Can the use of a rapid nutrition screening tool facilitate timely dietetic referrals on the acute renal wards? – A validation study

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Yizhou Andrew Xia

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Abstract

Background: The percentage of malnourished patients in the acute renal hospital wards has been reported as 52.6% and associated with increased hospital stay and morbidity. There are currently no published nutrition screening tools that are sensitive enough to detect undernutrition risk in this patient group.

Aim: To develop and validate a rapid nutrition screening tool that is sensitive and specific to recognise renal inpatients at undernutrition risk.

Method: The renal nutrition screening tool (R-NST) was modified from the malnutrition screening tool (MST) that has been validated in the acute care setting. It includes the traditional risk variables such as involuntary weight loss and reduction in food intake, as well as biochemical measures to increase the effectiveness of recognising undernutrition risk. It was designed in three simple, accumulative steps. The new R-NST was validated using a prospective, blind comparison to a gold standard study design (N = 122). The undernutrition risk of each participant identified by the research assistants using the R-NST was compared to the nutritional status independently assessed by the researchers using the 7-point subjective global assessment (SGA) as a gold standard and hand grip strength (HGS) as a functional indicator. The R-NST was autonomously undertaken by nursing staff to determine its feasibility as a routine screening on ward level.

Results: The SGA and R-NST tools classified 63.9% and 68.0% of participants as malnourished or at undernutrition risk, respectively. The R-NST was valid to detect undernutrition risk (sensitivity = 97.3%, specificity = 74.4%, positive predictive value (PPV) = 88.0%, negative predictive value (NPV) = 93.6%) compared to the SGA. The HGS in malnourished participants were lower than those that are well nourished in either women ($p = 0.001$) or participants aged under 65 years ($p = 0.009$). The R-NST showed ability to recognise participants requiring dietetic intervention due to their renal conditions. The compliance rate in the R-NST screening by the nursing staff was low (22.6%).

Conclusion: The R-NST is a good diagnostic tool for identifying acute renal patients at undernutrition risk and facilitating timely dietetic referral. Further research is warranted to explore innovative yet effective interventions to enhance nutrition screening compliance in ward practice.

Key words: nutrition screening tool, undernutrition, renal failure

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Chapter One

1. Introduction

Renal failure describes a medical condition in which the kidney becomes inadequate to filter toxins and waste from the blood (Levey et al., 2002). There are two forms of renal failure, namely acute kidney injury (AKI) that is identified by the rapid loss of kidney function, and chronic kidney disease (CKD) that occurs when the function of the kidney declines slowly and steadily (Levey et al., 2002). Chronic kidney disease could take up to several years to develop with initial few symptoms (Levey et al., 2002).

The prevalence of renal failure around the globe is increasing, particularly among indigenous people (Grace et al., 2012, Steenkamp et al., 2011, United States Centers for Disease Control and Prevention, 2010). In New Zealand, the prevalence of end-stage renal failure was found to be higher in Māori and Pacific peoples (indigenous people) than in New Zealand Europeans (Simmons et al., 1994). McDonald and colleagues (2011) reported that the incidence rates of indigenous people in New Zealand commencing renal replacement therapy are considerably greater than non-indigenous people. In New Zealand, Auckland has the largest urban Polynesian population, which includes New Zealand Māori, Western Samoans, Tongans, Niueans, and Cook Islands Māori (Ministry of Pacific Island Affairs, n.d.). According to the 2006 census (Statistics New Zealand, 2006), Counties Manukau District Health Board (CMDHB) is responsible for providing healthcare services for people living in South Auckland, which has a population of 433,086 of whom 15.5% are Māori, 21.5% are of Pacific Island origin, 16.9% are Asian and the remainder being predominantly New Zealand Europeans. This large proportion of the Māori and Pacific Island population may also have a different impact on the need for healthcare services within the CMDHB.

A health needs assessment conducted by the Health and Disability Intelligence Unit (2008) indicate that in CMDHB, the rate of hospitalisations of people with renal failure due to diabetes (30.5 per 100,000) was significantly higher than the national rate (19.7

per 100,000). Furthermore, the hospitalisation rates of Māori and Pacific Island peoples with renal failure due to diabetes were markedly greater, 103.7 per 100,000 and 106.8 per 100,000, respectively, compared to New Zealand European, 9.1 per 100,000 (Health and Disability Intelligence Unit, 2008). Therefore, it is important to strive for delivering better quality of healthcare in treating renal disease among Māori and Pacific peoples in the area serviced by CMDHB.

1.1 Justification of the study

Undernutrition among patients with both acute and chronic renal failure has been well documented and the causes are often multifactorial (Strejc, 2005, Dukkipati and Kopple, 2009, Kopple, 1999). Decreased nutrient intake caused by loss of appetite is considered as a major contributing factor. (Strejc, 2005, Dukkipati and Kopple, 2009, Kopple, 1999). Loss of appetite may be induced by increased uremic toxins built up in the body that is associated with renal failure, as well as emotional depression, medications or inflammatory state (Dukkipati and Kopple, 2009). Undernutrition in patients with renal failure are associated with longer hospital stay and increased morbidity (Ikizler et al., 1999, Pupim et al., 2003, Fiaccadori et al., 1999). The quality of life in malnourished CKD patients is often compromised even before the start of dialysis (Campbell et al., 2008, Rambod et al., 2009). The decline in nutrition status in CKD patients is defined by Kaysen and colleagues (2004) as decreased serum albumin and body mass index (BMI) associated with increased mortality. However, the percentage of malnourished patients in the hospital who were neither identified nor referred for further nutrition assessments and treatment found in several retrospective studies was 60 – 85% in UK hospitals, 64% in a Norwegian hospital and 73% in a Singaporean hospital (Raja et al., 2004, Mowé et al., 1994, Campbell et al., 2002, Edington et al., 2000, Kelly et al., 2000, McWhirter and Pennington, 1994). A recent British study by Lamb et al. (2009) also found that only 68·9 % of the inpatients had been screened for malnutrition. This research study pointed out that more than half of patients identified as having the highest risk of undernutrition by ward staff, were not referred to dietetic services via the local hospital referral system (Lamb et al., 2009). As the incidence of undernutrition in hospital is high and failure to recognise or to refer for further nutrition assessments also

remains high, renal patients are particularly vulnerable. It is thus clear that screening of patients' nutritional status by health care professionals is imperative to ensure that appropriate and timely referral can occur to avoid further deterioration of nutrition status and to reduce hospital stay and related complications (Lamb et al., 2009, Campbell et al., 2002, Edington et al., 2000, Kelly et al., 2000).

Nutrition screening tools typically use a questionnaire format to assess factors known to lead to or be associated with malnourishment. There has been various nutrition screening tools developed worldwide, such as the Malnutrition Universal Screening Tool (MUST), Malnutrition Screening Tool (MST), Short Nutritional Assessment Questionnaire (SNAQ), Mini Nutritional Assessment - Short Form (MNA-SF) and Nutritional Risk Score (NRS 2002) (Rubenstein et al., 2001, Kruizenga et al., 2005a, Ferguson et al., 1999, Elia, 2003, Kondrup et al., 2003b) (see Table 1.1).

Table 1.1 A summary of various nutrition screening and assessment tools

Nutrition screening tools	Specific groups and settings	Reference standard	References
Malnutrition Universal Screening Tool (MUST), (Elia, 2003)	All adults, acute care setting, residential aged care setting and the community setting	Severe undernutrition: BMI < 18.5 kg/m^2, or unintentional weight loss (≥ 10%) with severe loss of subcutaneous fat and/or severe muscle wasting due to inadequate intake. Moderately undernutrition: BMI < 18.5 kg/m^2, or unintentional weight loss (5-9%) with moderate loss of subcutaneous fat and/or moderate muscle wasting due to inadequate intake.	(Stratton et al., 2004, Stratton et al., 2006, Elia, 2003, Kyle et al., 2006)
Malnutrition Screening Tool (MST), (Ferguson et al., 1999)	Adult patients, acute care setting	Subjective global assessment (SGA)	(Ferguson et al., 1999, van Venrooij et al., 2007)
Short Nutritional Assessment Questionnaire (SNAQ), (Kruizenga et al., 2005a)	Adult patients, acute care setting, the community setting	If one or more of the following conditions, then severely malnourished: BMI < 18.5 kg/m^2, or unintentional weight loss > 5% in the last month, or > 10% in the last 6 months. Moderately malnourished: 5-10% unintentional weight loss in the last 6 months.	(van Venrooij et al., 2007, Neelemaat et al., 2008)

Mini Nutritional Assessment - Short Form (MNA-SF), (Rubenstein et al., 2001)	Older adults (aged ≥ 65 years), acute care setting, rehabilitation setting, residential aged care setting and the community setting	The Mini-Nutritional Assessment (MNA)	(Rubenstein et al., 2001, Ranhoff et al., 2005, Neumann et al., 2007, Kuzuya et al., 2005, Langkamp-Henken et al., 2005)
Nutritional Risk Score (NRS 2002), (Kondrup et al., 2003b)	Adult patients, acute care setting	Subjective global assessment (SGA)	(Kondrup et al., 2003b, Stratton et al., 2004, Kyle et al., 2006)

Nutrition assessment tools	**Specific groups and settings**	**Reference standard**	**Reference**
Subjective Global Assessment (SGA) (Detsky et al., 1987)	All adults, acute care setting, rehabilitation setting, residential aged care setting and the community setting	Anthropometric measures: percentages of ideal weight, ideal lean body weight and body. Biochemical measures: serum albumin and total cholesterol levels	(Baker et al., 1982a, Baker et al., 1982b, Duerksen et al., 2000, Christensson et al., 2002, Sacks et al., 2000)
Mini Nutritional Assessment (MNA) (Guigoz et al., 1997)	Older adults (aged ≥ 65 years), acute care setting, rehabilitation setting, residential aged care setting and the community setting	Anthropometric measures: weight, height, triceps skinfold, mid arm circumference, and calf circumference. Biochemical measures: serum albumin and total cholesterol levels For undernutrition: BMI < 18.5 kg/m^2, levels lower than 35 g/L of albumin or 1.5 g/L of total cholesterol	(Kuzuya et al., 2005, Persson et al., 2002, Compan, 1999, Gazzotti et al., 2000, Van Nes et al., 2001, Vellas et al., 1999, Neumann et al., 2005, Thomas et al., 2002, Donini et al., 2003, Christensson et al., 2002, Saletti et al., 2000, Visvanathan et al., 2003)

However, these tools are often designed for specific groups (e.g. oncology patients, hospital patients in certain disease states), specific age groups (e.g. older adults) and settings (e.g. acute care setting, rehabilitation setting, aged care setting or community setting) (Barendregt et al., 2008, Weekes et al., 2004, Kruizenga et al., 2005a, Rubenstein et al., 2001). Various reference standards are also employed to validate these tools since there is no 'gold standard' or universally accepted definition for the diagnosis of undernutrition (Elia et al., 2005). Among different nutrition screening tools, the MNA-SF for example was originally developed by Rubenstein and colleagues in 2001 to evaluate the nutritional status of participants aged over 60 years of age in a community setting (Rubenstein et al., 2001). Although this screening tool clearly identify malnourished participants even in multicentre settings, the reference standard used in the different studies using the tool was varied (Zhang et al., 2010, Kézachian and Bonnet, 2012, Poulia et al., 2012, Rubenstein et al., 2001). Since the MNA-SF was developed for the older cohort, it appears to be inappropriate to identify hospital patients younger than 60 years of age who are at risk of undernutrition, and may be unable to predict their health outcomes (Neelemaat et al., 2011, Raslan et al., 2010). Therefore a screening tool should not only be quick and easy to administer by staff and tolerable to patients, but should be appropriate for the specific patient group. Furthermore, the European Society of Parenteral & Enteral Nutrition (ESPEN) guidelines on nutritional screening also require it to satisfy the criteria for reliability, validity, sensitivity and specificity before widespread administration (Kondrup et al., 2003a).

The National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (K/DOQI) currently recommends the use of Subjective Global Assessment (SGA) as the diagnostic standard to identify undernutrition among renal patients (Levey et al., 2002). The Subjective Global Assessment was originally described by Detsky et al (1987) and Baker et al (1982a). Subjective Global Assessment is a comprehensive assessment of nutrition status considering a medical history (including parameters of involuntary weight change, dietary intake, gastrointestinal symptoms and functional capacity) and physical examination (consisting of muscle wasting, the loss of subcutaneous fat, the precence of sacral, ankle oedema and ascites) (Detsky et al., 1987). The nutritional status of an individual is classified by the SGA as well nourished, mild to moderately malnourished,

or severely malnourished (Detsky et al., 1987). Since the SGA is aimed at providing a full nutrition assessment requiring a clinician to physically evaluate the patient, the assessment can be time consuming, and is thus not preferred to use as a general screening tool. Especially for those who are not familiar with the procedures, it can take up to 30 minutes to complete. Moreover, the ability of the SGA scores to predict nutritional status relies on subjective clinical judgement, which requires following a standardised protocol strictly. Although dietitians are trained to perform the SGA, assessing all patients' nutritional status demands significant dietetic input and time. Thereby, Green and Watson (2005) advocate the development of a rapid nutrition screening tool that could be easily administered by any member of a multidisciplinary renal team (e.g. nurses or health care professionals) without the requirement of dietetic training so that patients who may be malnourished can be identified accurately and quickly and referred to dietetic services for in-depth nutrition assessments and/or intervention. Several studies have shown that some of the existing malnutrition screening tools such as the MUST, MST and NRS 2002 are significantly correlated with SGA to identify individuals at risk of undernutrition (Almeida et al., 2012, Isenring et al., 2012, Kyle et al., 2006). However, these studies were all conducted in renal outpatients undergoing dialysis. Published studies aiming to investigate the effective of these nutrition screening tools in acute renal patients are limited. One research study compares the accuracy of two of the malnutrition screening tools, MUST and MST, with the SGA to assess recognition of CKD and AKI patients at risk of undernutrition (Lawson et al., 2011). The results from this study showed that the two screening tools are not as sensitive to identify the malnourished renal inpatients as SGA (Lawson et al., 2011). Therefore, there is a need for a rapid nutrition screening tool that is specifically developed to identify renal inpatients at risk of undernutrition. This early recognition of undernutrition in renal inpatients can lead to timely nutrition interventions and may subsequently yield better health outcomes for this particular group of patients.

1.2 Statement of the research problem

Undernutrition in renal patients is significantly associated with negative health outcomes. The prevalence of malnourished renal inpatients was found to be 52.6% by

Lawson et al. (2011). Renal inpatients appear to have a much higher prevalence of undernutrition compared to the prevalence of all acute care wards regardless of medical specialities, since the prevalence of undernutrition in patients admitted to 370 acute care wards from 56 hospitals across Australia (n = 42) and New Zealand (n = 14) was found to be 32% (Agarwal et al., 2012b). Nevertheless, there is little published data on the undernutrition prevalence of renal inpatients in New Zealand. Although there is conclusive evidence indicating that the MUST and MST tools are effective in identifying hospital patients at risk of undernutrition (Almeida et al., 2012, Neelemaat et al., 2011, Poulia et al., 2012), it was found that MUST and MST are insensitive among renal inpatients (Lawson et al., 2011). Since the format of the SGA is extensive (Levey et al., 2002), it would be clinically valuable to firstly develop a rapid nutrition screening tool specifically for renal inpatients to identify their specific nutritional risk and secondly to design this tool to be administered by health professionals without dietetic training. Philipson and colleagues (2013) found that the use of oral nutritional supplements in the hospital was associated with decreased length of stay, episode cost, and 30-day readmission risk. However, undernutrition can only be treated once it is recognised. Therefore, the results of this malnutrition screening tool would guide the dietetic referral practice for the renal inpatient ward to achieve timely dietetic input. Implementing such a renal nutrition screening tool might reduce undernutrition and hospital stay of renal inpatients.

1.3 Purpose of the research study

1.3.1 Aim

To develop and validate a rapid nutrition screening tool that is sensitive and specific to recognise renal inpatients at risk of undernutrition in the acute renal ward (Ward One) at Middlemore Hospital (MM Hosp), CMDHB, New Zealand.

1.3.2 Objectives

1.3.2.1 Primary objectives

To develop a nutrition screening tool aimed at identifying adult renal inpatients at risk of undernutrition.

To validate this newly developed renal nutrition screening tool (R-NST) in renal patients on an acute ward.

1.3.2.2 Secondary objective

To evaluate the feasibility of the newly developed R-NST as a standard practice by nursing staff on the renal ward in MM Hosp.

1.4 Structure of the thesis

The literature will be reviewed in chapter two regarding the various screening and assessment tools for undernutrition, the development and the validation of a nutrition screening tool in people with renal disease. Chapter three will describe the methods and equipment used in our investigation. This will be followed by chapter four where the results and feasibility of the newly developed screening tool will be reported. The findings will be discussed in chapter five. Finally chapter six will summarise the research study, its strengths, limitations, and a conclusion and recommendation for future studies will be made.

Chapter Two

2. Literature review

2.1 Introduction

2.1.1 Definition of renal failure

Renal failure is a medical condition in which the kidney becomes inadequate to filter toxins and waste from the blood (Levey et al., 2002). There are two forms of renal failure: acute kidney injury (AKI) and chronic kidney disease (CKD) (Levey et al., 2002). The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), United States, defined AKI as sudden, temporary, and sometimes fatal loss of kidney function (National Kidney and Urologic Diseases Information Clearinghouse (NKUDIC), 2012). There were no standard criteria of diagnosis of AKI until 2004, when the Acute Dialysis Quality Initiative (ADQI) developed the 'RIFLE' classification of AKI through a board agreement of experts worldwide (Bellomo et al., 2004). The 'RIFLE' classification stands for Risk of renal dysfunction, Injury to the kidney, Failure of kidney function, Loss of kidney function and End-stage kidney disease (Bellomo et al., 2004). This classification represents three levels of severity (risk, injury and failure) and two outcomes (loss of function and end-stage kidney disease) (Bellomo et al., 2004). Although these diagnostic criteria have been widely adopted in 2007, the Acute Kidney Injury Network (AKIN) further described AKI as an abrupt (within 48 hours) reduction in kidney function, characterised as a rise in serum creatinine of ≥ 26.4 μmol/l, or ≥ 50% increase of serum creatinine compared to baseline, or a decline in urine output to ≤ 0.5 ml/kg/h for 6 hours or longer (Mehta et al., 2007).

Chronic kidney disease, on the other hand, describes the abnormality of kidney function and/or structure, which is often irreversible and progress slowly (National Institute for Health and Clinical Excellence Chronic kidney disease, 2008, Levey et al., 2002). Although the precise aetiology is often unclear, diabetes is the single most common cause of end-stage renal failure (ESRF) in those starting dialysis, while hypertension,

glomerulonephritis and pyelonephritis are less frequent causes (National Institute for Health and Clinical Excellence Chronic kidney disease, 2008, Levey et al., 2002). The risk of developing CKD is directly associated with age, and the severity of co-morbidities increases as CKD advances (National Institute for Health and Clinical Excellence Chronic kidney disease, 2008). Advanced CKD can ultimately lead to death (Levey et al., 2002). Although CKD usually goes undiscovered until obvious symptoms appear, the United States National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) suggests the best indicator of kidney function is by measuring the glomerular filtration rate (GFR) or by calculating the estimated GFR using prediction equations that take into account the serum creatinine concentration and some or all of the following variables: age, gender, race and body size. (Levey et al., 2002). The GFR is represented as the volume of plasma cleared of a substance that is freely filtered at the glomerulus but is neither secreted nor reabsorbed at the tubule per unit time (ml/min) (Levey et al., 2002). Chronic kidney disease is diagnosed if either GFR is < 60 ml/min/1.73 m^2 or if there is evidence of chronic damage in the kidney on at least two occasions more than three months apart according to the definition of NKF-KDOQI (Levey et al., 2002). The NKF-KDOQI further divides CKD into five stages according to GFR (Table 2.1). Normal GFR is regarded as approximately 100 ml/min/1.73 m^2, whereas a GFR of <15 ml/min/1.73 m^2 is classified as ESRF (Levey et al., 2002).

Table 2.1 US Kidney Disease Outcomes Quality Initiative classification of chronic kidney disease (National Kidney Foundation, 2008)

Stage	Description	GFR (ml/min/1.73m^2)
1	Normal GFR with other evidence of chronic kidney damage	>90
2	Mild impairment with other evidence of chronic kidney damage	60–89
3	Moderate impairment	30–59
4	Severe impairment	15–29
5	End-stage renal failure	<15 (or dialysis)

GFR: glomerular filtration rate

2.1.2 Prevalence of chronic kidney disease in New Zealand and other countries

In the United States of America, more than 20 million people (10% of the population), have some level of CKD (United States Centers for Disease Control and Prevention, 2010). In the United Kingdom, there were 49,080 adults undergoing renal replacement therapy as of December 2009. Of these, 44% were undergoing haemodialysis and 8% were undergoing peritoneal dialysis, with the remaining patients requiring kidney transplants (Steenkamp et al., 2011). Not only are the rates of CKD increasing worldwide, but indigenous people are especially vulnerable (Grace et al., 2012). A cross-sectional study conducted in South Auckland, New Zealand in 1994 had provided a comparison of microalbuminuria and diabetic nephropathy in New Zealand European, Māori, and Pacific Islanders with Type 2 Diabetes (Simmons et al., 1994). The prevalence of end-stage renal disease (ESRD), proteinuria, and microalbuminuria were found to be higher in Māori and Pacific Islanders than in New Zealand European (Simmons et al., 1994). The Australian and New Zealand Dialysis and Transplant Registry (ANZDATA) reviews all patients commencing renal replacement therapy (RRT) in Australia and New Zealand annually. Their data for the period between 2003 and 2007 indicated that the incidence of Māori people commencing RRT was 262 per million, Pacific people 283 per million and people of European origin 77 per million (McDonald et al., 2008). The incidence rates (per million population) of Māori and Pacific Islanders (indigenous people) are considerably greater than non-indigenous people (McDonald et al., 2011). The report also found that diabetic nephropathy (51%) continued to be the greatest cause of ESRD in New Zealand followed by glomerulonephritis (22%) and hypertension (12%) (Grace et al., 2011) . Therefore, there is a need to investigate how to combat this disproportionate rate of renal disease among Māori and Pacific peoples in New Zealand.

2.1.3 Definition of undernutrition and risk of undernutrition

Traditionally, undernutrition refers to the presence of a low-nutrient intake or, at least, an intake that is inadequate to meet the nutritional requirements of an individual (White et al., 2012b). There is currently no consensus on the definition for adult malnutrition syndromes in the nutrition and medical literature using nonspecific biomarkers, disease severity, and existing classification systems. In 2010, an International Guideline Committee was constituted to develop a consensus approach to defining malnutrition syndromes for adults in the clinical setting (Jensen et al., 2010). This approach is based particularly upon aetiology that incorporates a current understanding of inflammatory response (Jensen et al., 2010). The Committee proposed the following nomenclature for nutrition diagnosis in a clinical setting:

- ‘‘Starvation-related malnutrition’’, when there is chronic starvation without inflammation,
- ‘‘chronic disease-related malnutrition’’, when inflammation is chronic and of mild to moderate degree,
- ‘‘acute disease or injury-related malnutrition’’, when inflammation is acute and of severe degree (Jensen et al., 2010).

In 2012, the Academy of Nutrition and Dietetics, in collaboration with the American Society for Parenteral and Enteral Nutrition (ASPEN), developed six clinical characteristics of undernutrition (White et al., 2012a). The six clinical characteristics of malnutrition are:

(1) Insufficient food and nutrition intake compared with nutrition requirements,
(2) Weight loss over time,
(3) Loss of muscle mass,
(4) Loss of fat mass,
(5) Fluid accumulation, and
(6) Measurably diminished handgrip strength (White et al., 2012a).

The ESPEN guideline suggests that individuals at risk of undernutrition are those with body mass index (BMI) less than 20 kg/m^2 , or those with BMI greater than 20 kg/m^2 as well as a greater than 10% involuntary weight loss in the past three to six months (Lochs

et al., 2006). The National Institute for Health and Clinical Excellence (NICE) guidelines in the United Kingdom (UK) further differentiate the risk of undernutrition into three categories, namely low, moderate and high risk (National Institute for Health and Clinical Excellence (NICE), 2006). Individuals with an optimal BMI (18.5 to 25 kg/m^2), yet have less than 5% of unintentional weight loss within the last three to six months, are considered to be at low risk of undernutrition, whereas the risk for those with an optimal BMI rises to moderate when experiencing five to ten percents unintentional weight loss within three to six months (National Institute for Health and Clinical Excellence (NICE), 2006). A high risk of undernutrition is assigned if individuals with BMI below 18.5 kg/m^2 also experience unintentional weight loss that is greater than 10% within the last three to six months (National Institute for Health and Clinical Excellence (NICE), 2006) (see Table 2.2).

Table 2.2 The classification of undernutrition risk in adults according to both BMI and recent unintentional weight loss (Lochs et al., 2006, National Collaborating Centre for Acute Care, 2006)

Measurement	Normal nutritional status	Low risk of undernutrition	Moderate risk of undernutrition	High risk of undernutrition
BMI (kg/m^2)	18.5 – 25	18.5 – 25	18.5 – 25	< 18.5
Unintentional weight loss in the past 3-6 months (%)	0	< 5	5 – 10	> 10

BMI: body mass index.

2.1.4 Definition and terminology of undernutrition in adults with renal failure

Undernutrition is common among patients with renal failure including both AKI and CKD (Kalantar-Zadeh, 2005, Locatelli et al., 2002, Fouque et al., 2008). In 1960, Scribner et at. (1960) first pointed out that undernutrition may be a serious problem for patients with renal failure. Approximately 18 - 75% of patients with CKD undergoing maintenance dialysis therapy were reported to show evidence of wasting (Kalantar-Zadeh et al., 2003). Here, wasting describes abnormalities that cannot be corrected solely by increasing dietary intake (White et al., 2012b). There has been increasing evidence

indicating a strong link between wasting and inflammation in patients with renal disease (Avesani et al., 2006, Yao et al., 2004, Stenvinkel, 2005, Maltzman and Berns, 2005). Wasting driven by inflammation is believed to elaborate the catabolic state, which leads to anorexia, progressive weight loss, and ultimately depletion of both fat and lean body mass. Many terminologies have been used to describe this condition, for example, uremic malnutrition, uremic (renal) cachexia, protein-energy malnutrition, malnutrition-inflammation atherosclerosis syndrome, or malnutrition-inflammation complex syndrome (MICS) (Fouque et al., 2008). Hence, protein-energy wasting (PEW) was recommended by the International Society for Renal Nutrition and Metabolism to describe the decline in the body stores of energy and protein as fuels among individuals with renal disease (Fouque et al., 2008). The prevalence of PEW in maintenance haemodialysis was estimated by Mehrotra and Kopple (2001) to be 40% on average. The prevalence of severe PEW has been estimated to be 6% to 8% (Mehrotra and Kopple, 2001).

2.1.5 Causes of undernutrition in adults with renal failure

There are many causes of PEW in renal patients particularly in dialysis patients. Anorexia and the concurrent reduction of protein and energy intake is one of the major side effects of renal failure and one of the causes of PEW (Carrero, 2011, Carrero et al., 2007, Kalantar-Zadeh et al., 2004a, Kopple et al., 2000). Kalantar-Zadeh and colleagues (2004a) requested 331 maintenance haemodialysis patients to rate their appetite subjectively and found that 124 patients (38%) were perceived to have a fair to poor appetite. A decrease in appetite was also reported in 66 (13%) patients (Kalantar-Zadeh et al., 2004a). Carrero et al. (2007) suggested that dialysis patients with a poor appetite was associated with a worse nutritional status (lower serum concentrations of insulin-like growth factor I, albumin, urea, and creatinine), increased inflammation, and worse clinical outcomes compared to those reporting a good appetite (Carrero et al., 2007). Moreover, a cross-sectional study by Kopple et al. (2000) indicate that dietary protein intake estimated from both the urea nitrogen appearance and dietary records, serum albumin and transferrin levels as well as percentage body fat measured by skinfold thickness were directly correlated with the GFR in 1785 clinically stable patients with

moderate to advanced CKD. This study implies that there is a gradual decline in nutritional status as the GFR decreases, which is not only related to dietary intakes of protein and energy but also to biochemical and anthropometric measures (Kopple et al., 2000).

Inflammation may also induce PEW via the elevation of inflammatory cytokines that promote catabolism and may suppress protein synthesis (Heimbürger et al., 1997, Young et al., 1997). These catabolic conditions not only promote the breakdown of muscle into amino acids, which can be used in normal body functions and transformed into glucose as fuel, but shift the balance of skeletal muscle turnover toward excessive protein degradation (Workeneh and Mitch, 2010). As a consequence, these catabolic conditions will result in muscle wasting (Workeneh and Mitch, 2010). Observational studies suggest that muscle wasting in CKD patients has increased in the past decade (Lin and Curhan, 2008, Qureshi et al., 1998). These inflammatory cytokines can also stimulate anorexia by diminishing appetite and subsequently lowering food intake (Heimbürger et al., 1997, Young et al., 1997).

Nutrients such as amino acid, proteins, vitamins and minerals can be removed by the process of dialysis (Kopple et al., 1973, Hemmeloff Andersen, 1977, Sullivan and Eisenstein, 1972, Westra et al., 2007, Alp Ikizler et al., 2002, Blumenkrantz et al., 1981). Patients undergoing peritoneal dialysis was reported to lose about 9 g total protein per day and 6 g albumin per day (Kopple et al., 1973). A more recent study showed that the average protein losses within 24 hours were 9.4 ± 0.6 and 10.8 ± 0.8 g per day in two 24-hour dialysate collections in nine peritoneal dialysis patients (Westra et al., 2007). Patients undergoing dialysis also have a higher chance of protein catabolism resulting in negative protein balance due to acidaemia, which is an increase of protons in the blood (Reaich et al., 1993, Mochizuki, 1991). The accumulation of protons in the blood peaks prior to the start of the next dialysis, at which time the degradation of proteins and amino acids is accelerated (Papadoyannakis et al., 1984, De Brito-Ashurst et al., 2009, Stein et al., 1997).

In addition, the increase of various hormones that are stimulated in renal failure (e.g. insulin-like growth factor-1, growth hormone, parathyroid hormone) may further promote PEW (Moxley et al., 1974, Siew et al., 2007, Fouque, 1996). It is imperative to treat PEW in renal patients early since the association of undernutrition with increased mortality has been well documented (De Mutsert et al., 2009).

2.2 Nutrition screening vs. nutrition assessment

Undernutrition is a condition that can only be treated once it has been identified. As a result of this, nutrition screening on admission plays a vital role in recognising patients at risk of undernutrition in an acute setting. Nutrition screening tools typically use a questionnaire format to assess factors known to lead to or be associated with undernutrition in a specific population group and setting (Kondrup et al., 2003a). Conversely, nutrition assessment continues the data gathering process initiated in the screening (Lochs et al., 2006, Teitelbaum et al., 2005). Assessment allows the dietitian to gather more nutrition-focused information and conduct a physical examination to determine if there is truly a nutrition problem and to determine its severity (Lochs et al., 2006, Teitelbaum et al., 2005). However, the completion of a comprehensive nutritional assessment tool is time consuming and requires clinical judgement to produce a subjective global score accurately (Green and Watson, 2005). The evaluation of nutritional status requires extensive dietetic input from dietitians and it may therefore not be appropriate to be administered by healthcare professionals without dietetic training. Nutrition screening tools, on the other hand, are developed to be administered by healthcare professionals to rapidly recognise individuals at risk of undernutrition so that they can be swiftly and aptly referred to dietitians for nutritional care (Rubenstein et al., 2001, Kruizenga et al., 2005a, Ferguson et al., 1999, Elia, 2003, Kondrup et al., 2003b). These rapid nutrition screening tools are not designed to evaluate the nutritional status of individuals, but are developed to recognise individuals who may be at risk of undernutrition (Rubenstein et al., 2001, Kruizenga et al., 2005a, Ferguson et al., 1999, Elia, 2003, Kondrup et al., 2003b). This allows for their nutritional status to be further evaluated by dietitians.

2.3 Evaluation of nutritional status in adults with renal failure

There are a number of comprehensive nutritional assessment tools developed specifically to determine the nutritional status of individuals (Enia et al., 1993, Jones et al., 2004, Steiber et al., 2007, Visser et al., 1999), such as the mini-nutritional assessment (MNA), subjective global assessment (SGA) and its variations including the malnutrition inflammation score (MIS) and dialysis malnutrition score (DMS) (Detsky et al., 1987, Kalantar-Zadeh et al., 1999, Kalantar-Zadeh et al., 2001, Guigoz et al., 1997). Since there is currently no agreement on the definition for the diagnosis of undernutrition (Elia et al., 2005), the evidence-based practice guidelines for nutrition management in CKD recommend the use of the subjective global assessment (SGA) as one of the parameters in clinical practice (such as biochemical markers) to assess nutritional status of individuals with CKD (Levey et al., 2002, Ash et al., 2006, McCann, 1999). This recommendation has been made in consideration of the nature of renal failure that may affect interpretation of traditional nutritional assessment methods such as anthropometric (e.g. weight change, skinfold measurements) and biochemical (e.g. serum albumin) measures. The weight change may be due to fluid retention between dialysis and hypoalbuminaemia may be a result of acute inflammation, hence, may not accurately reflect the nutritional status. Thus, SGA is considered by Steiber et al. (2004) as a comprehensive and cost-effective assessment, not influenced by the metabolic anomalies of renal failure. Therefore, the SGA which was first developed by Detsky and colleagues (Detsky et al., 1987), has been widely adopted to determine the nutritional status of individuals with renal failure (Campbell et al., 2007).

2.3.1 Nutritional assessment tools: SGA and its variations

The SGA is a comprehensive nutrition assessment tool based on two components, one being a medical history including assessments of weight change, dietary intake change, gastrointestinal symptoms that have continued for longer than two weeks and changes in functional capacity (Detsky et al., 1987). The other component being the physical examination determining the loss of subcutaneous fat, muscle wasting, ankle and/or sacral oedema and ascites (Detsky et al., 1987). The complete nutritional status of

individuals is determined by combining the scores of the two components subjectively into an overall score, where they are classified as being well nourished (SGA A); moderately malnourished, or suspected of being, malnourished (SGA B); or severely malnourished (SGA C) (Detsky et al., 1987). Individuals classified as SGA B or C is considered to be in a state of undernutrition and consequently dietetic interventions are required.

There are at least six different SGA-derived tools that are evident in the literature being used in individuals with renal failure. This include the modified SGA (mSGA), the 4-point SGA scale, the 7-point SGA scale, the patient-generated SGA (PG-SGA), the malnutrition-inflammation score (MIS) and the dialysis malnutrition score (DMS) (Eknoyan and Levin, 2000, Enia et al., 1993, Desbrow et al., 2005, Visser et al., 1999, Stenvinkel et al., 1999, Kalantar-Zadeh et al., 1999, Kalantar-Zadeh et al., 2001, Heimbürger et al., 2000).

- The **7-point SGA** is a modified version of the original SGA as described by Detsky et al. (1987). It is based on expanding the three final classifications of the original SGA (A, B and C) to seven classifications (points 1 to 7), with 1 being severely malnourished and 7 being well nourished (Churchill et al., 1996). This overall classification of the 7-point SGA was calculated from four domains with four seven-point Likert-type subscales (Churchill et al., 1996, De Mutsert et al., 2009) . The four domains are weight loss during the past six months (subscale 1), dietary intake and presence of gastro-intestinal symptoms (loss of appetite, nausea, vomiting and diarrhoea) (subscale 2), physical examination of loss of subcutaneous fat (subscale 3) and muscle wasting (subscale 4) (Churchill et al., 1996, De Mutsert et al., 2009). To obtain a 7-point classification for each of the four subscales, each patient is first classified into one of the three categories of well nourished, moderately and severely malnourished. This is followed by fine-tuning the final scores on the basis of clinical judgement using the following questions:
    - ‘‘Can the status of the patient improve or worsen within the category?’’,
    - ‘‘What has been the development/pattern within the past 2 weeks?’’, and
    - ‘‘What has been the change compared with the previous SGA assessment?’’ (Churchill et al., 1996, De Mutsert et al., 2009) .

For instance, if a patient is classified as well nourished, a score of 6 is assigned instead of 7 when it is possible to improve or when the nutritional status worsened since the previous assessment. In a subjective weighting of the scores of the 4 subscales an overall SGA classification of 1 to 7 is assigned (Churchill et al., 1996, De Mutsert et al., 2009)

- The **PG-SGA** was first modified from the SGA and developed specifically for oncology patients by Ottery (1994). The purpose of the modification was to transform the medical history component so that it can be completed by the patient, while the physical examination remains to be performed by a trained healthcare professional (Ottery, 1994). Another change made in the PG-SGA was to incorporate a numerical score as well as providing a global classification as being well nourished, moderately malnourished or severely malnourished (Ottery, 1994). This numerical score indicates the level of nutrition intervention required, with the higher the score the greater the risk of undernutrition. Ottery (1996) suggested that the PG-SGA can not only facilitate the quantification of the nutritional status of oncology patients, but can also help track the progress of nutritional status in response to nutritional interventions.
- The **MIS**, is a comprehensive nutritional assessment tool developed and validated by Kalantar-Zadeh et al. (2001) to better predict the prospective hospitalisation and mortality in maintenance of haemodialysis patients. It includes seven components of the conventional or modified SGA method combined with the 3 additional components of BMI, serum albumin, and serum total iron-binding capacity (TIBC) (Kalantar-Zadeh et al., 2001) .
- The **DMS** is a quantitative scoring system built into the original SGA. It consists of seven components including weight change, dietary intake, gastrointestinal symptoms, functional capacity, co-morbidity, subcutaneous fat and signs of muscle wasting (Kalantar-Zadeh et al., 1999). The sum of seven components that each has a subscale from 1 (normal) to 5 (severe) gives rise to a ‘malnutrition score’, with a minimum score of ‘7’ being normal while the maximum score of ‘35’ being severely malnourished (Kalantar-Zadeh et al., 1999). The DMS was then further developed by the same research group aiming to measure the clinical status and maybe predict the outcome in maintenance haemodialysis patients (Kalantar-Zadeh et al., 2001).

Body mass index, serum albumin and TIBC were the three additional components being incorporated into this new tool making the DMS contain 10 components (Kalantar-Zadeh et al., 2001). Patients on maintenance haemodialysis are prone to undernutrition caused by inflammation, which may correlate with increased morbidity and mortality (Kalantar-Zadeh et al., 2001). Consequently, Kalantar-Zadeh et al. (2001, 2004b) suggested that these three new components were able to detect inflammation response in these patients in order to better predict clinical outcome such as hospitalisation and mortality.

2.3.2 Other nutritional assessments: MNA

The MNA was originally constructed by Guigoz and colleagues (1997) to evaluate the nutritional status of adults aged 65 and over. Since then, the MNA has been validated against the objective measures (anthropometric and biochemical) of nutritional status across different setting including the acute care setting, rehabilitation setting, residential aged care setting and the community setting (Kuzuya et al., 2005, Persson et al., 2002, Compan, 1999, Gazzotti et al., 2000, Van Nes et al., 2001, Vellas et al., 1999, Neumann et al., 2005, Thomas et al., 2002, Donini et al., 2003, Christensson et al., 2002, Saletti et al., 2000, Visvanathan et al., 2003) . However, the population in which the MNA has been validated has been limited to older adults. Studies using the MNA to evaluate the nutritional status of individuals with renal failure are lacking. Thus, the MNA appears to be inappropriate to be used in renal inpatients.

2.3.3 Prevalence of undernutrition in adults with renal failure in the acute setting

Although the prevalence of undernutrition has been estimated to be approximately 30% (ranging from 28.7% to 60.2%) among patients undergoing dialysis in various studies depending on the reference criteria used (Chan et al., 2007, Gower, 2002, Jones et al., 2004, Lawson et al., 2011, Szeto et al., 2010, Yamada et al., 2008) (see Table 2.3), the prevalence of patients with renal disease in the acute setting is limited. The percentage of malnourished renal patients in the hospital with not only established renal failure on

haemodialysis, peritoneal dialysis or transplant, but also pre-dialysis patients with AKI or all stages of CKD, was investigated by Lawson and colleagues (2011). The authors identified 52.6% of the 276 renal patients to be malnourished when evaluated by the SGA, which is higher than the prevalence of renal outpatients undergoing dialysis. Further studies with a larger number of renal patients in the acute setting are therefore suggested to determine the true prevalence of undernutrition in this population.

Table 2.3 The prevalence of undernutrition among individuals with renal failure

References	Subjects	Age (years)	Setting	Nutrition screening or assessment tool	Reference standard	Prevalence of undernutrition
(Yamada et al., 2008)	422 HD (275 M, 147 F)	63.8 ± 12.1[1]	Outpatient facilities, Japan	GNRI	MIS	MIS: 38.6%
(Szeto et al., 2010)	314 PD (149 M, 165 F)	60.0 ± 11.9[1]	Outpatient facility, Hong Kong, China	GNRI	MIS and 7-point SGA	MIS: 60.2% 7-point SGA: 28.7%
(Jones et al., 2004)	72 HD (42 M, 30 F)	63.8 ± 17.3[1]	Outpatient facility, England	3-point SGA, 7-point SGA	A composite nutrition score[3]	3-point SGA: 30.6% 7-point SGA: 29.2%
(Chan et al., 2007)	165 PD (70 M, 95 F)	59.2 ± 11.5[1]	Outpatient facility, Hong Kong, China	MIS	7-point SGA	7-point SGA: 32.9%
(Gower, 2002)	184 HD (109 M, 75 F)	64 (25 to 85)[2]	Outpatient facilities, England	Objective measures[4]	SDA[5]	SDA: 42.0% Objective measures: 36%
(Lawson et al., 2011)	276 renal inpatients[6] (144 M, 132 F)	65 (17 to 98)[2]	Renal inpatient wards, Australia	MUST MST	7-point SGA	7-point SGA: 52.6% MUST: 38.8% MST: 32.4%

HD, haemodialysis patients; GNRI, geriatric nutrition risk index; MIS, malnutrition-inflammation score; PD, peritoneal dialysis patients; SGA, subjective global assessment; SDA, standardised dietetic assessments; MUST, malnutrition universal screening tool; MST, malnutrition screening tool.

[1] Mean ± standard deviation

[2] Medium (rage)

[3] A composite nutrition score was derived from a model described by Harty et al. (1994).

[4] The criteria used to define risk of malnutrition included 2 or more of the following objective measures: 10% weight loss; dialysis adequacy <1.1; predialysis urea < 20 mmol/L; phosphate < 0. 75 mmol/L and potassium < 3.3 mmol/L.

[5] An SDA includes a review of medical history, social history, biochemistry (blood and urine) tests, dialysis prescription, treatment plans, medications, weight changes, body mass index (BMI), and dietary intake compared with therapeutic guidelines with documented aims.

[6] Renal inpatients include acute kidney injury, chronic renal failure and established renal failure (on HD, PD or transplant).

2.4 Nutrition screening tools

There has been various nutrition screening tools developed worldwide, such as the Malnutrition Universal Screening Tool (MUST), Malnutrition Screening Tool (MST), Short Nutritional Assessment Questionnaire (SNAQ), Mini Nutritional Assessment - Short Form (MNA-SF) and Nutritional Risk Score (NRS 2002) (Rubenstein et al., 2001, Kruizenga et al., 2005a, Ferguson et al., 1999, Elia, 2003, Kondrup et al., 2003b) (see Table 1.1). Most of the nutrition screening tools take the approach of a numerical scoring system to identify individuals at risk of undernutrition. The size fractions of scores reflect the severity of each risk variable for undernutrition identified. A nutrition screening tool is often constructed by selecting risk variables that are the most associated with the diagnostic definition of undernutrition within a selected patient group. The accumulating scores indicate the magnitude of undernutrition risk for each individual. Some screening tools only differentiate individuals who are either at risk of undernutrition or not, for example, the MST (Ferguson et al., 1999). Whereas other screening tools further describe the undernutrition risk of screened individuals as low, moderate or high, such as the MUST and NRS 2002 (Barendregt et al., 2008, Elia, 2003). These nutrition screening tools are summarised in Table 1.1.

2.4.1 Application of various nutrition screening tools in different population groups and care settings

The application of rapid nutrition screening tools is often limited by the population group and care setting in which they were developed and validated, such as oncology patients, hospital patients in acute disease states or older adults (Barendregt et al., 2008, Weekes et al., 2004, Kruizenga et al., 2005a, Rubenstein et al., 2001). For example, the MNA-SF was originally developed by Rubenstein and colleagues in 2001 to evaluate the nutritional status of subjects aged 60 years of age and older in a community setting (Rubenstein et al., 2001). Hence, the MNA-SF appears to be inappropriate to identify hospital patients younger than 60 years of age at risk of undernutrition and may be unable to predict their health outcomes since it was developed for the older cohort

(Neelemaat et al., 2011, Raslan et al., 2010). Alternatively, some nutrition screening tools are constructed to be used in all kind of settings including the acute care setting, rehabilitation setting, aged care setting or community setting (Barendregt et al., 2008, Weekes et al., 2004, Kruizenga et al., 2005a, Rubenstein et al., 2001). For example, the MUST tool was developed in 2003 by the multidisciplinary Malnutrition Advisory Group, a Standing Committee of the British Association for Parental and Enteral Nutrition (BAPEN) (Elia, 2003). It has been shown to achieve the desired outcome in different care settings and population groups, including the adult patients in the acute care setting, older adults in the residential aged care setting as well as the community setting (Elia, 2003, Stratton et al., 2006, Stratton et al., 2004, Kyle et al., 2006, Harris et al., 2008). A survey conducted by BAPEN reported that 73% of 185 British surveyed hospitals adopted the MUST into their standard practice in identifying hospital patients at risk of undernutrition on admission (Bennett et al., 2005, Bennett et al., 2006). Therefore, the MUST appears to be the most widely adopted screening tool in hospital practice in the UK (Elia, 2003).

2.4.2 Nutrition screening tools Available for Adults with Renal Failure

There have been limited screening tools developed specifically for individuals with kidney disease identified in the literature. However, there are some existing screening tools that have been used to compare their ability to recognise malnourished renal patients undergoing the treatment of dialysis. These tools are MUST, MST, MNA-SF, Nutrition Risk Score (NRS) and the Geriatric Nutritional Risk Index (GNRI) (Yamada et al., 2008, Kobayashi et al., 2010, Lawson et al., 2011, Szeto et al., 2010). Yamada et al. (2008) employed the above five quick-and-easy screening tools to screen the nutritional status of 422 haemodialysis patients in order to determine the best tool suitable for this population. In this study, the result of each screening tool was compared to the MIS. The authors found that the MUST and MST have the least correlation with the MIS out of the five screening tools among patients on maintenance haemodialysis, whereas the GNRI was the most accurate in identifying haemodialysis patients at nutritional risk (Yamada et al., 2008). Geriatric Nutritional Risk Index is a predictive equation modified from the NRI for older people (Bouillanne et al., 2005). This index incorporates serum albumin,

current and ideal body weights to calculate the nutrition risk of dialysis patients and to predict mortality (Yamada et al., 2008, Kobayashi et al., 2010, Szeto et al., 2010). Kobayashi et al. (2010) followed 490 patients on maintenance haemodialysis for 60 months and revealed that patients with a GNRI <90 had a significantly lower survival rate, compared to those with GNRI ≥90. Furthermore, GNRI was considered to be significantly associated with MIS and SGA in peritoneal dialysis patients (Szeto et al., 2010). As a result, GNRI appears to be an effective tool to recognise patients undergoing the treatment of dialysis. Although the GNRI may be a simple way to classify the undernutrition risk of an individual, this index has not been examined on the population of acutely ill renal patients in the hospital. The feasibility of implementing this index on the acute wards has not been investigated either, particularly the acceptability of calculating nutritional risk using this index by the nursing staff.

In contrast, the effectiveness of the MUST and MST in recognising undernutrition risk of patients on the acute wards have been evaluated against the SGA (Lawson et al., 2011). Unfortunately, the authors concluded that these two nutrition screening tools were less sensitive in recognising renal inpatients at risk of undernutrition than in other patient groups (Lawson et al., 2011). Thus, there is a need to develop a new nutrition screening tool that is effective in detecting undernutrition risk early among the acutely ill renal patients in the acute care setting (hospital).

2.5 Approaches to Develop a Nutrition screening tool

There are different approaches that could be followed to develop a nutrition screening tool in an intended subject population and setting. The most logical, simplest and cheapest approach is to adapt an existing tool. This first step is by critically reviewing the literature to identify potentially relevant screening tools (Jones, 2004a). Once the most relevant screening tool is identified, it can be adapted to suit the intended subject population by considering opinions from both academic and clinical experts in the field as well as the practical and methodological issues of modifying this tool for such population (Jones, 2004a). Finally a validation study should be conducted to test the effectiveness and feasibility of this tool in relation to its suitability for the intended

subject population (Jones, 2004b, Jones, 2004a). An example of such an approach was the Four-Element Nutrition Screening tool (Bennett et al., 2005) that was adapted from nine known risk variables in the literature to detect haemodialysis patients who may be at risk of undernutrition (Chertow et al., 1996, Bergstrom, 1995). These nine risk variables were BMI, weight change, poor appetite, gastrointestinal symptoms, serum albumin, predialysis urea, predialysis serum potassium, predialysis serum phosphate and glycosylated haemodialysis levels, which were considered to be specific predictors of undernutrition among patients with renal failure (Chertow et al., 1996, Bergstrom, 1995). Bennett et al. (2005) found that four out of the nine risk variables showed the highest alpha reliability coefficient against the result of a full Standard Dietitian Assessment as described by Gower (2002). Therefore, these four risk variables, namely weight change, poor appetite, and serum potassium and serum phosphate levels, were incorporated into the Four-Element Nutrition Screening tool specifically for haemodialysis patients (Bennett et al., 2005). This is a good example on how to develop a nutrition screening tool by selecting the most suitable predictors for undernutrition in the intended subject population from existing risk variables identified in the literature and/or by experts in the field.

If no relevant tool exists or the deficiencies of existing tools severely limit their usefulness in the intended subject population, then clearly there is a need for the development of a new tool. The development of a new tool can be started by firstly identifying the risk variables for undernutrition in the intended subject population, followed by ranking the degree of association between these risk variables and undernutrition using predictive models, algorithms or scoring systems to determine the magnitude of undernutrition risk for each individual (Elia, 2003, de Aquino and Philippi, 2011). In general, risk variables employed to evaluate the undernutrition risk in adults are anthropometric, clinical and dietary data, which have been discussed and listed in the previous section. Risk variables that show the most significant association with undernutrition can then be identified by performing a multiple logistic regression. For instance, BMI, recent weight loss and any decline in food intake for more than five days due to acute illness were identified by Elia (2003) as the three risk variables associated with undernutrition. Hence, three questions examining these three factors are included

in the MUST screening tool (Elia, 2003). Although the methodological design of a study that uses a multiple logistic regression appears to be robust, this approach may require a relatively large sample size if the prevalence of undernutrition and the degree of association between each risk variable and undernutrition is low (Jones, 2004a). With a larger sample size, other resources such as a longer study period and extra funding may subsequently be required. Therefore, this may not be the most preferred approach to develop a new nutrition screening tool.

Another approach to develop a new nutrition screening tool is to count criteria in a list of nutritional screening questions to determine the best cut-off (Ferguson et al., 1999, Kruizenga et al., 2005a). The MST developed by Ferguson et al. (1999) in Australia adopted this approach by selecting two questions out of the 21 questions that were associated with undernutrition risk the most. These two questions focused on recent involuntary weight loss and reduction in food intake. The best cut-off point for involuntary weight loss in order to identify individuals at risk of undernutrition was determined by ranking the significance of association between different amounts of weight loss and the nutrition status of an individual, as evaluated by the SGA (Ferguson et al., 1999). Since the amount of weight loss was measured in kilograms by Ferguson et al. (1999), the question in the MST had been constructed to evaluate weight loss in kilogram rather than percentage body weight loss as in the other screening tools. This approach allows the screening tool to construct the most appropriate yet effective cut-off for a particular group of individuals in a specific setting. Thus this approach appears to be the most preferable when developing a new nutrition screening tool.

2.5.1 Risk variables associated with undernutrition in adults

Having discussed how to construct a nutrition screening tool, the format and areas covered within the screening tools are based on known risk variables for undernutrition. The European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines recommend that four risk variables (BMI, recent involuntary weight loss, food intake and disease process) should be considered when designing any nutrition screening tools particularly for hospitalised patients (Kondrup et al., 2003a).

- The **BMI** is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults (Kondrup et al., 2003a). Body mass index is calculated from weight and height using the following equation, BMI = Weight (kg) / Height^2 (m^2) (Eknoyan, 2008, Garrow and Webster, 1985). Undernutrition is defined by a BMI below 18.5 kg/m^2 and borderline underweight is between 18.5 and 20 kg/m^2 (Kondrup et al., 2003a).
- Any recent **involuntary weight loss** determines the stability of an indivdual's nutritional status (Kondrup et al., 2003a). More than 5% unintentional weight loss in the past three months is considered to be significant (Kondrup et al., 2003a).
- A **decrease in food intake** reflects the likelihood of the worsening of an individual's nutritional status (Kondrup et al., 2003a). This involves the assessment of an individuals' current dietary intake in relation to their usual dietary intake (Kondrup et al., 2003a), and ifcurrent food intake is less than usual, it is essential to consider the length and the degree of this decrease in food intake (Kondrup et al., 2003a). The continuation of decreased food intake may imply further weight loss, which may worsen their undernutrition status (Kondrup et al., 2003a).
- The **assessment of the disease process** may accelerate the decline of an individual's nutritional status (Kondrup et al., 2003a). Kondrup et al. (2003a) illustrates that severe diseases such as major surgery, sepsis, multi-trauma and cancer may stimulate a catabolic state in the body, resulting in rapid deterioration of nutritional status.

2.5.1.1 Determination of weight and weight Loss in a nutrition screening tool

Weight or Involuntary weight loss is considered to be the most significant risk variable associated with undernutrition (de Aquino and Philippi, 2011, Ferguson et al., 1999, Kruizenga et al., 2005a). Kruizenga et al. (2005a) found that hospital patients who had lost more than 6 kg body weight unintentionally in the past six months were 267% more likely to be malnourished in comparison to those without unintentional weight loss recently. A cross-sectional study conducted among 300 hospitalised adults in Sao Paulo, Brazil (de Aquino and Philippi, 2011) also indicated that the strongest predictor of

undernutrition was weight loss (OR = 58.03, 95% CI: 18.46-182.41, $p < 0.001$). Hence, the measurement of weight and the calculation of recent involuntary weight loss are essential indicators for recognising individuals at risk of undernutrition.

For many nutrition screening tools, the format for the determination of weight is the calculation of BMI (Rubenstein et al., 2001, Elia, 2003, Kondrup et al., 2003b). However, the measurement of height may become a problem amongst older people, frail or bed-bound individuals, as well as for those for whom a standing height may be impossible to obtain. These difficulties in obtaining height for BMI calculations may often result in a decrease in the efficacy of a screening tool. In fact, there is little evidence that BMI is a good predictor of undernutrition risk (Cohen et al., 2009, British Dietetic Association, 2003). The Imperial Nutritional Screening System (INSYST) that was newly developed by Tammam et al. (2009) does not require the calculation of BMI. When the nutrition risk of 61 hospitalised patients was assessed by the INSYST, MUST and the Mini Nutritional Assessment (MNA), the INSYST demonstrates a high agreement in the number of patients recognised as at risk of undernutrition in comparison to the MUST and MNA with the Kappa vales of $\kappa = 0.73$ and $\kappa = 0.76$, respectively (Tammam et al., 2009). Hence, this suggests that BMI is unnecessary to for recognising patients at risk of undernutrition. Alternatively the measurement of mid upper arm circumference (MUAC) is suggested as a surrogate indicator, since current weight and height may not always be accessible for acutely ill individuals in the hospital (Kondrup et al., 2003a). Powell-Tuck and Hennessy (2003) showed MUAC to correlate directly with BMI in undernourished patients. Also, for clinical purposes BMI can be approximated from regression equations derived from MUAC when patients cannot be easily weighed or their height measured. However, these equations are only applicable to a population similar to the study population from which the equations are derived.

In terms of weight loss, the MUST screening tool incorporates the measurement of the percentage of weight loss in the previous three to six months as one of the three compulsory questions to identify individuals at risk of undernutrition (Elia, 2003). However, whether the recent weight loss is involuntary or not is not specified in the screening tool. Hence, the individuals who are purposely trying to lose weight may be

mistakenly identified as at risk of undernutrition (Tammam et al., 2009). This is a result of a higher score contributed by the high percentage of intentional weight loss, which may not be relevant to undernutrition. In other words, an overweight or obese individual who has successfully lost a considerable amount of weight in the past three months under the instruction of doctors or dietitians has the potential to be recognised by the MUST tool as at risk of undernutrition. Hence, the risk of undernutrition should only increase when recent weight loss is involuntary and it is vital to specify this in the course of developing any screening tools.

2.5.1.2 Dry weight in adults with renal failure

Fluid retention is a major clinical problem in individuals with CKD, and is associated with morbid conditions such as lower extremity oedema, ascities, pulmonary vascular congestion, hypertension and worsening heart failure (Charra et al., 1996, Kraemer et al., 2006, Katzarski, 1996). Dry weight is an individual's body weight without the excess fluid that builds up between dialysis treatments, which is the lowest weight this individual can tolerate without the development of symptoms or hypotension (Henderson, 1980, Charra et al., 1996). Several different techniques have been used to derive a more standard method of assessing dry weight (Kouw et al., 1992, Lauster et al., 1990, Horejs et al., 1990, Kouw et al., 1993), such as using a bioelectrical impedance assessment. (Lawson et al., 2011). However, there are no reliable scientific ways of measuring dry weight (Jaeger and Mehta, 1999). In most cases, dry weight is an estimate determined by the medical team, based on an individual's weight when he or she has:

- Normal blood pressure,
- The absence of oedema or swelling,
- Neck veins that are not distended,
- The absence of lung sounds related to fluid overload,
- No shortness of breath or congestive heart failure,
- A normal size heart shadow on X-ray (Jaeger and Mehta, 1999).

To prevent misclassification of undernutrition risk, a dry weight should be used to determine the BMI of individuals with renal failure rather than a fluid-based weight

(Lawson et al., 2011). In a study conducted by Lawson et al. (2011), even though there was a strong correlation found between the results of BMI calculated using the fluid-based and dry weights ($n = 40$, $r = 0.986$, $p < 0.001$), the degree of recent weight loss was unable to be accurately established (Lawson et al., 2011). This is because only the dry weight at screening was obtained, none of the previous dry weights were provided or assessed (Lawson et al., 2011). This may not reflect the true unintentional weight loss without the previous dry weights as comparison. Since both MUST and MST employ recent weight loss as one of the determinants in recognising individuals at risk of undernutrition, Lawson et al. (2011) argue that the insensitivity of MUST and MST in renal patients may be due to the difficulty of identifying fluid-based weight loss compared to dry weight loss. Thus, it is essential to specifically state 'dry weight' for both the present and previous weights in the questionnaire when developing a renal specific nutrition screening tool.

2.5.1.3 Determination of food intake in a nutrition screening tool

Poor food intake due to a decreased appetite is regarded as an additional risk variable to involuntary weight loss (Ferguson et al., 1999, Kruizenga et al., 2005a, de Aquino and Philippi, 2011). Ferguson et al. (1999) found that both the sensitivity and specificity of the MST was greatly improved at recognising individuals at risk of undernutrition, by measuring both involuntary weight loss and inadequate food intake. Kruizenga et al. (2005a) also indicated that hospital patients who experienced a decreased appetite in the previous month, were 4.2 times more likely of developing undernutrition compared to those that did not experience any decrease in appetite. Hence, a recent reduction in usual food intake that lasted for more than five days appears to be an effective predictor of undernutrition risk, particularly in those that are hospitalised (Elia, 2003, Kruizenga et al., 2005a).

The format of a nutrition screening tool on assessing the adequacy of an individual's energy intake often employs a polar question whose expected answer is either a "yes" or "no" (Rubenstein et al., 2001, Kruizenga et al., 2005a, Ferguson et al., 1999, Elia, 2003, Kondrup et al., 2003b) . This polar question aims to recognise individuals with an

inadequate energy intake. The ways of identifying individuals with an inadequate energy intake vary among different screening tools. The MUST tool defines individuals with high risk of undernutrition as “no food intake for more than five days” (Elia, 2003). The MST tool on the other hand classifies individuals at risk of undernutrition only if they have been eating poorly in combination with involuntary weight loss of less than five kg in the past six months (Ferguson et al., 1999). The criteria for poor eating is specified by the MST tool as consuming less than three quarters of usual intake (Ferguson et al., 1999). However, the NRS 2002 screening tool appears to be the only one of the many quick-and-easy screening tools that stratifies the risk of undernutrition into three categories according to the proportion of reduction in food intake in comparison to normal requirement (Kondrup et al., 2003b). Individuals consuming between three quarters and half of normal requirements is categorised as at low risk of undernutrition (Kondrup et al., 2003b). Individuals consuming between half and one quarter of normal requirement may be at moderate risk if they also had a more than 5% weight loss in the past two months or a BMI between 18.5 and 20.5, whereas high risk of undernutrition may be identified in those with a food intake less than one quarter of normal requirements (Kondrup et al., 2003b). Moreover, the causes of this decreased food intake described in the screening tools differ from one another. For example, the MST and the MNA-SF interpret the decline in food intake as a result of a decreased appetite, digestive problems or difficulties with chewing and swallowing (Ferguson et al., 1999, Rubenstein et al., 2001). Whereas the MUST tool generalises it as caused by any acute diseases (Elia, 2003). In addition, Kruizenga et al. (2005a) discovered that hospital patients who had been on nutritional supplements during the previous month were 4.3 times more likely to be malnourished as opposed to those who were not. Subsequently, the intake of nutritional supplements via either oral or enteral route was incorporated in the SNAQ tool as a risk variable for undernutrition (Kruizenga et al., 2005a).

2.5.1.4 Additional considerations for the determination of undernutrition risk

Apparent bony structure, diarrhoea, age, male sex, being single, divorced or widowed and being a smoker, were also significantly associated with undernutrition (de Aquino

and Philippi, 2011, Amaral et al., 2010). It is interesting to note that illiteracy was also found to be associated with an increased risk of undernutrition (OR: 2.45, CI: 1.52-3.96) (Amaral et al., 2010). However, the associations of these risk variables were considerably smaller compared to involuntary weight loss and inadequate food intake (Amaral et al., 2010).

2.5.2 Incorporation of biochemical measures in a nutrition screening tool

Although Green and Watson (2005) identified 71 different nutritional screening and assessment tools published worldwide, merely 10% of these tools actually incorporated the use of biochemical measures. Serum albumin levels have been used in combination with anthropometric measures to predict the risk of undernutrition (Buzby et al., 1988a, Buzby et al., 1988b, Elmore et al., 1994, Naber et al., 1997). The Nutrition Risk Index (NRI) that was first described by Buzby et al. (1988a, 1988b) to classify the severity of postoperative complications, combines two nutritional indicators, serum albumin and present weight loss compared to usual weight. Naber et al. (1997) later adopted it to be used as a predictive equation [(1.489 X albumin) + (41.7 x present/usual weight)] for the detection of undernutrition among apparently healthy adults. The Nutrition Risk Index classifies the nutritional status of these hospitalised participants into four categories: no undernutrition, mild, moderate or severe undernutrition (Naber et al., 1997). Six percent of the healthy participants aged over 70 years were identified as mildly malnourished by the NRI index (Naber et al., 1997). However, this study did not investigate the effectiveness of the NRI index in recognising undernutrition among malnourished individuals (Naber et al., 1997). Similarly, another predictive equation integrating the percentage of weight loss with the levels of serum albumin and total lymphocyte count was developed by Elmore et al. (1994). In this study, serum albumin level less than 35 g/L was considered as a major determinant for undernutrition risk (Elmore et al., 1994). The inclusion of the albumin level improved the sensitivity and the negative predictive value of the predictive equation when compared to the standard nutrition screening (Elmore et al., 1994). Nevertheless, this equation failed to identify 9% of patients who should have been recognised as at high risk (Elmore et al., 1994). The authors consequently concluded that the levels of serum albumin may be a sensitive marker of

clinical condition but one not necessarily being specific to undernutrition (Elmore et al., 1994).

2.5.2.1 Biochemical measures in adults with renal failure

The use of biochemical measures has also been investigated to identify renal patients at risk of undernutrition (Gower, 2002, Elliott and Robb, 2009) . Studies considering the effectiveness of biochemical measures are summarised in Table 2.4.

Table 2.4 A summary of studies investigated the undernutrition criteria for objective measures in adults with renal failure

References	Subject and setting	Undernutrition criteria for objective measures	Comments
(Tai et al., 1998)	213 outpatient dialysis facilities	Serum albumin < 35 g/L Serum urea < 16 mmol/L Serum potassium < 3.4 mmol/L Serum phosphorus < 0.9 mmol/L	Dietitians' perspective on the identification of undernutrition
(Gower, 2002)	184 HD, outpatient facilities	Kt/V < 1.1, pre-dialysis urea <20 mmol/L, phosphate < 0.75 mmol/L, potassium < 3.3 mmol/L, 10% weight loss	The objective measures identified 36% of HD patients at risk of undernutrition, compared with 42% by SDA.
(Elliott and Robb, 2009)	122 HD, outpatient facilities	Pre-dialysis serum urea < 15 mmol/L ($p < 0.001$), Serum albumin < 35 g/L ($p < 0.001$), CRP > 10 mg/L ($p = 0.005$), Weight loss over three months >5% ($p < 0.001$)	Significantly correlated with SGA

HD, haemodialysis patients; SDA, standardised dietetic assessments; CRP, C-reactive protein.

p value < 0.05 indicates statistical significance.

Serum albumin, serum urea, serum potassium and serum phosphorus were firstly reported to be the most frequently used biochemical measures by the dietitians working in the dialysis facilities in Texas to identify renal patients at risk of undernutrition (Tai et al., 1998). This survey indicates that the cut-offs for undernutrition perceived by the facility dietitians were serum albumin levels <35 g/L, serum urea levels <16 mmol/L, potassium <3.4 mmol/L and phosphorus <0.9 mmol/L (Tai et al., 1998). Not only did these cut-offs not take into consideration the effects of age, ethnicity and sex on the likelihood of increased undernutrition risk, but the survey was merely an observational study reporting the renal dietitians' perspective on the identification of undernutrition. Hence, more studies were warranted to further evaluate the criteria for biochemical measures indicating the risk of undernutrition.

Since low pre-dialysis serum urea levels may indicate a decreased protein intake while low serum phosphate and potassium levels may suggest episodes of severe diarrhoea, vomiting, and/or a reduction in oral intake, these biochemical measures could be useful in identifying dialysis patients at risk (Goldstein, 1998). In 2002, Gower (2002) investigated the feasibility of using objective measures including percentage weight loss and four biochemical measures (Kt/V – dialysis adequacy, pre-dialysis serum urea, phosphate, and potassium) to identify undernutrition in 184 haemodialysis outpatients. However, the percentage of haemodialysis patients at undernutrition risk identified by these objective measures (36%) was observed to be lower than the 42% of patients identified using the standardised dietetic assessments (SDA) by experienced dietitians (Gower, 2002). The SDA was considered by the author as a reference method in identifying the nutritional status of the participants (Gower, 2002). The author concluded that these objective measures were not specific enough to accurately recognise all haemodialysis patients at undernutrition risk (Gower, 2002). In 2009, senior renal dietitians at the Royal Infirmary of Edinburgh, Scotland, Elliott and Robb (2009), continued to define the undernutrition criteria for these objective measures in recognising haemodialysis patients at risk of undernutrition. They found that pre-dialysis serum urea < 15 mmol/L, albumin < 35 g/L and C-reactive protein (CRP) > 10 mg/L and > 5% weight loss over three months were significantly correlated with SGA (Elliott and Robb, 2009). Although more studies are required to investigate the effectiveness of

these biochemical measures on other renal populations such as peritoneal dialysis patients or patients at different kinds and stages of renal failure, biochemical measures, particularly serum urea and albumin, appear to be effective in identifying haemodialysis patients at risk of undernutrition.

In summary, the screening of renal patients at risk of undernutrition should incorporate multiple factors impacting on nutritional status. In another words, an effective nutrition screening tool should include both biochemical measures and body composition parameters. This may explain the insensitivity of MUST and MST in identifying renal patients at risk of undernutrition due to the lack of renal specific biochemical measures. As Elliott and Robb (2009) observed, combining serum urea, albumin and CRP with percentage of weight loss may enhance the sensitivity and specificity of a nutrition screening tool in renal patients.

2.6 Approaches to validate a nutrition screening tool

The validity of a nutrition screening tool is determined by comparing its ability at recognising individuals at risk of undernutrition against the assessment of one's nutritional status (Elia, 2003, Kruizenga et al., 2005a, Ferguson et al., 1999). The definitions of various types of validity are summarised in Table 2.5.

Table 2.5 Definitions for different types of validity

Types	Definition
Face validity	Assess the extent to which a nutrition screening tool is subjectively viewed as covering the concept it purports to measure (Holden, 2010).
Content validity	Explores the relevance and completeness of a nutrition screening tool's content to its targeted construct (Haynes et al., 1995, Jones, 2004b) and usually requires expert review (DeVellis, 2012).
Construct validity	Focuses on the extent to which a measure performs in accordance with theoretical expectations (Jones, 2004b, Remler and Van Ryzin, 2011).
Criterion validity	Evaluates agreement and performance (sensitivity/specificity) of the tool, against a valid, gold standard reference measure (Chassany et al., 2002)
Clinical validity	Explores the relationship that exists in known parameters associated with nutrition status, but not used in the tool. Validity is then only established against the parameter within that investigation (Chassany et al., 2002)
Predictive validity	Explores the correlation with another measure assessed in the future (e.g. morbidity and mortality) (Chassany et al., 2002)

If a nutrition screening tool is to be used in a different care setting or patient group, the effectiveness of this screening tool in this different care setting and patient group will require further validation prior to implementation. Criterion validity evaluates the sensitivity and specificity of the screening tool against a valid, gold standard reference measure in order to determine the agreement and performance of the tool as to the reference measure (Chassany et al., 2002).

There are three main reference measures employed by researchers to determine the criterion validity of these screening tools.

- The first measure is using the diagnostic criteria of undernutrition including the measurements of BMI and percentage of involuntary weight loss (FAO/WHO/UNU, 1985, Lochs et al., 2006). Kruizenga et al. (2005a) assessed the nutritional status of 291 hospitalised patients using the classification of well nourished (<5% weight loss in the last 6 months and BMI >18.5), moderately malnourished (5–10% weight loss in the last 6 months and BMI >18.5) or severely malnourished (>10% weight loss in the last 6 months or >5% in the last month or BMI <18.5). This classification was then used as a reference method to validate the 26 questions related to dietary intake and disease conditions (Kruizenga et al., 2005a). A set of questions that was the most associated with the reference method based on the results of odds ratio, binary and multinomial logistic regression was selected into the screening tool, which is believed to best predict the nutritional status of this group of patients (Kruizenga et al., 2005a).
- The second reference measure is the SDA. The components of SDA can be different from one study to another. It is dependent on the characteristics of the intended patient group and care setting within which the screening tool will be implemented. The SDA generally include all aspects of normal dietetic clinical assessment, such as anthropometry, biochemistry, clinical conditions, dietary intake, medications and psychosocial issues (Harris et al., 2008, Bennett et al., 2006).
- The last reference measure that has been widely adopted is the SGA (Detsky et al., 1987). Subjective Global Assessment has been validated across a broad range of care settings including adults in acute care settings and older adults in rehabilitation, residential aged care and community settings (Baker et al., 1982b, Baker et al.,

1982a, Detsky et al., 1987, Duerksen et al., 2000, Sacks et al., 2000, Christensson et al., 2002). Although there are many versions of the SGA since it was first developed to suit various care settings and patient groups, the essence of the assessment remains intact.

2.6.1 Validity of Nutritional Assessment Tools in Adults with Renal Failure

The validity of the 7-point SGA in determining the nutritional status of dialysis patients has been well demonstrated (Churchill et al., 1996, Jones et al., 2004, Steiber et al., 2007, Visser et al., 1999).

- The criterion validity of the 7-point SGA was investigated by Jones et al. (2004) in 72 haemodialysis patients. The reference measure used to validate this modified tool is a composite nutrition score described by Harty et al. (1994) including a 3-day food diary, anthropometric parameters (dry weight, BMI, triceps skinfold thickness and mid arm muscle circumference), SGA score and serum albumin (Jones et al., 2004). Jones et al. (2004) found that the 7-point SGA score was significantly associated with all of the components in the composite nutrition score except for serum albumin. This may be due to the non-specificity of low serum albumin to undernutrition (Elmore et al., 1994). Conversely, there were three misclassifications, where patients with undernutrition scores assessed by the composite nutrition score were recognised as well nourished by the 7-point SGA score. There is also overlap between the 7-point SGA scores and the composite nutrition scores observed in the midrange of nutritional status (Jones et al., 2004). However, the 7-point SGA was demonstrated to have good discrimination of composite nutrition scores between patients with the most abnormal and normal (Jones et al., 2004). As a consequence, the 7-point SGA appears to be effective in distinguishing between haemodialysis patients who are well nourished or malnourished.
- The clinical validity of the 7-point SGA has also been considered in three studies (Churchill et al., 1996, Steiber et al., 2007, Visser et al., 1999). Clinical validity explores the relationship between the proposed tool and known parameters indicating nutritional status not included in the tool (Chassany et al., 2002). When the clinical validity of the 7-point SGA was first examined in 680 renal patients

starting peritoneal dialysis by Churchill et al. (1996), they found that higher SGA scores were significantly associated with greater percentage of lean body mass, increased serum albumin levels and increased adequacy of dialysis, which was estimated by greater measurements of weekly dialysis adequacy (Kt/V) for urea, total weekly creatinine clearance and serum beta-2-microglobulin. The 7-point SGA was also found to be correlated with BMI ($r = 0.79$, $p < 0.001$), percentage of body fat ($r = 0.77$, $p < 0.001$), mid arm circumference ($r = 0.71$, $p < 0.001$), and mid arm muscle circumference ($r = 0.38$, $p = 0.09$) among 22 dialysis patients - 13 haemodialysis and 9 peritoneal dialysis (Visser et al., 1999). In this study, only serum pre-albumin was reported to be significantly associated with the scores of the 7-point SGA by Visser et al. (1999). The authors also found that the reliability of the 7-point SGA was not attenuated by increasing the number of classifications of nutritional status in order to enhance the ability to detect smaller changes (Visser et al., 1999). It was suggested to completing the 7-points SGA by the same observer or a select group of observers because of the higher intra-observer reliability (0.88) compared to inter-observer reliability (0.72) (Visser et al., 1999). The clinical validity of the 7-point SGA in haemodialysis patients was demonstrated by Steiber et al. (2007) through statistically significant differences in mean BMI and serum albumin across five classifications of SGA from 3 to 7.

The predictive validity of 7-point SGA has also been investigated (Churchill et al., 1996, De Mutsert et al., 2009). Predictive validity explores the relationship between the assessment or screening tool and another measure assessed in the future, for example, mortality and length of hospital stay (Chassany et al., 2002). Churchill et al. (1996) reported that every unit decrease in the 7-point SGA score was significantly associated with a 25% increase in mortality, whereas every one unit increase in the SGA score predicted 18% less time spent in the hospital. De Mutert and colleagues (2009) also found a dose-dependent response of the 7-point SGA with mortality. This means that a decrease of every one-point of the SGA score was associated with a higher mortality risk (De Mutsert et al., 2009). Since all four subscales in the 7-point SGA were associated with mortality individually, the authors suggested that all four components in the SGA were significant to the assessment of nutritional status in dialysis patients (De Mutsert

et al., 2009). Nevertheless, the lengths of follow-up in both studies were considerably short even though the follow-up period in the study of Churchill et al. (1996) was two to three years. Hence, a longer term of follow-up period is required to determine the true predictive validity of the 7-point SGA.

The clinical and criterion validity of the PG-SGA was initially considered in 60 haemodialysis patients by Desbrow et al. (2005). A PG-SGA score <9 showed a sensitivity of 83% and a specificity of 92% at predicting the classification of original SGA, indicating a good criterion validity (Desbrow et al., 2005). The PG-SGA score was also significantly associated with serum albumin, which shows good clinical validity (Desbrow et al., 2005). However, there was no association between PG-SGA score and BMI or anthropometric measures including the corrected arm muscle area and triceps skinfold (Desbrow et al., 2005). Since the anthropometric measures are reported by patients, the lack of association between PG-SGA score and actual anthropometric measures implies that results reported by patients might not necessarily represent the true anthropometric measurements. As this is the only published study conducted in renal patients, more studies are required to further investigate the validity of PG-SGA in assessing the nutritional status of renal patients.

Although the clinical and predictive validity of both DMS and MIS have been examined in these studies, the criterion validity of them in assessing nutritional status was not considered (Kalantar-Zadeh et al., 1999, Kalantar-Zadeh et al., 2001, Kalantar-Zadeh et al., 2004b). Hence, they may not be appropriate to be used to validate a screening tool in this patient group. Moreover, published data on the validity of MIS on the detection of undernutrition in peritoneal dialysis patients are limited. In a cross-sectional study by Chan et al. (2007), the MIS showed a modest correlation with the 7-point SGA score in 165 peritoneal dialysis patients (r = -0.667, P < 0.001). This means only less than 50% of the variability in the MIS could be explained by the SGA, even though the components in the SGA are largely included by the MIS. Cheng and colleagues (2009) also reported a moderate agreement between the 7-point SGA and MIS in recognising changes in the nutritional status of 59 peritoneal dialysis patients over a 12-month period. Therefore, MIS may not be the most appropriate reference measure to be used on the acute renal

wards that encompass a variety of renal patients with acute illness. The 7-point SGA appears to be the more suitable reference measure to evaluate the nutritional status for this patient group.

2.6.2 Handgrip strength assessing nutritional status of adults

Although the 7-point SGA has undergone rigorous testing for validity, reliability, specificity, and sensitivity, no reference method provides a true measure of an individual's nutritional status (Churchill et al., 1996, Jones et al., 2004, Visser et al., 1999). Instead, the extent of the agreement between the test and reference method is used to demonstrate the relative validity of the test method, as well as the extent to which the reference method is believed to yield the truth (Gibson, 2005). If the 7-point SGA is used as a reference method to assess the nutritional status of each renal inpatient against the newly developed screening tool, a good agreement between the results obtained from the proposed tool and reference method does not necessarily indicate validity as it may only reveal similar errors in both methods. (Gibson, 2005). Hence, an approach using biomarkers or functional markers is developed to validate the nutrition screening tool that is independent of the measurement of nutritional status (Gibson, 2005).

In this case, handgrip strength (HGS) may be used as an independent reference measure, because one of the best indicators of undernutrition is the measurement of muscle reserves and function (Carrero et al., 2008, Heimbürger et al., 2000). Handgrip strength has been demonstrated to be a reliable method to evaluate skeletal muscle function in healthy adults (Schlüssel et al., 2008a), but also as a monitoring parameter in surgical patients (Bohannon, 2001), and as one of the determinants for recurrent fall falls in older adults (Stalenhoef et al., 2002).

2.6.2.1 Validity of handgrip strength in adults with renal failure

The handgrip strength of 115 patients with chronic renal failure aged younger than 70 years close to the start of dialysis were measured by a dynamometer (Heimbürger et al.,

2000). The authors found that the mean HGS values of well nourished patients, 43.5 ± 8.0 kg for males and 27.7 ± 6.3 kg for females, were higher than the malnourished ones, 29.2 ± 11.2 kg for males and 20.6 ± 5.8 kg for females, given the nutritional status was defined by the SGA results (Heimbürger et al., 2000). Comparably, Stenvinkel et al. (2002) reported that the mean HGS values of well nourished pre-dialysis patients were significantly higher than those categorised by SGA as malnourished for both male (42 ± 1 vs. 25 ± 2 kg) and female (29 ± 2 vs. 20 ±1 kg). This observation may be due to the HGS being greatly correlated with lean body mass (LBM) (Heimbürger et al., 2000, Stenvinkel et al., 2002, Wang et al., 2005, Jones et al., 1997). Since LBM responds earlier to nutritional deprivation and restoration, a reduction in LBM is an early marker of undernutrition as well as a useful tool for monitoring nutritional intervention in adult patients (Thibault and Pichard, 2012, Kerr et al., 1996, Norman et al., 2009). The significant correlation between HGS and LBM in renal patients closer to dialysis was first observed by Heimbürger and colleagues (2000) and confirmed by Stenvinkel et al. (2002). The values of LBM in both studies were determined by dual-energy x-ray absorptiometry (DXA), which is considered the most reliable method to evaluate LBM (National Kidney Foundation, 2000, Kerr et al., 1996). For patients on peritoneal dialysis, HGS was also showed to be strongly correlated with LBM estimated according to creatinine kinetics (Wang et al., 2005, Jones et al., 1997). Hence, HGS appears to be a reliable tool to measure the LBM of individuals with renal failure.

The predictive validity of HGS was investigated by Stenvinkel et al. (2002) and found that HGS is an effective predictor of outcome in male pre-dialysis patients only. Whereas Wang et al. (2005) argues that HGS may be a better predictor for morbidity and mortality to cardiovascular disease with decreased muscle function regardless of gender since correlation of other nutritional parameters used in their study including serum albumin, SGA and LBM did not reach significance.

When comparing HGS to other nutritional parameters, Heimbürger et al. (2000) found that well nourished pre-dialysis patients evaluated by SGA performed significantly better in the HGS test and had greater LBM compared to those classified as malnourished by SGA. Conversely, no correlation was reported by Heimbürger et al. (2000) between

serum albumin level and HGS. This was in line with a previous study conducted by Jones et al (1997) showing no correlation found between HGS and serum albumin levels or any other nutritional index in patients undergoing continuous ambulatory peritoneal dialysis. In contrast, Wang and colleagues (2005) observed that HGS was significantly associated with serum albumin levels ($r = 0.237$, $p < 0.001$) and SGA ($r = - 0.20$, $p = 0.002$).

Despite it being evident that HGS is a simple and non-invasive measurement to assess muscle function in renal patients without the influence of inflammation, there are some limitations of the HGS test. Firstly, HGS values for renal patients were associated with sex and age (Schlüssel et al., 2008a). Stenvinkel and colleagues (2002) reported that there was a sex difference in both HGS and LBM among these patients, however, no significant differences were observed in serum albumin levels and the prevalence of undernutrition assessed by SGA between male and female patients. In regards to age, Qureshi et al. (1998) indicated that HGS was negatively correlated to age ($r = −0.54$, $p < 0.001$) and % HGS values from controls were significantly higher in patients under 65 years of age (70.2 ± 24.5%) as opposed to those over 65 (45.2 ± 23%). Hence, differences in sex and age of the participants should be adjusted when analysing the results of HGS. Schlüssel et al. (2008a) stated that HGS increased with age and significantly declined after 40 and 50 years of age for both healthy women and men, respectively.

Secondly, the diagnostic criterion for muscle depletion estimated by HGS for renal patients requires further investigation (Schlüssel et al., 2008a, Schlüssel et al., 2008b). Schlüssel et al. (2008a) attempted to establish the reference values for healthy populations by measuring the HGS of 3050 Brazilian adults. The mean values of right and left HGS for males were reported to be 42.8 and 40.9 kg, and 25.3 and 24.0 kg for females, respectively. However, it is extremely difficult to establish the reference values for the HGS in very specific disease states, as it requires a large sample size (Schlüssel et al., 2008a). Moreover, the HGS of populations with renal disease, even for those that are well nourished, are believed to be less than their healthy counterparts. For example, the HGS in both well nourished men (45 ± 8 kg, $P < 0.0001$) and women (28 ± 6 kg, $P < 0.0001$) were less than healthy controls of similar age and body size (Heimbürger et al., 2000). Nevertheless, the reference values of HGS specifically for renal patients was

lacking in the literature. Hence, it is essential to take this difference into consideration when interpreting the result of HGS in renal patients. The need to define the cut-off point to categorise muscle wasting is also warranted. In addition, the procedure used to measure HGS varies among studies. The most common measuring procedure is to assess HGS in both the dominant and non-dominant arm using a mechanical dynamometer three times on each, and the greatest value was recorded (Heimbürger et al., 2000, Stenvinkel et al., 2002). Data from the dominant arm were used in the analysis in these two studies to accommodate haemodialysis patients who had an arteriovenous fistula in their non-dominant arm (Heimbürger et al., 2000, Stenvinkel et al., 2002). On the other hand, Wang et al. (2005) only measured the HGS on the non-dominant hand. This may have been due to the characteristics of the participants investigated, as they were peritoneal dialysis patients where an arteriovenous fistula on the arm is not often required. A standard operating procedure that has been validated should be followed for each measurement to reduce inter- and intra-reliability.

2.7 Conclusion

The number of people with renal failure is increasing worldwide. In New Zealand, the hospitalisation rate of people with renal failure is high in Māori and Pacific Island populations especially in CMDHB, which is disproportionate in relation to the remaining New Zealanders. There is increasing evidence that people with renal failure are more prone to undernutrition, which can ultimately lead to increased morbidity and mortality if left untreated. Nutrition screening that is administered by any healthcare professionals on admission can effectively identify patients at risk of undernutrition so that timely and appropriate dietetic interventions can take place. Nevertheless, data on the prevalence of undernutrition in renal patients on the acute wards are lacking in the literature. A validated nutrition screening tool is also required to be developed and implemented specifically for this patient group.

Chapter Three

3. Methodology

3.1 Introduction

This research study commenced with the development of a renal nutrition screening tool (R-NST), followed by an investigation of the validity and feasibility of the new R-NST in identifying adult renal inpatients at risk of undernutrition. The objective of this chapter is to present the study design, method, setting of the study and procedures used to carry out the investigation.

3.2 Study design

A prospective, blind comparison to a gold standard study design was used to validate the newly developed R-NST for adult renal inpatients (see Figure 3.1). The seven-point SGA was considered to be an acceptable gold standard as a diagnostic method of undernutrition among individuals with renal failure (Levey et al., 2002), and has been validated in dialysis patients by Visser and colleagues (1999). The handgrip strength of each participant was measured by a validated hand dynamometer as an independent functional indicator of undernutrition to the SGA. Participants recruited from the acute renal ward (Ward One) at MM Hosp were screened by the research assistants using the newly developed R-NST and assessed by the researcher using the seven-point SGA and the hand dynamometer. Training on using the R-NST was undertaken with the research assistants, who worked alongside the researchers during the entire data collection period. However, the researchers were blinded to the results of the R-NST administered by the research assistants. The same researcher performed the SGA on all the participants in order to reduce inter-individual variability. Each participant was their own control. After implementing this R-NST on ward level, the undernutrition risk of each participant was assessed using the R-NST by both the nursing staff and research assistants. The performance of nursing staff on completing this newly developed R-NST

was also evaluated, as well as their acceptability of implementing the R-NST by using a two-page written survey with seven questions.

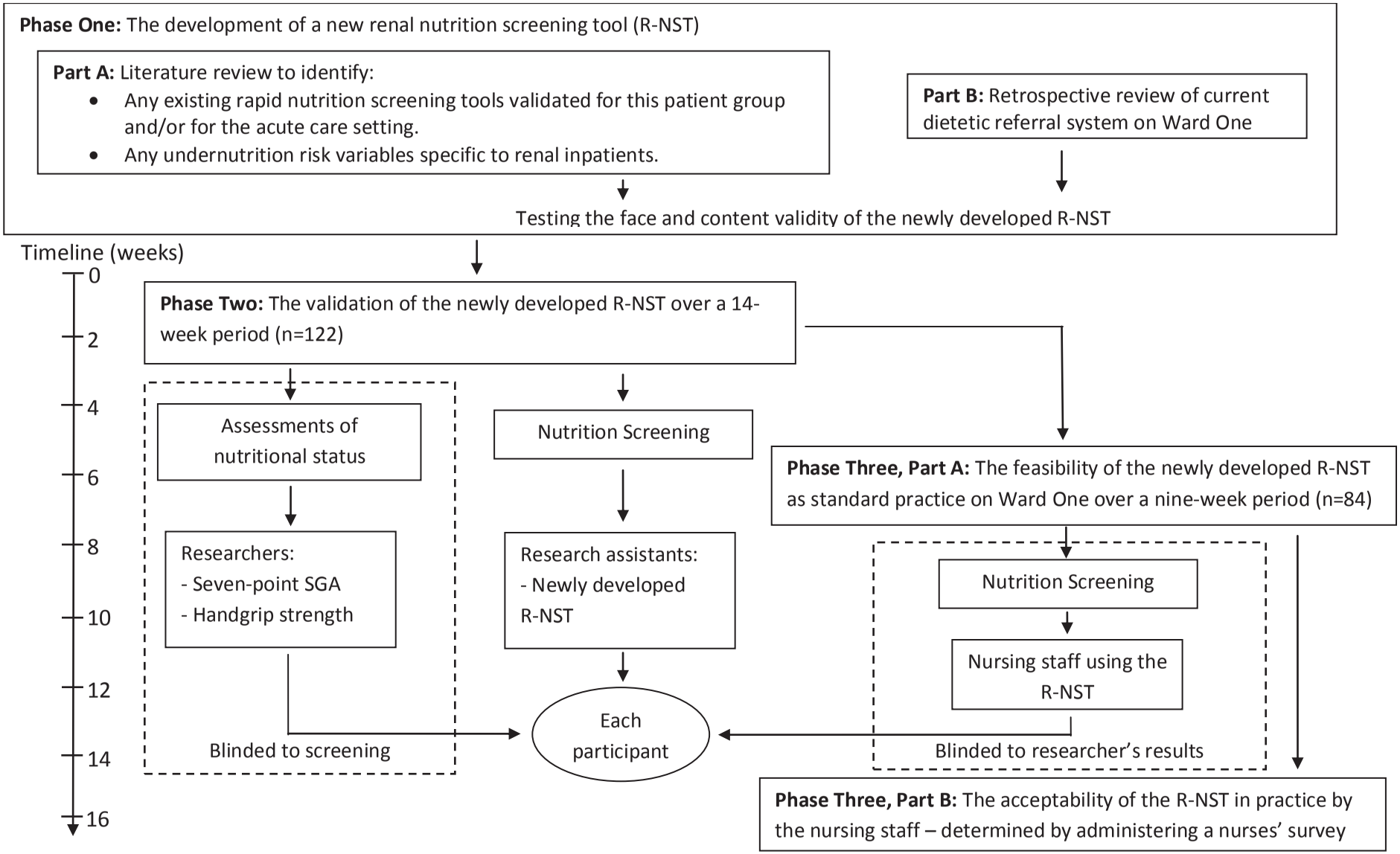


Figure 3.1 Research Design

3.3 Ethics approval

Ethical approval was obtained from the Health and Disability Ethics Committees: Northern A (Application 13/NTA/1), and in accordance with this the participants gave informed consent to participate in the research study. Counties Manukau District Health Board (CMDHB) organisational approval (Research Registration Number: 1431) and approval from renal services were sought to recruit participants from the acute renal ward (Ward One), MM Hosp. Approval from Counties Manukau Māori Research Review Committee was also obtained. The research study has also been registered in the Australian New Zealand Clinical Trials Registry (Registration Number: ACTRN12613000318785).

3.4 Participants

The research study was conducted in the acute renal ward (Ward One), MM Hosp, Auckland, New Zealand. Ward One is a 20 bed ward that provides observation, diagnosis and treatment for adult patients with renal disease. The participant recruitment was aimed at any adult renal patients who were admitted to Ward One regardless of sex or ethnicity.

The inclusion criteria for this research study were patients older than 18 years of age with the following diagnosis:

- Acute kidney injury,
- Chronic renal failure,
- Established renal failure (on haemodialysis, peritoneal dialysis or transplant).

Exclusion criteria were patients with:

- Terminal illness,
- Being unconscious,
- Emergency situations (e.g. medically unstable),

- Inability to consent for themselves (due to learning disabilities, mental illness or dementia).

3.4.1 Participant recruitment

Participants were recruited from patients who were admitted to the acute renal ward (Ward One) on a daily basis. A list of patients that complied with the inclusion and exclusion criteria was compiled on weekdays over a period of 14 weeks. Eligible patients were visited by researchers or research assistants according to the list and availability within the ward activities. Each patient was first greeted and their identity was verified. Permission was sought to briefly explain the purpose of the research study. The participant information sheet (see Appendix A) was then provided to them to read in their own time. They were also encouraged to discuss the research study with other people, such as family, whānau, friends or healthcare providers. On return to the patient any questions they may have had regarding the research study were answered. Once they agreed to participate in the research study, a written consent (see Appendix B) was obtained from the participants. Participants were assigned sequentially to the research study with a study number.

3.5 Study process

The research study was carried out in three phases (see Figure 3.2).

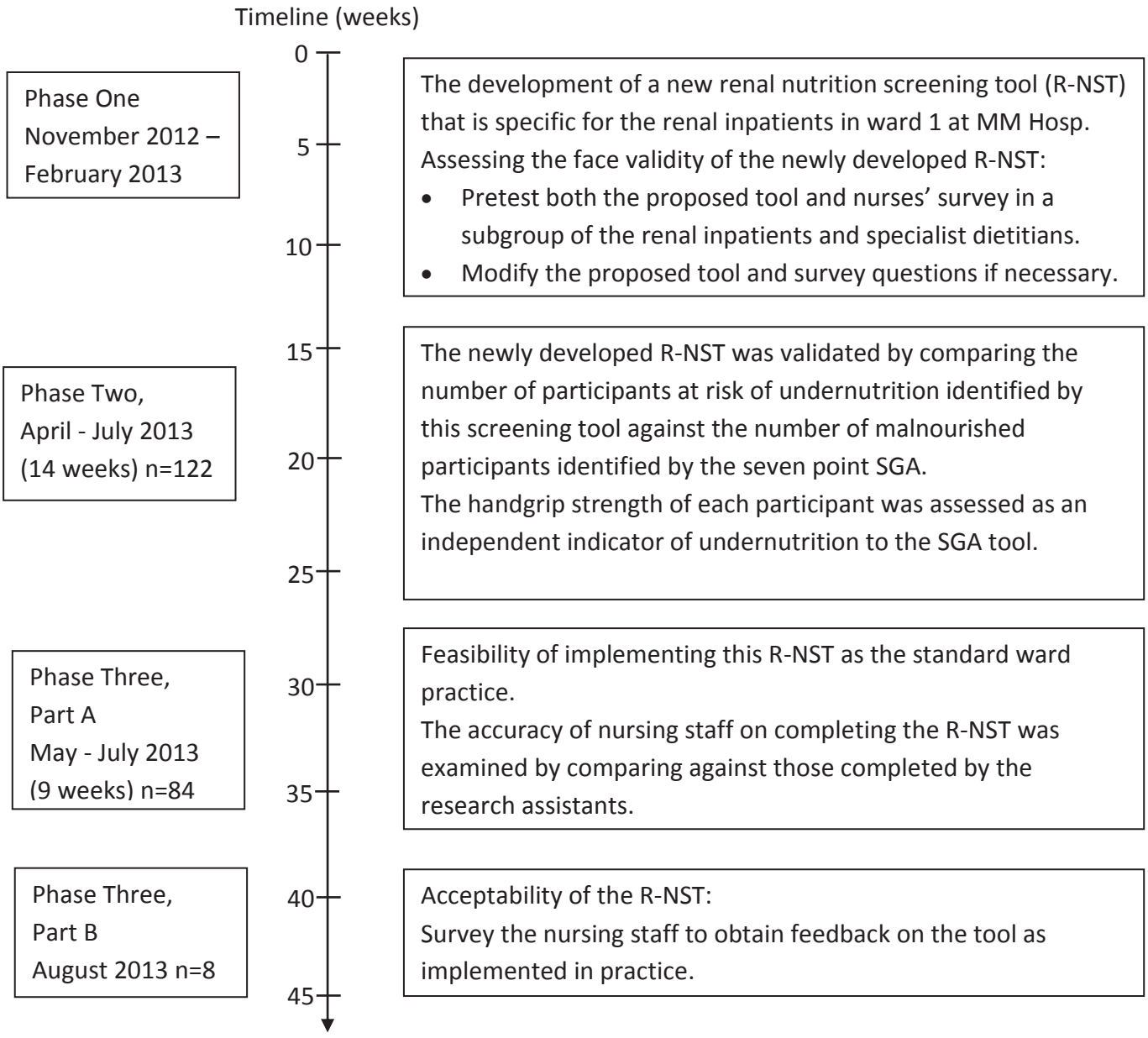


Figure 3.2 Flowchart detailing the study process

3.5.1 Phase One – The development of a new R-NST

Phase one occurred off-site and included several investigations to facilitate the development of a rapid nutrition screening tool specific to renal patients in the acute care setting. A literature search was carried out to identify any existing rapid nutrition screening tools that have been validated for this particular population group and/or for the acute care setting. The screening tools that had been identified to be effective in detecting renal patients at risk of undernutrition were the Geriatric Nutritional Risk Index (GNRI) (Szeto et al., 2010, Yamada et al., 2008), MUST and MST (Lawson et al., 2011). However, the GNRI was only validated among dialysis patients in an outpatient setting; it has yet to be validated in an acute care setting. Therefore, the GNRI may be inappropriate to be adopted for the patient group in the present research study. Conversely, both MUST and MST have shown good validity and reliability in patients in acute care settings (Elia, 2003, Kyle et al., 2006, Stratton et al., 2004, Stratton et al., 2006, Ferguson et al., 1999, van Venrooij et al., 2007). Moreover, both the MUST and the MST had been trialled in renal patients in the acute care setting by Lawson et al. (2011). Although they are both developed to be administered by the nursing staff, the MUST requires more time and skills from nursing staff due to measuring weight and height, calculating body mass index (BMI) and percentage unintentional weight loss and evaluating disease severity (Elia, 2003). In contrast, the MST is developed for nursing staff to screen the nutritional status in a quick and easy way as it features easy questions that are most predictive of undernutrition (Ferguson et al., 1999, van Venrooij et al., 2007). In a study comparing the effectiveness between quick-and-easy screening tools and more comprehensive screening tools, the Malnutrition Screening Tool appears to perform as well as the MUST (Neelemaat et al., 2011). Neelemaat and colleagues (2011) suggested that each hospital should implement the most appropriate screening tool for its setting. Since the aim of this research study was to develop a rapid nutrition screening tool that could be administered by the nursing staff, the Malnutrition Screening Tool was chosen instead of the MUST. Nevertheless, Lawson et al. (2011) found the MUST and MST to be insensitive in detecting undernutrition risk among renal inpatients. Therefore, the evaluation of both involuntary weight loss and eating behaviour alone do not appear to be effective enough in recognising undernutrition risk

among this particular patient group. Hence, specialist renal dietitians in both academic and clinical settings were consulted. Other nutritional measures that are specific to renal patients such as renal specific biochemical markers for undernutrition were incorporated into the screening tool.

A retrospective review to investigate the current dietetic referral system on Ward One was conducted by the researchers within a twelve week period from November 2012 to February 2013. Historical statistics and information from a service perspective were collected. These included:

- The number of renal patients from Ward One who had been referred to the Nutrition and Dietetic Services,
- The routes of these dietetic referrals (via fax, pager or verbal) and from whom (e.g. nursing staff, the ward dietitian or other healthcare professionals on the ward),
- The reasons for referral,
- The nutrition diagnosis of each referred patient and the number of inappropriate referrals.

This audit was conducted to obtain background information regarding the current dietetic referral system aiming to facilitate the development of the R-NST.

The new R-NST (see Appendix C) was developed by utilising some of the content of the MST (e.g. weight and appetite) and incorporating best practice dietetic content (e.g. using specific biochemical measures) to achieve all the outcomes aimed for. These outcomes are identifying renal inpatients at risk of undernutrition or requiring dietetic input due to their renal conditions. The R-NST consists of nine questions, which must be completed in three steps. Among the three steps, there are two pathways to generate a dietetic referral indicating undernutrition risk.

The first pathway to generate a dietetic referral is when the total score in Step one reaches three points or more. Step one consists of five compulsory questions (question one to five). It not only contains determinants which are the most predictive of undernutrition (e.g. recent involuntary weight loss and change in eating behaviour), but

also includes renal specific nutrition indicators (e.g. serum phosphate and potassium and episodes of peritonitis) that required timely dietetic input. While the MST has a threshold of a score of two for the determination of undernutrition risk, the threshold for the R-NST was raised by one point to three because of the characteristic of renal patients. This is because that individuals with renal failure may often experience episodes of anorexia resulting from various degree of uraemia (Carrero, 2011, Carrero et al., 2007, Kalantar-Zadeh et al., 2004a, Kopple et al., 2000) and their weight may fluctuate due to fluid retention as a result of a decline in renal function (Charra et al., 1996, Kraemer et al., 2006, Katzarski, 1996). Having these signs and symptoms may not necessarily indicate undernutrition for this patient group. Hence, the threshold was increased to a score of three aiming to capture those that are the most likely to be malnourished. If the score is less than three points, it may not necessarily show that this patient is without any risk of undernutrition. Step two and three therefore need to be completed to further obtain information to assist the determination of undernutrition risk. This becomes the second pathway to generate a dietetic referral. Step two includes the remainder of four questions (question six to nine) assessing any episodes of persistent gastrointestinal symptoms that may be indicative of increased risk of undernutrition, as well as three renal specific biochemical markers for renal patients, namely albumin, C-reactive protein (CRP) and blood urea. These elements may provide insight into the actual nutritional status of a renal patient beyond the manifestation of any physical symptoms (Elliott and Robb, 2009, Gower, 2002, Heimbürger et al., 2000, Jones and Wright, 2010, Qureshi et al., 1998, White et al., 2012a). Step three is the final step in the R-NST where the scores of Step one and two are combined into a final score. If the score in Step three is three points or more, the participant is predicted to be at risk of undernutrition and a dietetic referral will be generated. Each element will be discussed in more detail in the following sections.

3.5.1.1 Substantiating inclusion of questions one to five

The first question developed in the R-NST focused on involuntary weight loss over a six month period via recording of current and previous weight. The calculated weight loss is then assessed according to pre-set criteria that each have a point assigned. Points

increase by increment, resulting in higher score, the more involuntary weight loss is observed (see Figure 3.3).

Question	Criteria	
1. How much **DRY/GOAL** weight has the patient lost without trying in the past six months?	None	0 point
	1 – 5 kg	2 points
	6 – 10 kg	3 points
Ask for patient's weight in around 6 months ago _____kg Patient's current measured weight _____ kg (Dry☐ Wet☐)	11 – 15 kg	4 points
	> 15 kg	5 points
	Unsure	2 points

Figure 3.3 Question 1: Recent involuntary weight loss

This question was constructed closely following the MST's, which has been shown to be effective in recognising weight loss among adults in the acute care setting (Ferguson et al., 1999, van Venrooij et al., 2007). However, the involuntary weight loss was specified as 'dry/goal' weight. This was done to counteract the day-to-day changes of body weight due to the shift of fluid balance on renal replacement therapy. Dry weight is an individual's body weight without the excess fluid that builds up between dialysis treatments, which is the lowest weight this individual can tolerate without the development of symptoms or hypotension (Henderson, 1980, Charra et al., 1996). Although several different techniques have been used to derive a more standard method of assessing dry weight (Kouw et al., 1992, Lauster et al., 1990, Horejs et al., 1990, Kouw et al., 1993), no single method has emerged as a gold standard, as clinical assessment of dry weight can be crude and often imprecise (Jaeger and Mehta, 1999). In this research study, dry weight was determined by the medical team, postdialysis for the participants undergoing dialysis. For the R-NST, the percentage of weight loss was not calculated to measure the magnitude of weight loss, as it would have been too time consuming for the nursing staff or other healthcare professionals to complete. Hence, reporting weight loss in kilograms accommodates the fast-pace hospital environment and may encourage completion rate. Therefore weight loss were scored in increments of 5kg. Any weight loss greater than 1kg generates points as in an average person of 60kg, a 5 kg weight loss will mean a loss of 8% of weight.

Question two (see Figure 3.4) was also constructed based on the MST (Ferguson et al., 1999), and focused on eating behaviour. The proportion of each meal consumed since being admitted to hospital was further defined in the second part of this question when low appetite or difficulty in chewing and swallowing is investigated. This allows the screening form to better quantify actual food intake in hospital as this will assist in determining their severity of undernutrition risk and rate of recovery.

Question	**Criteria**	
2. Does the patient have a decreased appetite or problems with swallowing or chewing foods at present?	**No**	0 point
If yes, what proportion of each meal has the patient been able to eat since admission to hospital?	¾ to all	0 point
	½ - ¾ of a plate	1 point
	¼ - ½ of a plate	2 points
	less than ¼	3 points

Figure 3.4 Question 2: eating behaviour

It was decided to add two questions on biochemical markers specifically related to undernutrition to the R-NST to verify their level of undernourishment. Question three and four (see Figure 3.5) were incorporated into the R-NST due to the importance of serum phosphate and potassium levels in individuals with renal disease. Low phosphate and potassium levels are suggestive of diarrhoea, vomiting, and/or a decrease in oral intake,

making them useful for targeting renal patients at risk (Goldstein, 1998).

Question	**Criteria**	
3. What is the patient's serum phosphate (PO_4^{3-}) level at present?	0.8 - 1.6 mmol/L	0 point
	> 1.6 mmol/L	1 points
	< 0.8 mmol/L	3 points
4. What is the patient's serum potassium (K^+) level at present?	3.5 - 5.8 mmol/L	0 point
	< 3.5 mmol/L	2 points
	> 5.8 mmol/L	3 points

Figure 3.5 Question3 and 4: serum phosphate and potassium

Phosphorus is filtered freely in the glomerulus and reabsorbed in the proximal tubule under the effect of various hormones (Prié et al., 2009). As the kidney function of patients with CKD decreases, phosphorus is retained in the blood resulting in a positive

phosphorus balance (Prié et al., 2009). The elevated blood level of phosphate (hyperphosphatemia), increases the blood levels of parathyroid hormone (PTH), which exert significant effects on the function of almost every organ via soft tissue calcification in the long term (Mathew et al., 2008, Komaba and Fukagawa, 2010, Hruska et al., 2009). Hyperphosphatemia also appears to be associated with increased mortality (Massry et al., 2003). Research studies show that dietary restriction in phosphorus resulted in a decrease in blood PTH inducing a normal bone turnover rate (Lafage-Proust et al., 1999, LaFage et al., 1992). However, high protein foods such as meats contain high levels of phosphorus in the form of adenosine triphosphate (Wilkens et al., 2012). Restricting phosphorus intake can therefore reduce protein intake, which may lead to an increased risk of undernutrition especially for dialysis patients who require higher intake of protein (Wilkens et al., 2012). Therefore, the presence of a low serum phosphate in dialysis patients may indicate insufficient dietary protein intake especially for those who do not receive phosphate-binding agents.

In terms of the cut-off for serum phosphate, Gower (2002) found that serum phosphate less than 0.75 mmol/L was significantly correlated to lower nutritional status assessed by SDA in 3005 renal patients. Seventy seven percent of surveyed dietitians in Texas considered low serum phosphate (< 0.9 mmol/L) as an objective measure of nutritional status (Tai et al., 1998). Hence, 3 points would be given if phosphate was less than 0.8 mmol/L. In contrast, elevated serum phosphate is associated with increased risk of bone disease and mortality (Massry et al., 2003). The K/DOQI guidelines recommended that the serum level of phosphorus should be maintained no higher than 1.49 mmol/L in patients with stages 3 and 4 CKD and 1.78 mmol/L in those with renal failure (stage 5) (Massry et al., 2003). However, the CARI Guidelines – Caring for Australasians with Renal Impairment suggest that a pre-dialysis serum phosphate level should be kept within normal laboratory reference ranges (0.87 – 1.49 mmol/L) for patients with stage 3 and 4 CKD, whilst between 0.8 and 1.6 mmol/L in patients with stage 5 CKD (Hawley, 2005). After consultation with the specialist renal dietitians at MM Hosp, the upper level of serum phosphate was set to be 1.6 mmol/L, which is in line with the CARI Guidelines. It is believed that this cutoff is the most suitable in clinical practice for this population in CMDHB.

Alterations in serum potassium are common in patients with renal disease (Iseki et al., 1996, Lowrie and Lew, 1990). The elevation of serum potassium (hyperkalaemia) continues to worsen as the disease progresses; eventually dialysis treatment may be required to remove accumulated potassium in the blood (Gonick et al., 1971, Schrier and Regal, 1972, De Marchi and Cecchin, 1990, Hayes Jr and Robinson, 1965). Both low and high serum potassium levels (hypokalaemia and hyperkalaemia) are associated with higher mortality in patients undergoing dialysis (Iseki et al., 1996, Lowrie and Lew, 1990, Kovesdy et al., 2007). A study of 81013 patients on maintenance haemodialysis found that poor nutritional status associated with hypokalaemia resulted in an increased mortality (Kovesdy et al., 2007). This may be due to the physiologic role of potassium in maintaining the resting cell membrane potential, neuromuscular excitability and cardiac pacemaker rhythmicity (Wilkens et al., 2012). Hyperkalaemia can develop as a result of net positive potassium balance between intra- and extracellular fluid concentrations combined with impaired redistribution responses observed in uraemia. Hypokalaemia, on the other hand, can be an indicator of decreased dietary intake and/or increased extra-renal losses (Fernandez et al., 1986, Alvo et al., 1989, Gonick et al., 1971, Goldstein, 1998). Thus, the assessment of serum potassium can further determine the nutritional status of renal patients.

Moreover, 79% of surveyed dietitians in Texas considered low serum potassium (< 3.4 mmol/L) as an objective measure of nutritional status (Tai et al., 1998). Gower (2002) found that serum potassium less than 3.3 mmol/L was associated with lower SDA scores indicating lower nutritional status. The K/DOQI guidelines suggest that the intake of potassium rich food should be restricted if serum potassium is above 6.0 mmol/L. Elevated serum potassium levels have also been shown to be associated with higher nutrition risk as determined by SDA (Bennett et al., 2005, Bennett et al., 2006). Counties Manukau District Health Board renal guidelines: Hyperkalaemia – Acute Management, define mild hyperkalaemia as serum potassium less than 6.0 mmol/L and indicate that all patients with serum potassium above 5.8 mmol/L should be referred to dietitian (Counties Manukau Distric Health Board, 2013). Hence, the normal range of serum

potassium in renal patients was set to be 3.5 – 5.8 mmol/L on consensus with the specialist renal dietitians working in CMDHB.

Question five was designed to identify patients admitted to hospital due to peritonitis (see figure 3.6).

Question	Criteria	
5. Does the patient have peritonitis at present?	No	0 point
	Yes	3 points

Figure 3.6 Question 5: presence of peritonitis

Even in patients with mild peritonitis, an increase in total protein losses during peritoneal dialysis was observed, ranging from 8.8 ± 0.5 to 15.1 ± 3.6 g per day (Blumenkrantz et al., 1981). Since protein losses increase substantially in patients with peritonitis, a higher protein intake is required (Blumenkrantz et al., 1981). The Australia and New Zealand Renal Guidelines Taskforce recommends a protein requirement for individuals with peritonitis of 1.5 g per kg ideal or adjusted body weight (Ash et al., 2006). The Australia and New Zealand Renal Guidelines Taskforce provided a summary of the existing guidelines published between April 2002 and October 2003 (e.g. the CARI and K/DOQI guidelines) to include the strongest level of evidence for each nutritional component (Ash et al., 2006). When conflicting and supporting evidence was equal in quality and depth, CARI guidelines were selected preferentially as more relevant to the local environment (Ash et al., 2006). Therefore, it is important to recognise patients with peritonitis on the ward in order for them to receive timely dietetic input.

3.5.1.2 Substantiating inclusion of questions six to nine

Questions six to nine were intended to enhance the ability of the R-NST in detecting individuals at risk of mild undernutrition as it focused on more generalised symptoms highlighting apparent undernutrition. They were answered only if the total scores of the previous five questions did not reach 3 points. These four additional questions provided more information regarding the nutritional status of an individual. These further assist the determination of undernutrition risk, especially for individuals without apparent

undernutrition, where it is necessary to rely on biomarkers to detect risk. Therefore, the same construct is assessed in the two steps to identify patients at different stages of undernutrition to ensure all malnourished patients are captured.

Question six investigates the presence of gastrointestinal symptoms such as nausea, vomiting or diarrhoea continuously at least for three days (see figure3.7). Since a functioning gastrointestinal tract is critical for the delivery of nutrients and prevention of undernutrition, once the normal functions of the gastrointestinal tract are disturbed, the risk of undernutrition in an individual increases (Zoran, 2003). Haemodialysis patients with diabetes mellitus were observed to have more gastrointestinal symptoms such as nausea, vomiting and diarrhoea, which may lead to protein depletion long term (Cano et al., 2002). Hence, examining any unresolved gastrointestinal symptoms for more than three consecutive days appears to be a useful indicator for determining the risk of undernutrition.

Question	**Criteria**	
6. Has the patient experienced any of the following gastrointestinal symptoms for the past three days or longer?	None	0 point
	Nausea +/- Vomiting	1 point
	Diarrhoea	1 point

Figure 3.7 Question 6: the presence of gastrointestinal symptoms

Question seven focus on serum albumin, which has been considered as a marker for visceral protein and one of the diagnostic criteria for detecting undernutrition (White et al., 2012b, Jones and Wright, 2010). Lower serum albumin levels have also been associated with morbidity and mortality among dialysis patients (Beddhu et al., 2002, Iseki et al., 1993, Kalantar-Zadeh et al., 2005, Lowrie and Lew, 1990). One hundred percent of surveyed dietitians in Texas used a serum albumin level (< 35 g/L) as an objective measure of nutritional status (Tai et al., 1998). When serum albumin levels of 122 haemodialysis patients were compared against the SGA scores, Elliott and Robb (2009) found that patients with a serum albumin level less than 35 g/L were more likely to be at risk of undernutrition according to their SGA scores. This shows that serum albumin appears to be useful in predicting the undernutrition risk of haemodialysis

patients (Elliott and Robb, 2009, Steiber et al., 2007). The Renal Association Standards also advise that an albumin level less than 35g/L should prompt assessment for undernutrition (The Renal Association, 2002). Nonetheless, albumin level is influenced by non-nutritional factors such as plasma volume expansion, albumin redistribution, exogenous loss, increased catabolism, and decreased synthesis (Heimbürger et al., 2000, Jones et al., 1997, Steinman, 2000). Serum albumin is an acute phase reactant protein, its use as a marker of protein status can therefore be masked by inflammation (Jones et al., 1997). Thus, it was incorporated into the nutrition screening form as an additional objective measure in recognising participants at risk of undernutrition (see Figure 3.8).

Question	**Criteria**	
7. Is the patient's serum albumin level **LESS** than 35 g/L at present?	No	0 point
	Yes	1 point

Figure 3.8 Question 7: serum albumin

Question eight and nine were constructed to evaluate the levels of serum C-reactive protein (CRP) and serum urea. An elevated CRP has been suggested to be an independent factor associated with undernutrition (Heimbürger et al., 2000, Qureshi et al., 1998). The high prevalence of an elevated CRP (> 10 mg/L) has been documented in both dialysis (Qureshi et al., 1998, Zimmermann et al., 1999, Owen and Lowrie, 1998) and pre-dialysis patients (Stenvinkel et al., 1999). Elevated levels of serum CRP appear to be associated with increased production of pro-inflammatory cytokines among CKD patients (Pereira et al., 1994, Kimmel et al., 1998). The increased accumulation of pro-inflammatory cytokines may stimulate muscle wasting by promoting protein catabolism via the ubiquitin-proteosome pathway (Bistrian et al., 1992) as well as by decreasing albumin synthesis and the suppression of appetite (Steinman, 2000). Consequently, increased serum levels of CRP that is associated with pro-inflammatory cytokines may be predictive of undernutrition risk. A level of serum CRP greater than 10 mg/L was found to be significantly associated with an increased risk of undernutrition (Elliott and Robb, 2009). In terms of serum urea levels, there are various non-dietary factors that may affect blood urea levels including renal function, catabolism and inadequate or over-dialysis. However, in clinical practice, patients with pre-dialysis urea levels less than 15 mmol/L have been observed to have a greater risk of undernutrition possibly due to

inadequate protein intake (Elliott and Robb, 2009, Gower, 2002). Thus, serum CRP and urea levels were included into the screening tool in combination with albumin as the three additional objective measures (see figure 3.9). These measures may contribute to increase the specificity of the screening tool in identifying renal patients at risk of undernutrition without any physical symptoms.

Question	**Criteria**	
8. Is the patient's C-reactive protein (CRP) level **GREATER** than 10 mg/L at present?	No Yes	0 point 1 point
9. Is the patient's blood urea level **LESS** than 15 mmol/L at present?	No Yes	0 point 1 point

Figure 3.9 Questions 8 and 9: serum C-reactive protein and blood urea levels

Once development was completed (see Appendix C), the face validity of the new R-NST was assessed by the researchers and its content validity was further assessed by the specialist renal dietitians at MM Hosp. The aim was to ensure that the content of the R-NST was recorded and interpreted in the way that it was intended. The R-NST was modified with any necessary changes including the comprehension of the questions, the layout of the tool and the scoring assigned for each question. The R-NST was piloted by a New Zealand registered dietitian in MM Hosp and the researchers using de-identified patient information to ensure its effectiveness on recognising undernutrition risk.

3.5.2 Phase Two – The validation of the newly developed R-NST

The validity of the newly developed screening tool in identifying adult renal patients in the acute care setting was examined in this phase. The undernutrition risk of each participant was assessed by a research assistant using the R-NST. The actual nutritional status of each participant was determined independently by the researcher using the 7-point SGA as a gold standard nutrition assessment tool and by measuring handgrip strength with a Smedley-type handheld dynamometer (100 kg YOII, Tsutsumi, Japan) as a functional measure. The validity of this proposed screening tool was determined by comparing it's accuracy in recognising participants at risk of undernutrition against the results of the 7-point SGA and handgrip strength.

3.5.2.1 The R-NST

The R-NST was performed on each participant by a research assistant. The biochemical results required in the screening form were obtained from the Concerto Clinical Information System, which is the clinical workstation used by clinicians in New Zealand to view electronic patient information such as demographics, laboratory and radiology results, clinical notes and documents, etc. A dietetic referral was generated if a score of three or more points were generated at any of the stages.

3.5.2.2 Seven-point SGA

The researcher was trained by a New Zealand registered dietitian to use the seven-point SGA rating form (see Appendix D) to assess the nutritional status of all participants according to a standardised protocol (McCusker et al., 1996).
The seven-point SGA rating form consists of four subscales:

- The patients' history of weight change in the previous six months (subscale one),
- Dietary intake, and presence of gastro-intestinal symptoms (loss of appetite, nausea, vomiting, and diarrhoea) (subscale two),
- A physical examination of subcutaneous fat mass (subscale three), and
- A physical examination of muscle wasting (subscale four).

A seven-point classification was assigned for each of the four subscale with "1" being the least nourished and "7" being the most well nourished. Each participant was first categorised into one of the three classifications malnutrition, ranging from severely malnourished (scoring "1" to "2"), to moderately malnourished (scoring "3" to "5") and well nourished (scoring "6" to "7"). Secondly, the final classification of each subscale was fine-tuned on the basis of clinical judgement using the following criteria:

- ''Can the status of the participant improve or worsen within the category?'',
- ''What has been developed within the past two weeks?'', and
- ''What has been the change compared with the previous SGA scores if available?''.

For instance, if a participant was categorised as severely malnourished in one of the subscales, and his or her condition could get worse, a rating of one was assigned; but if their condition had improved since the previous assessment, a rating of two was given. When a participant was categorised as moderately malnourished, a score could be assigned from “3” and “5” on the basis of the criteria if the condition tended toward severe undernutrition with a lower rating of “3” or to well nourished with a higher rating of “5” or was somewhere in between. As for participants classified as well nourished, a rating of “6” was given when the condition was likely to improve or when it worsened compared to the previous assessment. Lastly, an overall SGA classification of “1” to “7” was calculated for each participant consisting of 60% of the history part (subscale one and two) and 40% of the physical examination (subscale three and four). A final rating of “7” indicated an adequate nutritional status, whereas a rating of “1” indicated severe undernutrition (McCusker et al., 1996, Visser et al., 1999).

3.5.2.3 Handgrip Strength

The HGS f each participant was measured following the standardised protocol of the 100 kg Smedley hand dynamometer (Tsutsumi, YOII). The dominant hand of each participant was first identified and recorded. The arm that had a fistula (if any) was also recorded for participants on haemodialysis. The participants were required to measure their handgrip strength on both arms twice. The first measurement was always started on the dominant arm followed by the non-dominant arm, and then repeated. The participants were sitting down in a chair with the feet slightly apart, the arm placed along the body and grasp naturally while preventing the dynamometer from contacting the body or clothes. The hand dynamometer was grasped with the scale facing away from the body. The width of the grip was such that when grasped, the second joint of the fore-finger were almost at a 90° angle. The same position for the same participant was kept to ensure a 90° angle was achieved by recording the position of the grip corresponding to the scale labelled on the side of the hand dynamometer. In that position, the participants were encouraged to close the hand in a squeezing motion without swinging the dynamometer around. The final handgrip strength was the average between the

better measurements for each arm and was recorded in kg. The HGS measurement was then graded against a predefined reference standard (population that is age and sex specific) as “below average”, “average” and “below average”. This predefined reference standard was based on the reference values published in Australian fitness norms: a manual for fitness assessors by Gore and Edwards (1992) (See Appendix E)

3.5.3 Phase Three – The feasibility of the newly developed R-NST in practice

The feasibility of adopting the R-NST as standard ward practice to identify patients at risk of undernutrition will be described in the section. The R-NST was developed to be administered by nursing staff to detect adult renal inpatients at risk of undernutrition shortly after admission to the acute renal ward in MM Hosp. During the feasibility study period, the R-NST was inserted into the medical notes of each patient by the ward clerk upon admission. Over a nine week period the nursing staff was required to screen all patients admitted to Ward One, MM Hosp within 48 hours of admission using the R-NST. The R-NST was introduced to the nursing staff at the beginning of their handover meetings on three different occasions in order to capture as many staff as possible. The purpose of the R-NST was explained, followed by a ten minute education session on how to administer and complete it. The charge nurse was responsible to train the nursing staff that was unable to attend the education session.

The performance of nursing staff completing the R-NST was assessed over a nine week period. The number of forms administered and completed by the nursing staff on consented patients was recorded. During the same period, the R-NST was also administered and completed by the trained research assistants. Hence, the accuracy of nursing staff on completing the screening forms was able to be examined by comparing against those completed by the research assistants.

3.5.3.1 The acceptability of the R-NST in practice

The acceptability of the R-NST in practice by the nursing staff was explored by administering a survey at the beginning of nursing staff handover meetings on five

occasions over seven days. The survey was aiming to investigate not only the nurses' perspective on the content, layout and the usefulness of the R-NST, but also the impact of the R-NST on their workload and any perceived barriers on screening compliance.

3.6 Data dandling and analysis

The data analysis was performed using SPSS software. Nutrition screening is used to identify an increased risk of undernutrition (Kondrup et al., 2003a). Ideally such screening correctly identifies all individual with undernutrition, and similarly correctly identifies all individuals who are well nourished. When evaluating a nutrition screening tool, the terms sensitivity and specificity are used. They are independent of the population of interest subjected to the test. The terms positive predictive value (PPV) and negative predictive value (NPV) are used when considering the diagnostic performance of a nutrition screening tool to a clinician and are dependent on the prevalence of undernutrition in the population of interest. Sensitivity is defined as the proportion of individuals who were correctly identified as being nutritionally at risk, and specificity is defined as the proportion of individuals who are correctly identified as not at risk. SGA and handgrip strength results were used as the gold standard for assessing the sensitivity and specificity of the screening tool. Area under the receiver operating characteristic (ROC) curve, sensitivity, specificity, PPV and NPV and their 95% confidence intervals were summarised. An accepted a priori definition for an appropriate nutrition screening tool recommends a sensitivity >80% and a specificity of 60% (Ferguson et al., 1999). Multiple logistic regression models were used to correlate results from the screening tool against the gold standard results, adjusted by patients' characteristics.

Chapter Four

4. Results

4.1 Introduction

This research study was conducted on an acute renal ward (Ward One) at Middlemore Hospital (MM Hosp), Auckland, New Zealand. The study procedures described in Chapter Three were followed. The objective of this chapter is to present the results regarding the piloting validity and feasibility of a newly developed renal nutrition screening tool (R-NST). The retrospective review of dietetic referral system on Ward One will be first presented, followed by the demographic data of study participants. The results regarding the diagnostic performance of the R-NST are presented subsequently. They include the results of the R-NST for each participant completed by the research assistants as well as the results of the 7-point subjective global assessment (SGA) and handgrip strength (HSG) assessed separately by the researchers who were blinded to the R-NST results. Finally, the results regarding the feasibility of the R-NST including the performance of the R-NST as a standard practice on the ward level and the acceptability of the R-NST by the nursing staff will be presented.

4.2 The Retrospective review of dietetic referral system on Ward One

Since there was no nutrition screening protocol implemented on Ward One, it is essential to investigate the current situation of nutrition screening and dietetic referral on the ward level. The current standard practice for dietetic referral on Ward One is to fax a completed Acute Adult Dietitian Referral form to the Nutrition and Dietetic services (see Appendix F). There were 74 dietetic referrals generated on Ward One within a twelve week period from November 2012 to February 2013 (12 weeks). On average, six referrals were received each week. Of 74 dietetic referrals generated during this period, there were only 10.8% were referred by using this form. The rest were generated either

by the ward dietitians themselves (51.4%) or by a healthcare colleague on the ward (including doctors, nursing staff and speech language therapists) verbally or via the pager (37.8%).

The reasons for dietetic referrals from November 2012 to February 2013 are summarised in Table 4.1. Fifty percent of the dietetic referrals were generated due to renal disease requiring dietetic input, whereas other 24.3% of patients were referred as a result of undernutrition or increased undernutrition risk. According to the nutrition diagnosis determined by the ward dietitian, three patients were diagnosed with undernutrition and 35 patients (47.3%) were considered at risk of undernutrition. There were eight inappropriate dietetic referrals from the 28 referrals that were generated by healthcare colleagues when comparing the reasons for referral to the nutrition diagnosis determined by the ward dietitian.

Table 4.1 Reasons for dietetic referral (November 2012 – February 2013)

Reasons for dietetic referral	Frequencies (n = 74) (%)
Undernutrition domain (Total):	18 (24.3%)
Poor intake	8
Unintentional weight loss	4
Existing undernutrition	3
Low albumin	3
Renal nutrition domain (Total):	37 (50.0%)
Commencing dialysis	11
Peritonitis	10
Hyperkalaemia	5
Dietary review/education regarding renal conditions	4
Acute kidney injury	3
Other renal disease related issues	2
Iron deficiency	1
General nutrition domain (Total):	15 (20.3%)
Requesting/requiring oral nutritional supplements	8
Texture modified diets	3
Constipation	1
Weight reduction/Obesity	1
Pressure area	1
Ongoing bacteraemia	1
Dietetic referrals generated by healthcare professionals (Total):	28 (37.8%)
Inappropriate referrals	8

Results expressed in frequencies.

4.3 Demographic description of the study participants

One hundred and twenty two participants who were admitted to the acute renal ward (Ward One) at MM Hosp between April and July 2013 (14 weeks) were recruited for this research study. The response rate for participating in the research study was 85.3%. The characteristics of participants are summarised in Table 4.2.

Table 4.2 Demographic description of the participants (n=122)

Characteristics	n (%)[1]
Gender	
males	64 (52.5)
females	58 (47.5)
Age (year)	57.1 ± 14.1
Length of hospital stayed (day)	4 [2 – 6]
Time of nutritional screening completed after admission (day)	1 [1 – 3]
Nutritional status assessment[2] by SGA	
Well nourished	44 (36.1)
Malnourished	78 (63.9)
Dietetic referrals generated[3] by R-NST	
No	31 (25.4)
Yes	91 (74.6)
Reasons for dietetic referral among the 91 referrals generated by R-NST	
At risk of undernutrition	83 (91.2)
Requiring dietetic input due to renal conditions	8 (8.8)

SGA, subjective global assessment; R-NST, renal nutrition screening tool.

[1] Results expressed as frequencies, mean ± standard deviation and median [25th and 75th percentiles].

[2] Nutritional status was evaluated by the SGA with a rating from "1" to "7". "6 – 7" being well nourished, "< 6" being malnourished.

[3] Dietetic referrals were generated by the scores of the newly developed R-NST. A score of three or more generates a dietetic referral.

The mean age of the participants was 57.1 ± 14.1 years. The majority of participants (see Table 4.2) were Pacific Islanders (44.3%) and New Zealand Maori (23.8%). Among the 54 participants that are from Pacific Island countries, 44.4% were Samoan followed by Cook Island Maori (29.6%) and Tongan (16.7%), respectively. Other Pacific Island countries included Fiji, Niue and Tokelau.

The renal medical condition of each participant was also collected according to their medical notes on admission (summarised in Table 4.3 below). Ninety three (76.2%) participants were on renal replacement therapy, of which two third were on haemodialysis.

Table 4.3 Ethnicity and renal medical condition of participants by gender

	Males (n=64)	Females (n=58)	Total N (%) (n=122)
Ethnicities:			n=122
New Zealand European	17	9	26 (21.3%)
New Zealand Maori	14	15	29 (23.8%)
Pacific Islander	25	29	54 (44.3%)
Chinese	3	2	5 (4.1%)
Indian	2	2	4 (3.3%)
Other	3	1	4 (3.3%)
Renal medical conditions:			n=122
Haemodialysis	29	34	63 (51.6%)
Peritoneal dialysis	18	12	30 (24.6%)
Acute kidney injury	2	1	3 (2.5%)
Chronic kidney disease (non-dialysis)	9	10	19 (15.6%)
Post kidney transplant	4	1	5 (4.1%)
Nephrotic syndrome	2	0	2 (1.6%)

4.4 The Validation of the newly developed R-NST in identifying renal inpatients at risk of undernutrition

One hundred and twenty two participants were screened by the research assistants using the newly developed R-NST in a 14 week period from April to July 2013. Blinded to this, the nutritional status of all 122 participants was evaluated by the researcher using the gold standard subjective global assessment (SGA) method as well as the hand grip strength (HGS) using a dynamometer. However, only 121 participants were measured as one participant being unable to perform the HGS test at the time of measurement. The R-NST and SGA results of this participant were included in the diagnostic analysis of the R-NST against the SGA. The results generated from the R-NST, SGA and HGS are summarised in Table 4.4.

Table 4.4 Results for the R-NST, the 7-point SGA and the HGS among renal inpatients in MM Hosp

	Males (n = 64)	Females (n =58)	Total (n = 122)
R-NST[1]	4 [3 – 5]	4 [2 – 5]	4 [2 – 5]
7-point SGA[2]	6 [4 – 6]	5 [4 – 6]	5 [4 – 6]
HGS (kg)[3]	29 [22 – 35]	18 [15 – 23]	23 [17 – 30]

Results expressed as median [25th and 75th percentiles].

R-NST, renal nutrition screening tool; SGA, subjective global assessment; HGS, handgrip strength; MM Hosp, Middlemore hospital.

[1] The R-NST has scores from "0" to "22", with a score of greater than or equal to "3" being at nutrition risk and a score of less than "3" being not at risk.

[2] The 7-point SGA has a rating from "1" to "7", with "1 – 2" being severely malnourished, "3 – 5" being mildly to moderately malnourished and "6 – 7" being well nourished.

[3] The HGS is graded based on the reference values published in Australian fitness norms: a manual for fitness assessors by Gore and Edwards (1992) (See Appendix E).

4.4.1 Results of the R-NST

The R-NST was developed to facilitate the dietetic referrals on Ward One based on its scores. The scores of greater than or equal to three will generate a dietetic referral. In total, 91 participants were referred to the Nutrition and Dietetic services at MM Hosp based on the outcome of the R-NST. Of these 91, 83 of the referrals were due to an increased risk of undernutrition, whereas the other eight referrals identified by the outcome of the R-NST resulted from these participants requiring dietetic input for their renal conditions, such as hyperkalaemia rather than being at risk of undernutrition.

The R-NST can be completed in three simple steps. **Step one** consists of five compulsory questions (see Appendix C). When the scores in Step one are less than three points, proceed to steps two and three to obtain further information (scores) to assist the determination of nutrition risk. **Step two** includes four questions and **Step three** combines all the scores into a final score. These scores are used to generate a dietetic referral indicating increased nutrition risk, which can be generated from two pathways. The first pathway to generate a dietetic referral is when the scores in Step one reach three points or more. The second pathway is when the scores in Step three are greater than or equal to three points.

Of the 91 referred participants, 64 (70.3%) were referred through the first pathway after Step one. Of these, 57 (89.1%) were referred because of an increased risk of undernutrition, whilst seven (10.9%) was referred as a result of requiring dietetic input for their renal conditions. Conversely, 27 of the 91 referred participants were identified via the second pathway of the R-NST with the majority of them, 26 (96.3%), referred due to an increased risk of undernutrition and only one referred due to his or her renal condition.

4.4.2 Results of the 7-point SGA

The 7-point SGA was performed for each participant by the searchers who have been provided with the standardised training. The 7-point SGA has a rating ranged from "1" to "7" which is categorised into three classifications of one's nutritional status ("1 – 2" being severely malnourished, "3 – 5" being mildly to moderately malnourished and "6 – 7" being well nourished). Of 122 participants assessed by the 7-point SGA, 44 were classified as well nourished, 70 as mildly to moderately malnourished and eight as severely malnourished. During this 14 week period, the prevalence of the undernutrition on Ward One is 63.9% based on the results of the 7-point SGA.

4.4.3 Results of the HGS

The handgrip strength of each participant was measured by the researchers using a hand dynamometer. The median HGS of 121 participants are summarised in Table 4.4. The HGS of 28 participants was graded as "average" compared to a reference population that is age and sex specific, whereas 93 participants had HGS "below average". No participants were found to be "above average". The average HGS was graded based on the reference values published in Australian fitness norms: a manual for fitness assessors by Gore and Edwards (1992) (See Appendix E).

4.4.4 The diagnostic performance of the R-NST

The R-NST was specifically developed to recognise patients in an acute care setting with a variety of renal conditions requiring dietetic input. The participants referred by the R-NST due to reasons other than being at risk of undernutrition were excluded in the validation of the R-NST in identifying renal inpatients at risk of undernutrition. Therefore, the number of participants used to validate the diagnostic performance of the R-NST is 114.

The diagnostic performance of the R-NST is assessed using predictions of sensitivity and specificity. Sensitivity is defined as the proportion of participants who were correctly identified as being at risk of undernutrition, and specificity is defined as the proportion of participants who are correctly identified as not at risk. The subjective global assessment and HGS results were used as the gold standard measures for assessing the sensitivity, and specificity of the R-NST. Area under the Receiver Operating Characteristic curve (AUC), sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) and their 95% confidence intervals are summarised in Table 4.5.

Table 4.5 The diagnostic performance of the R-NST and HGS in comparison to the SGA

Diagnostic performance analyses	R-NST (%) [95% CI]	HGS (%) [95% CI]
Sensitivity	97.3 [90.7, 99.7]	82.4 [71.8, 90.3]
Specificity	74.4 [57.9, 87.0]	25.6 [13.0, 42.1]
Positive predictive value	88.0 [79.0, 94.1]	67.8 [57.1, 77.3]
Negative predictive value	93.6 [78.6, 99.2]	43.5 [23.2, 65.5]
AUC	0.95*	0.63*

R-NST, renal nutrition screening tool; HGS, handgrip strength; AUC, area under the Receiver Operating Characteristic curve; CI, confidence interval.
* This value is not a percentage.

The PPV of 88.0% indicates that of the 83 test positives (at risk of undernutrition by the R-NST), 73 of them were real positives, and 10 of them that were indicated as being at risk, were not malnourished according to the SGA results. The negative predictive value of 93.6% indicates that of the 31 test negatives by the R-NST, 29 of them were the real negatives (well nourished) and two were missed in comparison with the SGA. In other

words, the area under the receiver operating characteristic curve for using the R-NST to predict the SGA is 0.95, which indicates the accuracy of this diagnostic test for the R-NST is excellent (see Figure 4.1).

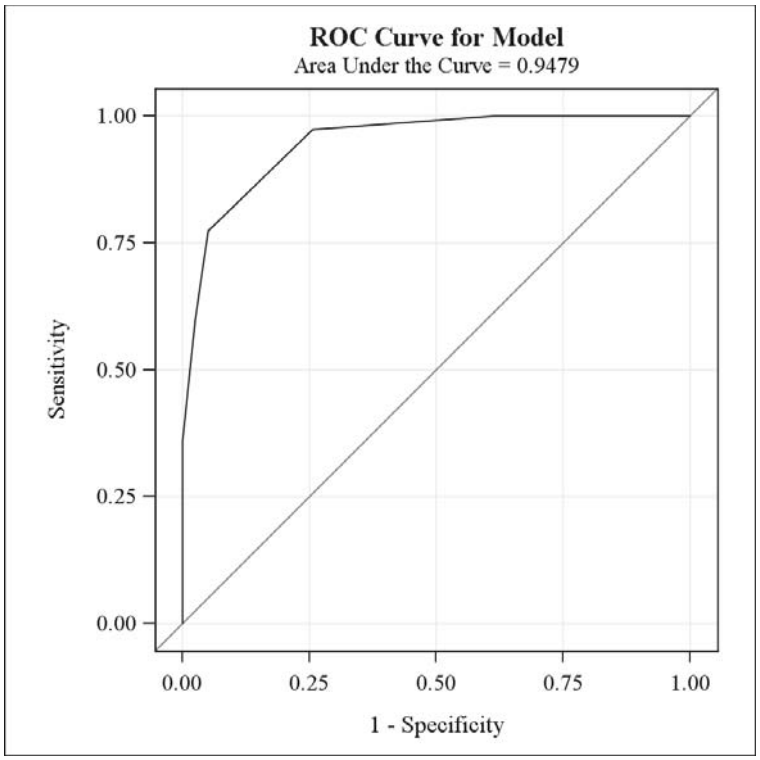


Figure 4.1 The area under the receiver operating characteristic curve for the R-NST in comparison to the SGA

Correlations between the R-NST and SGA, the R-NST and Average of HGS were determined (see Table 4.6). There are significantly strong negative associations between SGA and the R-NST with a Spearman correlation coefficient -0.74 ($p<0.001$). The range of correlation coefficient is between -1 and 1. For negative association, the bigger the correlation coefficient value indicates the stronger negative association. The associations between the HGS and the SGA is 0.27 ($p = 0.002$), which is very weak; the associations between the HGS and the R-NST is -0.12 ($p = 0.20$), which does not reach significance.

Table 4.6 Correlations between the R-NST and SGA, the R-NST and average of HGS

Spearman correlation coefficients (p values)	SGA	Average of HGS
R-NST	- 0.74 (<0.0001)	- 0.12 (0.20)
SGA	—	0.24 (0.009)

R-NST, renal nutrition screening tool; SGA, subjective global assessment; HGS, hand grip strength
p value < 0.05 indicates statistical significance.

Multiple logistic regression models were used to correlate results from the R-NST against the gold standard SGA results, adjusted by participants' characteristics. They showed that participant's gender and age were both significantly associated with being malnourished. Females are more likely to be malnourished than male patients, and elderly patients were more likely, to be malnourished than younger patients. An increase of one score in the R-NST was associated with 2.7 times [95% C.I. 1.9-3.9] the odds of being malnourished, and associates with 3.0 times [95% C.I. 2.0-4.4] the odds of being malnourished when age and gender were accounted.

4.4.5 Comparisons between handgrip strength and nutritional status

The hand grip strength of malnourished participants determined by the SGA are significantly lower than those that are well nourished in women (p = 0.001), but not in men (p = 0.790). Malnourished participants aged under 65 have a significantly lower HGS compared to those that are well nourished (p = 0.009) (Table 4.7). However, there was no significant difference in HGS between participants who are at risk of undernutrition and those that are not at risk determined by the R-NST even when gender and age were accounted for.

Table 4.7 Hand Grip Strength of Participants by Nutritional Status, Gender and Age[1]

Participants	Hand grip strength (kg)					
	Nutritional Status determined by SGA[2]			Undernutrition risk determined by R-NST[3]		
	Well nourished[4]	Malnourished[4]	p value[5]	Not at risk[4]	At risk of undernutrition[4]	p value[5]
Male	26.9 [23.2, 30.8]	26.3 [23.4, 29.5]	0.790	26.2 [22.7, 30.8]	25.9 [23.3, 29.0]	0.900
Female	22.3 [19.1, 26.1]	16.3 [14.9, 18.0]	0.001	20.0 [16.7, 23.3]	17.1 [15.5, 19.8]	0.100
Aged under 65	26.2 [23.5, 29.6]	20.4 [17.7, 23.4]	0.009	24.5 [21.8, 28.1]	21.3 [18.8, 24.2]	0.161
Aged 65 or older	20.3 [16.0, 24.8]	21.2 [18.9, 23.9]	0.742	17.8 [13.4, 22.0]	21.5 [19.1, 24.2]	0.228

[1] Significant differences in hand grip strength between groups were determined by using the Independent T-test. R-NST, renal nutrition screening tool; SGA, subjective global assessment; CI, confidence interval.

[2] Nutritional status of 121 participants was evaluated by the SGA.

[3] Undernutrition risk of 113 participants was determined by the R-NST.

[4] Geometric mean [95% CI] (all such values).

[5] $p < 0.05$ indicates statistical significance.

4.5 The feasibility of the newly developed R-NST in practice

4.5.1 The trial of R-NST in practice administered by the nursing staff on Ward One, MM Hosp

The newly developed R-NST was trialled by the nursing staff on the ward level. In a nine-week period, the nursing staff was independently assessing patients using the R-NST alongside the research assistants. The performance of the nursing staff on completing the R-NST was compared with the results of the R-NST on the same participant completed by the research assistants. Over the nine week period, 84 recruited participants were screened by the research assistants using the newly developed R-NST. From all the ward patients, including the recruited participants, only 19 (22.6%) R-NSTs were completed by the nursing staff. The referral procedure was correctly followed with only 16 (19.0%) participants based on the scores of the R-NST completed by the nursing staff, when compared to the referrals made for the same participants by the research assistants. To further investigate the accuracy of the R-NST scoring by the nursing staff, the scores of each participant assigned by the nursing staff were compared to the ones generated by the research assistants. Of the 84 participants, there were only seven (8.3%) who had been correctly scored on the R-NST by the nursing staff in comparison to the research assistants. Of the 19 R-NSTs completed by the nursing staff, 36.8% were accurately scored.

4.5.2 Results of the Nurses' Survey

Following the trial of using the R-NST as a standard dietetic referral by the nursing staff, the nurses' surveys were administered to all the nursing staff at the beginning of handover meetings on Ward One on five occasions over seven days. This was to investigate the acceptability of adopting the R-NST as a standard dietetic referral by the nursing staff. Twenty five surveys were handed out. The completed surveys were submitted anonymously; eight surveys (32%) were completed and returned to the

researchers. The nursing staff who used this R-NST were encouraged to complete this survey. The results of the survey are summarised in Table 4.8.

Table 4.8 Results of the nurses' survey

Survey questions	Scores
The presentation of the R-NST	1.88 ± 0.83
The usefulness of the R-NST	1.75 ± 0.89
The R-NST is logical to complete	1.88 ± 0.83
The R-NST is easy to complete	2.00 ± 0.93

Scores are expressed in one number, from "1" to "5", "1" being excellent and "5" being poor.
Results expressed as mean ± standard deviation.

The renal nutrition screening tool is perceived by the nursing staff as being well presented and useful at identifying patients at risk of undernutrition as well as being logical and easy to complete. They identified that the R-NST takes on average five to ten minutes to complete, which was considered to be an appropriate time period for such a tool. Half of the nursing staff who responded stated that the determination of any weight loss in the previous six months took the longest to complete, followed by the searching of biochemical markers on Concerto Clinical Information System. Seventy five percent of respondents reported that the benefit of nutrition screening is to identify patients at risk of undernutrition and improve timely dietetic referral. The main barriers for completing the R-NST were time constraints and increasing workload. One suggestion that was made by one respondent is to appoint a designated staff to perform the nutrition screening on all newly admitted patients.

Chapter Five

5. Discussion

5.1 Introduction

The renal nutrition screening tool (R-NST) was designed to be administered by the nursing staff to identify renal adult patients at risk of undernutrition after admission to an acute renal ward in Middlemore hospital (MM Hosp). The objective of this chapter is to discuss firstly the development of the R-NST, followed by a discussion of the results of this validation study as presented in chapter four. These will include a discussion of the diagnostic performance of the R-NST in this patient group against the 7-point subjective global assessment (SGA) and handgrip strength (HGS). Lastly, the feasibility of the R-NST as a standard practice on the ward level by the nursing staff will be discussed.

5.2 Retrospective review of dietetic referral system on Ward One, MM Hosp

The retrospective review findings presented important background information regarding the current dietetic referral system on Ward One in MM Hosp. This review highlighted that patients at risk of undernutrition were unlikely to be recognised during admission due to the lack of a nutrition screening protocol in practice. Of the 74 dietetic referrals created during this period, only 24.3% were generated because of an increased risk of undernutrition. This is below the average undernutrition prevalence of 32% found in 56 hospitals across Australia and New Zealand (Agarwal et al., 2012b). When comparing to the undernutrition prevalence of 52.3% observed on the acute renal wards in Australia (Lawson et al., 2011), it is estimated that more than half of the renal inpatients who were at risk of undernutrition could have been unrecognised during their admission to Ward One. Therefore, there is an urge to determine the true prevalence of undernutrition on Ward One and to explore the feasibility of using a nutrition screening tool as a standard nutrition screening protocol on ward level.

Since the dietetic services in MM Hosp operates on a referral system, the routes of dietetic referral on Ward One consisted of verbal, fax and pager referrals from various healthcare professionals on the ward including nursing staff, dietitians and speech language therapists. However, of the 74 referrals, 51.4% were generated by the ward dietitians themselves, whereas less than 37.8% of the referrals were made by the nursing staff. Green and Watson (2005) advocate the development of a rapid nutrition screening tool that could be easily administered by any member of a multidisciplinary renal team without the requirement of dietetic training. This would be valuable to ensure that patients who may be malnourished can be accurately identified and referred to the dietetic services. Hence, it is beneficial to develop a nutrition screening tool that could also facilitate timely dietetic referral on ward level.

5.3 Characteristics of the study participants

There were a large proportion of the 122 study participants who were Māori (23.8%), Pacific Island (44.3%) and Asian (7.4%) peoples. According to the 2006 census (Statistics New Zealand, 2006), the population of South Auckland was made up of 15.5% Māori, 21.5% Pacific Island origin, 16.9% Asian and the remainder being predominantly New Zealand Europeans. Although there is no updated census, the study participants were a good representation of the ethnic groups living in South Auckland.

Of the 122 participants, the majority of the participants were on maintenance dialysis treatment, 51.6% (n = 63) on haemodialysis and 24.6% (n = 30) on peritoneal dialysis. The remainder were 15.6% (n = 19) CKD patients not receiving dialysis, 2.5% (n = 3) AKI patients, 4.1% (n = 5) post kidney transplant patients and 1.6% (n = 2) with nephrotic syndrome. Similarly, Lawson et al. (2011) reported the treatment modality of 190 participants recruited from the acute renal wards were 55% haemodialysis, 18% peritoneal dialysis, 30% not receiving dialysis and 7% kidney transplant. Hence, the participants recruited in the present study appear to well represent the treatment modality of an acute renal ward.

5.4 Development of the R-NST

The R-NST was developed with the aim firstly to identify renal patients who are at risk of undernutrition on admission to the acute renal ward, and secondly to provide timely referrals for those requiring dietetic input due to their renal conditions. Based on a review of current literature and to the best of our knowledge, it appears that a nutrition screening tool specifically developed to detect the undernutrition risk of acute renal inpatients with a variety of renal conditions, does not exist. Although there are existing nutrition screening tools that have been used to identify renal patients at risk of undernutrition, most of these have only been used to screen individuals on renal replacement therapy. For example, the Geriatric Nutritional Risk Index (GNRI) has been shown to be effective in recognising individuals on either haemodialysis or peritoneal dialysis who are at risk of undernutrition (Szeto et al., 2010, Yamada et al., 2008). Nevertheless, the GNRI has yet to be examined in renal patients from an acute care setting. Despite nutrition screening tools such as the MUST and MST that have been found to be valid in detecting the undernutrition risk of patients in the acute care setting (Elia, 2003, Ferguson et al., 1999, Kyle et al., 2006, Stratton et al., 2004, Stratton et al., 2006, van Venrooij et al., 2007), they were shown to be insensitive to identify undernutrition risk specifically among Australian inpatients with renal failure (Lawson et al., 2011). Therefore, modifying these existing tools to increase their diagnostic performance among this patient group is warranted.

Since nutrition screening tools are generally constructed to include four risk variables, namely: weight/BMI, involuntary weight loss in the past three to six months, food intake and disease process (Kondrup et al., 2003a, Elia, 2003, Ferguson et al., 1999), Lawson and colleagues (2011) suggested that these risk factors alone may not be sensitive and specific enough to identify renal patients who are at risk of undernutrition in an acute care setting. Considering that the GNRI is effective in detecting dialysis outpatients who are at risk of undernutrition. It is important to consider its unique feature. The GNRI incorporates biochemical measures as risk variables, which is different from other rapid nutrition screening tools (e.g. MUST and MST). In fact, the use of biochemical measures in combination with the traditional risk variables has been demonstrated to be useful in

recognising the undernutrition risk among haemodialysis patients (Gower, 2002, Elliott and Robb, 2009). Particularly the combination of serum levels of albumin, C-reactive protein (CRP) and urea together with involuntary weight loss is significantly associated with the results of the SGA among these haemodialysis patients (Elliott and Robb, 2009). Therefore, the R-NST was modified from the MST that has been validated in the acute care setting to include the traditional risk variables such as involuntary weight loss and reduction in food intake (Ferguson et al., 1999, van Venrooij et al., 2007), as well as biochemical measures to increase the sensitivity and specificity of the tool in detecting undernutrition risk.

Adding biochemical measures to the R-NST have contributed to increase the effectiveness of the R-NST in identifying renal inpatients at risk of undernutrition without any physical symptoms. These are:

- Decreased serum albumin levels have been linked to increased morbidity and mortality among dialysis patients (Beddhu et al., 2002, Iseki et al., 1993, Kalantar-Zadeh et al., 2005, Lowrie and Lew, 1990). When serum albumin levels of 122 haemodialysis patients were compared against the SGA scores, Elliott and Robb (2009) found that patients with a serum albumin level less than 35 g/L were significantly associated with increased undernutrition risk defined by the SGA. Therefore serum albumin appears to be a useful predictor of undernutrition risk among patients undergoing dialysis (Elliott and Robb, 2009, Steiber et al., 2007). The Renal Association Standards also advise to perform a full nutrition assessment in renal patients with an albumin level less than 35g/L (The Renal Association, 2002). However, non-nutritional factors such as plasma volume expansion, albumin redistribution, exogenous loss, increased catabolism, and decreased synthesis have been reported to affect the levels of serum albumin level (Heimbürger et al., 2000, Jones et al., 1997, Steinman, 2000). This is because serum albumin is an acute phase reactant protein and its use as a predictor of undernutrition can be disguised by inflammation (Jones et al., 1997). Serum albumin was consequently incorporated into the R-RST as an additional objective measure to increase the diagnostic performance at recognising renal inpatients at risk of undernutrition.

- The high prevalence of an elevated CRP (> 10 mg/L) has been reported in both dialysis (Qureshi et al., 1998, Zimmermann et al., 1999, Owen and Lowrie, 1998) and pre-dialysis patients (Stenvinkel et al., 1999). Serum CRP levels greater than 10 mg/L were demonstrated to be significantly correlated with an increased risk of undernutrition (Elliott and Robb, 2009). This elevated CRP levels may be contributed by an increased production of pro-inflammatory cytokines among CKD patients (Pereira et al., 1994, Kimmel et al., 1998). Subsequently, the over accumulation of pro-inflammatory cytokines may stimulate muscle wasting by promoting protein catabolism via the ubiquitin-proteosome pathway (Bistrian et al., 1992) as well as by decreasing albumin synthesis and the suppression of appetite (Steinman, 2000). Thus, an increased CRP level appears to be an independent risk variable associated with undernutrition (Heimbürger et al., 2000, Qureshi et al., 1998). The assessment of serum CRP levels among this patient group was included in the R-NST as one of the additional risk variables.
- Renal patients with predialysis urea levels less than 15 mmol/L have been reported to have a greater risk of undernutrition, which is likely a result of inadequate protein intake (Elliott and Robb, 2009, Gower, 2002). However, since there are various non-dietary factors that may affect serum urea levels such as renal function, catabolism and inadequate or over-dialysis, serum urea were only incorporated as one of the three additional objective measures into the R-NST.

Furthermore, the R-NST was designed to be completed in three simple steps. This three-step format is aimed to facilitate timely generation of dietetic referrals; not only to recognise acute renal inpatients at risk of undernutrition, but also to identify those requiring dietetic input due to their renal conditions.

The five compulsory questions in Step one includes involuntary loss of dry weight in the past six months, reduction in food intake, serum potassium and phosphate levels and the presence of peritonitis. These questions encompass the essential risk variables for the risk of undernutrition (Kondrup et al., 2003a) as well as risk factors indicating dietetic input required due to renal conditions among acute renal inpatients (Bennett et al., 2006). A total score of three points or more from these five questions will generate a

dietetic referral. As a result of this approach, 91 (74.6%) of the total group of 122 participants were referred, of which 64 (70.3%) were identified in Step one already. In other words, these five compulsory questions in Step one is responsible for almost three quarters of the total dietetic referrals generated in this research study. Of the 64 referrals generated from Step one, these five compulsory questions were further able to distinguish between those participants identified due to increased risk of undernutrition (n=57, 89.1%) and those referred due to their renal conditions requiring dietetic input (n=7, 10.9%). These compulsory questions ensure that the R-NST identifies participants requiring dietetic input in the timeliest manner.

In Step two, the four additional questions regarding gastrointestinal symptoms and serum levels of albumin, CRP and urea, provide an opportunity to further examine the undernutrition risk of participants whose scores were less than three points. These additional questions are specifically related to undernutrition risk among individuals with renal failure (Elliott and Robb, 2009, Cano et al., 2002, Zoran, 2003, Beddhu et al., 2002, Iseki et al., 1993, Kalantar-Zadeh et al., 2005, Lowrie and Lew, 1990, Gower, 2002, Kimmel et al., 1998, Pereira et al., 1994) to allow the R-NST to capture as many participants at risk of undernutrition as possible. Because of this extra screening step, 27 (29.6%) of the 91 referred participants were recognised as at risk of undernutrition after the completion of these additional questions. Therefore, this three-step R-NST was successfully designed to facilitate timely dietetic referral on an acute renal ward in addition to the recognition of undernutrition risk among this population group.

Although the effectiveness of some of the existing nutrition screening tools at identifying undernutrition risk among individuals with renal failure have been examined, such as the GNRI, MUST and MST (Szeto et al., 2010, Yamada et al., 2008, Lawson et al., 2011), the ability of recognising renal patients requiring dietetic input due to their renal conditions has not yet been considered by the authors. Conversely, a Four-Element Nutrition Screening Tool (FENST) was developed by Bennett et al. (2006) in Australia to detect haemodialysis patients requiring dietetic input due to their renal conditions in outpatient facilities. The FENST employs four specific nutritional concerns that affect non-hospital haemodialysis patients, namely weight change, poor appetite, serum

potassium and serum phosphate levels (Bennett et al., 2006). Nonetheless, the FENST was not aimed to identify individuals at risk of undernutrition per se (Bennett et al., 2006). Thus, the R-NST is the first nutrition screening tool that was developed not only to identify renal patients at risk of undernutrition, but also to refer those requiring dietetic input due to their renal conditions in an acute care setting.

5.5 Nutrition screening and prevalence of undernutrition on Ward One

Of the 122 participants, 91 were referred to the Nutrition and Dietetic services at MM Hosp based on the outcome of the R-NST. Of these 91 participants, 83 (68.0%) were identified as at risk of undernutrition. The other eight participants were recognised by the R-NST as in need of dietetic interventions because of their renal conditions. On average, six participants per week was recognised by the R-NST as at risk of undernutrition, compared with only two patients per week, identified by the retrospective audit under the normal ward practice. Since the retrospective review only reported 24.3% of the 74 patients referred to the Nutrition and Dietetic services under the normal ward practice, as opposed to 68.0% identified by the R-NST, there is a likelihood that the normal ward practice failed to recognise more than half of the patients from Ward One that would have been identified by the R-NST as at risk of undernutrition. When MUST and MST were used to identify 190 renal inpatients at risk of undernutrition, only 38.8% and 32.4% were classified as at risk of undernutrition, respectively (Lawson et al., 2011). The R-NST appears to recognise a higher percentage of undernutrition risk than the ones classified by the MUST and MST in this patient group (Lawson et al., 2011).

Approximately two thirds (n=65, 63.9%) of the participants in this research study was malnourished based on the results of the 7-point SGA, which is considered as a diagnostic method of undernutrition among adults with renal failure by the NKF-KDOQI (Chassany et al., 2002, Levey et al., 2002). Similarly, the prevalence of undernutrition in acute renal inpatients in Australia was reported to be approximately 50% (Lawson et al., 2011). This highlights the importance of nutrition screening to identify malnutrition early for this patient group. In comparison to the prevalence of undernutrition among

hospitalised patients in Australia and New Zealand regardless of the medical specialities, it was found to be 32% within a total of 3122 participants from 370 acute care wards from 56 hospitals across Australia (n = 42) and New Zealand (n = 14) (Agarwal et al., 2012b). Hence, the prevalence of undernutrition in acute renal inpatients is almost twice as high as other medical specialities in hospital. However, a recent study of screening of randomly selected acute care hospital patients (n=275) in a tertiary Australian hospital showed that malnutrition was poorly documented (Gout et al., 2009). Only 15% of malnourished patients were identified and correctly documented by the dietitians as being malnourished in the medical history (Gout et al., 2009). Therefore, it is imperative to implement a routine nutrition screening protocol to facilitate the recognition of malnourished patients on the acute renal wards.

5.6 Validation of the newly developed R-NST

To be able to recommend this R-NST to be used in clinical practice, its diagnostic performance needed to be validated against gold standard measures. The seven-point SGA and the HGS as an independent functional indicator were chosen for this purpose.

5.6.1 Diagnostic performance of the R-NST in comparison to the SGA

The R-NST showed a great ability at detecting undernutrition risk (sensitivity = 97.3%, specificity = 74.4%, positive predictive value (PPV) = 88.0%, negative predictive value (NPV) = 93.6%), compared to the seven-point SGA.

The R-NST met the recommendation for an appropriate nutrition screening tool by having a sensitivity ≥ 80% and a specificity of 60% (Ferguson et al., 1999). A high sensitivity in relation to the results of the SGA (97.3%) indicates that the R-NST is particularly sensitive at correctly identifying malnourished individuals in this patient group. Although the specificity was much lower (74.4%) than sensitivity, it still exceeded the a priori definition of 60% specificity (Ferguson et al., 1999). A specificity of 74.4% shows that the R-NST correctly identified 74.4% of participants who were not at risk of

undernutrition as test negative (true negatives) but 25.6% participants without undernutrition were incorrectly identified as test positive (false positives).

In the acute care setting, the sensitivity and specificity for both the MUST and MST have been well investigated (Amaral et al., 2008, Ferguson et al., 1999, Gibson et al., 2012, Kyle et al., 2006, Almeida et al., 2012). The sensitivities and specificities of the MUST were found in three published studies as 85% and 93% (Almeida et al., 2012), 80% and 85% (Gibson et al., 2012), 61% and 76% (Kyle et al., 2006), respectively. Similarly, the sensitivities and specificities of the MST were reported in three published studies as 48.7% and 94.6% (Amaral et al., 2008), 93% and 93% (Ferguson et al., 1999), 77% and 83% (Gibson et al., 2012), respectively. The low sensitivity of 48.7% was conducted among oncology inpatients (Amaral et al., 2008), the reference method used in this study was a nutrition screening tool, NRS 2002, not a full nutrition assessment tool. Van Venrooij et al. (2007) argue that the lack of ability for nutrition screening tools to evaluate the nutritional status of individuals may contribute to this low sensitivity observed. Although the MUST and MST have showed evidence on identifying patients at risk of undernutrition in an acute setting and their sensitivities and specificities were comparable to the R-NST, these studies were not conducted specifically among individuals with renal failure (Amaral et al., 2008, Ferguson et al., 1999, Gibson et al., 2012, Kyle et al., 2006). Hence, it is not plausible to compare the results of these studies with the present research study.

In terms of the sensitivity and specificity of nutrition screening tools that have been examined among renal patients, the effectiveness of the GNRI in recognising undernutrition risk among dialysis patients in outpatient facilities against the MIS and SGA has been investigated (Szeto et al., 2010, Yamada et al., 2008). When compared to the MIS, the sensitivities and specificities of the GNRI in both haemodialysis and peritoneal dialysis patients were 73.0% and 81.9% (Yamada et al., 2008) and 68.0% and 67.7% (Szeto et al., 2010), respectively. However, when compared to the SGA, the sensitivity of the GNRI in peritoneal dialysis outpatients decreased to 54.5%, whilst its specificity increased to 71.1% (Szeto et al., 2010). Although the GNRI has demonstrated moderate ability in identifying dialysis patients at risk of undernutrition in the outpatient

facilities, its effect was unable to be compared with this research study due to the difference in settings.

Individuals with renal failure in an acute care setting has only been examined by one Australian study conducted by Lawson et al. (2011). The authors explored the validity of both the MUST and MST at recognising the undernutrition risk in this patient group against the SGA (Lawson et al., 2011). Both the MUST and MST show considerably lower sensitivity, 53.8% and 48.7%, respectively, in comparison to the 97.3% sensitivity of the R-NST. However, the specificity of the MUST and MST, 78.3% and 85.5% respectively, were reasonably higher than the R-NST (74.4%) (Lawson et al., 2011).

For nutrition screening, the benefit of having a higher sensitivity ensures that all individuals with undernutrition are correctly identified as at increased risk of undernutrition and receive timely dietetic input (Lawson et al., 2011). This is particularly significant to Counties Manukau DHB, which is responsible for providing healthcare services for areas with a high population of Māori and Pacific Island peoples (Statistics New Zealand, 2006). Since Māori and Pacific Island peoples were found to have a higher prevalence of renal failure than New Zealand European (McDonald et al., 2011, Simmons et al., 1994), and the rate of hospitalisations of Māori and Pacific Island peoples with renal failure was greater (Health and Disability Intelligence Unit, 2008), implementing a nutrition screening tool that is able to identify almost all malnourished renal inpatients in MM Hosp will be the most beneficial to the Māori and Pacific Island patients. Therefore, the R-NST shows great potential to be implemented as a standard nutrition screening protocol on Ward One in MM Hosp.

Having a tool with moderate specificity implies that more resources may be spent on individuals who are not actually malnourished (Lawson et al., 2011, Isenring et al., 2009). Nevertheless, it is far more important to ensure that all malnourished participants are being identified by the R-NST than misclassifying the well nourished participants as undernourished. This is because the implications of untreated undernutrition in hospital are beyond extra resources required to exclude well nourished patients recognised as at risk of undernutrition(Elia and Stratton, 2009). Undernutrition in renal patients has been

found to be significantly associated with longer hospital stay and increased morbidity (Ikizler et al., 1999, Pupim et al., 2003, Fiaccadori et al., 1999). Recent economic estimates suggest that the cost of undernutrition to the UK in 2007 was at least £13 billion because of the adverse clinical effects of malnutrition, which increase treatment costs, hospitalisations, general practitioner visits and general healthcare use (Elia and Stratton, 2009). In contrast, Kruizenga and colleagues (2005b) indicate that early screening with low HGS and treatment of malnourished patients reduced the length of hospital stay in all malnourished patients by one day. Therefore, a nutrition screening tool with a high sensitivity is clinically more meaningful than specificity.

Predictive values are useful to reflect the diagnostic performance of a screening test as they indicate the likelihood of disease in an individual when the test result is positive (PPV). In contrast, the NPV indicates the likelihood of being disease free in an individual when the test result is negative (Lalkhen and McCluskey, 2008). The 88.0% PPV of the R-NST indicates that if an individual tests as at risk of undernutrition, there is an 88.0% chance that he or she is malnourished. This means that if 100 individuals are recognised by the R-NST as at risk of undernutrition, 88 of them are likely to be malnourished, whilst 12 of them are likely to be well nourished. In other words, there is a good probability that an individual does have some level of undernutrition if he or she tests positive by the R-NST. Conversely, the NPV of 93.6% demonstrates that if an individual tests as not at risk of undernutrition by the R-NST, there is a 93.6% chance that he or she is well nourished. Therefore, high percentages of both the PPV and NPV indicate that the undernutrition risk of a renal inpatient predicted by the R-NST is very likely to be accurate.

The MUST and MST have been shown to have good PPV and NPV in the acute care setting (Ferguson et al., 1999, Almeida et al., 2012, Kyle et al., 2006). Ferguson et al. (1999) demonstrated that the PPV and NPV of the MST were 98.4% and 72.7% in 408 hospitalised patients in Australia. Although the MUST shows moderate PPV (65%) and NPV (76%) in a mixture of surgical and medical inpatients (Kyle et al., 2006), it illustrates much higher scores of the PPV (89%) and NPV (99%) in surgical patients alone (Almeida et al., 2012). When comparing the PPVs and NPVs of MUST and MST in renal inpatients

with that of the R-NST, it demonstrates remarkably higher PPV (88%) and NPV (93.6%) than both the MUST (73.7% and 60%) and MST (78.7% and 60%), respectively (Lawson et al., 2011). Consequently, Lawson and colleagues (2011) concluded that the MUST and MST may not be suitable for this patient group. This shows that the R-NST has far superior diagnostic performance in identifying undernutrition risk in this patient group than both screening tools. The superior results of PPV and NPV may be resulting from the risk variables employed in the R-NST. These risk variables consist of traditional risk variables such as involuntary weight loss in the past six months and reduction in food intake due to a decreased appetite as well as risk variables that are specific to acute renal inpatients including some biochemical measures. Furthermore, the GNRI that incorporates anthropometric and biochemical measures aiming to recognise haemodialysis outpatients at risk of undernutrition demonstrated moderate scores of PPV (71.7%) and NPV (78.7%) (Yamada et al., 2008). However, the reference method used in the study by Yamada et al. (2008) was the MIS, which was different from the reference method used to validate the R-NST. The settings, in which these two screening tools were validated, were also different. Hence, it would be interesting to examine the diagnostic performance of the R-NST and GNRI in the renal inpatients using the same reference method in future studies.

5.6.2 Handgrip strength and nutritional status in adult acute renal patients

Handgrip strength has been considered to be a reliable method to evaluate skeletal muscle function in a variety of population groups (Bohannon, 2001, Schlüssel et al., 2008a, Stalenhoef et al., 2002), including individuals with renal failure (Heimbürger et al., 2000, Stenvinkel et al., 2002, Wang et al., 2005, Jones et al., 1997). Since the reduction of lean body mass (LBM) occurs earlier than physical symptoms of nutritional deprivation and restoration, (Thibault and Pichard, 2012, Kerr et al., 1996), HGS appears to be an early tool to recognise early undernutrition by measuring any decrease in LBM among individuals with renal failure (Heimbürger et al., 2000, Stenvinkel et al., 2002, Wang et al., 2005, Jones et al., 1997) .

In the present research study, 93 participants (76.9%) had a below average HGS when compared to a set of age- and sex-specific reference values (Gore and Edwards, 1992). The mean HGS values of well nourished patients were 26.9 [95% CI: 23.2, 30.8] kg for males and 22.3 [95% CI: 19.1, 26.1] kg for females, whereas the mean HGS for malnourished patients were 26.3 [95% CI: 23.4, 39.5] kg for males and 16.3 [95% CI: 14.9, 18.0] kg for females, given the nutritional status was defined by the SGA results. Although the mean HGS of study participants were much lower than those not receiving dialysis (Heimbürger et al., 2000, Stenvinkel et al., 2002), the mean HGS of renal patients on maintenance dialysis reported by both Qureshi et al. (1998) and Axelsson et al. (2006) were comparable to the findings of present research study (see Table 5.1). This may be explained by the majority of the study participants (76.2%) being on maintenance dialysis. The length of individuals being on maintenance dialysis treatment may reflect their levels of HGS and LBM. Maintenance dialysis can be viewed as leading to a chronic inflammatory state, which has an elevated resting energy expenditure associated with decreased lean body mass (Stenvinkel et al., 2000, Dinarello and Roubenoff, 1996). Therefore patients on maintenance dialysis often have decreased LBM (Axelsson et al., 2006, Qureshi et al., 1998).

Table 5.1 Handgrip strength reported in various research studies according to nutritional status and sex

Subjects	HGS (kg)				
	Males		Females		
	Well nourished[1]	Malnourished[1]	Well nourished[1]	Malnourished[1]	
121 renal inpatients	26.9 [23.2, 30.8]	26.3 [23.4, 29.5]	22.3 [19.1, 26.1]	16.3 [14.9, 18.0]	(Xia et al., 2013)
115 ESRD patients starting dialysis	43.5 ± 8.0	27.7 ± 6.3	29.2 ± 11.2	20.6 ± 5.8	(Heimbürger et al., 2000)
206 ESRD patients predialysis	42.0 ± 1.0	25.0 ± 2.0	29.0 ± 2.0	20.0 ± 1.0	(Stenvinkel et al., 2002)
128 ESRD patients on haemodialysis	34.0 ± 12.0	24.0 ± 9.0 (mildly)	22.0 ± 9.0	13.0 ± 7.0 (mildly)	(Qureshi et al., 1998)
		12.0 ± 11.0 (moderately – severely)		11.0 ± 6.0 (moderately – severely)	
193 ESRD patients on dialysis	40.4 ± 1.3 (non-inflamed[2])	29.1 ± 2.6 (non-inflamed[2])	25.7 ± 1.5 (non-inflamed[2])	22.8 ± 1.9 (non-inflamed[2])	(Axelsson et al., 2006)
	38.6 ± 1.7 (inflamed[2])	25.8 ± 1.7 (inflamed[2])	19.4 ± 2.7 (inflamed[2])	19.0 ± 1.4 (inflamed[2])	

Results are expressed as geometric mean [95% CI] and mean ± standard deviation.

HGS, handgrip strength; ESRD, end-stage renal disease.

[1] Nutritional status of participants was evaluated by the subjective global assessment tool.

[2] Inflammation was defined as C-reactive protein greater or equal to 10 mg/L.

The HGS of well nourished patients reported in these four studies were significantly higher than those that were malnourished (Heimbürger et al., 2000, Stenvinkel et al., 2002, Axelsson et al., 2006, Qureshi et al., 1998). Heimbürger et al. (2000) found that well nourished predialysis patients evaluated by the SGA performed significantly better in the HGS test and had greater LBM compared to those classified as malnourished by the SGA. However, the difference in HGS between well nourished and malnourished participants in this present research study only reached significance in females, but not in males. And a weak correlation was observed between the average of the HGS and the SGA (0.24, $p = 0.009$) among acute renal inpatients, and no significant correlation was found between the average of the HGS and the R-NST (- 0.12, $p = 0.20$).

There are some confounding factors that may have influenced the effectiveness of HGS in identifying acute renal inpatients who are malnourished. Handgrip strength values were observed to be associated with sex and age in renal patients (Schlüssel et al., 2008a). Not only was the mean HGS of well nourished female participants based on the SGA significantly higher than the ones that were malnourished (22.3kg vs. 16.3kg, $p = 0.001$), but well nourished participants aged under 65 also showed a significantly higher HGS compared to those that were malnourished (26.2kg vs. 20.4kg, $p = 0.009$). Nonetheless, no difference in HGS between well nourished and malnourished participants was observed if they were male or over 65 years of age. Therefore, HGS appears to be an ineffective tool to detect malnourished individuals who are either male or over 65 years of age in this patient group.

This weak association between the HGS and nutritional status may firstly be influenced by the type of patients this research study was aiming for, which was a mixture of renal inpatients with various degrees of disease state. The studies that have shown significant association were conducted in homogeneous groups of renal patients (Heimbürger et al., 2000, Stenvinkel et al., 2002, Wang et al., 2005, Jones et al., 1997). Since the HGS between predialysis patients and those on maintenance dialysis, which results from chronic dialysis, is associated with a reduction in LBM (Stenvinkel et al., 2000, Dinarello and Roubenoff, 1996), having a heterogeneous sample group of both predialysis and maintenance dialysis patients is likely to attenuate the diagnostic performance of HGS

on nutritional status. Secondly, while the analysis accounts for age and sex, it does not account for anthropometric factors, such as height (Balogun et al., 1991, Hanten et al., 1999, Desrosiers et al., 1995, Peolsson et al., 2001) weight (Balogun et al., 1991, Hanten et al., 1999) or hand size (Desrosiers et al., 1995), which have been found to affect HGS. Therefore, further research should be conducted to investigate the plausibility of using the HGS as an early screening tool for undernutrition in an acute care setting with a variety of patient groups, particularly renal patients.

5.7 Feasibility of the newly developed R-NST in practice

Evidence-based best practice guidelines in Australia (Watterson et al., 2009) and in the UK (National Collaborating Centre for Acute Care, 2006) recommend the implementation of nutrition screening protocol for every patient admitted to the hospital. Nevertheless, many cases of undernutrition are unrecognised resulting from the absence of such a protocol in hospital (Elia et al., 2005, Kruizenga et al., 2005b), or because of a lack of compliance of routine nutrition screening (Raja et al., 2008). Since physicians and nursing staff examine patients on admission to hospital, Green and Watson (2005) suggested that physicians and nursing staff are in an ideal situation to conduct nutrition screening. Subsequently, this newly developed and validated R-NST was trialled as a nutrition screening protocol to be administered by the nursing staff on the ward level for nine weeks. The research assistants were also performing the screening independently of the staff during this period, to act as a control.

Of the 84 participants who were screened by the research assistants in this period, only 22.6% were also screened by the nursing staff. This is comparable with the findings from the retrospective review, in which 24.3% of the 74 renal patients were identified by the nursing staff as at risk of undernutrition. The rate of compliance for nursing staff to screen every patient on admission varies from one hospital to another. Raja et al. (2008) found that the screening compliance ranged from 2% to 61% in three Melbourne hospitals in Australia. Porter et al. (2009) also reported low rates of compliance in two hospital wards as 17% and 62% in a survey of 46 admitted patients in Australia. This indicates that the compliance rate in the present study is at the lower end of the range.

The low compliance rate also suggests that implementation of a nutrition screening tool within patient admission procedures does not automatically translate into nursing practice. However, these data do not provide explanations for compliance or noncompliance. Hence, a nurses' survey was administered following the trial to investigate any barriers to the use of the R-NST as a screening practice in this research study. The main barriers reflected from the survey were their perceived workload pressures and the importance of nurses' education about malnutrition and nutrition screening. Porter et al. (2009) also discovered that the use of MUST by the nursing staff was limited by task priorities and their self-perceptions of skill, and uncertainty about screening protocols. Therefore, factors that limit the time nursing staff give to completing the screening may include competing patient care tasks, nurses' skill in use of the tool and acceptance of evidence-based practice (Porter et al., 2009, Raja et al., 2008). Furthermore, 36.8% of the R-NSTs were accurately completed by the nursing staff when compared to the ones completed by the research assistants. This indicates that there was a large gap between the quality of screening performed by the nursing staff and the research assistants representing the correct procedure of using the R-NST. Although the initial training on using the R-NST was provided to the nursing staff, the low accuracy on completing the R-NST implies that ongoing training and support are required and may promote screening compliance.

Since knowledge and skills were two of 12 key domains identified as enabling behaviour change in implementing evidence-based practice (Michie et al., 2005), nurse education and staff support are demonstrated to have a positive impact on overcoming the barriers to screen and subsequently to increase screening compliance (Raja et al., 2008, Bailey, 2006). After providing nursing staff with screening education, informal support and supervision as well as offering additional education sessions to charged nurses for four months, the rates of compliance in screening in two wards had increased from 25% and 61% to 46% and 70%, respectively (Raja et al., 2008). Bailey (2006) also reported that the initial screening rate in a stroke ward (87%) soon after implementation of the MUST was increased to 94% after refresher training sessions were provided. Thus, offering education and support to nursing staff are imperative to the success of implementing a nutrition screening tool as a standard ward practice.

Chapter Six

6. Conclusion

6.1 Research problem and aims of the research study

Individuals with renal failure are prone to undernutrition and the causes are often multifactorial (Strejc, 2005, Dukkipati and Kopple, 2009, Kopple, 1999). Undernutrition is a condition that can only be treated once it has been identified. Nutrition screening tools have been showed to be more reliable than personal judgment in identifying hospital patients at risk (Davis and Stables, 1996). Hence, nutrition screening on admission plays a vital role in recognising patients at risk of undernutrition in hosptial. However, only half malnourished hospital patients were identified by nursing and medical staff in the absence of routine screening (Elia, 2003, Kruizenga et al., 2005b). The implications of unrecognised and untreated undernutrition in hospital are substantial, not only for patients' quality of care but also from a cost perspective (Tappenden et al., 2013).

Undernutrition in renal patients has been found to be significantly associated with longer hospital stay and increased morbidity (Ikizler et al., 1999, Pupim et al., 2003, Fiaccadori et al., 1999). However, there is currently no published nutrition screening tool developed specific for renal patients in an acute care setting. Although there are two existing rapid nutrition screening tools that have been investigated in this patient group, they are shown to be insensitive at identifying those at risk of undernutrition (Lawson et al., 2011). Therefore, the aim of this research study was to develop and validate a rapid nutrition screening tool that is sensitive and specific to recognise renal patients at risk of undernutrition in the acute care setting. The researchers also evaluated the feasibility of the newly developed Renal Nutrition Screening Tool (R-NST) as a routine nutrition screening protocol performed by nursing staff on an acute renal ward.

6.2 The main findings of the research study

The results of this research study indicates that the prevalence of undernutrition (63.9%) on the acute renal ward in MM Hosp was twice as high as the average prevalence of 32% reported in New Zealand (Agarwal et al., 2012a) and worldwide (Barker et al., 2011, Bistrian et al., 1974, Christensen and Gstundtner, 1985, Somanchi et al., 2011) .

Since the primary objectives of this research study were to develop and validate a nutrition screening tool aimed at identifying adult renal inpatients at risk of undernutrition, the nine-question R-NST was therefore designed to screen renal inpatients at risk of undernutrition in three simple steps. It was also designed to recognise renal inpatients requiring dietetic intervention due to their renal conditions. Furthermore, this research study has shown that the R-NST has excellent criterion validity (sensitivity = 97.3%, specificity = 74.4%, positive predictive value (PPV) = 88.0%, negative predictive value (NPV) = 93.6%), when compared with a comprehensive nutritional assessment tool, the SGA. This suggests that the R-NST is an effective tool at identifying renal patients at risk of undernutrition in the acute setting. Although there was no significant correlation found between the R-NST and the average of HGS among this patient group, the average HGS was significantly lower in malnourished participants who are either male or under 65 years of age as opposed to the well nourished ones.

The feasibility of the R-NST as a standard practice by the nursing staff on the acute renal ward in Middlemore hospital (MM Hosp) was explored by the researchers as a secondary objective. However, the rate of compliance in nutrition screening using the R-NST by the nursing staff on the ward level was lower. Hence, the feasibility of using the R-NST as a standard nutrition screening on the ward level was unable to be fully investigated. Future studies might explore innovative yet effective ways to increase screening compliance such as additional education and ongoing support to the nursing staff.

In summary, this research study has achieved the aim of developing and validating a nutrition screening tool that is sensitive and specific to recognise renal inpatients at risk of undernutrition in the acute renal wards.

6.3 Strengths

This is the first study to develop a new and rapid nutrition screening tool that can be administered by the nursing staff or other healthcare professionals on acute renal wards. This newly developed R-NST can not only detect renal inpatients requiring dietetic input due to their renal conditions, but also identify those that are at risk of undernutrition. Although there has been a nurse-performed nutrition screening tool developed for outpatients undergoing maintenance haemodialysis to identify the needs of dietetic input because of their renal conditions, this screening tool was not constructed to recognise patients at risk of undernutrition (Bennett et al., 2006). When Lawson and colleagues (2011) compared the ability of two rapid screening tools, the MUST and MST at identifying renal inpatients at risk of undernutrition against the comprehensive nutrition assessment tool, the SGA, these two rapid screening tools were found to be ineffective in this patient group. In contrast, the R-NST was demonstrated to be significantly associated with the SGA and produced excellent ability to differentiate renal inpatients who are at risk of undernutrition from those being well nourished.

Another key strength of this research study is that the research assistants performing the R-NST were blinded to the alternative measures of the SGA and HGS and visa versa, thereby reducing the influence of bias in this study. The R-NST has also been trialled by the nursing staff on the ward level to investigate the feasibility of using it as a standard nutrition screening protocol. We believe the results observed from this part of the research study reflect a great likelihood of representing true practice of nutrition screening on the ward level.

In addition, this research study is the first study to provide a snapshot of undernutrition prevalence among renal patients from the acute renal ward setting in New Zealand hospitals. It provides significant evidence indicating that the prevalence of

undernutrition in this patient group is particularly higher compared to other patient groups in the acute care setting.

6.4 Limitations

The process of selecting a nutrition assessment tool as the reference method to validate the R-NST is challenging since there is no gold standard for assessing nutritional status (Watterson et al., 2009). The SGA is a valid and reliable tool for use in the renal patients and has good intra- and inter-individual reliability (Churchill et al., 1996, Jones et al., 2004, Steiber et al., 2007, Visser et al., 1999). Although the ICD-10-AM definition of undernutrition uses BMI < 18.5 kg/m^2 or presence of at least 5% weight loss, decreased intake and presence of subcutaneous fat loss and/or muscle wasting, these risk variables are already the components of the SGA. (World Health Organization, 2010, Detsky et al., 1987). Therefore it was selected as the reference method of choice for the present research study. However, the evidence on the validity of the SGA at evaluating the nutritional status of New Zealand Māori and Pacific Island peoples is lacking, especially since 68% of the participants in this research study were from Māori and Pacific Island people decent. This may subsequently affect the validity of the R-NST particularly with the lower specificity calculated when comparing to the SGA.

The low completion rate of the R-NST by the nursing staff hindered the researchers to further investigate the feasibility of using it as a routine nutrition screening tool. It reflects the necessity of offering sufficient education and ongoing support for the nursing staff to ensure the compliance on the ward level. Nevertheless, any ward staff (e.g. the health care assistant, allied health assistant or ward clerk) should be able to conduct the routine nutrition screening by using the R-NST. This is because of the unique design of the R-NST so long as the training given is standardised and adequate. Therefore, these alternative ways to implement the R-NST as a routine nutrition screening protocol may enhance the compliance rate of nutrition screening on the ward level.

This weak association between the HGS and nutritional status may firstly be influenced by the type of patients this research study was aiming for, which was a mixture of renal inpatients with various degrees of disease state. Having a heterogeneous sample group of both predialysis and maintenance dialysis patients is likely to attenuate the diagnostic performance of HGS on nutritional status. Secondly, while the analysis accounts for age and sex, it does not account for anthropometric factors, such as height (Balogun et al., 1991, Hanten et al., 1999, Desrosiers et al., 1995, Peolsson et al., 2001) weight (Balogun et al., 1991, Hanten et al., 1999) or hand size (Desrosiers et al., 1995), which have been found to affect HGS. Thirdly, the reference values for the HGS was developed based on a reference population that was from individuals who did manual labour as a job (Gore and Edwards, 1992). Since the circumstances of manual labourers and acutely ill patients are vastly different, the actual HGS values of the study population were likely to be underestimated. Therefore, further research should be conducted to investigate the effectiveness of using HGS as an early screening tool for undernutrition among renal inpatients.

6.5 Use of the findings of this research study

With the high prevalence of undernutrition observed on the acute renal ward, the need of implementing a nutrition screening tool that is specific to the renal inpatients has never been higher. This newly developed R-NST is the first nutrition screening tool to show great ability at detecting undernutrition in this patient group and setting. It can also identify renal inpatients in need of dietetic intervention due to their renal conditions. In addition, the three-step design allows the tool to be completed by any healthcare professionals on the ward in a timely manner. Thus, it is highly beneficial to incorporate the R-NST as a routine nutrition screening protocol on all acute renal wards to identify not only patients at risk of undernutrition but also those requiring dietetic input because of their renal problems. The findings from this research study also increase value for publication.

6.6 Recommendations

- Although the R-NST has shown excellent PPV and NPV for undernutrition risk among renal acute patients, future studies with a larger sample size is needed to ensure precision of these results.
- Future studies should compare the diagnostic performance of the R-NST and GNRI in the renal inpatients using the same reference method.
- The validity of the SGA at evaluating the nutritional status of Māori and Pacific Island peoples requires further investigation. This is particularly important for New Zealand where significant diet related morbidity and mortality disparities persist among Māori and Pacific Island peoples (Ministry of Health, 2012).
- Further examine the association between HGS and nutritional status among this patient group prior to using HSG as an early indicator of undernutrition.
- Further investigation on how to increase the rate of compliance in nutrition screening among nursing staff in the light of the findings from this research study and other current literature. It may be worthwhile to examine the effectiveness of offering ongoing training and support to the nursing staff to increase screening compliance.
- Since the R-NST can be administered by any trained ward staff, it would be worthwhile to explore any alternative ways to conduct routine nutrition screening on the ward levels to ensure that it is implemented with all patients as they are admitted.

References

AGARWAL, E., FERGUSON, M., BANKS, M., BATTERHAM, M., BAUER, J., CAPRA, S. & ISENRING, E. 2012a. Nutrition care practices in hospital wards: Results from the Nutrition Care Day Survey 2010. *Clinical Nutrition,* 31**,** 995-1001.

AGARWAL, E., FERGUSON, M., BANKS, M., BAUER, J., CAPRA, S. & ISENRING, E. 2012b. Nutritional status and dietary intake of acute care patients: Results from the Nutrition Care Day Survey 2010. *Clinical Nutrition,* 31**,** 41-47.

ALMEIDA, A. I., CORREIA, M., CAMILO, M. & RAVASCO, P. 2012. Nutritional risk screening in surgery: Valid, feasible, easy! *Clinical Nutrition,* 31**,** 206-211.

ALP IKIZLER, T., PUPIM, L. B., BROUILLETTE, J. R., LEVENHAGEN, D. K., FARMER, K., HAKIM, R. M. & FLAKOLL, P. J. 2002. Hemodialysis stimulates muscle and whole body protein loss and alters substrate oxidation. *American Journal of Physiology - Endocrinology and Metabolism,* 282**,** E107-E116.

ALVO, M., KRSULOVIC, P., FERNANDEZ, V., ESPINOZA, A. M., ESCOBAR, M. & MARUSIC, E. T. 1989. Effect of a simultaneous potassium and carbohydrate load on extrarenal potassium homeostasis in end-stage renal failure. *Nephron,* 53**,** 133-137.

AMARAL, T. F., ANTUNES, A., CABRAL, S., ALVES, P. & KENT-SMITH, L. 2008. An evaluation of three nutritional screening tools in a Portuguese oncology centre. *Journal of Human Nutrition and Dietetics,* 21**,** 575-583.

AMARAL, T. F., MATOS, L. C., TEIXEIRA, M. A., TAVARES, M. M., ALVARES, L. & ANTUNES, A. 2010. Undernutrition and associated factors among hospitalized patients. *Clinical Nutrition,* 29**,** 580-5.

ASH, S., CAMPBELL, K., MACLAUGHLIN, H., MCCOY, E., CHAN, M., ANDERSON, K., CORKE, K., DUMONT, R., LLOYD, L., MEADE, A., MONTGOMERY-JOHNSON, R., TASKER, T., THRIFT, P. & TROTTER, B. 2006. Evidence based practice guidelines for the nutritional management of chronic kidney disease. *Nutrition and Dietetics,* 63**,** S35-S45.

AVESANI, C. M., CARRERO, J. J., AXELSSON, J., QURESHI, A. R., LINDHOLM, B. & STENVINKEL, P. 2006. Inflammation and wasting in chronic kidney disease: Partners in crime. *Kidney International,* 70**,** S8-S13.

AXELSSON, J., QURESHI, A. R., DIVINO-FILHO, J. C., BÁRÁNY, P., HEIMBÜRGER, O., LINDHOLM, B. & STENVINKEL, P. 2006. Are insulin-like growth factor and its binding proteins 1 and 3 clinically useful as markers of malnutrition, sarcopenia and inflammation in end-stage renal disease? *European Journal of Clinical Nutrition,* 60**,** 718-726.

BAILEY, R. 2006. Implementing nutrition screening. *Nursing Management,* 13**,** 20-24.

BAKER, J. P., DETSKY, A. S. & WESSON, D. E. 1982a. A comparison of clinical judgment and objective measurements. *New England Journal of Medicine,* 306**,** 969-972.

BAKER, J. P., DETSKY, A. S., WHITWELL, J., LANGER, B. & JEEJEEBHOY, K. N. 1982b. A comparison of the predictive value of nutritional assessment techniques. *Human Nutrition: Clinical Nutrition,* 36 c**,** 233-241.

BALOGUN, J. A., AKINLOYE, A. A. & ADENLOLA, S. A. 1991. Grip strength as a function of age, height, body weight and Quetelet index. *Physiotherapy Theory and Practice,* 7**,** 111-119.

BARENDREGT, K., SOETERS, P. B., ALLISON, S. P. & KONDRUP, J. 2008. Basic concepts in nutrition: Diagnosis of malnutrition – Screening and assessment. *e-SPEN, the European e-Journal of Clinical Nutrition and Metabolism,* 3**,** e121-e125.

BARKER, L. A., GOUT, B. S. & CROWE, T. C. 2011. Hospital malnutrition: Prevalence, identification and impact on patients and the healthcare system. *International Journal of Environmental Research and Public Health,* 8**,** 514-527.

BEDDHU, S., KAYSEN, G. A., YAN, G., SARNAK, M., AGODOA, L., ORNT, D. & CHEUNG, A. K. 2002. Association of serum albumin and atherosclerosis in chronic hemodialysis patients. *American Journal of Kidney Diseases,* 40**,** 721-727.

BELLOMO, R., RONCO, C., KELLUM, J. A., MEHTA, R. L. & PALEVSKY, P. 2004. Acute renal failure - definition, outcome measures, animal models, fluid therapy and information technology needs: the Second International Consensus Conference of the Acute Dialysis Quality Initiative (ADQI) Group. *Critical care (London, England),* 8**,** R204-212.

BENNETT, P. N., BREUGELMANS, L., MEADE, A. & PARKHURST, D. 2005. A haemodialysis nutritional screening tool for nurses - A pilot study. *EDTNA-ERCA Journal,* 31**,** 143-146.

BENNETT, P. N., BREUGELMANS, L., MEADE, A. & PARKHURST, D. 2006. A simple nutrition screening tool for hemodialysis nurses. *Journal of Renal Nutrition,* 16**,** 59-62.

BERGSTROM, J. 1995. Nutrition and mortality in hemodialysis. *Journal of the American Society of Nephrology,* 6**,** 1329-1341.

BISTRIAN, B. R., BLACKBURN, G. L., HALLOWELL, E. & HEDDLE, R. 1974. Protein status of general surgical patients. *Journal of the American Medical Association,* 230**,** 858-860.

BISTRIAN, B. R., SCHWARTZ, J. & ISTFAN, N. W. 1992. Cytokines, muscle proteolysis, and the catabolic response to infection and inflammation. *Proceedings of the Society for Experimental Biology and Medicine,* 200**,** 220-223.

BLUMENKRANTZ, M. J., GAHL, G. M., KOPPLE, J. D., KAMDAR, A. V., JONES, M. R., KESSEL, M. & COBURN, J. W. 1981. Protein losses during peritoneal dialysis. *Kidney International,* 19**,** 593-602.

BOHANNON, R. W. 2001. Dynamometer measurements of hand-grip strength predict multiple outcomes. *Perceptual and Motor Skills,* 93**,** 323-328.

BOUILLANNE, O., MORINEAU, G., DUPANT, C., COULOMBEL, I., VINCENT, J. P., NICOLIS, I., BENAZETH, S., CYNOBER, L. & AUSSEL, C. 2005. Geriatric Nutritional Risk Index: A new index for evaluating at-risk elderly medical patients. *American Journal of Clinical Nutrition,* 82**,** 777-783.

BRITISH DIETETIC ASSOCIATION 2003. Challenging the use of body mass index (BMI) to assess under-nutrition in older people. *Diet. Today,* 38**,** 15-19.

BUZBY, G. P., KNOX, L. S., CROSBY, L. O., EISENBERG, J. M., HAAKENSON, C. M., MCNEAL, G. E., PAGE, C. P., PETERSON, O. L., REINHARDT, G. F. & WILLIFORD, W. O. 1988a. Study protocol: A randomised clinical trial of total parenteral nutrition in malnourished surgical patients. *American Journal of Clinical Nutrition,* 47**,** 366-381.

BUZBY, G. P., WILLIFORD, W. O., PETERSON, O. L., CROSBY, L. O., PAGE, C. P., REINHARDT, G. F. & MULLEN, J. L. 1988b. A randomised clinical trial of total parenteral nutrition in malnourished surgical patients: The rationale and impact of previous clinical trials and pilot study on protocol design. *American Journal of Clinical Nutrition,* 47**,** 357-365.

CAMPBELL, K. L., ASH, S., BAUER, J. & DAVIES, P. S. W. 2007. Critical review of nutrition assessment tools to measure malnutrition in chronic kidney disease. *Nutrition and Dietetics,* 64**,** 23-30.

CAMPBELL, K. L., ASH, S. & BAUER, J. D. 2008. The impact of nutrition intervention on quality of life in pre-dialysis chronic kidney disease patients. *Clinical Nutrition,* 27**,** 537-544.

CAMPBELL, S. E., AVENELL, A. & WALKER, A. E. 2002. Assessment of nutritional status in hospital in-patients. *QJM - Monthly Journal of the Association of Physicians,* 95**,** 83-87.

CANO, N. J. M., ROTH, H., APARICIO, M., AZAR, R., CANAUD, B., CHAUVEAU, P., COMBE, C., FOUQUE, D., LAVILLE, M. & LEVERVE, X. M. 2002. Malnutrition in hemodialysis diabetic patients: Evaluation and prognostic influence. *Kidney International,* 62**,** 593-601.

CARRERO, J. J. 2011. Mechanisms of altered regulation of food intake in chronic kidney disease. *Journal of Renal Nutrition,* 21**,** 7-11.

CARRERO, J. J., CHMIELEWSKI, M., AXELSSON, J., SNAEDAL, S., HEIMBÜRGER, O., BÁRÁNY, P., SULIMAN, M. E., LINDHOLM, B., STENVINKEL, P. & QURESHI, A. R. 2008. Muscle atrophy, inflammation and clinical outcome in incident and prevalent dialysis patients. *Clinical Nutrition,* 27**,** 557-564.

CARRERO, J. J., QURESHI, A. R., AXELSSON, J., AVESANI, C. M., SULIMAN, M. E., KATO, S., BÁRÁNY, P., SNAEDAL-JONSDOTTIR, S., ALVESTRAND, A., HEIMBÜRGER, O., LINDHOLM, B. & STENVINKEL, P. 2007. Comparison of nutritional and inflammatory markers in dialysis patients with reduced appetite. *American Journal of Clinical Nutrition,* 85**,** 695-701.

CHAN, J. Y. W., CHE, K. I., LAM, K. M. C., CHOW, K. M., CHUNG, K. Y., LI, P. K. T. & SZETO, C. C. 2007. Comprehensive malnutrition inflammation score as a marker of nutritional status in Chinese peritoneal dialysis patients. *Nephrology,* 12**,** 130-134.

CHARRA, B., LAURENT, G., CHAZOT, C., CALEMARD, E., TERRAT, J. C., VANEL, T., JEAN, G. & RUFFET, M. 1996. Clinical assessment of dry weight. *Nephrology Dialysis Transplantation,* 11**,** 16-19.

CHASSANY, O., SAGNIER, P., MARQUIS, P., FULLERTON, S. & AARONSON, N. 2002. Patient-reported outcomes: The example of health-related quality of life - A European guidance document for the improved integration of health-related quality of life assessment in the drug regulatory process. *Drug Information Journal,* 36**,** 209-238.

CHENG, T. H. T., LAM, D. H. H., TING, S. K. L., WONG, C. L. Y., KWAN, B. C. H., CHOW, K. M., LAW, M. C., LI, P. K. T. & SZETO, C. C. 2009. Serial monitoring of nutritional status in Chinese peritoneal dialysis patients by Subjective Global Assessment and comprehensive Malnutrition Inflammation Score. *Nephrology,* 14**,** 143-147.

CHERTOW, G. M., BILLIARD, A. & LAZARUS, J. M. 1996. Nutrition and the dialysis prescription. *American Journal of Nephrology,* 16**,** 79-89.

CHRISTENSEN, K. S. & GSTUNDTNER, K. M. 1985. Hospital-wide screening improves basis for nutrition intervention. *Journal of the American Dietetic Association,* 85**,** 704-706.

CHRISTENSSON, L., UNOSSON, M. & EK, A. C. 2002. Evaluation of nutritional assessment techniques in elderly people newly admitted to municipal care. *European Journal of Clinical Nutrition,* 56**,** 810-818.

CHURCHILL, D. N., TAYLOR, D. W., KESHAVIAH, P. R., THORPE, K. E., BEECROFT, M. L., JINDAL, K. K., FENTON, S. S. A., BARGMAN, J. M., OREOPOULOS, D. G., WU, G. G., LAVOIE, S. D., FINE, A., BURGESS, E., BRANDES, J. C., NOLPH, K. D., PROWANT, B. F., PAGÉ, D., MCCUSKER, F. X., TEEHAN, B. P., DASGUPTA, M. K., BETTCHER, K., CARUANA, R., DEVEBER, G. & HENDERSON, L. W. 1996. Adequacy of dialysis and nutrition in continuous peritoneal dialysis: Association with clinical outcomes. *Journal of the American Society of Nephrology,* 7**,** 198-207.

COHEN, G., MARY JOSE, S. & AHRONHEIM, J. C. 2009. Body mass index: Pitfalls in elderly people. *Journal of the American Geriatrics Society,* 57**,** 170-172.

COMPAN, B. 1999. Epidemiological study of malnutrition in elderly patients in acute, sub-acute\and long-term care using the mna®. *Journal of Nutrition, Health and Aging,* 3**,** 146-151.

COUNTIES MANUKAU DISTRIC HEALTH BOARD 2013. Counties Manukau Distric Health Board Renal Guideline: Hyperkalaemia - Acute Management. 2 ed. Auckland, New Zealand.

DAVIS, C. & STABLES, I. 1996. Audit of nutrition screening in patients with acute illness. *Nursing times,* 92**,** 35-37.

DE AQUINO, R. C. & PHILIPPI, S. T. 2011. Identification of malnutrition risk factors in hospitalized patients. *Revista da Associacao Medica Brasileira,* 57**,** 623-629.

DE BRITO-ASHURST, I., VARAGUNAM, M., RAFTERY, M. J. & YAQOOB, M. M. 2009. Bicarbonate supplementation slows progression of CKD and improves nutritional status. *Journal of the American Society of Nephrology,* 20**,** 2075-2084.

DE MARCHI, S. & CECCHIN, E. 1990. Severe metabolic acidosis and disturbances of calcium metabolism induced by acetazolamide in patients on haemodialysis. *Clinical Science,* 78**,** 295-302.

DE MUTSERT, R., GROOTENDORST, D. C., BOESCHOTEN, E. W., BRANDTS, H., VAN MANEN, J. G., KREDIET, R. T. & DEKKER, F. W. 2009. Subjective global assessment of nutritional status is strongly associated with mortality in chronic dialysis patients. *American Journal of Clinical Nutrition,* 89**,** 787-793.

DESBROW, B., BAUER, J., BLUM, C., KANDASAMY, A., MCDONALD, A. & MONTGOMERY, K. 2005. Assessment of nutritional status in hemodialysis patients using patient-generated subjective global assessment. *Journal of Renal Nutrition,* 15**,** 211-216.

DESROSIERS, J., BRAVO, G., HÉBERT, R. & DUTIL, E. 1995. Normative data for grip strength of elderly men and women. *The American journal of occupational therapy. : official publication of the American Occupational Therapy Association,* 49**,** 637-644.

DETSKY, A. S., MCLAUGHLIN, J. R., BAKER, J. P., JOHNSTON, N., WHITTAKER, S., MENDELSON, R. A. & JEEJEEBHOY, K. N. 1987. What is subjective global assessment of nutritional status? *Journal of Parenteral and Enteral Nutrition,* 11**,** 8-13.

DEVELLIS, R. F. 2012. *Scale development: theory and applications,* Los Angeles (CA), Sage Publications.

DINARELLO, C. A. & ROUBENOFF, R. A. 1996. Mechanisms of loss of lean body mass in patients on chronic dialysis. *Blood Purification,* 14**,** 388-394.

DONINI, L. M., SAVINA, C., ROSANO, A., DE FELICE, M. R., TASSI, L., DE BERNARDINI, L., PINTO, A., GIUSTI, A. M. & CANNELLA, C. 2003. MNA predictive value in the follow-up of geriatric patients. *Journal of Nutrition, Health and Aging,* 7**,** 282-293.

DUERKSEN, D. R., YEO, T. A., SIEMENS, J. L. & O'CONNOR, M. P. 2000. The validity and reproducibility of clinical assessment of nutritional status in the elderly. *Nutrition,* 16**,** 740-744.

DUKKIPATI, R. & KOPPLE, J. D. 2009. Causes and prevention of protein-energy wasting in chronic kidney failure. *Seminars in Nephrology,* 29**,** 39-49.

EDINGTON, J., BOORMAN, J., DURRANT, E. R., PERKINS, A., GIFFIN, C. V., JAMES, R., THOMSON, J. M., OLDROYD, J. C., SMITH, J. C., TORRANCE, A. D., BLACKSHAW, V., GREEN, S., HILL, C. J., BERRY, C., MCKENZIE, C., VICCA, N., WARD, J. E. & COLES, S. J. 2000. Prevalence of malnutrition on admission to four hospitals in England. *Clinical Nutrition,* 19**,** 191-195.

EKNOYAN, G. 2008. Adolphe Quetelet (1796-1874) - The average man and indices of obesity. *Nephrology Dialysis Transplantation,* 23**,** 47-51.

EKNOYAN, G. & LEVIN, N. W. 2000. K/DOQI clinical practice guidelines for nutrition in chronic renal failure. *American Journal of Kidney Diseases,* 35**,** S1-S140.

ELIA, M. 2003. Screening for Malnutrition: A Multidisciplinary Responsibility. Development and Use of the Malnutrition Universal Screening Tool ('MUST') for Adults. Redditch: BAPEN.

ELIA, M. & STRATTON, R. J. 2009. Calculating the cost of disease-related malnutrition in the UK in 2007. *In:* ELIA, M. & RUSSELL, C. A. (eds.) *Combating Malnutrition: Recommendations for Action.* Redditch: BAPEN.

ELIA, M., ZELLIPOUR, L. & STRATTON, R. J. 2005. To screen or not to screen for adult malnutrition? *Clinical Nutrition,* 24**,** 867-884.

ELLIOTT, H. A. & ROBB, L. 2009. Computer-based undernutrition screening tool for hemodialysis patients. *Dialysis and Transplantation,* 38**,** 12-23.

ELMORE, M. F., WAGNER, D. R., KNOLL, D. M., EIZEMBER, L., OSWALT, M. A., GLOWINSKI, E. A. & RAPP, P. A. 1994. Developing an effective adult nutrition screening tool for a community hospital. *Journal of the American Dietetic Association,* 94**,** 1113-1121.

ENIA, G., SICUSO, C., ALATI, G. & ZOCCALI, C. 1993. Subjective global assessment of nutrition in dialysis patients. *Nephrology Dialysis Transplantation,* 8**,** 1094-1098.

FAO/WHO/UNU 1985. Energy and protein requirements. Geneva: WHO.

FERGUSON, M., CAPRA, S., BAUER, J. & BANKS, M. 1999. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutrition,* 15**,** 458-464.

FERNANDEZ, J., OSTER, J. R. & PEREZ, G. O. 1986. Impaired extrarenal disposal of an acute oral potassium load in patients with endstage renal disease on chronic hemodialysis. *Mineral and Electrolyte Metabolism,* 12**,** 125-129.

FIACCADORI, E., LOMBARDI, M., LEONARDI, S., ROTELLI, C. F., TORTORELLA, G. & BORGHETTI, A. 1999. Prevalence and clinical outcome associated with preexisting malnutrition in acute renal failure: A prospective cohort study. *Journal of the American Society of Nephrology,* 10**,** 581-593.

FOUQUE, D. 1996. Insulin-Like Growth Factor 1 Resistance in Chronic Renal Failure. *Mineral and Electrolyte Metabolism,* 22**,** 133-137.

FOUQUE, D., KALANTAR-ZADEH, K., KOPPLE, J., CANO, N., CHAUVEAU, P., CUPPARI, L., FRANCH, H., GUARNIERI, G., IKIZLER, T. A., KAYSEN, G., LINDHOLM, B., MASSY, Z., MITCH, W., PINEDA, E., STENVINKEL, P., TREVINHO-BECERRA, A. & WANNER, C. 2008. A proposed nomenclature and diagnostic criteria for protein-energy wasting in acute and chronic kidney disease. *Kidney International,* 73**,** 391-398.

GARROW, J. S. & WEBSTER, J. 1985. Quetelet's index (W/H2) as a measure of fatness. *International Journal of Obesity,* 9**,** 147-153.

GAZZOTTI, C., ALBERT, A., PEPINSTER, A. & PETERMANS, J. 2000. Clinical usefulness of the mini nutritional assessment (MNA) scale in geriatric medicine. *Journal of Nutrition, Health and Aging,* 4**,** 176-181.

GIBSON, R. 2005. Validity in Dietary Assessment Methods. *Principles of Nutritional Assessment.* 2nd ed.: Oxford University Press.

GIBSON, S., SEQUEIRA, J., CANT, R. & KU, C. 2012. Identifying malnutrition risk in acute medical patients: Validity and utility of Malnutrition Universal Screening Tool and Modified Malnutrition Screening Tool. *Nutrition and Dietetics,* 69**,** 309-314.

GOLDSTEIN, J. D. 1998. Assessment of nutritional status in renal disease. *In:* MITCH, W. E. & KLAHR, S. (eds.) *Handbook of Nutrition and the Kidney.* 3 ed. Philadelphia, PA: Lippincott-Raven.

GONICK, H. C., KLEEMAN, C. R., RUBINI, M. E. & MAXWELL, M. H. 1971. Functional impairment in chronic renal disease. Studies of potassium excretion. *American Journal of the Medical Sciences,* 261**,** 281-290.

GORE, C. J. & EDWARDS, D. A. 1992. *Australian fitness norms: a manual for fitness assessors,* North Adelaide, SA, Health Development Foundation.

GOUT, B. S., BARKER, L. A. & CROWE, T. C. 2009. Malnutrition identification, diagnosis and dietetic referrals: Are we doing a good enough job? *Nutrition and Dietetics,* 66**,** 206-211.

GOWER, T. 2002. Computers in clinical practice: Screening renal patients for abnormal biochemistry and malnutrition. *Journal of Renal Nutrition,* 12**,** 107-112.

GRACE, B., HURST, K. & MCDONALD, S. 2011. New patients commencing treatments in 2010. Adelaide, South Australia: Australia and New Zealand Dialysis and Transplsant registry.

GRACE, B. S., CLAYTON, P. & MCDONALD, S. P. 2012. Increases in renal replacement therapy in Australia and New Zealand: Understanding trends in diabetic nephropathy. *Nephrology,* 17**,** 76-84.

GREEN, S. M. & WATSON, R. 2005. Nutritional screening and assessment tools for use by nurses: Literature review. *Journal of Advanced Nursing,* 50**,** 69-83.

GUIGOZ, Y., VELLAS, B. & GARRY, P. J. 1997. Mini nutritional assessment : A practical assessment tool for grading the nutritional state of elderly patients. *Facts, Research and Intervention in Geriatrics***,** 15-32.

HANTEN, W. P., CHEN, W. Y., AUSTIN, A. A., BROOKS, R. E., CARTER, H. C., LAW, C. A., MORGAN, M. K., SANDERS, D. J., SWAN, C. A. & VANDERSLICE, A. L. 1999. Maximum grip strength in normal subjects from 20 to 64 years of age. *Journal of Hand Therapy,* 12**,** 193-200.

HARRIS, D. G., DAVIES, C., WARD, H. & HABOUBI, N. Y. 2008. An observational study of screening for malnutrition in elderly people living in sheltered accommodation. *Journal of Human Nutrition and Dietetics,* 21**,** 3-9.

HARTY, J. C., BOULTON, H., CURWELL, J., HEELIS, N., UTTLEY, L., YENNING, M. C. & GOKAL, R. 1994. The normalized protein catabolic rate is a flawed marker of nutrition in CAPD patients. *Kidney International,* 45**,** 103-109.

HAWLEY, C. 2005. *The CARI Guidelines. Biochemical and Haematological Targets. Serum phosphate* [Online]. Available: http://www.cari.org.au/DIALYSIS_bht_published/Recommended%20target%20for%20Serum%20Phosphate.pdf [Accessed August 2013].

HAYES JR, C. P. & ROBINSON, R. R. 1965. Faecel potassium excetion in patients on chronic intermittent hemodialysis. *Transactions - American Society for Artificial Internal Organs,* 11**,** 242-246.

HAYNES, S. N., RICHARD, D. C. S. & KUBANY, E. S. 1995. Content validity in psychological assessment: A functional approach to concepts and methods. *Psychological Assessment,* 7**,** 238-247.

HEALTH AND DISABILITY INTELLIGENCE UNIT 2008. Counties Manukau DHB Health Needs Assessment September 2008. Manukau: Counties Manukau District Health Board.

HEIMBÜRGER, O., LÖNNQVIST, F., DANIELSSON, A., NORDENSTRÖM, J. & STENVINKEL, P. 1997. Serum immunoreactive leptin concentration and its relation to the body fat content in chronic renal failure. *Journal of the American Society of Nephrology,* 8**,** 1423-1430.

HEIMBÜRGER, O., QURESHI, A. R., BLANER, W. S., BERGLUND, L. & STENVINKEL, P. 2000. Hand-grip muscle strength, lean body mass, and plasma proteins as markers of nutritional status in patients with chronic renal failure close to start of dialysis therapy. *American Journal of Kidney Diseases,* 36**,** 1213-1225.

HEMMELOFF ANDERSEN, K. E. 1977. Folic acid status of patients with chronic renal failure maintained by dialysis. *Clinical Nephrology,* 8**,** 510-513.

HENDERSON, L. W. 1980. Symptomatic hypotension during hemodialysis. *Kidney International,* 17**,** 571-576.

HOLDEN, R. B. 2010. Face validity. *In:* WEINER, I. B. & CRAIGHEAD, W. E. (eds.) *The Corsini Encyclopedia of Psychology.* 4 ed. Hoboken, NJ: Wiley.

HOREJS, J., ORT, J., NEMECEK, K. & STRAKOVA, M. 1990. Echography of the inferior vena cava is a simple and reliable tool for estimation of 'dry weight' in haemodialysis patients. *Nephrology Dialysis Transplantation,* 5**,** 238.

HRUSKA, K. A., MATHEW, S., LUND, R. J., MEMON, I. & SAAB, G. 2009. The Pathogenesis of Vascular Calcification in the Chronic Kidney Disease Mineral Bone Disorder:

The Links Between Bone and the Vasculature. *Seminars in Nephrology,* 29**,** 156-165.

IKIZLER, T. A., WINGARD, R. L., HARVELL, J., SHYR, Y. & HAKIM, R. M. 1999. Association of morbidity with markers of nutrition and inflammation in chronic hemodialysis patients: A prospective study. *Kidney International,* 55**,** 1945-1951.

ISEKI, K., KAWAZOE, N. & FUKIYAMA, K. 1993. Serum albumin is a strong predictor of death in chronic dialysis patients. *Kidney International,* 44**,** 115-119.

ISEKI, K., UEHARA, H., NISHIME, K., TOKUYAMA, K., YOSHIHARA, K., KINJO, K., SHIOHIRA, Y. & FUKIYAMA, K. 1996. Impact of the initial levels of laboratory variables on survival in chronic dialysis patients. *American Journal of Kidney Diseases,* 28**,** 541-548.

ISENRING, E., BAUER, J., BANKS, M. & GASKILL, D. 2009. The Malnutrition Screening Tool is a useful tool for identifying malnutrition risk in residential aged care. *Journal of Human Nutrition and Dietetics,* 22**,** 545-550.

ISENRING, E. A., BANKS, M., FERGUSON, M. & BAUER, J. D. 2012. Beyond Malnutrition Screening: Appropriate Methods to Guide Nutrition Care for Aged Care Residents. *Journal of the Academy of Nutrition and Dietetics,* 112**,** 376-381.

JAEGER, J. Q. & MEHTA, R. L. 1999. Assessment of dry weight in hemodialysis: An overview. *Journal of the American Society of Nephrology,* 10**,** 392-403.

JENSEN, G. L., MIRTALLO, J., COMPHER, C., DHALIWAL, R., FORBES, A., GRIJALBA, R. F., HARDY, G., KONDRUP, J., LABADARIOS, D., NYULASI, I., CASTILLO PINEDA, J. C. & WAITZBERG, D. 2010. Adult starvation and disease-related malnutrition: A proposal for etiology-based diagnosis in the clinical practice setting from the International Consensus Guideline Committee. *Clinical Nutrition,* 29**,** 151-153.

JONES, C. & WRIGHT, M. 2010. *Clinical Practice Guidelines. Nutrition in CKD. UK Renal Association.* [Online]. Available: http://www.renal.org/clinical/guidelinessection/NutritionInCKD.aspx [Accessed August 2013].

JONES, C. H., NEWSTEAD, C. G., WILL, E. J., SMYE, S. W. & DAVISON, A. M. 1997. Assessment of nutritional status in CAPD patients: Serum albumin is not a useful measure. *Nephrology Dialysis Transplantation,* 12**,** 1406-1413.

JONES, C. H., WOLFENDEN, R. C. & WELLS, L. M. 2004. Is subjective global assessment a reliable measure of nutritional status in hemodialysis? *Journal of Renal Nutrition,* 14**,** 26-30.

JONES, J. M. 2004a. Development of a nutritional screening or assessment tool using a multivariate technique. *Nutrition,* 20**,** 298-306.

JONES, J. M. 2004b. Validity of nutritional screening and assessment tools. *Nutrition,* 20**,** 312-317.

KALANTAR-ZADEH, K. 2005. Recent advances in understanding the malnutrition-inflammation-cachexia syndrome in chronic kidney disease patients: What is next? *Seminars in Dialysis,* 18**,** 365-369.

KALANTAR-ZADEH, K., BLOCK, G., MCALLISTER, C. J., HUMPHREYS, M. H. & KOPPLE, J. D. 2004a. Appetite and inflammation, nutrition, anemia, and clinical outcome in hemodialysis patients. *American Journal of Clinical Nutrition,* 80**,** 299-307.

KALANTAR-ZADEH, K., IKIZLER, T. A., BLOCK, G., AVRAM, M. M. & KOPPLE, J. D. 2003. Malnutrition-Inflammation Complex Syndrome in Dialysis Patients: Causes and Consequences. *American Journal of Kidney Diseases,* 42**,** 864-881.

KALANTAR-ZADEH, K., KILPATRICK, R. D., KUWAE, N., MCALLISTER, C. J., ALCORN JR, H., KOPPLE, J. D. & GREENLAND, S. 2005. Revisiting mortality predictability of serum albumin in the dialysis population: Time dependency, longitudinal changes and population-attributable fraction. *Nephrology Dialysis Transplantation,* 20**,** 1880-1888.

KALANTAR-ZADEH, K., KLEINER, M., DUNNE, E., LEE, G. H. & LUFT, F. C. 1999. A modified quantitative subjective global assessment of nutrition for dialysis patients. *Nephrology Dialysis Transplantation,* 14**,** 1732-1738.

KALANTAR-ZADEH, K., KOPPLE, J. D., BLOCK, G. & HUMPHREYS, M. H. 2001. A malnutrition-inflammation score is correlated with morbidity and mortality in maintenance hemodialysis patients. *American Journal of Kidney Diseases,* 38**,** 1251-1263.

KALANTAR-ZADEH, K., KOPPLE, J. D., HUMPHREYS, M. H. & BLOCK, G. 2004b. Comparing outcome predictability of markers of malnutrition-inflammation complex syndrome in haemodialysis patients. *Nephrology Dialysis Transplantation,* 19**,** 1507-1519.

KATZARSKI, K. S. 1996. Monitoring of blood volume during haemodialysis treatment of acute renal and multiple organ failures. *Nephrology Dialysis Transplantation,* 11**,** 20-23.

KAYSEN, G. A., MÜLLER, H. G., YOUNG, B. S., LENG, X. & CHERTOW, G. M. 2004. The influence of patient- and facility-specific factors on nutritional status and survival in hemodialysis. *Journal of Renal Nutrition,* 14**,** 72-81.

KELLY, I. E., TESSIER, S., CAHILL, A., MORRIS, S. E., CRUMLEY, A., MCLAUGHLIN, D., MCKEE, R. F. & LEAN, M. E. J. 2000. Still hungry in hospital: Identifying malnutrition in acute hospital admissions. *QJM - Monthly Journal of the Association of Physicians,* 93**,** 93-98.

KERR, P. G., STRAUSS, B. J. G. & ATKINS, R. C. 1996. Assessment of the nutritional state of dialysis patients. *Blood Purification,* 14**,** 382-387.

KÉZACHIAN, L. & BONNET, P. A. 2012. Simplifying screening process of elderly malnutrition in general practice: Test match between a simple tool, the "Malnutrition Universal Screening Tool" (MUST) and the "Mini Nutritional Assessment-Short Form" (MNA-SF"). *Nutrition clinique et métabolisme,* 26**,** 109-113.

KIMMEL, P. L., PHILLIPS, T. M., SIMMENS, S. J., PETERSON, R. A., WEIHS, K. L., ALLEYNE, S., CRUZ, I., YANOVSKI, J. A. & VEIS, J. H. 1998. Immunologic function and survival in hemodialysis patients. *Kidney International,* 54**,** 236-244.

KOBAYASHI, I., ISHIMURA, E., KATO, Y., OKUNO, S., YAMAMOTO, T., YAMAKAWA, T., MORI, K., INABA, M. & NISHIZAWA, Y. 2010. Geriatric Nutritional Risk Index, a simplified nutritional screening index, is a significant predictor of mortality in chronic dialysis patients. *Nephrology Dialysis Transplantation,* 25**,** 3361-3365.

KOMABA, H. & FUKAGAWA, M. 2010. FGF23-parathyroid interaction: Implications in chronic kidney disease. *Kidney International,* 77**,** 292-298.

KONDRUP, J., ALLISON, S. P., ELIA, M., VELLAS, B. & PLAUTH, M. 2003a. ESPEN guidelines for nutrition screening 2002. *Clinical Nutrition,* 22**,** 415-421.

KONDRUP, J., RAMUSSEN, H. H., HAMBERG, O., STANGA, Z., CAMILO, M., RICHARDSON, R., ELIA, M., ALLISON, S., MEIER, R. & PLAUTH, M. 2003b. Nutritional risk screening (NRS 2002): A new method based on an analysis of controlled clinical trials. *Clinical Nutrition,* 22**,** 321-336.

KOPPLE, J. D. 1999. Pathophysiology of protein-energy wasting in chronic renal failure. *Journal of Nutrition,* 129**,** 247S-251S.

KOPPLE, J. D., GREENE, T., CHUMLEA, W. C., HOLLINGER, D., MARONI, B. J., MERRILL, D., SCHERCH, L. K., SCHULMAN, G., WANG, S. R. & ZIMMER, G. S. 2000. Relationship between nutritional status and the glomerular filtration rate: Results from the MDRD study. *Kidney International,* 57**,** 1688-1703.

KOPPLE, J. D., SWENDSEID, M. E., SHINABERGER, J. H. & UMEZAWA, C. Y. 1973. The free and bound amino acids removed by hemodialysis. *Transactions - American Society for Artificial Internal Organs,* 19**,** 309-313.

KOUW, P. M., KOOMAN, J. P., CHERIEX, E. C., OLTHOF, C. G., DE VRIES, P. M. J. M. & LEUNISSEN, K. M. L. 1993. Assessment of postdialysis dry weight: A comparison of techniques. *Journal of the American Society of Nephrology,* 4**,** 98-104.

KOUW, P. M., OLTHOF, C. G., TER WEE, P. M., OE, L. P., DONKER, A. J. M., SCHNEIDER, H. & DE VRIES, P. M. J. M. 1992. Assessment of post-dialysis dry weight: An application of the conductivity measurement method. *Kidney International,* 41**,** 440-444.

KOVESDY, C. P., REGIDOR, D. L., MEHROTRA, R., JING, J., MCALLISTER, C. J., GREENLAND, S., KOPPLE, J. D. & KALANTAR-ZADEH, K. 2007. Serum and dialysate potassium concentrations and survival in hemodialysis patients. *Clinical Journal of the American Society of Nephrology,* 2**,** 999-1007.

KRAEMER, M., RODE, C. & WIZEMANN, V. 2006. Detection limit of methods to assess fluid status changes in dialysis patients. *Kidney International,* 69**,** 1609-1620.

KRUIZENGA, H. M., SEIDELL, J. C., DE VET, H. C. W., WIERDSMA, N. J. & VAN BOKHORST-DE VAN DER SCHUEREN, M. A. E. 2005a. Development and validation of a hospital screening tool for malnutrition: The short nutritional assessment questionnaire (SNAQ©). *Clinical Nutrition,* 24**,** 75-82.

KRUIZENGA, H. M., VAN TULDER, M. W., SEIDELL, J. C., THIJS, A., ADER, H. J. & VAN BOKHORST-DE VAN DER SCHUEREN, M. A. E. 2005b. Effectiveness and cost-effectiveness of early screening and treatment of malnourished patients. *American Journal of Clinical Nutrition,* 82**,** 1082-1089.

KUZUYA, M., KANDA, S., KOIKE, T., SUZUKI, Y., SATAKE, S. & IGUCHI, A. 2005. Evaluation of Mini-Nutritional Assessment for Japanese frail elderly. *Nutrition,* 21**,** 498-503.

KYLE, U. G., KOSSOVSKY, M. P., KARSEGARD, V. L. & PICHARD, C. 2006. Comparison of tools for nutritional assessment and screening at hospital admission: A population study. *Clinical Nutrition,* 25**,** 409-417.

LAFAGE-PROUST, M. H., COMBE, C., BARTHE, N. & APARICIO, M. 1999. Bone mass and dynamic parathyroid function according to bone histology in nondialyzed uremic patients after long-term protein and phosphorus restriction. *Journal of Clinical Endocrinology and Metabolism,* 84**,** 512-519.

LAFAGE, M. H., COMBE, C., FOURNIER, A. & APARICIO, M. 1992. Ketodiet, physiological calcium intake and native vitamin D improve renal osteodystrophy. *Kidney International,* 42**,** 1217-1225.

LALKHEN, A. G. & MCCLUSKEY, A. 2008. Clinical tests: Sensitivity and specificity. *Continuing Education in Anaesthesia, Critical Care and Pain,* 8**,** 221-223.

LAMB, C. A., PARR, J., LAMB, E. I. M. & WARREN, M. D. 2009. Adult malnutrition screening, prevalence and management in a United Kingdom hospital: Cross-sectional study. *British Journal of Nutrition,* 102**,** 571-575.

LANGKAMP-HENKEN, B., HUDGENS, J., STECHMILLER, J. K. & HERRLINGER-GARCIA, K. A. 2005. Mini nutritional assessment and screening scores are associated with nutritional indicators in elderly people with pressure ulcers. *Journal of the American Dietetic Association,* 105**,** 1590-1596.

LAUSTER, F., GERZER, R., WEIL, J., FULLE, H. J. & SCHIFFL, H. 1990. Assessment of dry body-weight in haemodialysis patients by the biochemical marker cGMP. *Nephrology Dialysis Transplantation,* 5**,** 356-361.

LAWSON, C. S., CAMPBELL, K. L., DIMAKOPOULOS, I. & DOCKRELL, M. E. C. 2011. Assessing the Validity and Reliability of the MUST and MST Nutrition Screening Tools in Renal Inpatients. *Journal of Renal Nutrition*.

LEVEY, A. S., CORESH, J., BOLTON, K., CULLETON, B., HARVEY, K. S., IKIZLER, T. A., JOHNSON, C. A., KAUSZ, A., KIMMEL, P. L., KUSEK, J., LEVIN, A., MINAKER, K. L., NELSON, R., RENNKE, H., STEFFES, M., WITTEN, B., HOGG, R. J., FURTH, S., LEMLEY, K. V., PORTMAN, R. J., SCHWARTZ, G., LAU, J., BALK, E., PERRONE, R. D., KARIM, T., RAYAN, L., AL-MASSRY, I., CHEW, P., ASTOR, B. C., DE VINE, D., EKNOYAN, G., LEVIN, N., BURROWS-HUDSON, S., KEANE, W., KLIGER, A., LATOS, D., MAPES, D., OBERLEY, E., WILLIS, K., BAILIE, G., BECKER, G., BURROWES, J.,

CHURCHILL, D., COLLINS, A., COUSER, W., DEZEEUW, D., GARBER, A., GOLPER, T., GOTCH, F., GOTTO, A., GREER, J. W., GRIMM JR, R., HANNAH, R. G., ACOSTA, J. H., HOGG, R., HUNSICKER, L., KLAG, M., KLAHR, S., LEWIS, C., LOWRIE, E., MATAS, A., MCCULLOCH, S., MICHAEL, M., NALLY, J. V., NEWMANN, J. M., NISSENSON, A., NORRIS, K., OWEN JR, W., PATEL, T. G., PAYNE, G., RIVERA-MIZZONI, R. A., SMITH, D., STAR, R., STEINMAN, T., VALDERRABANO, F., WALLS, J., WAUTERS, J. P., WENGER, N. & BRIGGS, J. 2002. K/DOQI clinical practice guidelines for chronic kidney disease: Evaluation, classification, and stratification. *American Journal of Kidney Diseases,* 39**,** i-ii+S1-S266.

LIN, J. & CURHAN, G. C. 2008. Kidney function decline and physical function in women. *Nephrology Dialysis Transplantation,* 23**,** 2827-2833.

LOCATELLI, F., FOUQUE, D., HEIMBURGER, O., DRÜEKE, T. B., CANNATA-ANDÍA, J. B., HÖRL, W. H. & RITZ, E. 2002. Nutritional status in dialysis patients: A European consensus. *Nephrology Dialysis Transplantation,* 17**,** 563-572.

LOCHS, H., ALLISON, S. P., MEIER, R., PIRLICH, M., KONDRUP, J., SCHNEIDER, S., VAN DEN BERGHE, G. & PICHARD, C. 2006. Introductory to the ESPEN Guidelines on Enteral Nutrition: Terminology, Definitions and General Topics. *Clinical Nutrition,* 25**,** 180-186.

LOWRIE, E. G. & LEW, N. L. 1990. Death risk in hemodialysis patients: The predictive value of commonly measured variables and an evaluation of death rate differences between facilities. *American Journal of Kidney Diseases,* 15**,** 458-482.

MALTZMAN, J. S. & BERNS, J. S. 2005. Are inflammatory cytokines the "evil humors" that increase morbidity and cardiovascular mortality in chronic kidney disease? *Seminars in Dialysis,* 18**,** 441-443.

MASSRY, S. G., COBURN, J. W., CHERTOW, G. M., HRUSKA, K., LANGMAN, C., MALLUCHE, H., MARTIN, K., MCCANN, L. M., MCCARTHY, J. T., MOE, S., SALUSKY, I. B., SHERRAND, D. J., SMOGORZEWSKI, M., BOLTON, K., TURKELSON, C., TAPPE, K., TREGEAR, S., RESTON, J., BRUENING, W., MONTEFORTE, M., KACZMAREK, J., COATES, V., BAILIE, G., BECKER, B., BECKER, G., BURROWES, J., CARRERA, F., CHURCHILL, D., COLLINS, A., CROOKS, P. W., DEZEEUW, D., GOLPER, T., GOTCH, F., GOTTO, A., GREENWOOD, R., GREER, J. W., GRIMM JR, R., HALEY, W. E., HOGG, R., HULL, A. R., HUNSICKER, L., JOHNSON, C. A., KLAG, M., KLAHR, S.,

LAMEIRE, N., LOCATELLI, F., MCCULLOCH, S., MICHAEL, M., NALLY, J. V., NEWMANN, J. M., NISSENSON, A., NORRIS, K., OBRADOR, G., OWEN JR, W., PATEL, T. G., PAYNE, G., RONCO, C., RIVERA-MIZZONI, R. A., SCHOOLWERTH, A. C., STAR, R., STEFFES, M., STEINMAN, T., WAUTERS, J. P., WENGER, N., BRIGGS, J., HOSTETTER, T., EKNOYAN, G., LEVIN, A., LEVIN, N., ANDREOLI, S. P., BURROWS-HUDSON, S., LATOS, D., MAPES, D., OBERLEY, E., PEREIRA, B. J. G., FERGUSON, N., FINGERHUT, D., GUCCIARDO, A., KLETTE, M., MALLARD, D. & WILLIS, K. 2003. K/DOQI clinical practice guidelines for bone metabolism and disease in chronic kidney disease. *American Journal of Kidney Diseases,* 42**,** i-S201.

MATHEW, S., TUSTISON, K. S., SUGATANI, T., CHAUDHARY, L. R., RIFAS, L. & HRUSKA, K. A. 2008. The mechanism of phosphorus as a cardiovascular risk factor in CKD. *Journal of the American Society of Nephrology,* 19**,** 1092-1105.

MCCANN, L. 1999. Using subjective global assessment to identify malnutrition in the ESRD patient. *Nephrology news & issues,* 13**,** 18-19.

MCCUSKER, F. X., TEEHAN, B. P., THORPE, K. E., KESHAVIAH, P. R. & CHURCHILL, D. N. 1996. How much peritoneal dialysis is required for the maintenance of a good nutritional state? Canada-USA (CANUSA) Peritoneal Dialysis Study Group. *Kidney international. Supplement,* 56**,** S56-61.

MCDONALD, S., EXCELL, L. & LIVINGSTON, B. 2008. ANZDATA Report 2008. Adelaide, South Australia: Australia and New Zealand Dialysis and Transplsant registry.

MCDONALD, S., JOSE, M. & HURST, K. 2011. End-Stage Kidney Disease among indigenous peoples of Australia and New Zealand. Adelaide, South Australia: Australia and New Zealand Dialysis and Transplsant registry.

MCWHIRTER, J. P. & PENNINGTON, C. R. 1994. Incidence and recognition of malnutrition in hospital. *British Medical Journal,* 308**,** 945-948.

MEHROTRA, R. & KOPPLE, J. D. 2001. Nutritional management of maintenance dialysis patients: Why aren't we doing better?

MEHTA, R. L., KELLUM, J. A., SHAH, S. V., MOLITORIS, B. A., RONCO, C., WARNOCK, D. G., LEVIN, A., BAGGA, A., BAKKALOGLU, A., BONVENTRE, J. V., BURDMANN, E. A., CHEN, Y., DEVARAJAN, P., D'INTINI, V., DOBB, G., DURBIN JR, C. G., ECKARDT, K. U., GUERIN, C., HERGET-ROSENTHAL, S., HOSTE, E., JOANNIDIS, M., KIRPALANI, A., LASSNIGG, A., LE GALL, J. R., LOMBARDI, R., MACIAS, W., MANTHOUS, C.,

SCHETZ, M., SCHORTGEN, F., TAN, P. S. K., WANG, H. & WEBB, S. 2007. Acute kidney injury network: Report of an initiative to improve outcomes in acute kidney injury. *Critical Care,* 11.

MICHIE, S., JOHNSTON, M., ABRAHAM, C., LAWTON, R., PARKER, D. & WALKER, A. 2005. Making psychological theory useful for implementing evidence based practice: A consensus approach. *Quality and Safety in Health Care,* 14**,** 26-33.

MINISTRY OF HEALTH 2012. The Health of New Zealand Adults 2011/12: Key findings of the New Zealand Health Survey. Wellington: Ministry of Health.

MINISTRY OF PACIFIC ISLAND AFFAIRS. n.d. *About Pacific peoples in New Zealand* [Online]. Available: http://www.mpia.govt.nz/pacific-peoples-in-new-zealand/ [Accessed August 2013].

MOCHIZUKI, T. 1991. The effect of metabolic acidosis on amino acid and keto acid metabolism in chronic renal failue. *Japanese Journal of Nephrology,* 33**,** 213-224.

MOWÉ, M., BØHMER, T. & KINDT, E. 1994. Reduced nutritional status in an elderly population (> 70 y) is probable before disease and possibly contributes to the development of disease. *American Journal of Clinical Nutrition,* 59**,** 317-324.

MOXLEY, M. A., BELL, N. H., WAGLE, S. R., ALLEN, D. O. & ASHMORE, J. 1974. Parathyroid hormone stimulation of glucose and urea production in isolated liver cells. *American Journal of Physiology,* 227**,** 1058-1061.

NABER, T. H. J., DE BREE, A., SCHERMER, T. R. J., BAKKEREN, J., BÄR, B., DE WILD, G. & KATAN, M. B. 1997. Specificity of indexes of malnutrition when applied to apparently healthy people: The effect of age. *American Journal of Clinical Nutrition,* 65**,** 1721-1725.

NATIONAL COLLABORATING CENTRE FOR ACUTE CARE. 2006. *Nutrition support in adults: oral nutrition support, enteral tube feeding and parenteral nutrition* [Online]. London: National Collaborating Centre for Acute Care. Available: http://guidance.nice.org.uk/CG32 [Accessed November 2013].

NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE (NICE) 2006. Nutrition support in adults: oral nutrition support, enteral tube feeding and parenteral nutrition.

NATIONAL INSTITUTE FOR HEALTH AND CLINICAL EXCELLENCE CHRONIC KIDNEY DISEASE 2008. Early identification and management of chronic kidney disease in adults in primary and secondary care. NICE Clinical Guideline 73. London: NICE.

NATIONAL KIDNEY AND UROLOGIC DISEASES INFORMATION CLEARINGHOUSE (NKUDIC). 2012. *Kidney Disease Statistics for the United States* [Online]. Available: http://kidney.niddk.nih.gov/kudiseases/pubs/kustats/KU_Diseases_Stats_508.pdf [Accessed August 2013].

NATIONAL KIDNEY FOUNDATION 2000. KDOQI clinical practice guidelines for nutrition in chronic renal failure. *American Journal of Kidney Diseases,* 35**,** S1-S39.

NATIONAL KIDNEY FOUNDATION. 2008. *KDOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification; Part 4. Definition and classification of stages of chronic kidney disease; guideline 1. definition and stages of chronic kidney disease* [Online]. Available: http://www.kidney.org/professionals/KDOQI/guidelines_ckd/toc.htm [Accessed November 2013].

NEELEMAAT, F., KRUIZENGA, H. M., DE VET, H. C. W., SEIDELL, J. C., BUTTERMAN, M. & VAN BOKHORST-DE VAN DER SCHUEREN, M. A. E. 2008. Screening malnutrition in hospital outpatients. Can the SNAQ malnutrition screening tool also be applied to this population? *Clinical Nutrition,* 27**,** 439-446.

NEELEMAAT, F., MEIJERS, J., KRUIZENGA, H., VAN BALLEGOOIJEN, H. & VAN BOKHORST-DE VAN DER SCHUEREN, M. 2011. Comparison of five malnutrition screening tools in one hospital inpatient sample. *Journal of Clinical Nursing,* 20**,** 2144-2152.

NEUMANN, S. A., MILLER, M. D., DANIELS, L. & CROTTY, M. 2005. Nutritional status and clinical outcomes of older patients in rehabilitation. *Journal of Human Nutrition and Dietetics,* 18**,** 129-136.

NEUMANN, S. A., MILLER, M. D., DANIELS, L. A., AHERN, M. & CROTTY, M. 2007. Mini Nutritional Assessment in geriatric rehabilitation: Inter-rater reliability and relationship to body composition and nutritional biochemistry. *Nutrition and Dietetics,* 64**,** 179-185.

NORMAN, K., STOBÄUS, N., LOCHS, H. & PIRLICH, M. 2009. Measurement of hand grip strength as nutritional outcome parameter. *Messuna der Muskelkraft als ernährunasmedizinische Zielgröße,* 34**,** 263-268.

OTTERY, F. D. 1994. Rethinking nutritional support of the cancer patient: The new field of nutritional oncology. *Seminars in Oncology,* 21**,** 770-778.

OTTERY, F. D. 1996. Definition of standardized nutritional assessment and interventional pathways in oncology. *Nutrition,* 12**,** S15-S19.

OWEN, W. F. & LOWRIE, E. G. 1998. C-reactive protein as an outcome predictor for maintenance hemodialysis patients. *Kidney International,* 54**,** 627-636.

PAPADOYANNAKIS, N. J., STEFANIDIS, C. J. & MCGEOWN, M. 1984. The effect of the correction of metabolic acidosis on nitrogen and potassium balance of patients with chronic renal failure. *American Journal of Clinical Nutrition,* 40**,** 623-627.

PEOLSSON, A., HEDLUND, R. & OBERG, B. 2001. Intra- and inter-tester reliability and reference values for hand strength. *Journal of Rehabilitation Medicine,* 33**,** 36-41.

PEREIRA, B. J. G., SHAPIRO, L., KING, A. J., FALAGAS, M. E., STROM, J. A. & DINARELLO, C. A. 1994. Plasma levels of IL-1β, TNFα and their specific inhibitors in undialyzed chronic renal failure, CAPD and hemodialysis patients. *Kidney International,* 45**,** 890-896.

PERSSON, M. D., BRISMAR, K. E., KATZARSKI, K. S., NORDENSTRÖM, J. & CEDERHOLM, T. E. 2002. Nutritional status using Mini Nutritional Assessment and Subjective Global Assessment Predict Mortality in geriatric patients. *Journal of the American Geriatrics Society,* 50**,** 1996-2002.

PHILIPSON, T. J., SNIDER, J. T., LAKDAWALLA, D. N., STRYCKMAN, B. & GOLDMAN, D. P. 2013. Impact of oral nutritional supplementation on hospital outcomes. *American Journal of Managed Care,* 19**,** 121-128.

PORTER, J., RAJA, R., CANT, R. & ARONI, R. 2009. Exploring issues influencing the use of the malnutrition universal screening tool by nurses in two Australian hospitals. *Journal of Human Nutrition and Dietetics,* 22**,** 203-209.

POULIA, K.-A., YANNAKOULIA, M., KARAGEORGOU, D., GAMALETSOU, M., PANAGIOTAKOS, D. B., SIPSAS, N. V. & ZAMPELAS, A. 2012. Evaluation of the efficacy of six nutritional screening tools to predict malnutrition in the elderly. *Clinical Nutrition,* 31**,** 378-385.

POWELL-TUCK, J. & HENNESSY, E. M. 2003. A comparison of mid upper arm circumference, body mass index and weight loss as indices of undernutrition in acutely hospitalized patients. *Clinical Nutrition,* 22**,** 307-312.

PRIÉ, D., TORRES, P. U. & FRIEDLANDER, G. 2009. Latest findings in phosphate homeostasis. *Kidney International,* 75**,** 882-889.

PUPIM, L. B., EVANSON, J. A., HAKIM, R. M. & IKIZLER, T. A. 2003. The extent of uremic malnutrition at the time of initiation of maintenance hemodialysis is associated with subsequent hospitalization. *Journal of Renal Nutrition,* 13**,** 259-266.

QURESHI, A. R., ALVESTRAND, A., DANIELSSON, A., DIVINO-FILHO, J. C., GUTIERREZ, A., LINDHOLM, B. & BERGSTRÖM, J. 1998. Factors predicting malnutrition in hemodialysis patients: A cross- sectional study. *Kidney International,* 53**,** 773-782.

RAJA, R., GIBSON, S., TURNER, A., WINDERLICH, J., PORTER, J., CANT, R. & ARONI, R. 2008. Nurses' views and practices regarding use of validated nutrition screening tools. *Australian Journal of Advanced Nursing,* 26**,** 26-33.

RAJA, R., LIM, A. V., LIM, Y. P., LIM, G., CHAN, S. P. & VU, C. K. F. 2004. Malnutrition screening in hospitalised patients and its implication on reimbursement. *Internal Medicine Journal,* 34**,** 176-181.

RAMBOD, M., BROSS, R., ZITTERKOPH, J., BENNER, D., PITHIA, J., COLMAN, S., KOVESDY, C. P., KOPPLE, J. D. & KALANTAR-ZADEH, K. 2009. Association of Malnutrition-Inflammation Score With Quality of Life and Mortality in Hemodialysis Patients: A 5-Year Prospective Cohort Study. *American Journal of Kidney Diseases,* 53**,** 298-309.

RANHOFF, A. H., GJØEN, A. U. & MOWÉ, M. 2005. Screening for malnutrition in elderly acute medical patients: The usefulness of MNA-SF. *Journal of Nutrition, Health and Aging,* 9**,** 221-225.

RASLAN, M., GONZALEZ, M. C., GONCALVES DIAS, M. C., NASCIMENTO, M., CASTRO, M., MARQUES, P., SEGATTO, S., TORRINHAS, R. S., CECCONELLO, I. & WAITZBERG, D. L. 2010. Comparison of nutritional risk screening tools for predicting clinical outcomes in hospitalized patients. *Nutrition,* 26**,** 721-726.

REAICH, D., CHANNON, S. M., SCRIMGEOUR, C. M., DALEY, S. E., WILKINSON, R. & GOODSHIP, T. H. J. 1993. Correction of acidosis in humans with CRF decreases protein degradation and amino acid oxidation. *American Journal of Physiology - Endocrinology and Metabolism,* 265**,** E230-E235.

REMLER, D. K. & VAN RYZIN, G. G. 2011. *Research methods in practice: strategies for description and causation,* Thousand Oaks, Calif, SAGE Publications.

RUBENSTEIN, L. Z., HARKER, J. O., SALVÀ, A., GUIGOZ, Y. & VELLAS, B. 2001. Screening for undernutrition in geriatric practice: Developing the Short-Form Mini-Nutritional Assessment (MNA-SF). *Journals of Gerontology - Series A Biological Sciences and Medical Sciences,* 56**,** M366-M372.

SACKS, G. S., DEARMAN, K., REPLOGLE, W. H., CORA, V. L., MEEKS, M. & CANADA, T. 2000. Use of Subjective Global Assessment to identify nutrition-associated complications and death in geriatric long-term care facility residents. *Journal of the American College of Nutrition,* 19**,** 570-577.

SALETTI, A., LINDGREN, E. Y., JOHANSSON, L. & CEDERHOLM, T. 2000. Nutritional status according to mini nutritional assessment in an institutionalized elderly population in Sweden. *Gerontology,* 46**,** 139-145.

SCHLÜSSEL, M. M., DOS ANJOS, L. A., DE VASCONCELLOS, M. T. L. & KAC, G. 2008a. Reference values of handgrip dynamometry of healthy adults: A population-based study. *Clinical Nutrition,* 27**,** 601-607.

SCHLÜSSEL, M. M., DOS ANJOS, L. A. & KAC, G. 2008b. Hand grip strength test and its use in nutritional assessment. *Revista de Nutricao,* 21**,** 223-235.

SCHRIER, R. W. & REGAL, E. M. 1972. Influence of aldosterone on sodium, water and potassium metabolism in chronic renal disease. *Kidney International,* 1**,** 156-168.

SCRIBNER, B. H., BURI, R., CANER, J. E., HEGSTROM, R. & BURNELL, J. M. 1960. The treatment of chronic uremia by means of intermittent hemodialysis: a preliminary report. *Transactions - American Society for Artificial Internal Organs,* 6**,** 114-122.

SIEW, E. D., PUPIM, L. B., MAJCHRZAK, K. M., SHINTANI, A., FLAKOLL, P. J. & IKIZLER, T. A. 2007. Insulin resistance is associated with skeletal muscle protein breakdown in non-diabetic chronic hemodialysis patients. *Kidney International,* 71**,** 146-152.

SIMMONS, D., SHAW, L. M., SCOTT, D. J., KENEALY, T. & SCRAGG, R. K. 1994. Diabetic nephropathy and microalbuminuria in the community: The South Auckland diabetes survey. *Diabetes Care,* 17**,** 1404-1410.

SOMANCHI, M., XUGUANG, T. & MULLIN, G. E. 2011. The facilitated early enteral and dietary management effectiveness trial in hospitalized patients with malnutrition. *Journal of Parenteral and Enteral Nutrition,* 35**,** 209-216.

STALENHOEF, P. A., DIEDERIKS, J. P. M., KNOTTNERUS, J. A., KESTER, A. D. M. & CREBOLDER, H. F. J. M. 2002. A risk model for the prediction of recurrent falls in community-dwelling elderly: A prospective cohort study. *Journal of Clinical Epidemiology,* 55**,** 1088-1094.

STATISTICS New Zealand. 2006. *District Health Board Area summary tables* [Online]. Available: http://www.stats.govt.nz/Census/about-2006-census/district-health-board-area-summary-tables.aspx [Accessed August 2013].

STEENKAMP, R., CASTLEDINE, C., FEEST, T. & FOGARTY, D. 2011. UK Renal Registry 13th Annual Report (December 2010): Chapter 2: UK RRT prevalence in 2009: national and centre-specific analyses. *Nephron. Clinical practice,* 119 Suppl 2**,** c27-52.

STEIBER, A., LEON, J. B., SECKER, D., MCCARTHY, M., MCCANN, L., SERRA, M., SEHGAL, A. R. & KALANTAR-ZADEH, K. 2007. Multicenter Study of the Validity and Reliability of Subjective Global Assessment in the Hemodialysis Population. *Journal of Renal Nutrition,* 17**,** 336-342.

STEIBER, A. L., KALANTAR-ZADEH, K., SECKER, D., MCCARTHY, M., SEHGAL, A. & MCCANN, L. 2004. Subjective Global Assessment in chronic kidney disease: A review. *Journal of Renal Nutrition,* 14**,** 191-200.

STEIN, A., MOORHOUSE, J., ILES-SMITH, H., BAKER, F., JOHNSTONE, J., JAMES, G., TROUGHTON, J., BIRCHER, G. & WALLS, J. 1997. Role of an improvement in acid-base status and nutrition in CAPD patients. *Kidney International,* 52**,** 1089-1095.

STEINMAN, T. I. 2000. Serum albumin: Its significance in patients with ESRD. *Seminars in Dialysis,* 13**,** 404-408.

STENVINKEL, P. 2005. Inflammation in end-stage renal disease - A fire that burns within. *In:* RONCO, C., LEVIN, N. W. & BRENDOLAN, A. (eds.).

STENVINKEL, P., BARANY, P., CHUNG, S. H., LINDHOLM, B. & HEIMBÜRGER, O. 2002. A comparative analysis of nutritional parameters as predictors of outcome in male and female ESRD patients. *Nephrology Dialysis Transplantation,* 17**,** 1266-1274.

STENVINKEL, P., HEIMBÜRGER, O., PAULTRE, F., DICZFALUSY, U., WANG, T., BERGLUND, L. & JOGESTRAND, T. 1999. Strong association between malnutrition, inflammation, and atherosclerosis in chronic renal failure. *Kidney International,* 55**,** 1899-1911.

STENVINKEL, P., LINDHOLM, B., LÖNNQVIST, F., KATZARSKI, K. & HEIMBÜRGER, O. 2000. Increases in serum leptin levels during peritoneal dialysis are associated with inflammation and a decrease in lean body mass. *Journal of the American Society of Nephrology,* 11**,** 1303-1309.

STRATTON, R. J., HACKSTON, A., LONGMORE, D., DIXON, D., PRICE, S., STROUD, M., KING, C. & ELIA, M. 2004. Malnutrition in hospital outpatients and inpatients: Prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. *British Journal of Nutrition,* 92**,** 799-808.

STRATTON, R. J., KING, C. L., STROUD, M. A., JACKSON, A. A. & ELIA, M. 2006. 'Malnutrition universal screening tool' predicts mortality and length of hospital stay in acutely ill elderly. *British Journal of Nutrition,* 95**,** 325-330.

STREJC, J. M. 2005. Considerations in the nutritional management of patients with acute renal failure. *Hemodialysis International,* 9**,** 135-42.

SULLIVAN, J. F. & EISENSTEIN, A. B. 1972. Ascorbic acid depletion during hemodialysis. *Journal of the American Medical Association,* 220**,** 1697-1699.

SZETO, C.-C., KWAN, B. C.-H., CHOW, K.-M., LAW, M.-C. & LI, P. K.-T. 2010. Geriatric Nutritional Risk Index as a Screening Tool for Malnutrition in Patients on Chronic Peritoneal Dialysis. *Journal of Renal Nutrition,* 20**,** 29-37.

TAI, T. W., CHAN, A. M., COCHRAN, C. C., HARBERT, G., LINDLEY, J. & COTTON, J. 1998. Renal dietitians' perspective: identification, prevalence, and intervention for malnutrition in dialysis patients in Texas. *Journal of renal nutrition : the official journal of the Council on Renal Nutrition of the National Kidney Foundation,* 8**,** 188-98.

TAMMAM, J., GARDNER, L. & HICKSON, M. 2009. Validity, reliability and acceptability of the Imperial Nutritional Screening System (INSYST): A tool that does not require the body mass index. *Journal of Human Nutrition and Dietetics,* 22**,** 536-544.

TAPPENDEN, K. A., QUATRARA, B., PARKHURST, M. L., MALONE, A. M., FANJIANG, G. & ZIEGLER, T. R. 2013. Critical role of nutrition in improving quality of care: An interdisciplinary call to action to address adult hospital malnutrition. *Journal of Parenteral and Enteral Nutrition,* 37**,** 482-497.

TEITELBAUM, D., GUENTER, P., HOWELL, W. H., KOCHEVAR, M. E., ROTH, J. & SEIDNER, D. L. 2005. Definition of terms, style, and conventions used in A.S.P.E.N. guidelines and standards. *Nutrition in Clinical Practice,* 20**,** 281-285.

THE RENAL ASSOCIATION. 2002. *Treatment of adults and children with renal failure: standards and audit measures.* [Online]. Available: http://www.renal.org/Libraries/Old_Guidelines/Renal_Association_Standards_3rd_Edition_2002-2007.sflb.ashx [Accessed September 2013].

THIBAULT, R. & PICHARD, C. 2012. The evaluation of body composition: A useful tool for clinical practice. *Annals of Nutrition and Metabolism,* 60**,** 6-16.

THOMAS, D. R., ZDROWSKI, C. D., WILSON, M. M., CONRIGHT, K. C., LEWIS, C., TARIQ, S. & MORLEY, J. E. 2002. Malnutrition in subacute care. *American Journal of Clinical Nutrition,* 75**,** 308-313.

UNITED STATES CENTERS FOR DISEASE CONTROL AND PREVENTION 2010. National chronic kidney disease fact sheet 2010. Atlanta, GA: US Department of Health and Human Services, CDC.

VAN NES, M. C., HERRMANN, F. R., GOLD, G., MICHEL, J. P. & RIZZOLI, R. 2001. Does the Mini Nutritional Assessment predict hospitalization outcomes in older people? *Age and Ageing,* 30**,** 221-226.

VAN VENROOIJ, L. M. W., DE VOS, R., BORGMEIJER-HOELEN, A. M. M. J., KRUIZENGA, H. M., JONKERS-SCHUITEMA, C. F. & DE MOL, B. A. M. J. 2007. Quick-and-easy nutritional screening tools to detect disease-related undernutrition in hospital in- and outpatient settings: A systematic review of sensitivity and specificity. *e-SPEN,* 2**,** 21-37.

VELLAS, B., GUIGOZ, Y., GARRY, P. J., NOURHASHEMI, F., BENNAHUM, D., LAUQUE, S. & ALBAREDE, J. L. 1999. The mini nutritional assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition,* 15**,** 116-122.

VISSER, R., DEKKER, F. W., BOESCHOTEN, E. W., STEVENS, P. & KREDIET, R. T. 1999. Reliability of the 7-point subjective global assessment scale in assessing nutritional status of dialysis patients. *Advances in peritoneal dialysis. Conference on Peritoneal Dialysis,* 15**,** 222-225.

VISVANATHAN, R., MACINTOSH, C., CALLARY, M., PENHALL, R., HOROWITZ, M. & CHAPMAN, I. 2003. The nutritional status of 250 older Australian recipients of

domiciliary care services and its association with outcomes at 12 months. *Journal of the American Geriatrics Society,* 51**,** 1007-1011.

WANG, A. Y. M., SEA, M. M. M., HO, Z. S. Y., LUI, S. F., LI, P. K. T. & WOO, J. 2005. Evaluation of handgrip strength as a nutritional marker and prognostic indicator in peritoneal dialysis patients. *American Journal of Clinical Nutrition,* 81**,** 79-86.

WATTERSON, C., FRASER, A., BANKS, M., ISENRING, E., MILLER, M., SILVESTER, C., HOEVENAARS, R., BAUER, J., VIVANTI, A. & FERGUSON, M. 2009. Evidence based practice guidelines for the nutritional management of malnutrition in adult patients across the continuum of care. *Nutrition and Dietetics,* 66**,** S1-S34.

WEEKES, E. C., ELIA, M. & EMERY, P. W. 2004. The development, validation and reliability of a nutrition screening tool based on the recommendations of the British Association for Parenteral and Enteral Nutrition (BAPEN). *Clinical Nutrition,* 23**,** 1104-1112.

WESTRA, W. M., KOPPLE, J. D., KREDIET, R. T., APPELL, M. & MEHROTRA, R. 2007. Dietary protein requirements and dialysate protein losses in chronic peritoneal dialysis patients. *Peritoneal Dialysis International,* 27**,** 192-195.

WHITE, J. V., GUENTER, P., JENSEN, G., MALONE, A. & SCHOFIELD, M. 2012a. Consensus Statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition: Characteristics Recommended for the Identification and Documentation of Adult Malnutrition (Undernutrition). *Journal of the Academy of Nutrition and Dietetics,* 112**,** 730-738.

WHITE, J. V., GUENTER, P., JENSEN, G., MALONE, A. & SCHOFIELD, M. 2012b. Consensus statement: Academy of nutrition and dietetics and American society for parenteral and enteral nutrition: Characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). *Journal of Parenteral and Enteral Nutrition,* 36**,** 275-283.

WILKENS, K. G., JUNEJA, V. & SHANAMAN, E. 2012. Medical Nutrition Therapy for Renal Disorders. *In:* MAHAN, L. K., ESCOTT-STUMP, S. E. & RAYMOND, J. L. (eds.) *Krause's Food & the Nutrition Care Process.* 13 ed. St. Louis: Elsevier.

WORKENEH, B. T. & MITCH, W. E. 2010. Review of muscle wasting associated with chronic kidney disease. *American Journal of Clinical Nutrition,* 91**,** 1128S-1132S.

WORLD HEALTH ORGANIZATION. 2010. *International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10-AM)* [Online]. Available: http://apps.who.int/classifications/icd10/browse/2010/en#/E40-E46 [Accessed November 2013].

YAMADA, K., FURUYA, R., TAKITA, T., MARUYAMA, Y., YAMAGUCHI, Y., OHKAWA, S. & KUMAGAI, H. 2008. Simplified nutritional screening tools for patients on maintenance hemodialysis. *American Journal of Clinical Nutrition,* 87**,** 106-113.

YAO, Q., LINDHOLM, B. & STENVINKEL, P. 2004. Inflammation as a cause of malnutrition, atherosclerotic cardiovascular disease, and poor outcome in hemodialysis patients. *Hemodialysis International,* 8**,** 118-129.

YOUNG, G. A., WOODROW, G., KENDALL, S., OLDROYD, B., TURNEY, J. H., BROWNJOHN, A. M. & SMITH, M. A. 1997. Increased plasma leptin/fat ratio in patients with chronic renal failure: A cause of malnutrition? *Nephrology Dialysis Transplantation,* 12**,** 2318-2323.

ZHANG, C. H., XU, Y. & ZHU, H. X. 2010. Malnutrition screening by mini-nutritional assessment and short-form mini-nutritional assessment in patients with Alzheimer's disease. *Chinese Journal of Clinical Nutrition,* 18**,** 141-144.

ZIMMERMANN, J., HERRLINGER, S., PRUY, A., METZGER, T. & WANNER, C. 1999. Inflammation enhances cardiovascular risk and mortality in hemodialysis patients. *Kidney International,* 55**,** 648-658.

ZORAN, D. 2003. Nutritional management of gastrointestinal disease. *Clinical Techniques in Small Animal Practice,* 18**,** 211-217.

Appendix A: Participant Information Sheet

Participant Information Sheet

Study title:	*Can the use of a rapid nutrition screening tool facilitate timely dietetic referrals on the acute renal wards? – A validation study*		
Locality:	Ward 1, Middlemore Hospital, Manukau, Auckland, New Zealand	Ethics committee ref.:	13/NTA/1
Lead investigator:	Andrew Xia, Dr Rozanne Kruger, Alayne Healy	Contact phone number:	+64 21 88 77 30

Request for interpreter (Please circle one)

Maaori	E hiahia ana ahau ki tetahi kaiwhaka Maaori/kaiwhaka pakeha korero	Ae	Kao
Cook Island Maaori	Ka inangaro au i tetai tangata uri reo	Ae	Kare
Fijian	Au gadreva me dua e vakadewa vosa vei au	Io	Sega
Niuean	Fia manako au ke fakaaoga e taha tagata fakahokohoko kupu	E	Nakai
Sāmoan	Ou te mana'o ia i ai se fa'amatala upu	Ioe	Leai
Tokelaun	Ko au e fofou ki he tino ke fakaliliu te gagana Peletania ki na gagana o na motu o te Pahefika	Ioe	Leai
Tongan	Oku ou fiema'u ha fakatonulea	Io	Ikai
Deaf	I wish to have a NZ sign language interpreter	Yes	No

You are invited to take part in a research study about more efficient nutrition screening or patients admitted in the acute renal ward to identify any nutritional problems patients may have as soon as possible. Participation is entirely voluntary. If you choose not to take part, it will not affect the care you receive. You can withdraw from the study at anytime, even if you decide to participate now. This information sheet will provide information about this research study to help you decide if you'd like to participate. The researchers of this study will go through this information with you and answer any questions you may have. This is expected to take approximately 15 minutes. You may also want to talk about the study with other people, such as family, whaanau, friends, or healthcare providers. Feel free to do this.

If you agree to take part in this study, you will be asked to sign the Consent Form on the last page of this document. You will be given a copy of the Participant Information Sheet to keep.

Why are we doing the study?

When people do not feel like eating and drinking for more than a week, their body will not get enough nutrients and energy to function properly. This is called malnutrition and

common in people with kidney disease. If patients are malnourished they may have to stay in the hospital for longer, have more complications, and if not treated, it could be very dangerous.

We would like to test a screening tool that will help us identify this condition very early in all kidney patients. If we can identify patients early and refer them to the dietitians to treat their malnutrition, this will help patients to recover quicker.

What would your participation involve?

If you decide to take part in this study, you will be given the opportunity to ask any questions. You will be then requested to sign a consent form for taking part in the study. And for the permission to access your personal details (e.g. contact details, etc) and health information. These records will be treated as strictly confidential. Your health information includes your medical history and records, current conditions, medication chart and blood test results.

A full set of nutritional assessments will then be carried out to determine your current nutritional status. Nutritional assessments are routine evaluations performed by dietitians at the beginning of a new consultation. For this study this will involve:

- Measuring your body weight and height using an electronic scale and stadiometer;
- Asking about any changes in your eating habits during the past month compared to other times when you are not sick;
- Asking about:
    - any symptoms that may have kept you from eating as usual during the past two weeks;
    - your physical activity over the past month;
- Physical examination to check for signs and symptoms of malnutrition.
    - It involves the researcher / dietitian touching your shoulders, limbs and ankles, involving small movements only.
- Measuring your hand-grip strength using a dynamometer.
    - This is a quick and easy way of testing your muscle strength. The assessment requires you to be in a standing position. And squeeze the dynamometer as hard as possible. Only squeeze once for each measurement; two measurements are needed each for the left and right hands. There will be a pause of about 10-20 seconds between each measurement to avoid your hands getting tired.

The nutritional assessments will only take about 30 minutes. There will not be any further assessments required in this study.

What are the possible benefits and risks to you of participating?

Most of these assessments form part of your normal care in the hospital and will not involve any additional cost to you. You will receive a brief report summarising the main findings of the project via mail or email at completion of the study.

By participating in this research study, you will contribute to the development of a nutrition screening tool to improve health care services, which will ultimately be beneficial for kidney patients who are in need.

There are no personal risks to your health, and the screening / nutritional assessments could potentially identify undiagnosed nutrition problems early. A researcher / dietitian will review your assessment results. If they find that your results are outside normal parameters, a referral will be generated and sent to the Nutrition and Dietetic Services for your treatment. The referral will be prioritised and you will be seen by a Registered Dietitian within 48 hours upon receiving the referral.

The time that you will have to invest in this research study is a maximum of 45 minutes total of your time.

What would happen if you were injured in the study?

If you were injured in this study, which is highly unlikely, you would be eligible for compensation from ACC just as you would be if you were injured in an accident at work or at home.

If you have private health or life insurance, you may wish to check with your insurer that taking part in this study won't affect your cover.

What are the rights of participants in the study?

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study at any time and ask any questions about the study at any time;
- provide information on the understanding that your name will never be used;
- be given access to a summary of the project findings when it is completed.

What will happen after the study ends, or if you pull out?

The data will be used only for the purposes of this study. Only the investigators of the study (Andrew Xia, Rozanne Kruger and Alayne Healy) will have access to personal information. This will be held securely and treated strictly confidentially. Participants will be identified only by a study identification number. Results of this project may be published or presented at conferences or seminars. No individual will be able to be identified.

At the end of this study the list of participants and their study identification number will be disposed of. Any raw data that the study depends on will be retained in secure storage for 10 years, it will be destroyed afterward.

A summary of the study findings will be available to all participants. It will be sent via email or a personal letter at the completion of the study.

Ethical Approval

This study has been reviewed and approved by the Health and Disability Ethics Committee: Northern A, Application 13/NTA/1. If you have any concerns about the conduct of this research, please contact Dr Brian Fergus, Chairperson, Northern A Health and Disability Ethics Committee, telephone: 0800 4 ETHICS, email: hdecs@moh.govt.nz.

Where can you go for more information about the study, or to raise concerns or complaints?

If you have any questions, concerns or complaints about the study at any stage, you can contact:

Andrew Xia
Phone: 021 887 730
Email: y.xia@massey.ac.nz

Dr Rozanne Kruger
Senior lecturer, Institute of Food Nutrition and Human Health, Massey University
Phone: (09) 414 0800 ext 41209
Email: r.kruger@massey.ac.nz

Alayne Healy
Section Head Outpatient Dietitians, Acute Allied Health, Counties Manukau District Health Board
Phone: (09) 2760044 ext 8788
Email: Alayne.healy@middlemore.co.nz

If you want to talk to someone who isn't involved with the study, you can contact an independent health and disability advocate on:

Phone:	0800 555 050
Fax:	0800 2 SUPPORT (0800 2787 7678)
Email:	advocacy@hdc.org.nz

You can also contact the health and disability ethics committee (HDEC) that approved this study on:

Phone:	0800 4 ETHICS
Email:	hdecs@moh.govt.nz

Appendix B: Consent Form

Consent Form

Declaration by participant:

I have read, or have had read to me in my first language, and I understand the Participant Information Sheet. I have had the opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this study.

I have been given a copy of the Participant Information Sheet to keep.

Participant's name:

Signature: Date:

Declaration by member of research team:

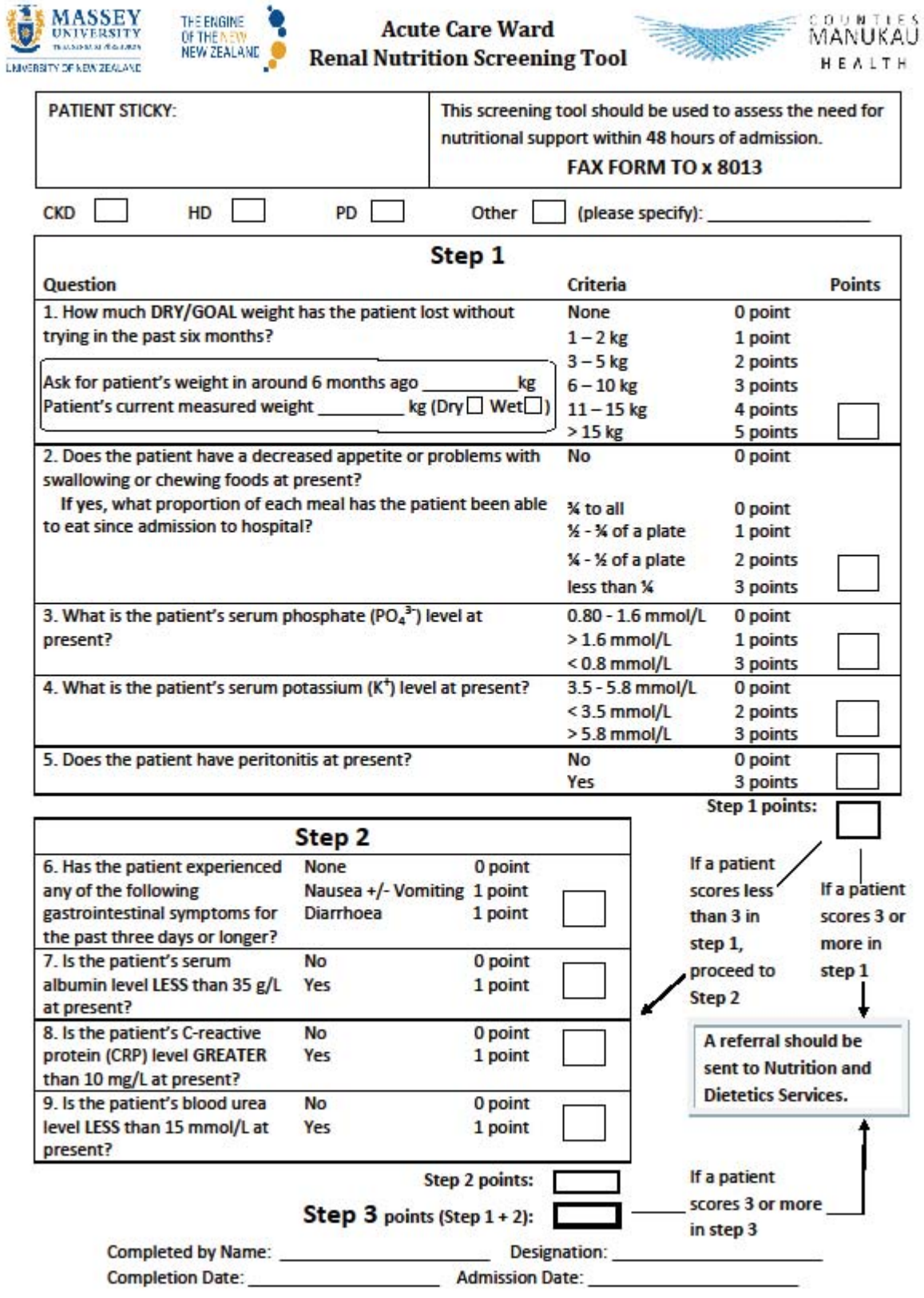
I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it.

I believe that the participant understands the study and has given informed consent to participate.

Researcher's name:

Signature: Date:

Appendix C: Acute Renal Ward Nutrition Screening Form



Acute Care Ward
Renal Nutrition Screening Tool

PATIENT STICKY:	This screening tool should be used to assess the need for nutritional support within 48 hours of admission. **FAX FORM TO x 8013**

CKD ☐ HD ☐ PD ☐ Other ☐ (please specify): _____

Step 1

Question	Criteria		Points
1. How much DRY/GOAL weight has the patient lost without trying in the past six months? Ask for patient's weight in around 6 months ago _____kg Patient's current measured weight _____ kg (Dry☐ Wet☐)	None 1 – 2 kg 3 – 5 kg 6 – 10 kg 11 – 15 kg > 15 kg	0 point 1 point 2 points 3 points 4 points 5 points	☐
2. Does the patient have a decreased appetite or problems with swallowing or chewing foods at present? If yes, what proportion of each meal has the patient been able to eat since admission to hospital?	No ¾ to all ½ - ¾ of a plate ¼ - ½ of a plate less than ¼	0 point 0 point 1 point 2 points 3 points	☐
3. What is the patient's serum phosphate (PO_4^{3-}) level at present?	0.80 - 1.6 mmol/L > 1.6 mmol/L < 0.8 mmol/L	0 point 1 points 3 points	☐
4. What is the patient's serum potassium (K^+) level at present?	3.5 - 5.8 mmol/L < 3.5 mmol/L > 5.8 mmol/L	0 point 2 points 3 points	☐
5. Does the patient have peritonitis at present?	No Yes	0 point 3 points	☐

Step 1 points: ☐

If a patient scores less than 3 in step 1, proceed to Step 2

If a patient scores 3 or more in step 1

A referral should be sent to Nutrition and Dietetics Services.

Step 2

6. Has the patient experienced any of the following gastrointestinal symptoms for the past three days or longer?	None Nausea +/- Vomiting Diarrhoea	0 point 1 point 1 point	☐
7. Is the patient's serum albumin level LESS than 35 g/L at present?	No Yes	0 point 1 point	☐
8. Is the patient's C-reactive protein (CRP) level GREATER than 10 mg/L at present?	No Yes	0 point 1 point	☐
9. Is the patient's blood urea level LESS than 15 mmol/L at present?	No Yes	0 point 1 point	☐

Step 2 points: ☐

Step 3 points (Step 1 + 2): ☐

If a patient scores 3 or more in step 3

Completed by Name: _____ Designation: _____

Completion Date: _____ Admission Date: _____

Appendix D: Seven-Point Subjective Global Assessment Rating Form

SUBJECTIVE GLOBAL ASSESSMENT RATING FORM

Patient Name: **ID #:** **Date:**

HISTORY

WEIGHT/WEIGHT CHANGE: ***(Included in K/DOQI SGA)*** **Rate 1-7**

1. **Baseline Wt:** _____(Dry weight from 6 months ago)
   Current Wt: _____(Dry weight today)
   Actual Wt loss/past 6 mo: _____ **% loss:**_____(actual loss from baseline or last SGA)
2. **Weight change over past two weeks:** _____No change _____Increase _____Decrease

DIETARY INTAKE No Change_____(Adequate) No Change_____(Inadequate)

1. Change: Sub optimal Intake: _____ Protein _____ Kcal _____ Duration_____
   Full Liquid: _____ Hypocaloric Liquid _____ Starvation _____

GASTROINTESTINAL SYMPTOMS ***(Included in K/DOQI SGA-anorexia or causes of anorexia)***

Symptom:	**Frequency:***	**Duration:+**
_____ None	_____	_____
_____ Anorexia	_____	_____
_____ Nausea	_____	_____
_____ Vomiting	_____	_____
_____ Diarrhea	_____	_____
	Never, daily, 2-3 times/wk, 1-2 times/wk	> 2 weeks, < 2 weeks

FUNCTIONAL CAPACITY b

Description	**Duration:**
_____ No Dysfunction	_____
_____ Change in function	_____
_____ Difficulty with ambulation	_____
_____ Difficulty with activity (Patient specific "normal")	_____
_____ Light activity	_____
_____ Bed/chair ridden with little or no activity	_____
_____ Improvement in function	_____

DISEASE STATE/COMORBIDITIES AS RELATED TO NUTRITIONAL NEEDS

Primary Diagnosis_____Comorbidities_____

Normal requirements ____Increased requirements____ Decreased requirements _____

Acute Metabolic Stress: _____None _____Low _____Moderate _____High

PHYSICAL EXAM

_____ Loss of subcutaneous fat (Below eye, triceps, biceps, chest) ***(Included in K/DOQI SGA)*** ____Some areas _____All areas

_____ Muscle wasting (Temple, clavicle, scapula, ribs, quadriceps, calf, knee, interosseous ***(Included in K/DOQI SGA)*** ____Some areas _____All areas

_____ Edema (Related to undernutrition/use to evaluate weight change)

OVERALL SGA RATING

Very mild risk to well-nourished=6 or 7 most categories or significant, continued improvement.

Mild-moderate = 3, 4, or 5 ratings. No clear sign of normal status or severe malnutrition.

Severely Malnourished = 1 or 2 ratings in most categories/significant physical signs of malnutrition.

Appendix E: Reference range for the grading of handgrip strength

PE 022

Tasmanian Occupational Health & Safety Services

Grip Strength: Assessment

FEMALES *AGES*

	16 - 19	20-29	30-39	40-49	50-59	60-69
Below Average	< 26	< 28	< 25	< 29	< 21	< 19
Average	26 - 34	28 - 36	25 - 37	25 - 35	21 - 34	19 - 31
Above Average	> 34	> 36	> 37	>35	> 34	> 31
MEAN	30	32	31	30	27.5	25
STANDARD DEVIATION (Female)	4.4	4.4	5.8	4.8	6.4	5.6

AGES

Males

	16 - 19	20-29	30-39	40-49	50-59	60-69
Below Average	< 41	< 42	< 44	< 42	< 38	< 35
Average	41 - 58	42 - 59	44 - 60	42 - 56	38 - 54	35 - 48
Above Average	> 58	> 59	> 60	> 56	> 54	> 48
MEAN	49.5	50.5	52	49	46	41.5
STANDARD DEVIATION (male)	6.8	6.8	7.8	6.9	8.2	6.4

REFERENCE

Australian Fitness Norms, 1993

Procedure: HA1
Revision Number: 0

1 of 1
Appendix A2

Appendix F: Acute Adult Dietitian Referral Form

COUNTIES MANUKAU DISTRICT HEALTH BOARD

Affix patient's identification label here

DIETITIAN REFERRAL FORM - ACUTE ADULT SERVICE
Fax 8013

Current medical problem/reason for admission **Ward** _____

Reason for Referral to Dietitian (you can tick more than one box):

- ☐ Tube feeding
- ☐ Intravenous Nutrition (IVN) and also contact Nutrition Support Team (NST) On pager - 938712
- ☐ Unintentional weight loss >10% over 3-6 months
- ☐ Inadequate oral intake e.g. eating and drinking less than 50% of meals > 5 days
- ☐ Liver cirrhosis
- ☐ Pressure Injury stage 3 – 4
- ☐ Complex wound management
- ☐ Newly diagnosed Type 1 Diabetes on insulin
- ☐ Currently on nutrition supplementation
- ☐ Nutrition education (specify) _____
- ☐ Other – please specify _____

Weight history:

	Yes	No
Weight loss prior to admission	☐	☐
Weight loss during admission	☐	☐

Current Weight: **PLEASE WEIGH:** _____ kg

Oral intake

☐ Nil by mouth ☐ Good ☐ Fair ☐ Poor

Hospital diet ordered: _____

Please start food chart

Date: _____

Referral requested by (Please print): Name: _____

Designation: _____

Contact Number: _____

Re-Order No. DIET075 September 2011

DIETITIAN REFERRAL FORM - ACUTE ADULT SERVICE