communicable disease. Despite existing nutrition policies and procedures in acute healthcare settings, nutrition interventions are normally short-lived (for example, for the duration of patients’ inpatient admission) and follow-up outpatient or community care can often be difficult. In the context of chronic disease, nutrition interventions in community healthcare settings will be required to treat chronic disease-related malnutrition. Furthermore, new approaches to screening patients for malnutrition should also be considered. For example, in our study, we found that acute and chronic disease severity scores predicted malnutrition and the use of objective data could, if validated, become a
more easily used proxy for questionnaire-based assessment. A future study that includes the development and validation of an integrated electronic decision support tool that utilises both patient’s history of food intake and weight history as well as objective data such as acute and chronic disease scores should be considered. The increasing utilisation of electronic medical records and electronic decision support tools would support the deployment of such a system. In turn this could potentially automatically trigger a dietitian referral and facilitate even earlier nutritional assessment and intervention.

In addition to these recommendations, further studies that aim to address malnutrition among Indigenous Australians need to consider patients’ preferences and culture values. During the nine months of data collection, as the author of this thesis, I was privileged to have meet such a diverse and culturally rich cohort of patients. In the many different stories told by the participants enrolled into this project, food insecurity (including access to nutritious food, access to fresh foods, not being able to afford food, and in some cases having to travel vast distances for food) was a major issue for many participants. Sustainable nutritional public health programs are essential for addressing these issues and it is imperative that nutritional programs include consumer perspectives.

As a personal reflection, as both a nurse and an early career researcher, I have learnt some important lessons. Although this project would not have been possible without the support and collaboration with key Indigenous Australian stakeholders, another major limitation of this study includes it not being led by an Indigenous Australian researcher and that the study investigators did not include an Aboriginal Australian and/or Torres Strait Islander researcher. One of the most important lessons I have learned from this project is the inclusion of Indigenous Australian people and the importance of viewing different perspectives through the lens of an Indigenous person.

Conclusions
The Indigenous Australian Malnutrition Project: Chapter 7

This chapter summarises the main findings from three studies that form the basis of the Indigenous Australian Malnutrition Project. The discussions within this chapter highlight the burden and impact of malnutrition in regional healthcare settings and more specifically, highlight the burden and impact of malnutrition among Indigenous Australians. This chapter also highlighted the burden of chronic disease among Indigenous Australians and factors that contribute to malnutrition including complex and severe chronic diseases as well as socio-demographic factors. The findings of the validation study were discussed and recommendations for new and novel approaches to malnutrition detection were discussed. In addition to discussing new approaches to screening, recommendations including further longitudinal studies to measure the full impact of malnutrition are required, including nutritional intervention programs and future studies that are led by Indigenous Australian people.
References


CHAPTER 8
CONCLUSIONS

This thesis has outlined the findings relating to one of the first and largest studies exploring malnutrition in Australian regional healthcare settings. It has reported the findings from three different but linked studies measuring the burden and impact of malnutrition among Indigenous Australians and a validation study of a malnutrition screening tool for use in Indigenous and non-Indigenous Australian hospital inpatient populations.

The burden of malnutrition in regional hospitals in the Northern Territory and Far North Queensland is greater than what was reported in the largest malnutrition prevalence survey conducted across 46 Australian hospitals. Furthermore, the burden of malnutrition is significantly higher among Indigenous Australians admitted into medical inpatient settings than non-Indigenous Australians. Indigenous Australians are at increased risk of malnutrition than non-Indigenous people due to multiple different factors including residing in remote or very remote regions with limited access to healthcare services and specialist care; economic disadvantage; and the presence of complex and severe chronic diseases. These factors particularly apply to Indigenous Australians residing in Central Australia.

Adverse short and longer-term health outcomes found in this study were comparable with other studies but notable key differences in our study included higher readmission rates for Indigenous Australians who were either nourished or malnourished. We also found that length of hospital stay was shorter in our study, however patient mortality was higher in both Indigenous and non-Indigenous patients who were malnourished. Further longitudinal studies are needed to understand the longer-term impact of malnutrition (i.e., greater than six months), and economic studies to appreciate the cost of malnutrition to healthcare services and the potential savings made through the utilisation of a culturally appropriate and valid screening tool.
ANT has been shown to be a valid screening tool for Indigenous and non-Indigenous Australian patients and in our study context, is a culturally appropriate tool for Indigenous Australian patients (see Appendix H). While the ANT has been validated for use among medical inpatients, further validation studies are required including renal inpatient settings and community healthcare setting such as aged care, primary health care services, and dialysis satellite centres. With the implementation of ANT into clinical practice, the reliability of the ANT needs to be established to test the inter-rater reliability of the tool by clinicians such as nurses against accredited dietitians.

While identifying malnutrition is important in any healthcare context, evaluation of client and patient centred nutrition is quintessential to improve nutrition-related health outcomes. In addition to existing nutrition policy and procedures, particularly in the inpatient setting, sustainable, effective and appropriate nutrition programs are required to address this chronic problem that is closely connected to the burden and current epidemic of chronic disease. In addition to nutrition intervention programs that are led by Indigenous Australian people, new and novel approaches to malnutrition screening are required. This includes the incorporation of both self-reported patient information and objective data such as acute and chronic disease severity markers into electronic decision support tools integrated into electronic medical records.

The findings from this thesis contribute to the national health agenda of closing the health disparity gap between Indigenous and non-Indigenous Australians. Furthermore, with the implementation of the ANT, patients who are malnourished are more likely to be detected and in turn early nutritional management facilitated. The findings from this thesis are also likely to be generalisable to other Indigenous populations in high income countries elsewhere in the world who, like Indigenous Australians, also experience economic disadvantage and experience poorer levels of health and well-being.
BIBLIOGRAPHY


The Indigenous Australian Malnutrition Project


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http://dx.doi.org/10.1787/eco_survey-aus-2017-en


https://doi.org/10.1016/j.clnme.2013.01.001.


The Indigenous Australian Malnutrition Project


The Indigenous Australian Malnutrition Project


The Indigenous Australian Malnutrition Project

APPENDICES
Appendix A: The Adult Nutrition Tool©

The Adult Nutrition Tool (ANT)

1. Do you think you have been eating enough food lately?
   Yes: 0
   A little bit less or not sure: 1
   No: 3

2. Do you think you have lost weight recently without trying?
   (prompt: ask the patient if they have been feeling weak or if their clothes have become loose recently)
   No: 0
   Not sure: 1
   Yes: 2
   If yes, how much weight do you think you have lost?
   A little bit: 1
   A lot: 2

3. Does the patient look frail or undernourished?
   (assess patient for signs of muscle wasting, poor skin integrity and loss of subcutaneous fat, i.e., hollow, sunken eyes)
   No: 0
   Somewhat (a bit): 2
   Yes: 3

Total Malnutrition Score =

References:

Acknowledgements:
Nutrition and Dietetic Department, Alice Springs Hospital, NT Department of Health. Aboriginal Liaison Officers: Alice Springs Hospital, NT Department of Health. Marie Ferguson, Clinical Academic Fellow, Nutrition and Dietetics, Princess Alexandra Hospital, Brisbane. Louise Moodie, Royal Darwin Hospital, NT Department of Health. Kerry Taylor, Deputy Director, Poche Centre for Indigenous Health, Flinders NT.
Appendix B: Central Australian Human Research Ethics Committee letter of approval

CENTRAL AUSTRALIAN HUMAN RESEARCH ETHICS COMMITTEE
Centre for Remote Health

Ms Natasha Franklin

29th September 2014
Our Ref: HREC-14-256

Dear Ms Franklin

RE: Ethics Application – Approval

The Central Australian Human Research Ethics Committee (CAHREC) Chair has considered your response to the Committee’s request for further information about your research project ‘The Indigenous Australian (I-A) Study: Burden, screening validation and impact of adult malnutrition in Indigenous Australians’.

The Chair agreed that this project now meets the requirements of the National Statement on Ethical Conduct in Human Research.

The Chair decided to grant approval for your project to proceed.

The period for which approval has been given is from the date of this letter until the 31st December 2015. If you do not complete the research within the projected time please request an extension from CAHREC.

Ethics approval is contingent upon the submission of an annual Progress report and a Final report upon completion of the project. It is the responsibility of researchers to make a note of the following dates and submit these reports in a timely manner, as reminders may not be sent out. Failure to submit reports will result in your ethics approval lapsing.

Your reports are due on:
29th September 2015
31st December 2015

Copies of the report form can be downloaded from the CAHREC website.

Yours sincerely

Chris Schwarz
Secretariat Support
Central Australian Human Research Ethics Committee
1 December 2014

Ms Natasha Franklin

Dear Ms Franklin,

HREC Reference Number: 2014-2282
Project Title: The Indigenous Australian Malnutrition (I-AM) Study: Burden, screening validation and impact of adult-malnutrition in Indigenous Australians

Thank you for submitting the above research project for ethical review. This project was considered by the by the Fast Track Committee of the Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research (HREC).

I am pleased to advise that the Fast Track Committee has granted full ethical approval of this research project. Please note: the contact phone number for the Ethics Administration office has changed, and is now 08 8946 8886 or 08 8946 8897. Could you please update the Participant Information Sheet and Consent Form to reflect this change. Please note that approval applies only to research conducted after the date of this letter.

This approval will be ratified at the next meeting of the Human Research Ethics Committee.

The nominated participating sites in this project are:

- Royal Darwin Hospital
- Alice Springs Hospital
- Cairns and Hinterland Hospital Health Service
- Cairns Base Hospital

Approved Project Timeline: 01/12/2014 – 31/12/2015

Approval is granted for a maximum period of twelve months. An annual progress report or final report is required on or before the 01/12/2015.

APPROVAL IS SUBJECT TO the following conditions being met:

1. The Coordinating Principal Investigator will immediately report anything that might warrant review of ethical approval of the project.

2. The Coordinating Principal Investigator will notify the Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research (HREC) of any event that requires a modification or amendment to the protocol or other project documents and submit any required amendments in accordance with the instructions provided by the HREC. These instructions can be found on the Menzies’ website, or by clicking here.
3. The Coordinating Principal Investigator will submit any necessary reports related to the safety of research participants (e.g. protocol deviations, protocol violations) in accordance with the HREC’s policy and procedures. These guidelines can be found on the Menzies’ website, or by clicking here.

4. The Coordinating Principal Investigator will report to the HREC annually and notify the HREC when the project is completed at all sites using the specified forms. Forms and instructions may be found on the Menzies’ website, or by clicking here.

5. The Coordinating Principal Investigator will notify the HREC if the project is discontinued at a participating site before the expected completion date, and provide the reason(s) for discontinuance.

6. The Coordinating Principal Investigator will notify the HREC of any plan to extend the duration of the project past the approval period listed above and will submit any associated required documentation. The preferred time and method of requesting an extension of ethical approval is during the annual progress report. However, an extension may be requested at any time.

7. The Coordinating Principal Investigator will notify the HREC of his or her inability to continue as Coordinating Principal Investigator, including the name of and contact information for a replacement.

8. The safe and ethical conduct of this project is entirely the responsibility of the investigators and their institution(s).

9. Researchers should immediately report anything which might affect continuing ethical acceptance of the project, including:
   - Adverse effects of the project on subjects and the steps taken to deal with these;
   - Other unforeseen events;
   - New information that may invalidate the ethical integrity of the study; and
   - Proposed changes in the project.

10. Approval for a further twelve months, within the original proposed timeframe, will be granted upon receipt of an annual progress report if the HREC is satisfied that the conduct of the project has been consistent with the original protocol.

11. Confidentiality of research participants should be maintained at all times as required by law.

12. The Patient Information Sheet and the Consent Form shall be printed on the relevant site letterhead with full contact details.

13. The Patient Information Sheet must provide a brief outline of the research activity including: risks and benefits, withdrawal options, contact details of the researchers and must also state that the Human Research Ethics Administrators can be contacted (telephone and email) for information concerning policies, rights of participants, concerns or complaints regarding the ethical conduct of the study.

14. You must forward a copy of this letter to all Investigators and to your institution (if applicable).
This letter constitutes ethical approval only. This project cannot proceed at any site until separate research governance authorization has been obtained from the CEO or Delegate of the institution under whose auspices the research will be conducted at that site.

Should you wish to discuss the above research project further, please contact the Ethics Administrators via email: ethics@menzies.edu.au or telephone: (08) 8946 8667 or (08) 8948 8686.

The Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research wishes you every continued success in your research.

Yours sincerely,

Ms Jennifer Wong
Chair – Fast Track Committee
Human Research Ethics Committee of Northern Territory Department of Health and Menzies School of Health Research
NHMRC Registration No. EC00153
http://www.menzies.edu.au/page/Research/Ethics_approval/

This HREC is constituted and operates in accordance with the National Health and Medical Research Council’s (NHMRC) National Statement on Ethical Conduct in Human Research (2007). The processes used by this HREC to review multi-centre research proposals have been certified by the National Health and Medical Research Council.
Appendix D: Far North Queensland Human Research Ethics Committee letter of approval

08 October 2014

Ms Natasha Franklin
Baker IDI Heart and Diabetes Institute
PO Box 1294
Alice Springs NT 0871

Dear Ms Franklin

HREC Reference number: HREC/14/QCH/06 - 927

Thank you for submitting the above project for ethical and scientific review. This project was first considered by the Far North Queensland Human Research Ethics Committee (HREC) held on 14 August 2014. I now refer to your undated correspondence which was received on 22 September 2014 and has undergone further review. I am pleased to advise that final approval is now granted to your application.

You are reminded that this letter constitutes ethical approval only. You must not commence this research project at a Queensland Health site, utilize Queensland Health staff or Queensland Health resources until separate authorisation from the District CEO or Delegate of that site has been obtained.

A copy of this approval must be submitted to the Research Governance Officer/Delegated Personnel at the site with a completed Site Specific Assessment (SSA) Form for authorisation from the Chief Executive or Delegate of that relevant Health Service. Send documents to: the Research Governance Officer of the relevant Health Service and also via email: RGO_Cairns@health.cld.gov.au

This HREC is constituted and operates in accordance with the National Health and Medical Research Council’s (NHMRC) National Statement on Ethical Conduct in Human Research (2007), NHMRC and Universities Australia Australian Code for the Responsible Conduct of Research (2007) and the CPMP/ICH Note for Guidance on Good Clinical Practice.

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</tr>
<tr>
<td>Investigator CV: Professor Simon Stewart CV (co-supervisor)</td>
<td>N/A</td>
</tr>
<tr>
<td>Bacteriologist Certificate of Insurance</td>
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</tr>
<tr>
<td>Letter of support from Cairns and Hinterland Hospital</td>
<td>N/A</td>
</tr>
<tr>
<td>Letter of support from Royal Darwin Hospital</td>
<td>N/A</td>
</tr>
<tr>
<td>Letter of support from Alice Springs Hospital</td>
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</tr>
<tr>
<td>Protocol: Indigenous Australian Malnutrition study protocol</td>
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</tr>
<tr>
<td>Participant Consent Form</td>
<td>2</td>
</tr>
<tr>
<td>Powerpoint Presentation: The Indigenous Australian Malnutrition Project</td>
<td>No version</td>
</tr>
<tr>
<td>Participant Information Flyer</td>
<td>2</td>
</tr>
<tr>
<td>Investigator CV: Dr Malcolm Riley CV</td>
<td>N/A</td>
</tr>
<tr>
<td>Investigator CV: Professor Simon Stewart CV (co-supervisor)</td>
<td>N/A</td>
</tr>
<tr>
<td>Investigator CV: Natasha Franklin CV (primary researcher and student).</td>
<td>2</td>
</tr>
<tr>
<td>Investigator CV: Graeme Maguire CV (primary research supervisor)</td>
<td>2</td>
</tr>
<tr>
<td>Contact Details of Researchers and Associate Researchers</td>
<td>No version</td>
</tr>
</tbody>
</table>

Approved Queensland Health study site/s as per Page 9 of your NEAF is:

- Cairns and Hinterland Hospital and Health Service
(If you are a student researcher you are obliged to advise your Supervisor as to the current status of your research application.)

Please note the following conditions of approval:

1. If relevant to your project, your attention is drawn to standards for clinical trials reporting as enunciated in the CONSORT statement [http://www.consort-statement.org/?o=1001] and a requirement by many journals for certain categories of clinical trials to be registered (see: http://www.enzctr.org.au/Support/HowToAdd.aspx)

2. The Principal Investigator will immediately report anything which might warrant review of ethical approval of the project in the specified format, including:
   a. Unforeseen events that might affect continued ethical acceptability of the project.
      Serious Adverse Events must be notified to the Committee as soon as possible. In addition the Investigator must provide a summary of the adverse events, in the specified format, including a comment as to suspected causality and whether changes are required to the Patient Information and Consent Form. In the case of Serious Adverse Events occurring at the local site, a full report is required from the Principal Investigator, including duration of treatment and outcome of event.

3. Amendments to the research project which may affect the ongoing ethical acceptability of a project must be submitted to the HREC for review. Major amendments should be reflected in a revised online NEAF (accompanied by all relevant updated documentation and a cover letter from the principal investigator, providing a brief description of the changes, the rationale for the changes, and their implications for the ongoing conduct of the study). Hard copies of the revised NEAF, the cover letter and all relevant updated documents with tracked changes must also be submitted to the HREC coordinator as per standard HREC SOP. Further advice on submitting amendments is available from http://www.health.clid.gov.au/cpic/documents/ethics/researcher_userguide.pdf

4. Amendments to the research project which only affect the ongoing site acceptability of the project are not required to be submitted to the HREC for review. These amendment requests should be submitted directly to the Research Governance Officer (by-passing the HREC).

5. Proposed amendments to the research project which may affect both the ethical acceptability and site suitability of the project must be submitted firstly to the HREC for review and, once HREC approval has been granted, then submitted to the RGO.

6. Amendments which do not affect either the ethical acceptability or site acceptability of the project (e.g. typographical errors) should be submitted in hard copy to the HREC coordinator. These should include a cover letter from the principal investigator providing a
brief description of the changes and the rationale for the changes, and accompanied by all relevant updated documents with tracked changes.

7. The HREC will be notified, giving reasons, if the project is discontinued at a site before the expected date of completion.

8. The Principal Investigator will provide an annual report to the HREC and at completion of the study in the specified format.

9. The Health Service administration and the Human Research Ethics Committee may inquire into the conduct of any research or purported research, whether approved or not and regardless of the source of funding, being conducted on hospital premises or claiming any association with the Hospital; or which the Committee has approved if conducted outside Cairns, Cape & Torres Hospital & Health Services.

10. If research is occurring in Indigenous Communities please ensure that you provide progress and feedback to relevant Indigenous Groups.

HREC approval is valid for three years from the date of this letter.

Should you have any queries about the HREC’s consideration of your project please contact the HREC Administrator on 07 4220 5513. The HREC terms of Reference, Standard Operating Procedures, membership and standard forms are available from:

Once authorisation to conduct the research has been granted via the SSA process, please complete the SF11 Research Commencement Form (Attachment I) and return the form to the office of the Human Research Ethics Committee.

The HREC wishes you every success in your research.

Yours faithfully

Dr Paul Cullen - Chair
Far North Queensland
Human Research Ethics Committee
The Indigenous Australian Malnutrition Project

Appendix E: Monash University Human Research Ethics Committee letter of approval

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

This is to certify that the project below was considered by the Chair of the Monash University Human Research Ethics Committee. The Chair was satisfied that the proposal meets the requirements of the National Statement on Ethical Conduct in Human Research and has granted approval.

Project Number: CF14/3350 - 2014001787
Project Title: The Indigenous Australian Malnutrition Project
Chief Investigator: Prof Graeme Maguire
Approved: From: 11 November 2014 To: 11 November 2019

Terms of approval - Failure to comply with the terms below is in breach of your approval and the Australian Code for the Responsible Conduct of Research.

1. Approval is only valid whilst you hold a position at Monash University and approval at the primary HREC is current.
2. Future correspondence: Please quote the project number and project title above in any further correspondence.
3. Final report: A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
4. Retention and storage of data: The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Professor Nip Thomson
Chair, MUHREC

cc: Ms Natasha Franklin, Prof Simon Stewart
Appendix F: Participant information brochure

Confidentiality
If you agree to participate in the study, the information obtained will be shared with the Cairns & Hinterland Health Service, other local and interstate government agencies, Baker IDI Heart and Diabetes Institute, Far North Queensland Human Ethics Research Committee as well health care professionals caring for you.

Your name and other contact details will not be revealed to any of these agencies. We are collecting information from 300 patients in Cairns, Darwin & Alice Springs. Your details will be coded and health information will be entered into a database which is locked and data is stored securely.

Information gathered from this study will be used for publication and educational purposes. Your identity will not be recognizable from published material. The information collected during this study will be securely stored and then destroyed after five years.

Cost
There is no form of payment for your participation although we thank you for considering to be a participant in this study. You will not incur any costs for participating.

Obtaining additional information
You are encouraged to ask any questions at anytime in the study. If you have any questions about the study, please call the study coordination Ms Natasha Morris or Professor Graeme Maguire on (08) 8959 0111.

This study has been approved by the Far North Queensland Human Research Ethics Committee (HREC 14/QCH/86-927). If you have any concerns or complaints about the conduct of the research study, you may contact the Far North Queensland Human Research Ethics Committee (07) 4226 3513.

The Indigenous Australian Malnutrition Project

Mrs Natasha Morris (PhD candidate)
Ms Emma Ferrari (Research Dietitian)
Prof. Graeme Maguire, (Research supervisor)
Baker IDI Heart and Diabetes Institute, Centre of Research Excellence, Alice Springs.
Monash University, Department of Epidemiology and Preventive Medicine

natahsa.morris@bakeridi.edu.au

Participant information sheet—version 2-20140906
Participant information sheet—version 2-20140906
Participant information sheet—version 2-20140906
Introduction

We would like to invite you to give permission to voluntarily participate in a study about malnutrition (not enough good food). This study has been approved by the Far North Queensland Human Research Ethics Committee (HREC 14/QCH/86-927).

Purpose

The purpose of the study is to collect information on patients who may not have a good balanced diet and suffer from malnutrition. This information will be used by doctors, nurses, dietitians and other health services to tell them about malnutrition so they can plan for improved services in the future.

Your involvement — will take approximately 20 minutes.

If you participate in this study you will receive the same treatment that you would normally get while you are in hospital. Information will be collected from yourself and from your medical records. The information collected from yourself will include the same information normally gathered while you are in hospital and some extra information including:

- Asking you some questions about your food intake, appetite and how hungry you have been recently.
- Asking you how about whether you have lost weight recently and if so, how much.
- Ask you whether you have been experiencing nausea, vomiting or diarrhea recently.
- Ask you some questions about how well you can perform your normal activities of daily living.

Natasha Morris & Emma Ferrari (Research Dietitian) will:

- Measure your height, weight, middle arm circumference, waist and hips with a tape measure.
- See how strong your hand-grip strength is with a hand-grip meter.
- Access your medical notes and blood test results to find out clinical information about your that relates to your nutrition and wellbeing. You will not be required to undergo any extra blood tests for this study.
- As part of this study the researchers will use a disease-severity calculator to measure the affects of your nutrition and wellbeing.
- We will also be following you up to see how long you need to stay in hospital, where you are discharge to and follow you up in 30 days and six months time using the hospital's admission and medical records.

Risks

There are no additional risks to yourself as a result of participating in this study. Apart from answering some questions, measuring your height, weight, waist, hips and hand-grip strength you are not required to have any additional procedures, tests or take any medications, other than those already prescribed by your doctor.

Benefits

If Natasha Franklin or Emma Ferrari believe you are at risk of malnutrition or malnourished, you will be referred to the hospital dietitian for further care. There may be future benefits to yourself and other patients in the future.

Sponsors

Natasha is supported by Baker IDI Heart and Diabetes Institute, Bollbery Limited, and the National Health and Medical Research Council.

Voluntary participation

Taking part in this study is entirely voluntary. Your may refuse to participate and withdraw your consent at anytime. Withdrawing from the study will not influence the care you are receiving while in hospital. If you withdraw your consent from the study your health information gathered prior to your withdrawal will not be used and no further information will be collected. There will be no further contact with you regarding this study after this time.
Appendix G: Participant consent form

CONSENT TO PARTICIPATE
THE INDIGENOUS AUSTRALIAN MALNUTRITION PROJECT
“This means you can say NO”

Have you read the information sheet and discussed the study with the researcher?
I ____________________________ (name) understand that:

1. This research project is about the rates of malnutrition and my information collected during this study will remain confidential.
2. That I will be answering some questions about my food, appetite, weight history and whether I have been suffering from any stomach upsets (nausea / feeling sick, vomiting, or diarrhoea / loose bowel motions).
3. That I will have my height, weight, waist and hips and BMI measured.
4. That I will have my grip (hand) strength measured.
5. That the researchers will access my medical records to look at my relevant blood results.
6. That the researchers will access my medical records when I am discharged from hospital and at 30 days and 6 months time.
7. Only those people working with the research study will have access to the information.
8. I will not be identified or name publicly in the results and findings of study.
9. I can choose to say no and/or stop being involved at any time.
10. I agree for the researchers to securely keep my information for a period of five years before destroying it.

I understand that if I have any questions relating to the participation in this study I may contact Ms Natasha Franklin or Professor Graeme Maguire on [contact details] who will be happy to answer my questions.

I understand that if I have any questions about my rights as a participant or any other administrative matter, I can contact the Human Ethics Research Committee of the NT Department of Health and Menzies School of Research on [contact details].
Name (print): ...........................................................................................................................

Signature: ................................................................. Date: .................................................

Name of witness (print): .......................................................... Date: ..................................

Signature of witness: .......................................................... Date: ..........................................

Interpreter name (print): .......................................................... Date: ..................................

Interpreter witness: .......................................................... Date: .....................................
Appendix H: Malnutrition Screening Tool

Malnutrition
Is your patient at risk?

Malnutrition Screening Tool\(^1\) (MST)

1. Have you/the patient lost weight recently without trying?
   - No: 0
   - Unsure: 2
   - Yes, how much (kg)?
     - 1 – 5: 1
     - 6 – 10: 2
     - 11 – 15: 3
     - > 15: 4
     - Unsure: 2

2. Have you/the patient been eating poorly because of a decreased appetite?
   - No: 0
   - Yes: 1

Total Score

Score 2 or more

Action

1. Refer to Malnutrition Action Flowchart and/or refer to Dietitian for full assessment and intervention
2. Document
3. Weigh patient’s on admission and:
   (a) weekly (acute)
   (b) monthly (long-term care)
4. Re-screen patients:
   (a) weekly (acute)
   (b) monthly (long-term care)

Small weekly weight losses add up to significant weight loss and malnutrition

Note: Overweight/biases residents who have unexplained weight loss and illness can become protein depleted/malnourished too

Malnutrition occurs in approximately 30–40% of acute and 50% of residential patients in Queensland Health Institutions\(^2\)

References:

Queensland Government

health + care + people
### Appendix I: Subjective Global Assessment

<table>
<thead>
<tr>
<th>Name:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td></td>
</tr>
</tbody>
</table>

#### Subjective Global Assessment

<table>
<thead>
<tr>
<th>Medical History</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WEIGHT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wt change past 6 months</td>
<td>Usual weight</td>
<td>Current weight</td>
<td></td>
</tr>
<tr>
<td>0-&lt;5% loss</td>
<td>Amount weight loss</td>
<td>% weight loss</td>
<td>*</td>
</tr>
<tr>
<td>5-10% loss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;10% loss</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight change past 2 weeks</td>
<td></td>
<td>Amount</td>
<td>*</td>
</tr>
<tr>
<td>No change, normal weight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase to within 5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase (1 level above)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No change, but below usual wt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase to within 5-10%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DIETARY INTAKE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No change; adequate</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>No change; inadequate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>Duration of change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suboptimal diet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full liquid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypocaloric liquid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Starvation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intake borderline; increasing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intake borderline; decreasing</td>
<td></td>
<td></td>
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<tr>
<td>Intake poor; no change</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Intake poor; increasing</td>
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</tr>
<tr>
<td>Intake poor; decreasing</td>
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<td></td>
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<tr>
<td><strong>GASTROINTESTINAL SYMPTOMS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency (never, daily, no. of times/week)</td>
<td>Duration (&lt;2wk, &gt;2wk)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nausea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vomiting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhoea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anorexia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None; intermittent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some (daily &gt;2 week)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (daily &gt;2 week)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FUNCTIONAL CAPACITY</strong></td>
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<td></td>
</tr>
<tr>
<td>No dysfunction</td>
<td>Duration of change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty with ambulation/normal activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed/chair-lidded</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Change past 2 week</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No change</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Regressed</td>
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This is a consensus document from Dietitians/ Nutritionists from the Nutrition Education Materials Online, "NEMO" team.


Posted: May 2009

Due for Review: November 2014
### Table: Physical Examination of Malnutrition

<table>
<thead>
<tr>
<th>Physical Examination</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUBCUTANEOUS FAT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under the eyes</td>
<td>Slightly bulging area</td>
<td>Hollowed look, depression, dark circles</td>
<td></td>
</tr>
<tr>
<td>Triceps</td>
<td>Large space between fingers</td>
<td>Very little space between fingers, or fingers touch</td>
<td></td>
</tr>
<tr>
<td>Biceps</td>
<td>Large space between fingers</td>
<td>Very little space between fingers, or fingers touch</td>
<td></td>
</tr>
<tr>
<td><strong>MUSCLE WASTING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temple</td>
<td>Well defined muscle/flat</td>
<td>Slight depression</td>
<td>Hollowing, depression</td>
</tr>
<tr>
<td>Clavicle</td>
<td>Not visible in males; may be visible but not prominent in females</td>
<td>Some protrusion, may not be all the way along</td>
<td>Protruding/prominent bone</td>
</tr>
<tr>
<td>Shoulder</td>
<td>Rounded</td>
<td>No square look; acromion process may protrude slightly</td>
<td>Square look; bones prominent</td>
</tr>
<tr>
<td>Scapula/rib</td>
<td>Bones not prominent; no significant depressions</td>
<td>Mild depressions or bone may show slightly, not all areas</td>
<td>Bones prominent; significant depressions</td>
</tr>
<tr>
<td>Quadriceps</td>
<td>Well rounded; no depressions</td>
<td>Mild depression</td>
<td>Depression; thin</td>
</tr>
<tr>
<td>Calf</td>
<td>Well developed</td>
<td>Thin; no muscle definition</td>
<td>Bones prominent</td>
</tr>
<tr>
<td>Knee</td>
<td>Bones not prominent</td>
<td>Muscle protrudes; could be flat in females</td>
<td>Flat or depressed area</td>
</tr>
<tr>
<td>Interosseous muscle</td>
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<tr>
<td>thumb and forefinger</td>
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<tr>
<td><strong>OEDEMA (related to malnutrition)</strong></td>
<td>No sign</td>
<td>Mild to moderate</td>
<td>Severe</td>
</tr>
<tr>
<td><strong>ASCITES (related to malnutrition)</strong></td>
<td>No sign</td>
<td>Mild to moderate</td>
<td>Severe</td>
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<tr>
<td><strong>OVERALL SGA RATING</strong></td>
<td>A</td>
<td>B</td>
<td>C</td>
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Adapted from: Detsky et al., 1994; Baxter Healthcare Corporation, 1993; McCann, 1996 (Ferguson, Bauer, Banks, Capra, 1996)
Appendix J: Data collection form

**APPENDIX E: CLINICAL AND ADDITIONAL NUTRITIONAL DATA COLLECTION**

Participant background information (age, residence by region and chronic health)

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<tr>
<th>HRN</th>
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<table>
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<table>
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<tr>
<th>Demographic background / region</th>
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<table>
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<th>Occupation</th>
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<table>
<thead>
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<th>Admission diagnosis</th>
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<table>
<thead>
<tr>
<th>Marital status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Past medical history (including history of AIDS, hepatic failure, cirrhosis, malignant lymphoma, metastatic cancer, leukemia or multiple myeloma, immune disease, immunosuppressed by therapy, chronic renal failure, chronic respiratory disease, chronic cardiovascular disease) |
|                                                                                                                                     |
|                                                                                                                                     |

<table>
<thead>
<tr>
<th>Body system/s impairment or failure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E: CLINICAL AND ADDITIONAL NUTRITIONAL DATA COLLECTION

Participant clinical information (based on the ANZICS score calculator and for the first 24 hours of admission and extra nutritional information).

<table>
<thead>
<tr>
<th>Clinical parameter</th>
<th>Admission obs</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission temperature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission blood pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean arterial pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission heart rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIO2 requirements for the first 24 hours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admission PaO2 or SpO2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR</td>
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THE INDIGENOUS AUSTRALIAN MALNUTRITION PROJECT_BURDEN AND IMPACT_VERSION 2_20140907

34
Participant pathology information (on admission or first pathology test).

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## Malnutrition outcome and follow-up

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