Identification and management of malnutrition in older adults

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This thesis is submitted for the degree of Doctor of Philosophy

Discipline of Medicine

Faculty of Health and Medical Sciences

The University of Adelaide

November 2017

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LIST OF ABBREVIATIONS

ADL: Activities of daily living

AIHW: Australian Institute of Health and Welfare

AMA: Arm muscle area

ANCOVA: Analysis of covariance

ANOVA: Analysis of variance

ANZCTR: Australian New Zealand Clinical Trial Registry

AQoL: Assessment of Quality of life

BIA: Bio impedance analysis

BMI: Body mass index

CAMA: Corrected arm muscle area

CBC: Complete Blood Count

CI: Confidence Interval

CON: Control group

CRP: C-Reactive Protein

DETERMINE: Determine Your Nutrition Health Checklist

Dietary advice: DA

DXA: Dual-energy X-ray absorptiometry

EMS: Elderly mobility scale

EQ-5D: European Quality of Life-5 Dimensions

ESPEN: European Society of Clinical Nutrition and Metabolism

EWGSOP: European Working Group on Sarcopenia in Older People

FFM: Fat free mass

FFMI: Fat free mass index

FIM: Functional independence measure

FRAIL: Fatigue, Resistance, Ambulation, Illness, and Loss of weight

GDS: Geriatric depression scale

GNRI: Geriatric Nutritional Risk Index

HDL-C: High-density lipoprotein cholesterol

HEHP: High Energy High Protein group

HR: hazard ratio

HRQOL: Health-Related Quality of Life

IADL: Instrumental activities of daily living

IGF-I: Insulin Growth Factor-I

IPAQ: International physical activity questionnaire

ISEL: Interpersonal Support Evaluation List

Kj: Kilo joule

LOC: Level of care

LOS: Length of hospital stay

LTCI: Long-term care insurance

MAC / MUAC: Mid upper arm circumference

MAMC: mid-arm muscle circumference

MCH: Mean corpuscular haemoglobin

MCHC: Mean corpuscular haemoglobin concentration

MCV: Mean corpuscular volume

MET: Metabolic equivalent of task

MJ: Mega joule

MMSE: Mini mental status examination

MNA: Mini Nutritional Assessment

MNA-SF: Mini Nutritional Assessment Screening Form

MOW: Meals on Wheels

MRI: Magnetic Resonance Imaging

MUFA: Monounsaturated fatty acid

MUST: Malnutrition Universal Screening Tool

NHANES: National Health and Nutrition Examination Survey

NHP: Nottingham Health profile

NRI: Nutrition Risk Index

NRS: Nutrition Risk Screening 2002

NSAIDs: Nonsteroidal anti-inflammatory drugs

NSI: Nutrition Screening Initiative

NUFFE: Nutritional Form for the Elderly

ONS: Oral nutrition support

OR: Odds ratio

PASE: Physical Activity Scale for the Elderly

PEM: Protein Energy Malnutrition

PGC MAI: Philadelphia Geriatric Centre Multilevel Assessment Instrument

PSQI: Pittsburgh Sleep Quality Index

PUFA: Polyunsaturated fatty acid

QALYs: Quality Adjusted Life Years

QLI-MH: Quality of Life Index for Mental Health

QOL: Quality of life

QUALIDEM: Quality of life measure for people with dementia

RBP: Retinol Binding Protein

RCTs: randomised controlled trials

RDI: Recommended Dietary Intake

RDW: Red blood cell distribution width

RR: Risk Ratio

SCREEN: Seniors in the Community Risk Evaluation for Eating and Nutrition

SD: Standard deviations

SEM: Standard error of the mean

SF-12: Short Form 12

SF-36: Short Form 36

SGA: Subjective Global Assessment

SLUMS: Saint Louis University Mental Status

SNAQ 65+: Short Nutritional Assessment Questionnaire 65+

SNAQ: Short Nutritional Assessment Questionnaire

SNAQb: Simplified Nutritional Appetite Questionnaire

SPPB: Short Physical Performance Battery

SQFFQ: Semi Quantitative-Food Frequency Questionnaire

STD: Standard group

TFEQ: Three Factor Eating Questionnaire

TLC: Total Lymphocyte Count

TSF: Triceps skin fold

TTO: Time trade off

VAS: Visual analogue scale

PUBLICATION AND PRESENTATION

Published manuscript

Arjuna, T, Luscombe-Marsh, N, Lange, K, Kang, A, Hickman, P, Edwards, C, Reid, S, Chapman, I & Soenen, S 2016, 'Body-weight and nutritional-status changes in South Australian nursing-home residents', Journal of Nursing Home Research, vol. 2, pp. 97-103.

Arjuna, T, Soenen, S, Hasnawati, R, Chapman, I, Lange, K & Luscombe-Marsh, N 2017, A cross-sectional study of nutrient intake and health status among older adults in Yogyakarta Indonesia, Nutrients, 9(11), 1240.

Arjuna, T, Miller, M, Soenen, S, Chapman, I, Visvanathan, R, Luscombe-Marsh, N, 2018, Meals on Wheels' South Australia Inc.: findings from a meal audit study. Foods, 7(2), 26.

Abstract Presentation (National and International Conferences)

T Arjuna, S Soenen, R Hasnawati, K Lange, I Chapman, N Luscombe-Marsh 2017, 'Relationships between nutritional status, cognitive impairment, and functional capacity: findings from a cross-sectional study of Indonesians aged 65 or older'.

Presented at the 10th Asia Pacific Conference on Clinical Nutrition, 26 – 29 November 2017, Adelaide, Australia

Arjuna, T, Luscombe-Marsh, N, Lange, K, Kang, A, Edwards, C, Reid, S, Chapman, I & Soenen, S 2017, 'Changes in body weight and nutritional status in South Australian nursing home residents".

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Presented at the 2017 IAGG World Congress, 23 – 27 July 2017, San Francisco, USA

Arjuna, T, Soenen, S, Hasnawati, R, Chapman, I, Lange, K & Luscombe-Marsh, N 2017, 'NUTRITIONAL AND FUNCTIONAL STATUS OF OLDER PEOPLE LIVING IN YOGYAKARTA, INDONESIA', Innovation in Aging, vol. 1, no. suppl_1, pp. 548-549.

Presented at the 2017 IAGG World Congress, 23 – 27 July 2017, San Francisco, USA

Arjuna, T, Chapman, I, Soenen, S, Miller, M, Visvanathan, R, Ueno, T, Luscombe-Marsh, N, 2016, 'Provision of Standard and Fortified 'Meals-on-Wheels' Meals to Improve Nutrition, Functional Status, Quality of Life, and Hospitalizations of Community-Dwelling Nutritionally At-Risk Elderly', Journal of Aging and Physical Activity, vol. 24, no. s1, p. S23.

Presented at the World Congress on Active Ageing 2016, 28 June – 1 July 2016, Melbourne, Australia

Arjuna, T, Visvanathan, R, Soenen, S, Miller, M, Chapman, I, Ueno, T & Luscombe-Marsh, N, 2016, 'Effects of standard and fortified Meals-on-wheels meals on clinical outcomes of nutritionally at risk elderly', Journal of Nutrition & Intermediary Metabolism, vol. 4, p. 20.

Presented at the Joint Annual Scientific Meeting of the Nutrition Society of NZ and the Nutrition Society of Australia, 1 – 4 December 2015, Wellington, NZ

DECLARATION

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Tony Arjuna, B.Nut, M.NutDiet, APD Date

ACKNOWLEDGEMENT

The completion of this PhD was possible with the support and guidance of a range of people and funding sources.

First of all, I would like to express my deepest appreciation and gratitude to my Supervisors Prof Ian Chapman, Dr Natalie Luscombe-Marsh and Dr Stijn Soenen for their intellectual input, excellent leadership, wisdom, and relentless encouragement. I feel very privileged to have them as my mentors.

Secondly, I am very grateful for the funding and support from the CIMB Foundation (CIMB Regional Scholarship), Universitas Gadjah Mada, CSIRO & School of Medicine Short Term Scholarship, and the Adelaide Medical School Research Travel Award that allowed me to pursue my PhD and attend a number of conferences.

I would also like to thank our collaborators, Prof Renuka Visvanathan, Prof Michelle Miller, Ms Rasita Amelia Hasnawati, Ms Tomoko Ueno, Ms Ai Choo Kang and the Southern Cross Care, SA&NT team, Meals on Wheels Inc. South Australia, and all of the study participants who made the projects possible.

My special thanks go to Dr Tim Murphy and Ms Kylie Lange for their friendly, enthusiastic, and invaluable support throughout my study.

Finally, I would like to thank my wife and children for their love, understanding and unparalleled patient, especially for every effort you made to help me focus on my study which were not acknowledged enough.

ABSTRACT

The world population is aging rapidly and it is expected that the number of people aged 65 years and older will rise from 841 million to 2 billion by 2050. The greatest increase in population aging will be amongst developing countries in Asia and Africa, including Indonesia. In addition, a large body of evidence shows that this increase in population ageing is being paralleled by a substantial rise in the prevalence of malnutrition among older people. These findings are of major concern due to the numerous deleterious consequences of malnutrition on the physical and mental health and quality of life of older people, as well as significant burden to the health care system. Thus, early identification using appropriate screening tools and intervention with pragmatic and affordable nutritional and lifestyle interventions, including commonly used high energy and protein supplements/meals, are amongst the most important strategies to prevent and reduce the prevalence of malnutrition in older people.

The theorectical framework of my PhD is depicted in Figure 1. The main aims of this work were to: (1) provide information or advice on selecting the appropriate screening tool for various clinical outcomes (i.e. mortality, morbidity, length of hospital stay (LOS), quality of life (QOL), level of care (LOC), muscle mass and muscle function) in older population across hospital, nursing home and community settings, (2) characterise the body weight and nutritional status of a cohort of older nursing home residents in South Australia, and the factors associated with changes in these measures over 6-12 months, (3) determine the body composition, nutrition, mental status and physical function at baseline and after 6 month and the relationships between exercise, nutritional state, muscle mass and physical function among institutionalised older people, (4) determine health, socio-demographic and anthropometric characteristics, nutritional, mental and functional status, energy and nutrient intake, of community-dwelling older men and women living in rural and urban areas in Yogyakarta Indonesia, and (5) determine the effect of providing at least 3 days/week of (i) standard MOW meals or (ii) high energy and high protein (HEHP) for 12 weeks

on energy and protein intakes and clinical outcomes (including nutritional status, physical capacity, general and psychological wellbeing, and quality of life and number and length of stay of hospitalisation).

Study from this thesis showed that almost 30% of South Australian nursing home residents were at medium or high nutritional risk (14% and 16%, respectively). There were 46% of residents who had marked weight change (≥ 5% weight loss or gain) over 12 months and residents in the lowest BMI tertile (≤ 23 kg/m^2) were most likely to experience both marked weight change (52%) and marked weight reduction (≥ 5%: 30% over 12 months). A further 6-month prospective examination of 32 residents from the same nursing home population indicated that weight was not changed (0 ± 2.3 kg), however, 70% participants either gained or lost >5% fat mass, 30% had gained or lost >5% fat free mass, and 82% had gained or lost more than > 5% corrected arm muscle area over 6 months.

Studies conducted among community-dwelling Indonesians aged 65 years and older demonstrated that prevalence rates for malnutrition/'at-risk' of malnutrition and parameters of physical functions were comparable to the figures observed in older adults from developed countries who are hospitalized or residing in nursing homes.. This study also highlighted that Indonesian specific cut offs indicative of risk of malnutrition, frailty and impaired physical and mental function, need to be determined, and that nutritional status, and certain indices of physical and mental health for older Indonesians is modulated by having lived a rural compared to urban lifestyle, i.e. rural participants had a lower cognitive function, poorer nutritional status and grip strength, but faster gait speed while being more dependent on assistance to perform daily activities.

Finally, findings from this thesis showed that both "standard (STD)" vs. "protein and energy enriched (HEHP)", Meals on Wheels (MOW) meals can assist older adults to meet their RDIs, especially for energy and protein, and while neither meal type differentially improved any of the measured markers of physical capacity or general and psychological wellbeing, further

deterioration over 12 weeks was not observed. In conclusion, malnutrition is a real and present danger for older adults around the world, and nutritional interventions through meal fortification, and or specific nutrient supplements, could potentially attenuate the progression and severity of malnutrition and related co-morbidities.

CHAPTER 1. INTRODUCTION: MALNUTRITION IN OLDER PEOPLE

1. Introduction

Population aging is a global phenomenon. Worldwide, the number of adults aged 65 years and older is expected to rise from 841 million to 2 billion by 2050 while in Australia, the number is projected to rise from 2.4 million in 2007 to 6.4 million by 2056 (1). Moreover, by 2056 almost 50% of older Australians will be classified as the 'old' old as they will be aged 85 years and over (1). Furthermore, developing countries in Asia and Africa are expected to have the greatest burden from population ageing as depicted in ***Figure 1*** (2) and of these developing countries, Indonesia will be one of the most affected with the Indonesian population aged ~65 years or older expected to reach ~32 million (11%) by 2035 (***Figure 2***) (3).

In parallel with population ageing, is the escalating number of older adults who are suffering, often in silence, from malnutrition. This is a major concern due to the numerous deleterious consequences of malnutrition to the health and quality of life of older people, as well as significant burden to the health care system. Thus, it is essential to devise an effective intervention strategy to prevent and treat malnutrition amongst older people, and the work contained in this thesis has been focused on examining these issues in Australia and the candidate's home country of Indonesia.

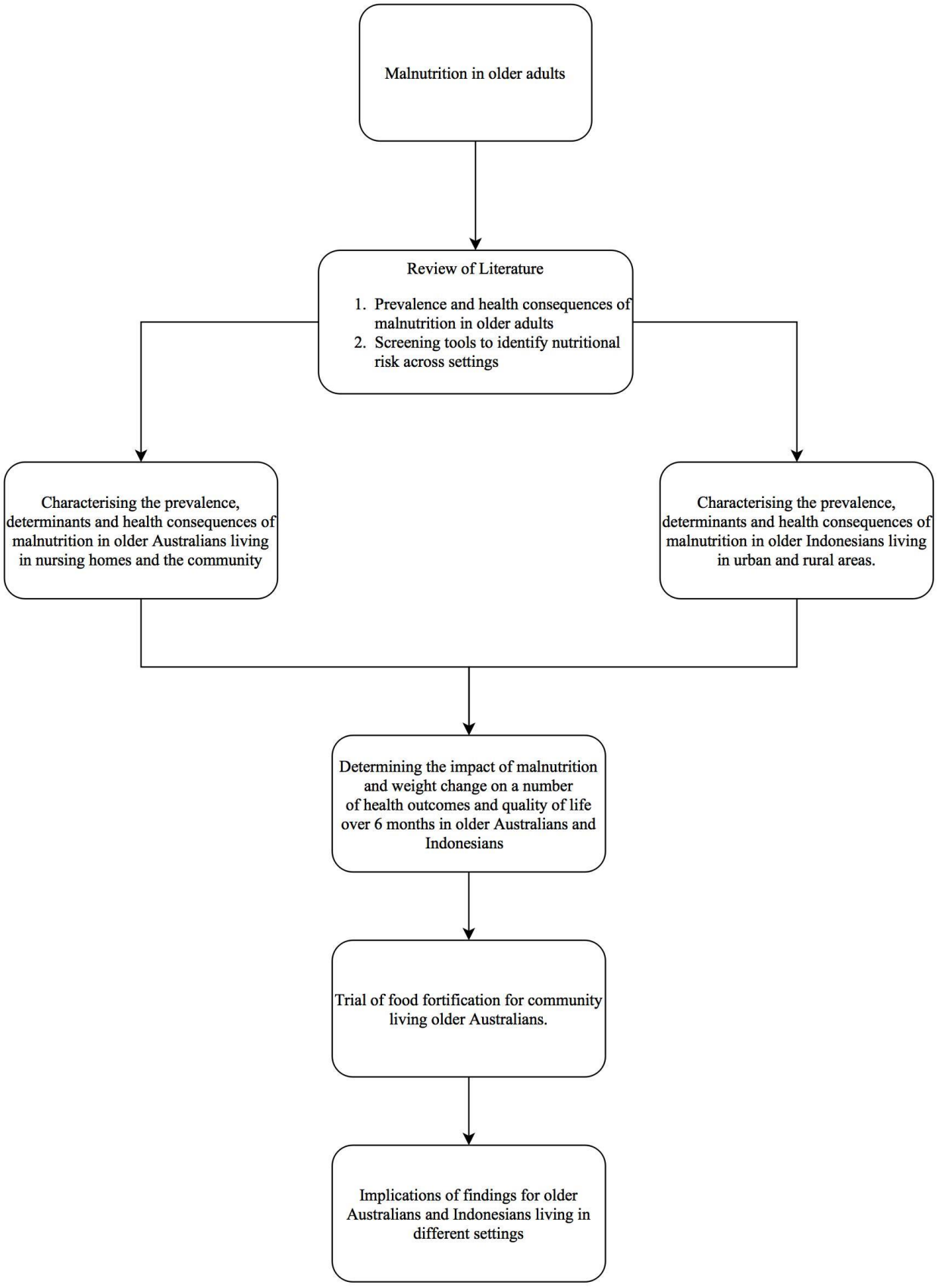


Figure 1. Theoretical Framework

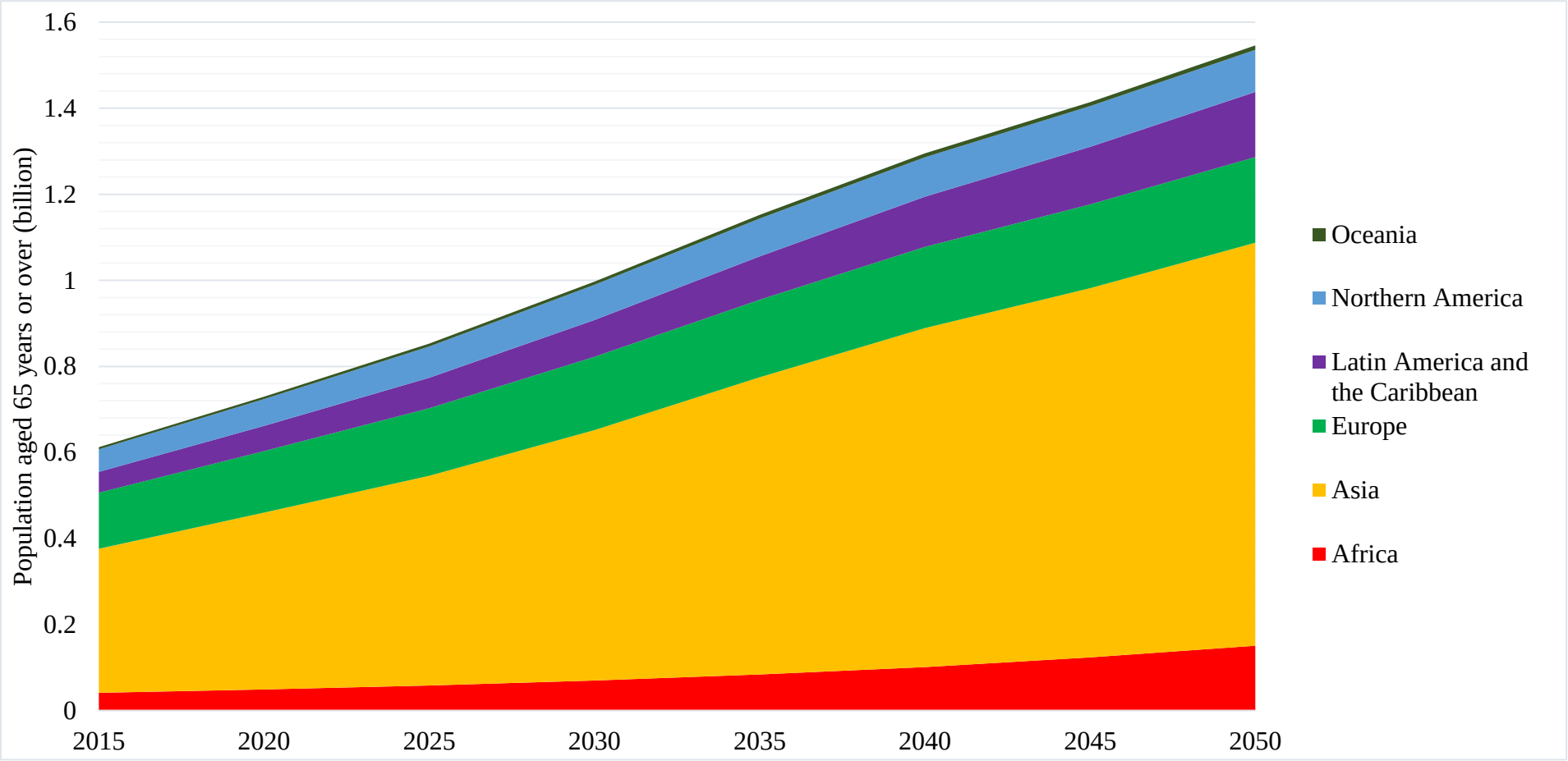
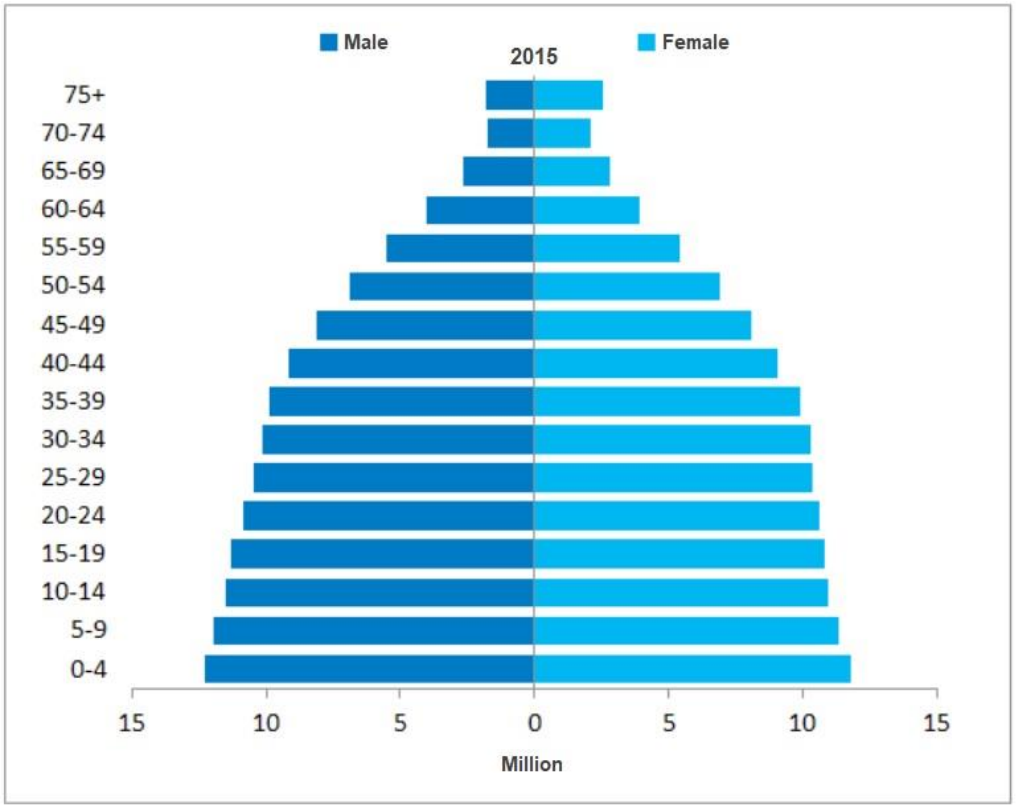


Figure 2. Older adults population growth projection from 2015 to 2050. Adapted from (2).



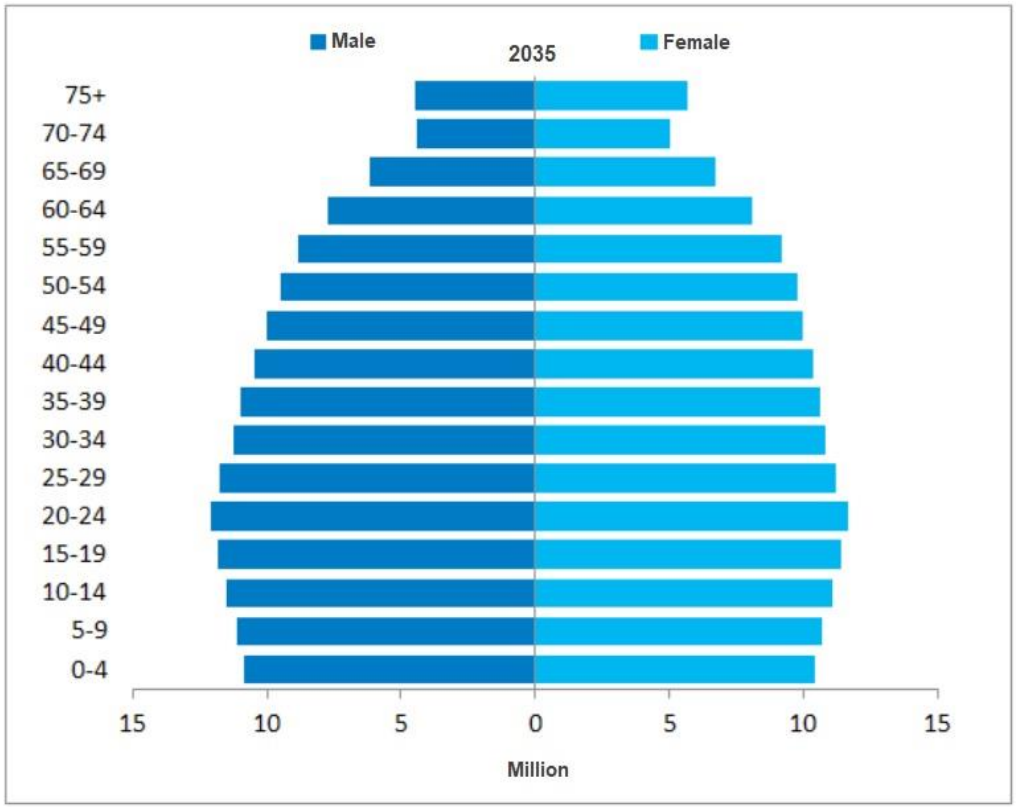


Figure 3. Indonesian population growth projection from 2015 to 2035. Adapted from (3)

The next chapters will try to address this question by summarising the definition, prevalence, aetiology, consequences, most frequently used methods to identify malnutrition, and nutritional management of malnutrition in older people.

2. Definition of malnutrition

Although it has been recognised for many years, there is still no univocal definition of malnutrition. In general, malnutrition is defined as "a state of nutrition in which a deficiency or excess (or imbalance) of energy, protein, and other nutrients causes measurable adverse effects on tissue/body form (body shape, size and composition) and function, and clinical outcome" (4). The most common form of malnutrition in the older population is Protein Energy Malnutrition (PEM), which is a deficient energy or protein intake or absorption (4). Throughout the research reported in this thesis, malnutrition refers to PEM or undernutrition. Malnutrition in older people entails certain characteristics that are unique to the older adults and not found in the other age groups. Thus, malnutrition in older adults is defined as "faulty or inadequate nutritional status; undernourishment characterised by insufficient dietary intake, poor appetite, muscle wasting and weight loss" (5).

Despite the clear characteristics of malnutrition in the older population, there is still no consensus on the most appropriate methods and criteria to diagnose malnutrition. Hence, malnutrition is often diagnosed by multiple methods and criteria such as the presence of one or more of the following condition: (a) weight loss ≥ 5% in 1 month or ≥ 10% in 6 months, (b) body mass index < 21 kg/m^2, and (c) serum albumin concentrations < 35 g/L (6). The European Society of Clinical Nutrition and Metabolism (ESPEN) proposed malnutrition diagnosis based on a) BMI <18.5 kg/m2 or b) weight loss (unintentional) > 10% indefinite of time, or >5% over the last 3 months combined with either BMI <20 kg/m^2 if <70 years of age, or <22 kg/m^2 if ≥ 70 years of

age or fat free mass index (FFMI) <15 and 17 kg/m^2 in women and men, respectively (7). Current methods for identification and diagnosis of malnutrition in people aged 65 years and older are covered in greater detail in Chapter 6.

3. Epidemiology of malnutrition in older adults

Various studies have indicated that malnutrition is a major public health problem in both developed and developing countries (8-11). Furthermore, malnutrition is not only rife among hospitalised and institutionalised older people, but it is also affecting those living in the community. A large scale study in Netherland involving 20,255 patients across three different health care settings (6021 hospitalised patients with mean age of 67 ±16 years; 11,902 nursing home patients with mean age of 81 ±10 years, and; 2,332 home care patients with mean age of 78 ±11 years) showed that overall, one in every five patients from these varied settings were malnourished (8). Another study in Finland involving 375 service house residents aged ≥ 65 years found that 65% of older people were at risk of malnutrition and 21% were malnourished (9). In Malaysia, 17.4% of people aged ≥ 60 years who resided in Government-funded shelter home were malnourished (11). Moreover, a large multinational study, which collected data from 12 different countries (Australia, Belgium, France, Germany, Italy, Japan, Netherlands, South Africa, Spain, Sweden, Switzerland, and United States) revealed that 67% of older adults in nursing homes are malnourished or at risk for malnutrition (12). In addition, 86% of hospitalised older people and 91% of those in rehabilitation centres were either malnourished or at risk of malnutrition and 38% of older people living the community were malnourished or at risk of malnutrition (12) (***Figure 3***).

Studies conducted specifically in Australia have found comparable figures to the large multinational study (***Figure 4***). In the hospital setting, 33 % and 51.5% of the older rehabilitation patients were classified as either malnourished or at risk of malnutrition, respectively (13). In

addition, data from residential care facilities found that 43.1% of residents were moderately malnourished and 6.4% were severely malnourished (14). While in the community, 34.5% of the older adults were classified as at risk of malnutrition and 8.1% were malnourished (15).

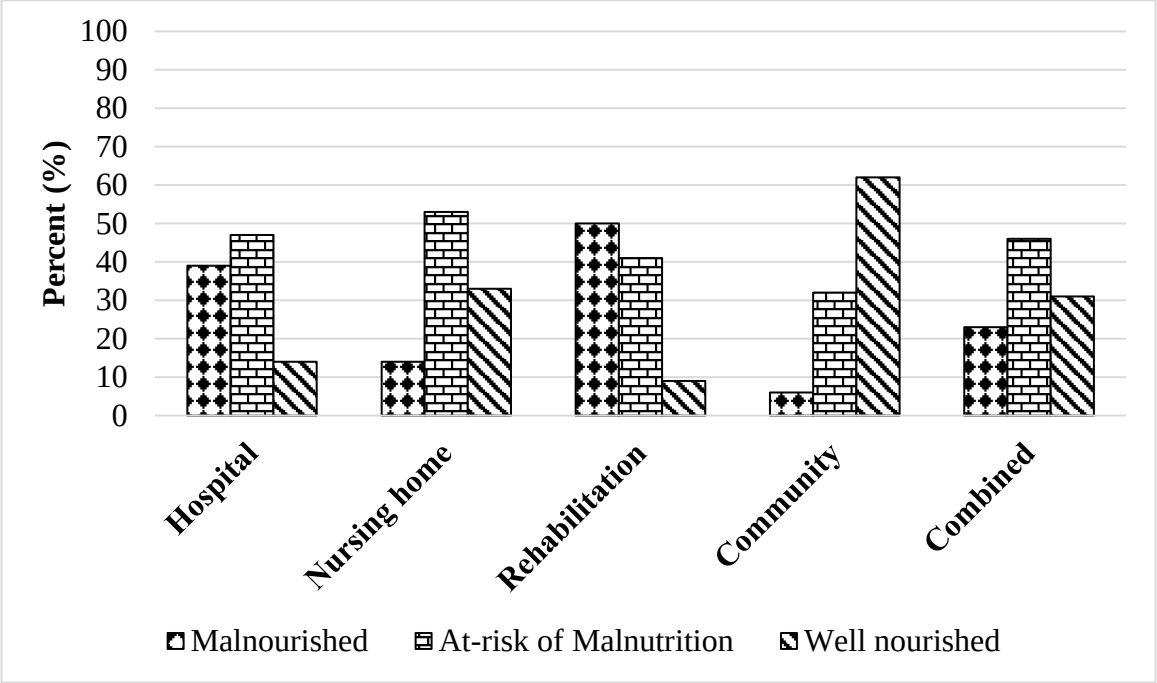


Figure 4. Multinational prevalence of malnutrition in older adults across settings*. Adapted from (12)

*The study was conducted in 12 different countries, i.e.: Australia, Belgium, France, Germany, Italy, Japan, Netherlands, South Africa, Spain, Sweden, Switzerland, and United States

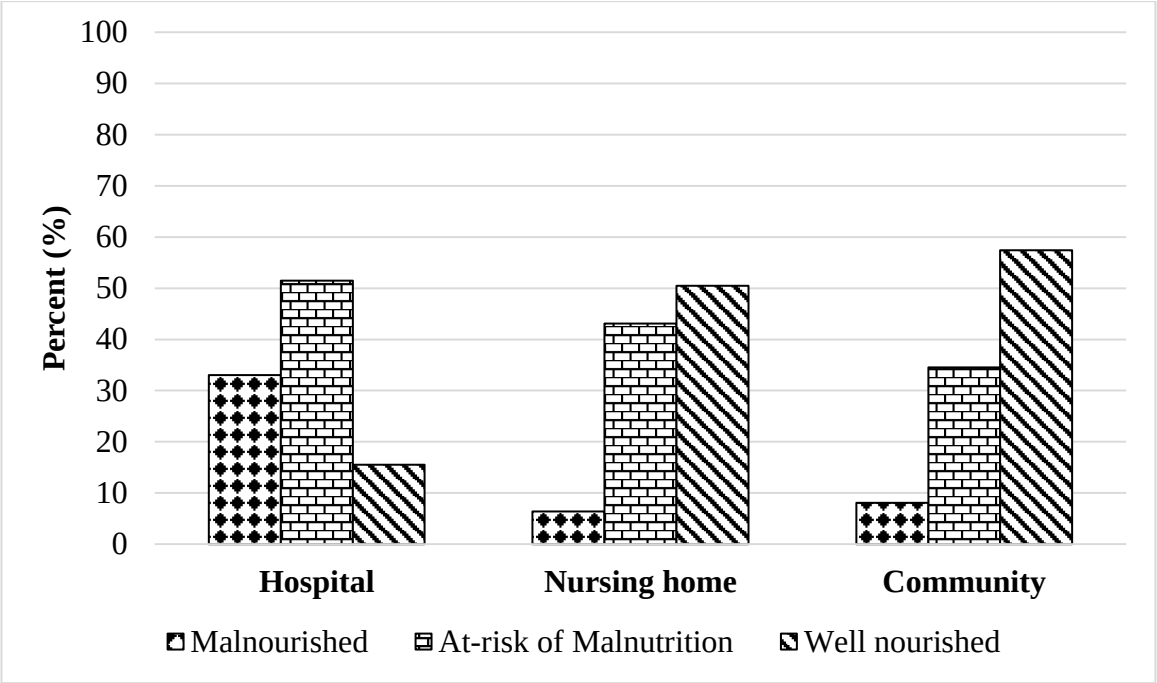


Figure 5. The prevalence of older adults malnutrition across settings in Australia. Adapted from (13-15)

Furthermore, studies from Indonesia have indicated comparable pattern. The rise of the older adults population is followed by a significant jump in the prevalence of malnutrition. Nearly a quarter (24%) of community-dwelling older adults were malnourished and 62.3% of those living in the nursing home were in a similar nutritional state (15, 16). However, it is important to note that the studies conducted in various regions of Indonesia have several major limitations which reduced the generalisability and power of the studies, including small sample size, non-randomised sampling and limited measures to diagnose malnutrition. Hence, a larger and more comprehensive study is essential to bridge the gaps in the literature and provide an accurate and reliable data on the magnitude of malnutrition in Indonesia.

4. Aetiology of malnutrition in the older adults

Malnutrition in the older adults population is a multi-factorial problem. However, the aetiology of malnutrition can be divided into two main categories, i.e. physiological and non-physiological factors. Physiological factors include reduced sense of smell and taste, reduced sensory-specific satiety, increased cytokine activity, changes in gastrointestinal function and hormonal changes (16-19). Meanwhile, the non-physiologic factors were more varied as shown in

Table 1 (page 7).**Table 1.** Non-physiological cause of older adults malnutrition. Adapted from (19, 20)

Non-physiological Factors	Examples
Social	Poverty
	Inability to shop
	Inability to prepare and cook meals
	Inability to feed
	Living alone
	Social isolation/ lack of social support network
	Failure to cater to ethnic food preferences
Psychological	Alcoholism
	Bereavement
	Cholesterol phobia
	Depression
	Dementia/Alzheimer's disease
Medical	Oral health: Mouth ulcers, Oral candida, Poor dentition
	Swallowing problem: Dysphagia, Esophagitis, Oesophageal stricture, Achalasia
	Other GI symptoms: Peptic ulcer disease/atrophic gastritis, Constipation, Colitis, Diarrhea, Malabsorption Cardiac failure
	Chronic obstructive pulmonary disease
	Infection
	Cancer
	Alcoholism
	Rheumatoid arthritis
	Malabsorption syndromes
	Hypermetabolism (e.g., hyperthyroidism)
Medications	Nausea/vomiting: antibiotics, opiates, digoxin, theophylline, nonsteroidal anti-inflammatory drugs (NSAIDs)
	Anorexia: antibiotics, digoxin
	Hypogeusia: metronidazole, calcium channel blockers, angiotensin-converting enzyme inhibitors, metformin
	Early satiety: anticholinergic drugs, sympathomimetic agents
	Reduced feeding ability: sedatives, opiates, psychotropic agents
	Dysphagia: potassium supplements, NSAIDs, biphosphonates, prednisolone
	Constipation: opiates, iron supplements, diuretics
	Diarrhea: laxatives, antibiotics
	Hypermetabolism: thyroxin, ephedrine

In developing countries such as Indonesia, poor intake is one of the major causes of malnutrition among older people, particularly those in the lowest socioeconomic group. This group of older people tends to have inadequate daily energy and protein intake due to limited food supply. Recent Total Diet Study conducted in Indonesia indicated that nearly half of Indonesian aged > 55 years had energy intake < 70% RDI and protein intake < 80% RDI (***Figure 5 and 6***) (21). Furthermore, there were higher prevalence of inadequate energy (49% vs 42%) and protein (41% vs 31%) intake in rural compared to urban areas (21).

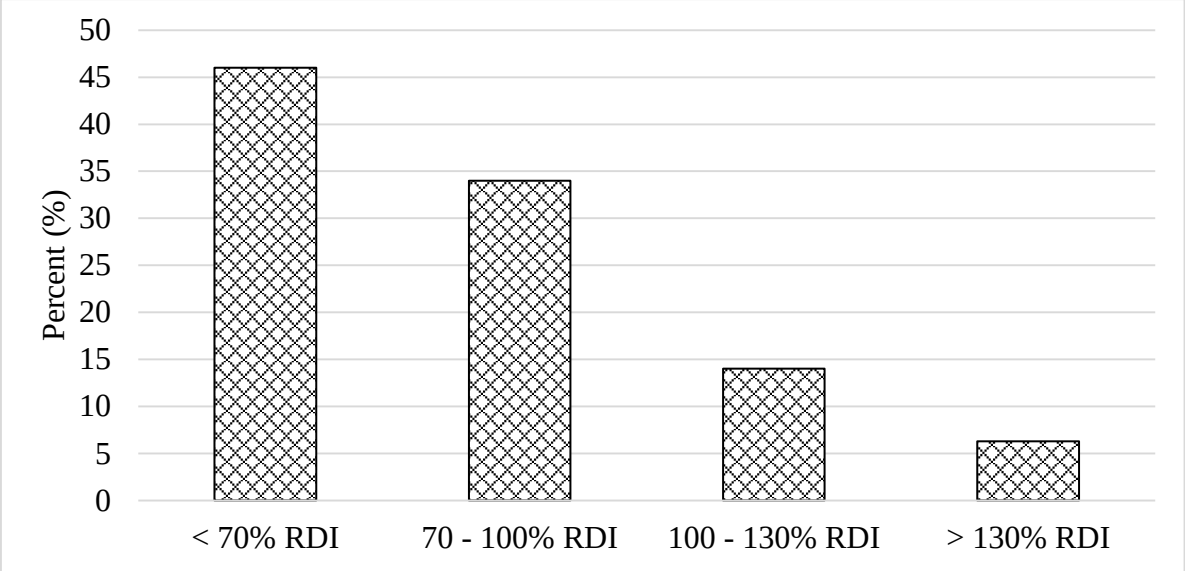


Figure 6. Percent Recommended Dietary Intake (RDI) for energy among Indonesian aged > 55 years. Adapted from (21)

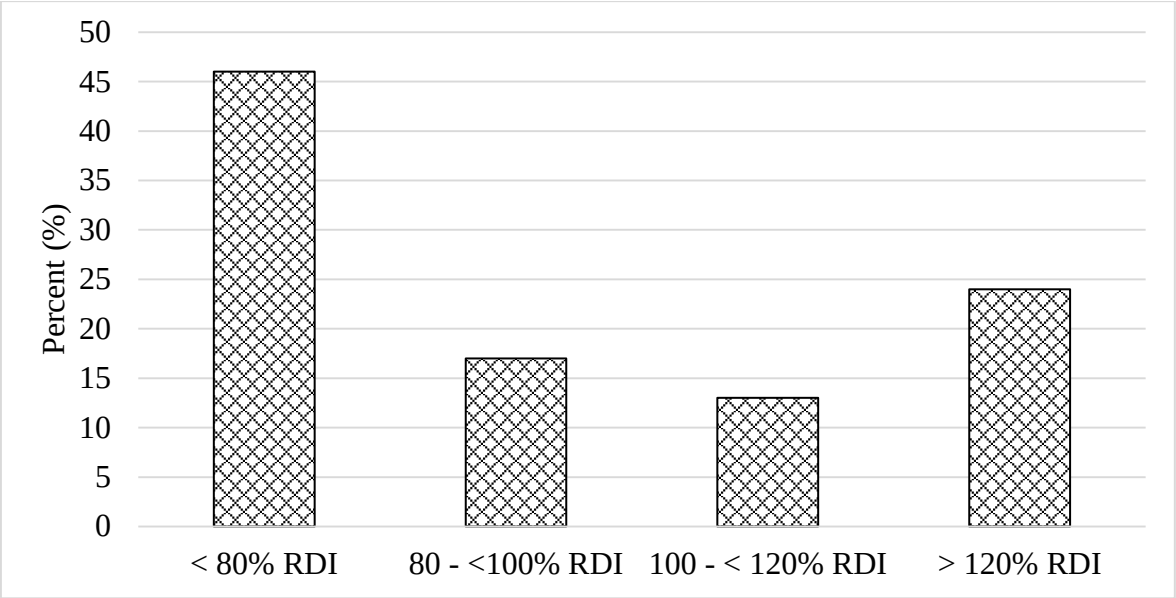


Figure 7. Percent Recommended Dietary Intake (RDI) for protein among Indonesian aged > 55 years. Adapted from (21)

5. Consequences of malnutrition and aging

5.1 Increased morbidity and mortality associated with malnutrition and aging

The high prevalence of malnutrition among the older adults is a major concern as ithas many negative implications for the older adults and the health care system. Many studies have documented that malnutrition is associated with decreased taste acuity and smell, impaired muscle function, decreased bone mass, anaemia, reduced cognitive function, poor wound healing, impaired immune function, increased infection, longer hospital stays, higher hospital re-admission rate and increased mortality (17, 20, 22). A study of 250 older domiciliary care clients in Australia revealed that compared to the well-nourished subjects, the malnourished subjects had a higher risk of being admitted to hospital (Risk Ratio/RR= 1.51, 95% CI: 1.07 – 2.14), have two or more emergency hospital admissions (RR=2.96, 95% CI : 1.15–7.59), spend more than 4 weeks in the hospital (RR = 3.22, 95% CI : 1.29 - 8.07), fall (RR=1.65, 95% CI : 1.13–2.41), and report weight loss (RR =2.63, 95% CI: 1.67–4.15) within 1 year (23).

In addition to malnutrition, advancing age is often followed by a worsening of unfavourable changes in body composition. The first change is a substantial reduction of muscle mass which leads to reduced strength and functionality known as 'Sarcopenia'. The European Working Group on Sarcopenia in Older People (EWGSOP) defines sarcopenia *as "a syndrome characterised by progressive and generalised loss of skeletal muscle mass and strength with a risk of adverse outcomes, such as physical disability, poor quality of life, and death" (24).* As clearly mentioned in its definition, sarcopenia is also associated with various adverse consequences such falls, functional impairment, loss of independence, disability, and increased hospitalisation and mortality (25).

The second change in older people's body composition is increased fat mass. The combination of increased fat mass and reduced muscle mass is known as sarcopenic obesity (26, 27). Like sarcopenia, sarcopenic obesity is also associated with disability, functional impairment, physical frailty, poor quality of life and significantly increased mortality rates (19, 28). In addition, sarcopenic obesity is linked to increased cardiovascular disease and diabetes risk (26, 29). In summary, malnutrition and aging bring considerable negative consequences to the health and quality of life of older adults.

5.2 Increased health care costs and financial burden associated with malnutrition

Malnutrition contributes a substantial financial burden to the health care system because malnourished patients tend to have longer hospital stays, poorer wound healing, a higher incidence of disease complications, and higher rate of hospital re-admission. A study in the US revealed that hospital costs for patients identified as being at risk of malnutrition was significantly higher than well-nourished group ("at risk of malnutrition" patients: AU$ 6918 vs well-nourished patients: AU$ 5095, $p< 0.02$) (30). Similarly, a study in Brazil showed that the mean daily expense for treatment of malnourished patients was increased by 60.5% compared to their well-nourished peers (malnourished patients: AU$ 255/patient vs well-nourished patients: AU$154/patients) (31).

In addition, when the costs of medications and health-related tests were included using respiratory infection patients for comparison, malnourished patients' costs increased up to 308.9% compared to the well-nourished patients (31). Moreover, studies in the UK estimated that the total costs of malnutrition range from AU$ 9.3 to 24.1 billion for direct health care costs and associated health and social care expenditure (32-34).

Australian studies have also found that malnutrition causes substantial financial losses to the health care system. A study conducted in 2003-2004 indicated that malnutrition represented 1.87% of all admissions across Victorian Hospitals and costs AU$ 10.7 million per annum (35). Malnutrition was estimated to contribute an additional cost of AU$ 1,745 per hospital admission (35). Likewise, another study performed in 2009 reported that undiagnosed or undocumented cases of malnutrition caused an estimated AU$ 1,850,540 deficit in hospital reimbursements (36). The Australian Institute of Health and Welfare (AIHW) also indicated that the average health expenditure per person in 2004-2005 rises sharply with advancing age – from $1,961 for person aged ≤65 years to $ 5,714 for 65 - 74 year olds, $8,500 for 75 - 84 year olds, and $ 9,717 for people aged ≥85 years (37). Moreover, it is important to note that none of these estimates included costs associated with disengagement from society due to depression / isolation which would likely contribute a substantial amount to the overall cost of malnutrition. Thus, it is critical that the Australian Government invest in strategies to improve the health of older Australians, and hence, the prevention, early identification, and treatment of malnutrition are essential to reduce health care costs associated with malnutrition.

6. Current methods for identification and diagnosis of malnutrition

There are multiple methods used to identify malnutrition in older adults, including the measurement of anthropometric indices, biochemical markers, and the use of nutrition screening and assessment tools. However, due to the absence of gold standard and the variable diagnostic

performance of these methods, most studies use a combination of two or more methods to determine the nutritional status of older people.

6.1 Anthropometric markers of malnutrition

Amongst the anthropometric indices used to diagnose malnutrition are Body Mass Index (BMI), skinfold thickness, mid arm circumference (MAC) and arm muscle area (AMA) (38). BMI is obtained from calculation of body weight (in kilogram) divided by the square of height (in meter) (kg/m^2). BMI could predict both undernutrition and over-nutrition (overweight and obesity). Despite the fact that both ends of the BMI range are associated with an increased risk of mortality among older people, longitudinal studies indicate that a higher BMI is associated with a better overall health (39). In the 60 to 69 years old group, the lowest mortality rate was found among those with higher body weight. A comparable trend was observed among those aged 70 – 80 years and > 80 years old, those with lower body weight have a higher mortality rate (16, 39). Similarly, a more recent meta-analysis of 32 studies involving 197,940 older adults indicated that those with a BMI range of 21.0–21.9 kg/m^2 and 20.0–20.9 kg/m^2 had 12% and 19% greater risk of mortality compared to older adults with BMI between 23 – 23.9 kg/m^2, and then the mortality risk increased again by 8% for those with BMI of >33 kg/m^2 (40). Thus, the Nutrition Screening Initiative (NSI) recommended that the ideal BMI for older people is between 22 – 27 kg/m^2, significantly higher than the ideal range for younger adults of 18.5 – 22.9 kg/m^2 (41). However, the reliability of BMI to diagnose nutritional status in this population is limited because a lower or higher BMI does not necessarily reflect ideal body composition. As mentioned earlier, older adults often experience reduced muscle mass and increased fat stores. Therefore, higher BMI could also reflect increased fat mass or sarcopenic obesity. Measurement of height might also be difficult due to vertebral pressure and postural changes (38).

Skinfold thickness, MAC and AMA are often used to determine nutritional status among older people as theyprovide anestimation of fat stores and muscle mass (38). These indices are

relatively simple and easy to obtain. Skinfold thickness is obtained by measuring the thickness of subcutaneous fat in selected sites (i.e. triceps, biceps, subscapular, and suprailiac) using skinfold callipers (example of skinfold sites is shown in ***Figure 7***) (42). Then, fat stores were estimated from the average of measurements at a single site or combination of 3 or more sites (42). MAC is obtained by measuring the midpoint of the upper arm, between the acromion process and the tip of the olecranon using a flexible, non-stretch tape (***Figure 8***) (42, 43). While AMA is derived from calculation using specific formula and results of triceps skinfold and MAC measurements (42). However, the presence of other clinical conditions such as oedema of the extremities and ascites can impair the reliability of the aforementioned indices (38, 39).

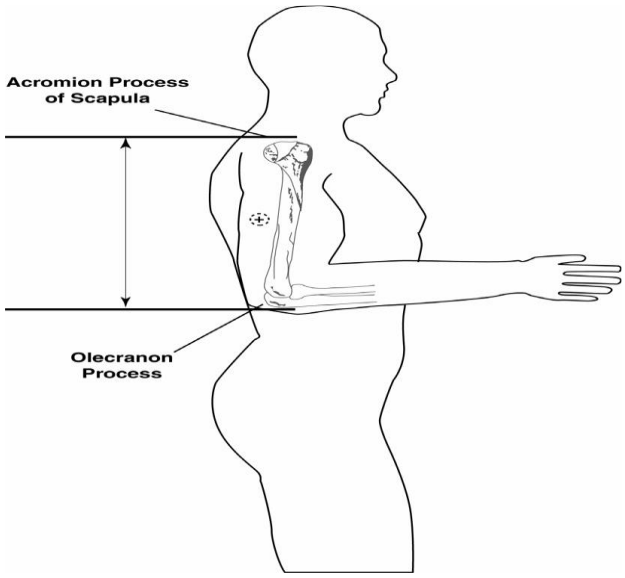


Figure 8. Measurement of triceps skinfold. Adapted from (43)

Figure 9. Position of MAC measurement. Adapted from (43)

6.2 Biochemical markers of malnutrition

Biochemical markers provide objective data to help diagnose malnutrition in older adults. Frequently used markers include albumin, transferring, pre-albumin, Retinol Binding Protein (RBP), Insulin Growth Factor-I (IGF-I), C-Reactive Protein (CRP) and Total Lymphocyte Count (TLC) (44). The effects of age and non-nutritional factors to each parameter and their relation to

mortality and morbidity risk among older people is shown in ***Table 2***. Despite offering objective data as criteria for malnutrition diagnosis, changes in the biochemical markers are not only affected by nutritional state (see Table 2 for details), but also other non-nutritional factors, for example, inflammation and infection could significantly impair the measured value of each markers. Hence, the biochemical markers might not always be a valid diagnostic method for detection of malnutrition, particularly in acutely ill older people (38).

Table 2. Effects of age and non-nutritional factors. Adapted from (44)

Biochemical measurement	Effects of age	Non-nutritional factors affecting value	Relation to prognosis
Albumin	Small decrease (0.8 g/L per decade); thus, only significant in centenarians	Posture, cytokines, nephrotic syndrome, heart failure, acidosis, dialysis (dye methods), para-proteinemias (dye methods)	24–56% increase in mortality for every 2.5-g/L decrement in serum level
Transferrin	Gradual decrease, lowest levels in centenarians	Iron deficiency, acute hepatitis, pregnancy, estrogen (contraceptives), end-stage liver disease, nephrotic syndrome, neoplasms, antibiotics	Controversial; when coupled with albumin, transferrin may indicate morbidity and mortality
Prealbumin	No major change, decreases in males after ninth decades	End-stage liver disease, renal failure, steroids, inflammation, stress, iron deficiency	Increased length of hospital stay in nursing-home residents when <80 mg/L; increased sepsis and mortality in burn patients; increased mortality in cancer patients if no improvement, despite adequate nutritional support
Retinol-binding protein	Slight decrease in males Slight increase in females	Renal failure Acute hepatic failure End stage liver disease Hypothyroidism Stress Zinc deficiency Vitamin a deficiency	Similar to prealbumin

Biochemical measurement	Effects of age	Non-nutritional factors affecting value	Relation to prognosis
Insulin growth factor-I	Decreases by 35–60% between the fourth and ninth decades	Renal failure, hepatic failure, autoimmune diseases, pregnancy, inflammation, stress	Inversely related to life-threatening complications in hospitalised patients
Fibronectin		Burns, infections, stroke, lipid feeding formulas	Not established
C-reactive protein	No change	Catabolic states, trauma, sepsis	Decreased levels herald short-term survival in hospitalised patients
Interleukins	Increase, particularly the soluble IL-2 (interleukin-2)	Inflammation, exercise	Increased mortality with increased soluble IL-2 receptor
Urine creatinine	Decrease due to decreased renal function	Renal failure, steroids	Low level reflects decrease in muscle mass
Total lymphocyte count	Decrease or no change	Stress, tumours, sepsis, steroids	Four-fold increase in mortality with total lymphocyte count <1500/mL
Delayed hypersensitivity reaction	More people become anergic	Conditions affecting cellular immunity	Anergy is associated with increased 3 y of mortality
Cholesterol	Increases between the sixth and ninth decade and then decreases		Ten-fold increase in mortality when less than 120
Leptin	Increases at middle age and declines in old age in females; lower in males than in females and increases throughout the lifespan in males	Hypogonadism	Unknown

6.3 Nutrition screening tools to diagnose malnutrition

Malnutrition screening and assessment tools offer the least invasive methods to diagnose malnutrition. This method also provides a wide variety of tools with unique parameters and criteria. However, systematic reviews have concluded that screening and assessment tools performed poorly in identifying malnutrition and predicting clinical outcomes of malnutrition in the older population (45, 46). Nevertheless, tools that have been tested and reviewed for their

specificity, sensitivity, validity, and reliability are still recommended as the best option to be used in the older population. For rapid screening of malnutrition, Mini Nutritional Assessment Screening Form (MNA-SF), Malnutrition Universal Screening Tool (MUST) and Short Nutritional Assessment Questionnaire (SNAQ) and Geriatric Nutritional Risk Index (GNRI) appeared to perform better than other tools to identify malnutrition among hospitalised, institutionalised and community-dwelling older adults (45, 47-51), while for a more comprehensive assessment of nutritional status, the Mini-Nutritional Assessment (MNA) and Subjective Global Assessment (SGA) are the preferred tools and often used as a valid standard (45, 46, 52). Iin Chapter 2 of this thesis, the performance of these nutrition screening tools to diagnose and predict the outcomes of malnutrition in older people across different settings were examined comprehensively. A brief description of each tool and criteria used to classify nutritional status is shown in ***Table 3*****.**

Table 3. Nutrition screening and assessment tools description and criteria

Nutrition screening and assessment tools	**Description**	**Criteria**
GNRI (53)	The GNRI used combination of biochemical and anthropometric measurements. GNRI consists of albumin, weight and ideal weight. The formula used to calculate GNRI is: GNRI = [1.489 X albumin (g/L)] + [41.7 X (weight/WLo)] WLo: weight determined according to the Lorentz formula	No risk: GNRI ≥ 98 Low risk: GNRI 92 to ≤ 98 Moderate risk: GNRI 82 to < 92 Major risk: GNRI <82
MNA (54)	A tool developed for screening and assessment of nutritional status of older people. It is an 18-item questionnaire related to: anthropometric assessment (weight, height, arm & calf circumference), weight loss, general assessment	Normal Nutritional Status: MNA = 24 – 30 At Risk of Malnutrition: MNA = 17 – 23.5 Malnourished> MNA <17

Nutrition screening and assessment tools	Description	Criteria
	(lifestyle, medication, and mobility), self-perception, lifestyle, medication, mobility, dietary assessment, and subjective assessment.	
MNA-SF (55, 56)	Short version of the MNA which was developed and validated against the full MNA. It is a 6-item questionnaire related to: food intake, weight loss, mobility, medical condition, neuropsychological problem, BMI (or calf circumference in the revised version)	Normal nutritional status : MNA-SF = 12 – 14 At risk of malnutrition: MNA-SF = 8 –11 Malnourished: MNA-SF = 0 – 7
MUST (57)	A screening tool developed for rapid assessment of nutritional risk of adult and older patients. MUST consists of 3 questions related to BMI, weight loss and acute disease.	Low risk: MUST = 0 Medium risk: MUST = 1 High risk: MUST ≥ 2
SNAQ (58)	A screening tool developed as a "quick and easy" tool to identify nutritional risk of adult patients. SNAQ consists of 3 questions related to weight loss, appetite and the use of nutritional supplements or tube feeding.	Moderately malnourished: SNAQ ≥ 2 Severely malnourished: SNAQ ≥ 3
SGA (59)	A tool developed for assessment of nutritional status of adult patients. It consists of 6-item related to: weight change, dietary intake change, gastrointestinal symptoms, functional capacity, disease and its relation to malnutrition, and physical examination.	Well nourished: SGA = A Moderately malnourished: SGA = B Severely malnourished: SGA = C

It also important to note that the nutrition screening tools were developed and validated in Western populations, and there isvery limited documentation on theiruse among Asian older populations, particularly in Indonesia. Hence, chapter 5 of this thesis provides detailed results on

performance of the screening tools in diagnosing malnutrition among rural and urban living older Indonesians.

7. Management of malnutrition in older people

7.1 Protein and energy supplementation as a strategy to manage malnutrition

One of the potential strategies to prevent and treat malnutrition in older adults is the provision of nutritional supplements to increase protein and energy intake and eventually improve the health, nutritional status and quality of life of older people. However, due to the wide variation of sample size, study duration, design, and outcomes assessed in studies investigating the beneficial effect of protein and energy supplementation in older population, it is difficult to draw firm conclusions. In the following paragraphs, several recent large studies will be discussed and the disparity in study quality and designs will be highlighted. A detailed summary of randomised controlled trials (RCTs) investigating the effect of energy and protein supplementation is available in ***Table 4***.

A study in Canada involving 83 free-living undernourished older people (Control= 41 and Intervention= 42; nutritional risk was based on involuntary weight loss and BMI) with mean age of 80 ± 7 years showed that provision of nutritional supplements (235 ml commercial formula, Ensure or Ensure Plus; nutritional compositions of supplements are shown in the Appendix 1) for 16 weeks significantly increase energy intake and weight gain in the intervention group compared to control group (1772 vs 1440 kcal, $p<0.001$ and 1.62 vs 0.04 kg, $p<0.001$) (60). Additionally, the intervention group had an improved emotional role function of the SF-36 questionnaire ($p<0.001$) and number of days spent in bed ($p=0.04$) than the control group. There were, however, no substantial improvements found in other anthropometric indices and functional parameters (60). Similarly, an RCT study in France involving 68 older shelter home residents (mean±SEM age: 82±7 years; nutritional risk was based on BMI$\leq$ 25 kg/m^2) indicated that protein and energy supplementation (nutritional compositions of supplements are shown in Table 4) for 6 months resulted in significant weight gain among subject in the intervention group (weight gain was +1.6

kg vs +0.3 kg in the control group; p=0.03) (61). Although no improvement was observed in overall perceived health measured using the Nottingham Health profile (NHP) for the intervention group when compared to control, there was a substantial increase in the 'sleep' domain of the NHP (intervention: 0.38±0.19 vs control: 0.24±0.19, p=0.03). There were no considerable changes observed in other anthropometric, functional or blood parameters (61).

In another RCT study conducted in the UK, which involved 100 malnourished community-living older adults, certain beneficial effects of energy and protein supplementation were also observed (62). Subjects in the control group received standard care, while the intervention group received additional supplements (details are shown in Table 4) for 8 weeks. After 24 weeks follow up, nutritional status was significantly improved from baseline in the intervention group ($p<0.05$), but not in the control group (62). There was also no significant difference in nutritional status between groups at week 24. Handgrip strength was improved significantly in the group receiving supplementation, and was significantly different from the control group at week 8 (change in handgrip strength in intervention group: +1.2 kg vs –0.5 kg in the control group, p=0.04), but decreased from week 8 to 24. Assessment of quality of life and health economic outcomes showed no substantial disparities between groups at week 24. The mean number of hospital admissions decreased significantly during the study period in both groups compared to 24 weeks prior the study (i.e. number of admission 24 weeks before and during the study in intervention group: 1.48 vs 1.04, p=0.0345 and control group: 1.74 vs 1.04, p=0.0015). However, reduction of hospitalisation cost was observed only in the control group (p=0.0001) (62). In addition, a study in the Netherlands involving 65 frail (frailty was assessed by FRIED criteria) older adults revealed that protein supplementation (details are shown in Table 4) given twice daily over 24 weeks significantly increased muscle strength in both intervention and control groups ($p<0.01$), and there also tended to be greater improvement in leg extension strength for the intervention than control (p=0.059) (63). Moreover, subjects in the intervention group had substantially better physical

performance (from 8.9±0.6 to 10.0±0.6 points), while those in the control group showed no significant difference (from 7.8±0.6 to 7.9±0.6 points) (p=0.02). Yet, this study found no significant change of muscle mass in both groups after 24 weeks of intervention (63).

Finally, an RCT study in Hong Kong involving 121 post-hip fracture older adults patients (nutritional risk was based on BMI < 25 kg/m^2 and MUST score) further demonstrated the inconsistent findings of energy and protein supplementation studies (64). Control subjects in this study received standard care and the intervention group received an extra 240 ml nutritional supplement (details are shown in Table 4) twice daily for 28 days. After 6 months follow up, significant differences were found in energy and protein intake between intervention and control group (p<0.001 for both) (64). The intervention group, compared with control had less change in BMI both at hospital discharge and at 6 months (intervention: 0.25 and 0.03 kg/m^2 Vs control: 0.72 and 0.49 kg/m^2, p=0.012). Compared to the control group, the intervention group also had a shorter length of stay in the rehabilitation ward (by 3.80 days; SEM: 1.81, p= 0.04) and a lower number of infection episodes (14 vs 29 episodes, p=0.019) (64). Nonetheless, no significant considerable difference was detected in the rate of change of the serum albumin level, the functional independence measure (FIM) and the elderly mobility scale (EMS) (64).

A comparable pattern of inconsistent results has been reported in systematic review and meta-analysis articles. A systematic review which included 15 studies (a total of 846 community-dwelling, institutionalised and hospitalised older adults) found limited evidence to support routine use of oral nutritional supplements as sip feeds among undernourished community-dwelling, institutionalised and post-discharge older people. However, interventions to improve the taste of food and offering food in a more sociable environment, or using more personal feeding assistants, could potentially offer more beneficial impact on nutritional status and quality of life of older people. In addition, a meta-analysis, which included 62 RCTs (a total of 10,187 hospitalised and community-dwelling older adults subjects) demonstrated that protein and energy supplementation

produced a small but consistent weight gain of 2 % (65). Reduced mortality risk was found only among those who were undernourished (RR=0.79). The review also noted a significant reduction in the number of complications among certain groups of older patients (hip fracture patients) (65).

In conclusion, despite the fact that protein and energy supplements are commonly prescribed for the older adults, current evidence is still inadequate to support the routine use of such nutritional supplements in clinical settings to improve the health, nutritional status and quality of life of older people. Limitations of previous studies in this field include: a limited number of RCTs, small study numbers, lack of single blinding for subject allocation, lack of intention to treat analysis, short duration of intervention. In addition, future studies also need to focus on measuring more meaningful clinical outcomes over intervention period (which should ideally be 12 months or more) such as quality of life, functional capacity, number of hospital admissions and length of stay (LOS), and the incidence of disease complications rather than just assessing weight gain, grip strength or other anthropometric indices. Moreover, the majority of published studies were conducted in developed countries in America, Europe and Asia. Similar studies on the use of oral nutrition support or food fortification in older people in developing and less developed countries have been nearly non-existent, and are needed.

Table 4. Summary of RCT studies examining the health benefits of nutritional supplementation for older adults identified as malnourished or 'at-risk of malnutrition

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
Studies involving older patients				
Myint et al., 2013 (64) Mean duration: 28 days supplementation, 6 months follow up Design: RCT Location: Hong Kong	N = 121 post hip fracture older patients Control= 60 (mean age: 81.7 ± 6.4 years) Intervention= 61 (mean age: 80.9 ±6.5 years) Nutritional risk was based on: BMI < 25 kg/m^2, MUST Score and post hip operation.	Control: standard care Intervention: nutritional supplementation x 2/day (18–24 g protein and 500 kcal per day, ∞ 240 ml) Types of nutritional supplements: **Ensure** contains (per 235 ml): Energy: 250 kcal, Protein: 9 g, Carbohydrate: 40 g, Fat: 6 g, Vitamins and minerals **Resource Breeze** contains (per 237 ml): Energy: 250 kcal, Protein: 9 g, Carbohydrate: 54 g, Fat: 0 g, Vitamins and minerals **Compleat** contains (per 250 ml): Energy: 265 kcal, Protein: 12 g, Carbohydrate: 33 g, Fat: 10 g, Vitamins and minerals **Glucerna** contains (per 237 ml):	Primary outcome: Serum albumin level, the body mass index (BMI), the functional independence measure (FIM) score and the elderly mobility scale (EMS). Secondary outcome: frequency and severity of complications, length of stay in rehabilitation ward, mortality and accident and emergency department attendance within 6 months after discharge. Other parameters: mid-arm circumference (MAC), triceps skin fold (TSF), serum insulin-like growth factor-1 (IGF-1) level, bilateral quadriceps	• There was a significant difference in energy and protein intake between Oral nutrition support (ONS) and control group (p= .000 and p=0.000, respectively) • There was a significant difference in change in BMI with a decrease of 0.25 and 0.03 kg/m2 in the ONS group and 0.72 and 0.49 kg/m2 in the control group at hospital discharge and follow–up, respectively (p=0.012). • The length of stay in rehabilitation ward was shortened by 3.80 (SEM=1.81, p=0.04) days in the ONS group. • The total number of infection episodes was significantly

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
		Energy: 190 kcal, Protein: 10 g, Carbohydrate: 23 g, Fat: 7 g, Vitamins and minerals Both groups were also prescribed oral vitamin D supplement of 800–1,000 IU /day and calcium tablets containing elemental calcium of 1,200 mg/day	strength and dominant hand grip strength.	lower in ONS group (14 vs 29, p=0.019) • No difference was observed in the rate of change of the serum albumin level, the FIM and the EMS.
Neelemaat et al., 2012 (66) Mean duration: 3 months Design: RCT Location: Netherland	N= 210 older patients Control = 105 Intervention = 105 Nutritional risk was based on BMI ≤20, and/or ≥5% unintentional weight loss in the previous month, and/or ≥10% unintentional weight loss in the previous six months.	Control: usual care, i.e. were given nutritional support only on prescription by their treating physician, and did not receive post-discharge nutritional support. Intervention: Nutritional support starting in hospital and continuing until three months after discharge: • Energy and protein enriched diet (during the in hospital period) • Two additional servings of an oral nutritional supplement (Nutridrink®, Nutricia), leading to an expected increase in intake of 2520 kJ/day (=600	• Quality Adjusted Life Years (QALYs) • Physical activities • Functional limitations • Cost effectiveness	• No statistically significant differences in quality of life and physical activities were observed between groups. • Functional limitations decreased significantly more in the intervention group (mean difference -0.72, 95% CI-1.15; -0.28). • There were no differences in costs between groups. • Cost-effectiveness for QALYs and physical activities could not be demonstrated. • For functional limitations, there was 0.95 probability that the intervention is cost-

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
		kilocalories/day and 24 g protein/day (during the entire study period) • 400 IE vitamin D3 and 500 mg calcium (Calci-Chew D3®, Nycomed) per day (during the entire study period) • Telephone counselling by a dietician to advice and to stimulate compliance every other week after discharge from the hospital, six in total.		effective in comparison with usual care for ceiling ratios > €6500.
Persson et al., 2007 (67) Mean duration: 4 months Design: RCT Location: Sweden	N= 108 older patients Control = 57 Intervention=51 Nutritional risk was based on MNA-SF of ≤ 10.	Control: standard dietary counselling Intervention: individualised counselling + liquid supplement " Complete" or "incomplete"(Sempers, 200 ml/package) **Complete** contains (per 100ml): Energy: 120 Kcal, Protein: 5 g, Carbohydrate: 0 g, Fat: 4 g, Vitamins and minerals **Incomplete** contains (per 100ml): Energy: 85 Kcal, Protein: 4 g, Carbohydrate: 0 g, Fat: < 0.1 g, Vitamins and minerals	• Body weight, BMI • Biochemical indices • Handgrip strength • Katz activities of daily living (ADL) index • Mini mental status examination (MMSE) • Quality of life (QoL) by SF-36	• Katz ADL index improved in the I-group ($p<0.001$; $p<0.05$ between the groups • Serum IGF-I levels increased in the I-group ($p<0.001$), but were unchanged in the C-group ($p=0.07$ between the groups) • No change in handgrip strength • QoL was assessed to be low and had not changed after nutritional treatment

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
		Both groups also prescribed multivitamin supplement (Friggs Multivitamin) x 1 /day		
Studies involving older nursing home residents				
Parsons et al., 2017 (68) Mean duration: 3 months Design: RCT Location: UK	N = 104 oldernursing home residents Dietary advice (DA): 51 Oral nutrition support (ONS): 53 Nutritional risk was based on MUST score of ≥ 1.	DA: were given a specially designed diet sheet ('Build yourself up', Southampton Dietitians, Southampton, UK), encouraging intake of high energy foods, drinks and snacks. ONS: were given access to a range of supplements (styles (drinks, soups, puddings, modules), flavours, volume (125–200 ml), energy density (1.3–4.5 kcal/ml)) (Nutricia Ltd, Trowbridge, Wiltshire, UK) to take them ad libitum according to choice.	• QoL assessed using EuroQol (EQ-5D), including time trade off (TTO) (range −0.59 to 1) • Visual analogue scale (VAS) (score 0 to 100) for self-perceived health. • Dietary intake	• QoL (adjusted for baseline QOL, malnutrition risk, type of care received (nursing or residential)) was significantly higher in the ONS than the DA group. EQ-5D TTO scores (mean ± SE) were 0.50 ± 0.04 vs 0.36 ± 0.05 (p=0.005). • VAS rescaled scores were 0.54 + 0.03 vs 0.046 + 0.03 (P = 0.006) and VAS scores were 61.3 ± 4.5 vs 54.6 ± 6.3 (p=0.533) for ONS vs dietary advice, respectively. • Total energy, protein and the majority of micronutrient intakes were significantly greater in the ONS group, energy intake was 423 kcal greater in the ONS than the dietary advice group at week 12.

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
Lee et al., 2013 (69) Mean duration: 24 weeks Design: RCT Location: Taiwan	N = 92 older nursing home residents Control: 45 Intervention: 47 Nutritional risk was based on: MNA, score ≤24 and BMI ≤24 kg/m^2.	Control: routine care and "normal" meals including an afternoon snack (usually a warm soup). Intervention: Not undernourished: similar to control group Undernourished based on MNA or BMI: 50 g/day soy-protein-based nutritional which contained 9.5 g protein, 250 kcal energy and all essential micro-nutrients. Supplement was served as "warm drink" and part of a routine afternoon snack. The supplementation would be suspended if MNA > 24 or BMI > 24 kg/m^2.	• Nutritional parameters • Biochemical indicators	• The intervention significantly improved body weight, BMI, mid-arm circumference, calf circumference, and serum albumin and cholesterol concentrations at all intervals (all $p<0.05$). • However, there was no improvement of haematocrit, haemoglobin or lymphocyte count status.
Stange et al., 2013 (70) Mean duration: 3 months Design: RCT Location: Germany	N = 77 (91% female) older nursing home residents Control Control: 35 Intervention: 42 Nutritional risk was based on: MNA score < 24 p, BMI of 22 kg/m² or lower,	Control (CG): usual care, which included provision of homemade snacks or ONS when prescribed by the physician or provided by family members. Intervention (IG): 2 bottles of ONS with low volume (125 mL per bottle) and high nutrient and energy density (Fortimel Compact,	• Nutritional parameters (weight, body mass index [BMI], upper arm and calf circumferences, MNA-SF) • Functional parameters (handgrip strength, gait speed, depressive mood	• Body weight, BMI, and arm and calf circumferences increased in the IG (n = 42) and did not change in the CG (n = 35). Changes of all nutritional parameters except MNA-SF significantly differed between groups in favour of the IG ($p<0.05$).

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
	a low food intake according to the nurses' perception, or weight loss of 5% or more in the past 3 months or 10% or more in the past 6 months.	Nutricia GmbH, Erlangen, Germany; 2.4 kcal/mL, 12 g protein and 300 kcal per bottle) per day	[GDS], cognition [MMSE] • Activities of daily living [Barthel ADL]) as well as Quality of Life (QUALIDEM)	• GDS, handgrip strength, and gait speed could not be assessed in 46%, 38%, and 49% of participants due to immobility and cognitive impairment. In residents able to perform the test at both times, functionality remained stable in IG and CG, except for ADLs, deteriorating in both groups. • From 10 QoL categories, "positive self-perception" increased in IG (78 [33–100] to 83 [56–100]; p<0.05) and tended to decrease in CG (100 [78–100] to 89 [56–100]; p=0.06), "being busy" significantly dropped in CG (33 [0–50] to 0 [0–50]; p<0.05).
Smoliner et al., 2008 (71) Mean duration: 3 months Design: RCT	N = 65 older adults nursing home residents (62 at risk of malnutrition, 3 malnourished, 52 eligible for final analysis).	Control: Standard diet according to German reference values. Intervention: same diet with protein- and energy-enriched soups and sauces, and two additional	• Dietary intake • Nutritional status by MNA and body composition measured	• Protein intake was significantly higher in the intervention group, but energy intake did not differ from the control group.

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
Location: Germany	Control: 22 Intervention: 30 Nutritional risk was based on MNA score ≤ 23.5.	snacks high in protein and energy served between meals.	with bioelectrical impedance analysis. • Functional status assessed by handgrip strength, peak flow, the Barthel Index, and the Physical Functioning component of the Short Form 36 questionnaire (SF-36)	• Both groups significantly improved most nutritional and body composition parameters during the intervention period. • There was no improvement in muscle function and the Barthel Index and the Physical Functioning component of the SF-36 declined in all participants.
Wouters-Wesseling et al., 2003 (61) Mean Duration: 6 months Design: RCT, double-blinded Location: France	N=68 older shelter home residents Mean age=82±7 years Nutritional risk was based on BMI ⩽25 kg/m2	Control: Placebo Intervention: nutritional supplement 2x/day for 6 months in 125 ml tetra pack, which contains (per 250 ml): Energy: 1.05 (MJ) / 250 kcal , Protein (whey): 8.75 g, Carbohydrates: 28.5 g, Fat: 11.25 g, Vitamins and minerals	• Anthropometric (body weight, bioelectrical impedance, calf circumference), • Biochemical (albumin, prealbumin), functional parameters (handgrip strength, timed ‘up and go’ test) • dietary intake • Activities of daily living and Nottingham Health Profile (NHP)	• No compensation of energy intake occurred. • After 6 months, the supplement group had gained more weight (+1.6kg) than the placebo group (+0.3 kg) (p=0.03). • No other significant changes in anthropometric, functional or blood parameters were seen. • There was a significant improvement on the section ‘sleep’ of the NHP
Studies involving community-living older adults				

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
Tieland et al., 2012 (63) Mean duration: 24 wk. Design: RCT Location: Netherland	N=65 frail community-living older adults Control= 31 (mean age: 81 ± 1 years) Intervention= 34 (mean age: 78 ±1 years) Samples were classified into pre-frail and frail based on the Fried criteria, i.e.: (1) unintentional weight loss, (2) weakness, (3) self- reported exhaustion, (4) slow walking speed, and (5) low physical activity. Subjects were considered pre-frail when 1 or 2 criteria were applicable and frail when 3 or more criteria were present.	Control: 250-mL placebo beverage containing no protein, 7.1 g lactose, and 0.4 g calcium Intervention: 250 ml beverage containing 15 g (milk protein concentrate [MPC80], 7.1 g lactose, 0.5 g fat, and 0.4 g calcium) Supplements served twice daily after breakfast and lunch	• Skeletal muscle mass (DXA) • Muscle fibre size (muscle biopsy) • Strength • Physical performance	• Skeletal muscle mass did not change in the protein or placebo supplemented group following 24 weeks of intervention (p>0.05). • Type I and II muscle fibre size did not change over time (p>0.05). • Muscle strength increased significantly in both groups (p<0.01), with leg extension strength tending to increase to a greater extent in the protein compared with the placebo group (p=0.059). • Physical performance improved significantly from 8.9 ±0.6 to 10.0±0.6 points in the protein group and did not change in the placebo group (from 7.8±0.6 to 7.9±0.6 points) (p= 0.02).
Edington et al., 2004 (62)	N= 100 malnourished community-living older adults Control=49	Control: standard care which means that patients do not routinely receive nutritional supplements on discharge.	• Weight, body mass index, anthropometrics • Handgrip strength • Quality of life	• Nutritional status improved significantly from baseline to week 24 in the intervention

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
Mean duration: 8 weeks supplementation 24 weeks follow up Design: RCT (open label) Location: UK	Intervention=51 Nutritional risk was based on: (i) a BMI < 20, or (ii) BMI ⩾20 but <25 with documented evidence of weight loss of ⩾10% of their body weight in the 6 months prior to the study period or ⩾5% in the 3 months prior to the study period.	Intervention: standard care+ Supplement containing 600 and 1000 kcal/day Supplement options: **Ensure Plus** contains (per 237 ml): Energy: 350 kcal, Protein: 13 g, Carbohydrate: 51 g, Fat: 11 g, Vitamins and minerals **Enlive** contains (per 220ml): Energy: 330 kcal, Protein: 10.56 g, Carbohydrate: 71.94 g, Fat: 0 g, Vitamins and minerals **Formance Pudding contains (per 113 g):** Energy: 170 kcal, Protein: 4 g, Carbohydrate: 27 g, Fat: 5 g, Vitamins and minerals **Ensure Bars**	• Requirements for health-care professionals' services and social services	group ($p<0.05$), but not in the control group. • There was no significant difference in nutritional status between groups at week 24. • Handgrip strength improved significantly in the intervention group during supplementation, and was significantly different from the control group at week 8 ($p=0.04$), but decreased thereafter. • There was no significant difference in quality of life or health economic outcomes between groups at week 24. • Mean prescription rates in the intervention group increased significantly during the 24 week study period compared with the 24 weeks before the study ($p=0.0465$). • In both groups, mean numbers of hospital admissions decreased significantly during

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
				the study period when compared with the 24 weeks before the study (Intervention, P = 0.0345; control p=0.0015) • The cost of hospitalisation decreased significantly in the control group (p=0.0001)
Payette et al., 2002 (60) Mean Duration: 16 weeks Design: RCT Location: Canada	N=83 undernourished free-living older adults Control = 41 Intervention = 42 Mean age = 80 ± 7 years Nutritional risk was based on: (a) involuntary weight loss of >5% body weight in the past month, >7.5% in the past 3 months, or >10% in the past 6 months and BMI<27 or (b) BMI<24.	Control: no treatment Intervention: 235 ml can of commercial formula Ensure or Ensure Plus. Ensure contains (per 235 ml): Energy: 250 kcal, Protein: 9 g, Carbohydrate: 40 g, Fat: 6 g, Vitamins and minerals Ensure Plus contains (per 235 ml): Energy: 350 kcal, Protein: 13 g, Carbohydrate: 51 g, Fat: 11 g, Vitamins and minerals	• Anthropometric indexes • Handgrip / muscle strength • Perceived health • Functional status	• Total energy intake and weight gain were higher in the supplemented group (1772 vs 1440 kcal, p< 0.001 and 1.62 vs 0.04 kg, p<0.001) • No significant changes in anthropometric indexes, muscle strength or functional variables • Improved emotional role function (p<0.001) and number of days spent in bed (p=0.04) in the intervention group compared to control group
Gray-Donald et al., 1995 (72) Mean duration: 3 months	N = 50 free-living frail older adults (2 died prior to the first visit, 48 eligible for analysis)	Control: Weekly visit by dietitian Intervention: two 235 mL cans per day of a commercial liquid	• Nutritional status (weight gain) • Handgrip strength • General well-being score	• Weight gain was greater in the intervention group • (2.1±2.3 vs. 0.6±1.6 kg; p<0.01).

Study Descriptions	Sample & Characteristics	Exposure	Outcome	Key Findings
Design: RCT Location: Canada	Control: 24 Intervention: 24 Nutritional risk was based on: a) involuntary weight loss of >5% of body weight in the last month, >7.5% in the last 3 months or >10% in the last 6 months and BMI <27, or b) BMI <24.	formula (Ensure®,Ensure Plus®,or Enrich®) which contains between 1045 – 1480 kj energy and 8.7 – 13.0 g.	• Perception of health • Number of falls	• There were no significant differences in functional measures, except for number of falls which was lower among intervention group vs. controls (0% vs. 21%; p=0.05).

7.2 Fortification of meals as a strategy to manage malnutrition among community-dwelling older adults

Considering the rising population of older people, the Australian Government has developed the Commonwealth Home Support Programme which aims to assist community-living older people (aged 65 years or older) with daily tasks to help them continue to live independently at home. In this program meal assistance is one of the major services (73). There are many commercial and not-for-profit meal services available for older people in Australia, such as Tender Loving Cuisine, silver chain (commercial), Meals on Wheels (MOW) and Australian Red-Cross (not-for -profit). MOW is the key provider of meals to community residing older adults in Australia, and hence, the remainder of this section will be focused on research conducted by various MOW associations around the world who have examined the effects of protein and energy fortification of meals.

MOW was first established in South Australia in late 1953 and the first meals were served to eight older adults people in their homes on 9 August 1954 (74). Since then, MOW has been growing significantly and reaching more older adults people in the community. Today, MOW has 90 branches across SA and serves an average of 4200 meals per year to nearly 5000 clients (75). MOW provides a standard 3-course lunchtime meals for up to 7 days a week (76). The meal is estimated to provide approximately one-third of daily nutritional requirements for older people (76).

For various reasons, MOW clients may not consume the lunchtime meal in a single sitting, instead preferring to spread the meal over the day. In some cases, it has been reported that the meal is shared with other family and household members, including pets. Furthermore, Australian studies have indicated that MOW clients consumed less than their daily nutritional requirements (77, 78). A study of 124 MOW clients in Sydney found that 70% of male clients did not meet the dietary requirement (RDI) for protein and around 30% did not meet the RDI for calcium, iron, thiamine and riboflavin (78). Female clients also had similar consumption pattern; 70 % of them

did not meet the RDI for protein, 80% and 40%, respectively, did not meet the RDI for iron and calcium (78). Similarly, a study in Victoria of 124 MOW clients found that more than 55% of clients had protein and calcium intakes below the RDI (77). Moreover, a study in Canada revealed that the average amount of energy and protein consumed from delivered meals by 150 MOW clients aged > 75 years was 81±18% and 82±19%, respectively (79). These consumption patterns put community-dwelling older adults at increased risk of being malnourished and lose their functional capacity.

Thus, it is very important to devise a strategy to improve nutritional intake of MOW clients to prevent and minimise further decline in nutritional, functional status and quality of life of community dwelling older adults. One of the feasible strategies is by fortifying the current MOW meals with energy and protein. This will allow MOW clients to achieve dietary targets more readily than the standard meals and facilitate improved overall health and quality of life. This hypothesis is strongly supported by promising findings from a recent meta-analysis investigating the effectiveness of food-based fortification to prevent malnutrition in hospitalised, institutionalised and community-living older adults (80). Of the 7 reviewed studies (total participants = 588), food fortification resulted in significant increase of energy and protein intake by 200.22 kcal/day and 7.01 g/day ($p<0.00001$), respectively (80). Previous studies have also shown that soup, protein-sources and desserts were the most well utilised food components of the delivered meals, with average consumption of > 82 % (79). This suggested that soup, protein-sources and desserts could be used as vehicles for energy and protein fortification, and hence, this strategy warrants further investigation which is the focus of the research presented in Chapter 6 of this thesis.

8. Conclusion

The older adults population in Australia and Indonesia is expected to increase significantly in the next few decades. At the same time, the prevalence of malnutrition and associated morbidity in this population are also rising. This is situation needs urgent attention from government and relevant stakeholders due to the considerable personal and community costs associated with malnutrition. There are several effective strategies to manage malnutrition in older people, although prevention and early identification is still the best.

Thus, studies that provide a better understanding on the magnitude, aetiology and the most appropriate tool to detect and diagnose malnutrition amongst older people across different settings, as well as the benefits of nutritional supplementation to improve nutritional, functional status, hospitalisation and quality of life of community-dwelling older adults are of substantial importance to help reduce the negative consequences of malnutrition. Therefore the overall aim of the work conducted during this PhD program was to improve understanding in identification and management of malnutrition among hospitalised, institutionalised and community-dwelling older people. And, the specific aims for each chapter are to answer questions raised in the theoretical framework (Figure 3) which include:

- Chapter 2:
  - Provide information or advice on selecting the appropriate screening tool for various clinical outcomes (i.e. mortality, morbidity, LOS, quality of life (QOL), level of care (LOC), muscle mass and muscle function) in older adults population across hospital, nursing home and community settings.

- Chapter 3:
  - To characterise the body weight and nutritional status of a cohort of older adults nursing home residents in South Australia, and the factors associated with changes in these measures over 6-12 months.

- Chapter 4:
  - To determine the body composition, nutrition, mental status and physical function at baseline and after 6 month and the relationships between exercise, nutritional state, muscle mass and physical function among institutionalised older people.

- Chapter 5:
  - To determine the effect of providing at least 3 days/week of (i) standard MOW meals or (ii) high energy and high protein (HEHP) for 12 weeks on energy and protein intakes and clinical outcomes (including nutritional status, physical capacity, general and psychological wellbeing, and quality of life and number and length of stay of hospitalisation). To determine the level of satisfaction with meals and general service provided by MOW.

- Chapter 6:
  - To determine health, socio-demographic and anthropometric characteristics, nutritional, mental and functional status, energy and nutrient intake, of community-dwelling older men and women living in rural and urban areas in Yogyakarta Indonesia.

CHAPTER 2. LITERATURE REVIEW: RECOMMENDED NUTRITION SCREENING TOOLS TO PREDICT CLINICAL OUTCOMES IN HOSPITALISED, NURSING HOME AND COMMUNITY-DWELLING OLDER PEOPLE

1. Introduction

Globally the percentage, and life expectancy, of people over 65 years is increasing (81). The older adults population is predicted to grow from 841 million in 2012 to 2 billion in 2050 (82). The prevalence of malnutrition, i.e. protein-energy undernutrition, in the older population is rising concurrently. Malnutrition affects hospitalised older people and individuals living in nursing homes as well as those living in the community. A large multinational study revealed that the percentage of older people malnourished or at risk for malnutrition was up to 91% in rehabilitation centres, 86% in hospitals, 67% in nursing homes, and 38% in the community (12). In Australia, the percentages of older people malnourished or at risk of malnutrition were 33% and 52% respectively in rehabilitation wards (13), 6% and 43% in residential care facilities (14) and 8% and 35% in the community (15). Recently, our group has found that 30% of a sample of South Australian nursing home residents were malnourished or at risk of malnutrition (83).

Malnutrition is a major public health problem in many countries, with negative implications for both the individual and health care systems (8-11). Numerous studies have documented that malnutrition has many adverse effects, including decreased taste acuity and smell, poor dental health, impaired immune function, increased infection, poor wound healing, anaemia, decreased bone and muscle mass, impaired muscle function, reduced cognitive function, longer hospital stay, higher hospital re-admission rate and increased mortality (17, 20, 22). These complications, resulting from poor state of nutrition, lead to increased direct health care costs and associated health and social care costs of malnourished patients causing an ~3-fold increase in hospital costs (31-34).

The aetiology of malnutrition in older people is multifactorial, with both physiological causes (such as reduced sense of taste and smell, change in hormone and gastrointestinal function) and non-physiological (such as poverty, depression, and side effects of medications) factors (19). These factors and their manifestations (such as weight loss, reduced appetite and food intake) can often be detected before they lead to a more dramatic and catastrophic declines of nutritional status (16, 19). Hence early identification and prevention of malnutrition have become recognised as essential aspects of health care in the ageing population. However, with more than 50 screening and assessment tools to choose from, and the absence of a gold standard, selecting the appropriate 'tool' to screen and assess nutritional status of older people is not an easy task. Furthermore, many of the nutrition screening tools were developed for specific purposes, age groups, care settings, diseases or medical condition and regions.

Numerous studies that reviewed nutrition screening tools used in older population have mainly focused on identifying the validity, reliability, sensitivity, specificity, and acceptability of the tools, or on identifying the specific age criteria of the screening tools, rather than examining the ability of screening tools to predict clinical outcomes (45-48, 84). Only two review articles by van Bokhorst-de van der Schueren and colleagues have examine the predictive ability of the screening tools and recommendations for older population. They found that the predictive performance of the Mini Nutritional Assessment (MNA) was fair to good, but that none of the screening tools performed well in predicting clinical outcomes (45, 46). Additionally, for nursing home populations no specific screening tools can be recommended strongly, as none of the tools performed better than "fair" in assessing nutritional status or predicting clinical outcomes, including tools that were specifically designed for nursing home setting (46). Nevertheless, those last two reviews only assessed screening tools used in hospital and nursing home settings, and focused solely on three outcome measures, i.e. mortality, length of hospital stay (LOS) and complications. Therefore, this Chapter reviews the various questionnaires/measurements for

various clinical outcomes including mortality, morbidity, LOS, quality of life (QOL), level of care (LOC), muscle mass and muscle function in older adults population across hospital, nursing home and community settings, and summarise their ability to be used as screening tools in older populations.

2. Methods

A literature search was performed using PubMed, Embase, CINAHL, and Scopus via The University of Adelaide Library databases. Search terms expressing or related to "malnutrition" or "undernutrition", "screening or assessment tools", "aged or elderly" and key words related to clinical outcomes such as "mortality or survival", "morbidity", "length of stay" "life quality", "level of care", "muscle mass", "muscle function" were used to identify relevant articles published up until December 2013. Detailed examples of included search parameters are shown in the ***Appendix*** in ***Table A.1 and A.2***. In addition, manual searching via Google Scholar was performed to locate relevant articles from reference list of key publications.

Articles which met the below inclusion and exclusion criteria were then used in the present review.

Inclusion criteria:

a) Screening tools developed for older adults populations or recommended to be used in older populations after validation study.

b) Screening tools used in hospital, nursing home, and community settings.

c) Subject's age > 65 years and or adult subjects with mean age ≥ 65 years.

d) Clinical outcomes including mortality, morbidity, LOS, QOL, LOC, muscle mass and muscle function.

Exclusion criteria:

a) Articles published in a non-English language.

b) Screening tools designed for specific clinical conditions (e.g., kidney disease, cardiac surgery, cancer, multiple sclerosis, Alzheimer's).

c) Modified version of the tools (e.g., Taiwanese version of MNA).

The scoring method introduced by van Bokhorst-de van der Schueren (45) was used to rate the ability of screening tools to predict clinical outcomes in older adults across different settings. Screening tools were classified as having good, fair and poor predictive ability to certain outcome measures if odds ratio (OR) / hazard ratio (HR) >3, 2 – 3, and <2, respectively. If the OR/HR was not measured in the study, screening tools were classified into good/fair ($p < 0.05$ and $n < 200$), poor ($p > 0.05$) and unable to rate ($p < 0.05$ and $n > 200$), based on *P*-value and sample size (45).

3. Results

3.1 Literature Search

Details of literature searching process were shown in ***Figure 9***. Search parameters resulted in 7,501 articles. Titles and abstracts of the articles were scanned which narrowed down the results into 207 articles. Finally, 59 articles that met the inclusion and exclusion criteria were selected for full text retrieval and review. Six additional articles were obtained from manual searching of references list of the relevant literature. In total, 65 articles were included.

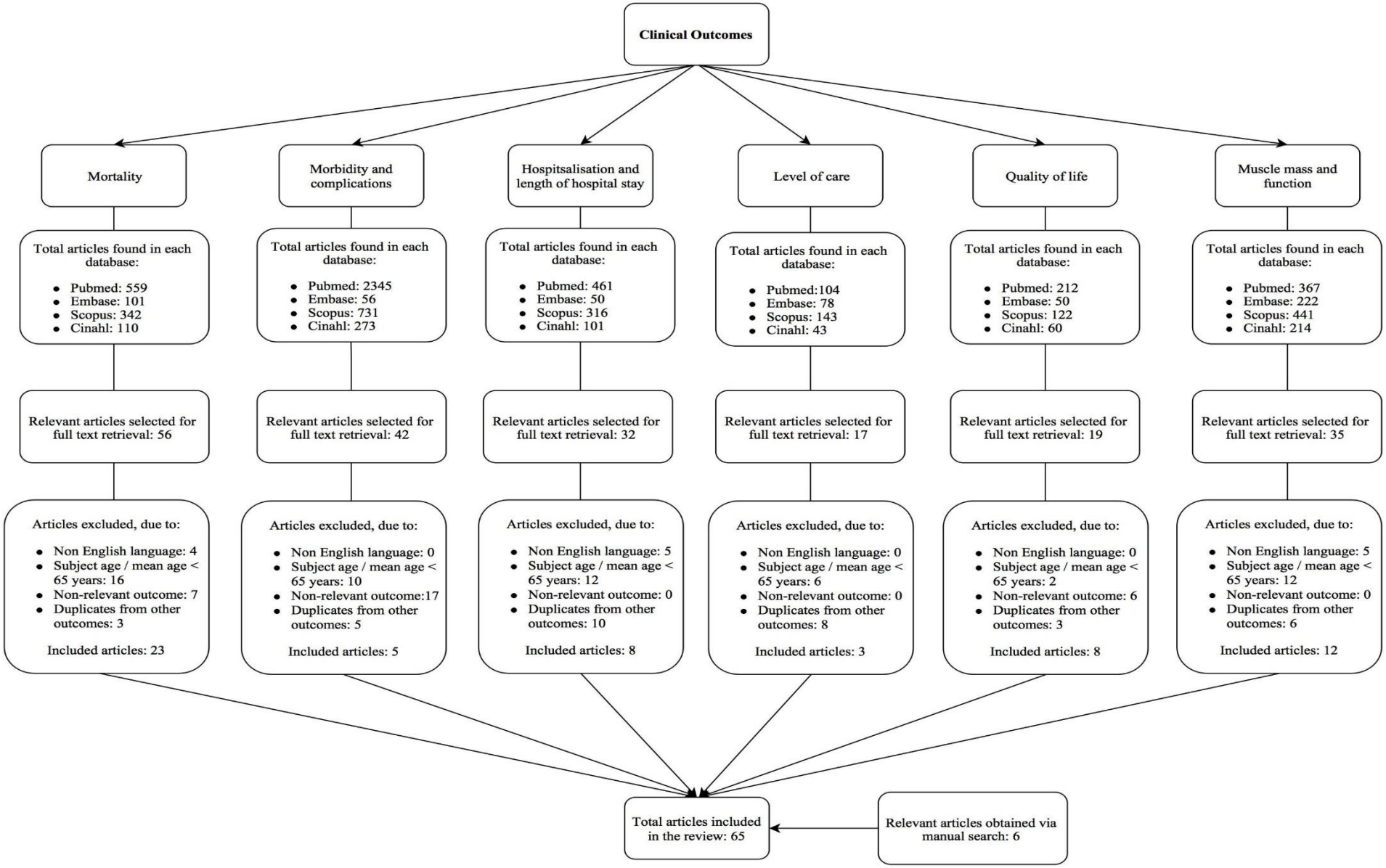


Figure 10. Literature searching process

The articles investigated the predictive ability of 11 nutrition screening and assessment tools developed for, or used in, older populations in varying settings including hospitals, nursing homes and community, i.e.,:

1. Mini Nutritional Assessment (MNA): was developed and validated in 1994 to screen nutritional state of older people in nursing home and hospital settings (54). It consists of 18 questions on body composition, diet characteristics, general health and environment and self-rating of health and nutritional state. An MNA score of <17 indicates that a person is malnourished, 17-23.5: at risk of malnutrition, >23.5: well nourished (54).
2. Mini Nutritional Assessment Short Form (MNA-SF): The MNA Short Form (MNA-SF) was developed to reduce time spent for nutritional screening and consists of 6 questions which were part of the full MNA (55). The MNA-SF was validated in ambulatory care setting in which 73.8% of the subjects were community dwelling, and used full MNA as reference(55). A score of 0-7 indicates that a person is malnourished, 8-11: at risk of malnutrition, and 12-14: well nourished (55).
3. Geriatric Nutrition Risk Index (GNRI): was developed and validated in 2005 to predict morbidity and mortality among hospitalised older adults (53). GNRI score was calculated based on weight / ideal weight (calculated with Lorentz formula) and albumin level. A score <82 indicates a major risk of malnutrition, 82-91: moderate risk, 92-98: low risk, ≥98: no risk.
4. Malnutrition Screening Tool (MUST): was originally developed in 2003 to screen nutritional state of hospitalised adult (57). MUST consists of 3 questions on weight, weight loss and acute disease effect / food intake (57). MUST score of 0 indicates a low risk of malnutrition, 1: medium risk, ≥2: high risk (57).
5. Subjective Global Assessment (SGA): was first introduced in 1987 and used to determine nutritional state of hospitalised adults (primarily surgical patients) (85). The SGA consists

of 11 items based on physical examination and medical history (85). SGA classifies individuals into A: well nourished, B: moderately malnourished or suspected malnutrition, and C: severely malnourished (85).

6. Short Nutritional Assessment Questionnaire 65+ (SNAQ 65+): was developed and validated in 2012 to screen nutritional state of community dwelling older people (86). Unlike other screening tools, the SNAQ65+ does not determine nutritional status based on score, but rather several indicators associated with 15-year mortality (86). Individuals is classified into undernourished: MUAC < 25 cm or involuntary weight loss 4 kg in 6 months, risk of undernutrition: poor appetite last week and difficulties climbing a staircase, no undernutrition: none of the previous indicators (86).
7. Nutrition Risk Screening 2002 (NRS): was developed to screen the presence and risk of developing malnutrition in hospital setting (87). The NRS-2002 contains similar question to MUST which include BMI, weight loss, reduced appetite and severity of disease (87). A score of ≥ 3: indicates high risk of malnutrition, 1-2: enhanced risk and 0: no risk (87).
8. Determine Your Nutrition Health Checklist (DETERMINE): was developed by the Nutrition Screening Initiative (NSI) to determine nutritional state of community-dwelling and institutionalised older people (88). It consists of 10 items related to disease, food intake, social contact, weight loss and independence (88). A score of ≥ 6 indicates high nutritional risk, 3 – 5: moderate risk, and 0 – 2: good nutritional status (88).
9. Nutrition Risk Index (NRI): was developed to determine nutritional state of community-living older people and was originally validated in older outpatients (predominantly male) (89). The NRI bears a close resemblance to the GNRI which includes body weight/usual weight and serum albumin (89). NRI score of and < 83.5 indicates severe malnourishment, 83.5- < 97.5: moderate malnourishment, 97.5-100: mild malnourishment and > 100: well-nourished (89).

10. Nutritional Form for the Elderly (NUFFE): was introduced in 2002 and developed in hospital setting to determine nutritional risk and its relation to quality of life among older inpatients (90). NUFFE contains items on BMI, weight loss, food intake and clinical signs of malnutrition (90). A score of ≥ 5 indicated high risk of undernutrition, 3 – 4: moderate risk, and 0 – 2: low risk (90).
11. Seniors in the Community Risk Evaluation for Eating and Nutrition (SCREEN): was developed in Canada in early 2000s to screen nutritional state among community-living older people and predict mortality (91). SCREEN consists of version I (15 items), version II (14 items) and abbreviated version II (8 items) which include questions on weight change, food intake, and food preparation (91). A score of 0 – 2 indicated risk of malnutrition and 3 – 4: no risk of malnutrition (91).

3.2 Clinical Outcomes

The ability of each tool to predict 'outcome measures' in older population across hospital, nursing home and community settings isreviewed in the next section. Summary of the reviewed studies according to each clinical outcomes and settings are shown in ***Table 5 - 10***, while the recommended nutrition screening tools for each clinical outcomes and settings are shown in ***Table 11***.

Table 5. Summary of reviewed studies investigating the ability of nutrition screening tools to predict mortality

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Kagansky et al., 2005) (92)	Mortality	MNA	Hospital	414	≤ 2.7 years	MNA score of survivors vs diseased patients = 18.5 ± 5.5 vs 14.9 ± 5.2, P < 0.001	Unable to rate	-
(Soderstrom et al., 2013) (93)		MNA	Hospital	1767	35 – 50 months	HR (95% CI) for all-cause mortality for at risk of malnutrition = 1.56 (1.18±2.07) and malnourished 3.71 (2.28±6.04)	Good	Adjusted for age, sex, BMI, number of drugs
(Van Nes et al., 2001) (94)		MNA	Hospital	1145	No applicable (in-hospital mortality)	Mortality rate of MNA < 17 vs ≥ 24 = 11.3% vs 3.7 %, P < 0.001	Unable to rate	-
(Gazzotti et al., 2000) (95)		MNA	Hospital	175	Not applicable	MNA score of survivors vs diseased patients = 20.9 vs 14.1, P <0.001	Good/fair	-
(Gentile et al., 2013) (96)		MNA-SF	Hospital	157	3 months	OR (95% CI) for mortality within 3 months after admission for malnourished patients = 20.2 (5.74-71.35, P < .001)	Good	Adjusted for age, gender and living alone

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Vischer et al., 2012) (97)		MNA-SF	Hospital	444	4 years	HR for mortality for at risk of malnutrition = 0.79 and malnourished = 0.89 (P > 0.05).	Poor	-
(Rasheed and Woods, 2013b) (98)		MNA-SF and MUST	Hospital	149	1 year	HR for mortality in malnourished group according to MNA-SF = 4.61 (95% CI: 1.76 – 12.04; P = 0.009) and MUST = 3.27 (95% CI: 1.42 – 7.53; P = 0.013)	MNA-SF: Good MUST: Good	Adjusted for age and sex
(Stratton et al., 2006) (99)		MUST	Hospital	150	6 months	Mortality 3 months and 6 months after discharge in medium and high risk group was significantly higher than low risk group (P = 0.01, 0.01 and 0.002, respectively)	Good/fair	-
(Henderson et al., 2008) (100)		MUST	Hospital	115	> 2 years (median time to death 446 days)	HR (CI 95 %) for mortality in medium and high risk groups = 1.91 (0.95 to 3.83) and 1.98 (1.15 to 3.42)	Poor	Adjusted for age and sex
(Rasheed and Woods, 2013a) (101)		MUST	Hospital	152	No applicable (in-hospital mortality)	Mortality rate in malnourished Vs low risk of malnutrition group = 22% vs 7%; P = 0.019	Good/fair	-

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Holst et al., 2012) (102)		MUST, MNA, and NRS-2002	Hospital	233	1 year	MUST, MNA or NRS-2002 were not a significant predictor of mortality	MUST :Poor MNA :Poor NRS-2002:Poor	-
(Persson et al., 2002) (103)		MNA and SGA	Hospital	83	3 years	OR (95% CI) for 1-year mortality in patients with Protein Energy Malnutrition (PEM) / at risk of PEM based on SGA = 2.48 (1.05–5.86), OR (95% CI) for 3-year mortality based on MNA=3.3 (1.11–9.79)	SGA: Fair MNA: Good	-
(Covinsky et al., 1999) (104)		SGA	Hospital	369	1 year	OR (95% CI) for mortality within 90 days and 1 year post discharge for severely malnourished patients were 3.26 (1.52-6.96; P = 0.03) and 2.83 (1.47-5.45; P = 0.03).	Good	Adjusted for age, race, gender, living situation on admission, disease severity, comorbidities and ADL
(Cereda et al., 2011) (105)		GNRI and MNA	Nursing home	358	5.7 years (25th to 75th	HR (95% CI) for mortality for GNRI <92 = 1.99 (1.38 - 2.88), P = 0.001 and GNRI	GNRI: Poor MNA: Poor	-

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
					percentile, 5.2-8.2 years)	92 – 98 = 1.51 (1.04-2.18) P = 0.029), while MNA showed no significant association.		
(Bouillanne et al., 2005) (53)		GNRI	Hospital	181	6 months	OR (95% CI) for mortality for: major risk (GNRI < 82) = 29.0 (5.2, 161.4), P < 0.001 moderate risk (GNRI 82 to < 92) = 6.6 (1.3, 33.0), P = 0.02 low risk (GNRI 92 to ≤98)= 5.6 (1.2, 26.6), P = 0.02	Good	-
(Cereda et al., 2008a) (106)		GNRI	Nursing home	220	3 months	OR (95% CI) for mortality for GNRI < 92=.82, (0.68–0.99) , P = 0.0373	Poor	Adjusted for age and sex
(Cereda et al., 2009) (49)		GNRI and MNA	Nursing home	241	6 months	OR (95% CI) for mortality for GNRI < 92= 30.5 (1.7 – 941), P < 0.001 and MNA < 17= 38.1 (2.0 – 607.1), P < 0.002	GNRI: Good MNA: Good	-
(Cereda et al., 2008b) (50)		GNRI	Nursing home	245	3 year	OR (95% CI) for 3-year mortality for severe risk (GNRI < 82) = 5.29, (1.43 - 19.57), P = 0.0127 and HR = 2.76 (1.89 - 4.03), P = 0.0072	Good	Adjusted for age and sex

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
						compared to GNRI > 98 (no risk).		
(Torma et al., 2013) (107)		MNA-SF	Nursing home	172	1 year	OR (95% CI) for 1-year mortality for MNA-SF score 8 - 14 or < 7= 2.37 (1.07 - 5.26), P = 0.03	Fair	-
(Diekmann et al., 2013) (108)		MNA, MUST and NRS	Nursing home	200	1 year	HR (95% CI) for 1-year mortality according to: MNA 17-24= 3.79 (1.32-10.80) and < 17 = 5.92 (1.88-18.63) NRS < 3 = 1.45 (0.75-2.80) and ≥3 =2.78 (1.06-7.30) MUST 1 point = 1.36 (0.48-3.87) and ≥2 points= 2.94 (1.29-6.72)	MNA: Good NRS: Fair MUST: Fair	Adjusted for age
(Sacks et al., 2000) (109)		SGA	Nursing home	53	3 months	SGA parameters (i.e. class and composite score) were significantly associated with 3 months mortality (P < 0.05)	good/fair	-
(Coe et al., 1993) (110)		NRI	Community	377	5 years	No association between nutritional status based on NRI with survival (P > 0.05)	Poor	-

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Sahyoun et al., 1997) (111)		DETERMINE	Community	581	up to 12 years	Unadjusted RR (95% CI) for mortality for DETERMINE ≥6 points = 1.10 (1.04 – 1.17), P <0.01 and adjusted RR = 1.04, (1.00 – 1.14), P < 0.05	Poor	Adjusted for age and the presence of one or more chronic disease
(Beck et al., 1999) (112)		DETERMINE and MNA	Community	115	5 years	DETERMINE score was not a significant predictor of mortality (RR = 1.45, 95% Cl: 0.78 - 2.71). MNA ≥ 24 had lower mortality rate compared to MNA 17 – 23.5 (RR = 0.35, 95% CI: 0.18 - 0.66)	DETERMINE: Poor MNA: Fair	-
(Keller and Ostbye, 2003) (113)		SCREEN	Community	367	18 months	HR (95% CI) for mortality based on SCREEN score = 0.88 (0.79 – 0.97), P = 0.009	Poor	-
(Ferreira et al., 2011) (114)		MNA	Community	1170	7 years	OR (95% CI) for mortality among undernourished 60 - 74 years old and ≥ 75 years old groups = 6.05 (5.76–6.35), P < 0.001 and 2.76 (2.51–3.04), P < 0.001	Good	Adjusted for sex, income, muscle strength, smoking, depression, co-morbidities.

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Lundin et al., 2012) (115)		MNA	Community	351	10 years	HR (95% CI) for 10-years mortality for MNA ≤ 23.5 = 2.36 (1.25–4.46), P < 0.01	Fair	Adjusted for age
(Saletti et al., 2005) (116)		MNA	Community	353	3 years	OR (95% CI) for 3-years mortality = 1.89 (1.18–3.01), P = 0.007	Poor	-
(Wijnhoven et al., 2012) (86)		SNAQ 65+	Community	Netherland: 1687 Italy: 1142	15 years	Netherland: HR (95% CI)for 6-years mortality for undernutrition and risk of undernutrition groups =2.64 (2.07- 3.39) and 1.47 (1.01-2.15), while HR for 15-years mortality= 2.22 (1.83-2.69) and 1.57 (1.22-2.01) Italy: HR (95% CI)for 6-years mortality for undernutrition and risk of undernutrition groups = 2.46 (1.27-3.62) and 2.12 (1.87 - 3.23)	Fair	-

Note: Not applicable = due to study design (cross sectional) or nature of outcome measure (i.e. LOS)

Table 6. Summary of reviewed studies investigating the ability of nutrition screening tools to predict morbidity and complications

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Lopez-Gomez et al., 2011) (117)	Morbidity and complications	MNA, GNRI and NRI	Hospital	113	Not applicable (retrospective study)	MNA and GNRI failed to predict complications (P > 0.05). Disease complications was significantly associated with NRI score (P = 0.007)	MNA: Poor GNRI: Poor NRI: Good/fair	-
(Velasco et al., 2011) (118)		MNA, NRS, MUST and SGA	Hospital	400	Not applicable (in-hospital complications)	Patients at nutritional risk were more likely to have complications during hospitalisations than those with better nutritional status: (MNA 14.1 vs 7.2%, P = 0.032; NRS-2002 21.7 vs 5.7%, P < 0.001; MUST 15.8 vs 9.1%, P = 0.047; SGA 19.1 vs 6.9%, P < 0.001)	MNA: Unable to rate NRS: Unable to rate MUST: Unable to rate SGA: Unable to rate	-
(Wakahara et al., 2007) (119)		SGA	Hospital	262	3 months	Higher rate of disease complications with increased SGA category (P = 0.025)	Unable to rate	-
(Bouillanne et al., 2005) (53)		GNRI	Hospital	181	6 months	OR (95% CI) for the occurrence of infectious complications, bedsores or	Good	-

					both in GNRI < 82= 4.4 (1.3 – 14.9), P = 0.03, GNRI 82 - < 92= 4.9 (1.9 – 12.5), P < 0.001 and GNRI 92 - ≤ 98 = 3.3 (1.4 – 8.0), P = 0.006		
(Gamaletsou et al., 2012) (120)	GNRI	Hospital	248	Not applicable (in-hospital complications)	HR (95% CI) for Healthcare-associated infections according to GNRI score= 0.97; (0.95 – 0.99), P = 0.01	Poor	-
(Cereda et al., 2008a) (106)	GNRI	Nursing home	220	3 months	OR (95% CI) for the occurrence of overall complications, infections and bedsores = 0.99 (0.9 – 1.09, P = 0. 0.8859), 1.11 (0.95 – 1.29, P = 0. 0.176) and 1.02 (0.80 – 1.31, P = 0. 0.8505)	Poor	Adjusted for age and sex
(Cereda et al., 2009) (49)	GNRI and MNA	Nursing home	241	6 months	OR (95% CI) for overall disease complications and infections for GNRI < 92 = 9.7 (3.0 – 130, P < 0.001) and 6.4 (1.6 – 186.7, P < 0.01), and GNRI 92 – 98= 3.6 (1.1 – 263, P <0.05) and 3.4 (0.9 – 351, P < 0.05), risk of developing bedsores for GNRI < 92 = 9.0 (1.0 – 486, P < 0.05)	GNRI: Good MNA: Good	-

					OR (95% CI) for overall complications and bedsores for MNA< 17= 6.4 (2.1 – 71.9, P < 0.001) and 12.3 (1.2 – 317.9, P < 0.05)		
(Beck et al., 1999) (112)	DETERMINE and MNA	Community	115	5 years	DETERMINE and MNA scores were associated with increased incidence of acute disease (P < 0.01 and P < 0.05)	DETERMINE: Good/fair MNA: Good/fair	
(Beck et al., 2001) (121)	MNA	Community	61	6 months	MNA score was not related to the incidence of acute disease (P > 0.05)	MNA: Poor	
(Yap et al., 2007) (122)	DETERMINE	Community	2605	1 year	OR (95% CI) to acquire ≥ 1 co-morbid medical conditions for DETERMINE ≥3= 3.14 (2.11–4.69), P < 0.01	DETERMINE: Good	Adjusted for age, sex, education, housing type, marital status, living arrangement

Note: Not applicable = due to study design (cross sectional) or nature of outcome measure (i.e. LOS)

Table 7. Summary of reviewed studies investigating the ability of nutrition screening tools to predict hospitalisation and LOS

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Van Nes et al., 2001) (94)	Hospitalisation and LOS	MNA	Hospital	1145	Not applicable	LOS for MNA < 17 vs ≥24=52.8 ±43.7 days vs 40.7 ±36.1 days, P < 0.001	Unable to rate	-
(Visvanathan et al., 2003) (23)		MNA	Community	250	Not applicable	RR (95% CI) for MNA<17 to require ≥ 2 admissions=2.17 (1.05–4.44; P = 0.035), ≥ 2 emergency admissions = 2.96 (1.15–7.59; P = 0.024]), and spend > 4 weeks in hospital= 3.22 (1.29–8.07; P = 0.012).	Good	Adjusted for age and living status
(Visvanathan et al., 2004) (123)		MNA	Rehabilitation centre	65	Not applicable	MNA < 17 were more likely to be re-admitted to acute care facility or discharged to long term care facility vs MNA ≥ 24 (50% vs 21.6%; P = 0.017)	Good/fair	
(Thomas et al., 2002) (124)		MNA	Sub-acute Care Centre	837	Not applicable	LOS for MNA<17 was significantly longer by 11 days compared to MNA 17-23.5 (P = 0.007)	Unable to rate	-

(Beck et al., 1999) (112)	DETERMINE and MNA	Community	115	Not applicable	MNA and DETERMINE were not associated with hospitalisation (P > 0.05)	NIS: Poor MNA: Poor	-
(Beck et al., 2001) (121)	MNA	Community	61	Not applicable	MNA was not associated with hospitalisation (P > 0.05)	Poor	-
(Vanderwee et al., 2010) (125)	MNA	Hospital	2329	Not applicable	LOS of MNA< 17 (23.7 ± 26.99 d), 17- 23.5 (21.8 ± 23.62 d) and ≥ 24 (18.7 ± 22.17 d) was significantly different (P <0.002)	Unable to rate	-
(Rasheed and Woods, 2013a) (10)	MUST	Hospital	152	Not applicable	LOS of malnourished patients was significantly longer (24 d [95% CI: 17 – 31]) than those at low risk of malnutrition (15 d [95% CI 9, 21)) (P = 0.026)	Good/fair	-
(Stratton et al., 2006) (99)	MUST	Hospital	150	Not applicable	LOS of low vs medium vs high nutritional risk = 15d vs 24d vs 28d (P = 0.02). However, no differences in hospital readmission	Good/fair	-
(Rasheed and Woods, 2013b) (98)	MNA-SF and MUST	Hospital	149	Not applicable	MNA-SF < 7 vs 8-11 vs ≥1212d vs 9 d vs 6 d (P = 0.037). Patients with MNA-SF < 7were more likely to be readmitted to hospital (P = 0.036).	MNA-SF: Good/fair MUST: Poor	Adjusted for age and sex

(Yap et al., 2007) (122)	DETERMINE	Community	2605	Not applicable	No significant association between MUST score and hospitalisation or LOS OR (95% CI) for hospitalisation in the past year for medium and high nutritional risk groups = 2.24 (1.49–3.36)	Fair	Adjusted for age, sex, education, housing type, marital status, living arrangement
(Lopez-Gomez et al., 2011) (117)	MNA, GNRI and NRI	Hospital	113	Not applicable	MNA, GNRI and NRI scores were not related to LOS	MNA: Poor GNRI: Poor NRI: Poor	-
(Velasco et al., 2011) (118)	MNA, NRS, MUST and SGA	Hospital	400	Not applicable	NRS-2002, MNA, MUST and SGA scores were associated with LOS (P < 0.001)	MNA: Unable to rate NRS: Unable to rate MUST: Unable to rate SGA: Unable to rate	-
(Wakahara et al., 2007) (119)	SGA	Hospital	262	Not applicable	LOS for SGA A vs B vs C = 24 ±31d vs 40±49d vs 57±74d (P < 0.01)	Unable to rate	-
(Bauer et al., 2005) (126)	MNA, SGA, and NRS	Hospital	121	Not applicable	Only MNA showed significant association with LOS (P = 0.044)	MNA: Good/fair SGA: Poor NRS: Poor	-

(Martins et al., 2005) (127)	MST, MNA, SGA, and NRS	Hospital	207	Not applicable	NRS-2002 was the only significant predictor of LOS more than 8 days with an OR of 2.25 (95% CI: 1.03 – 4.88; P = 0.04)	MST: Poor MNA: Poor SGA: Poor NRS: Fair	Adjusted for interviewer, sex, years of school
(Neumann et al., 2005) (128)	MNA and MNA-SF	Rehabilitation unit (Hospital)	133	Not applicable	LOS for malnourished/at risk of malnutrition according to MNA and MNA-SF was substantially longer than well-nourished patients (P < =0.023 and 0.003)	MNA: Good/fair MNA-SF: Good/fair	-
(Salvi et al., 2008) (129)	MNA-SF	Hospital	275	Not applicable	LOS for MNA ≥ 24 vs 17 – 23.5 vs <17 =10.7d vs 12.1d vs 16.6d (P <0.0001)	Unable to rate	Adjusted for age, comorbidities and emergency department admission

Note: Not applicable = due to study design (cross sectional) or nature of outcome measure (i.e. LOS)

Table 8. Summary of reviewed studies investigating the ability of nutrition screening tools to predict LOC

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Covinsky et al., 1999) (104)	LOC	SGA	Hospital	369	1 year	Malnourished patients were more likely to spend time in a nursing home during the year post discharge (OR = 3.22, 1.05-9.87)	Good	Adjusted for age, race, gender, living situation on admission, disease severity, comorbidities and ADL
(Brunt, 2006) (130)		DETERMINE	Community	249	3 years	Higher total DETERMINE score was negatively associated with continued community-dwelling (P = 0.0005), mid-range scores were inconclusive.	Unable to rate	-
(Rasheed and Woods, 2013a) (10)		MUST	Hospital	152	Not applicable	Malnourished compared to low risk patients were more likely to be discharged to long-term care (25% vs 9%, P = 0.005)	Good/fair	-

(Stratton et al., 2006) (99)	MUST	Hospital	150	Not applicable	There was no significant differences in discharge destination between high and low risk patients (51% vs 40%, P > 0.05)	Poor	-
(Gazzotti et al., 2000) (95)	MNA	Hospital	175	Not applicable	MNA scores of patients who were transferred to nursing homes or hospitals were comparable to those returning to private homes (20.3 ± 4.9 vs 21.7 ± 4.6, P = 0.080).	Poor	-
(Thomas et al., 2002) (124)	MNA	Sub-acute Care Centre	837	Not applicable	There was no significant differences in discharge destination between malnourished and well-nourished patients (P > 0.05).	Poor	-
(Visvanathan et al., 2003) (23)	MNA	Community	250	Not applicable	There were comparable number of nourished (MNA ≥ 24) and not well nourished (MNA < 24) older people moved to more supportive accommodation (10 vs 12, P > 0.005).	Poor	Adjusted for age and living status
(Van Nes et al., 2001) (94)	MNA	Hospital	1145	No applicable	Malnourished (MNA < 17) were more likely to be discharged to nursing home	Unable to rate	-

					than at-risk (MNA = 17 – 23.5) and well-nourished patients (MNA≥ 24) (20.3%, vs 18.3% vs 7.7%, P < 0.001).		
(Neumann et al., 2005) (128)	MNA and MNA-SF	Rehabilitation unit (Hospital)	133	Not applicable	At risk of malnutrition/malnourished patients were more likely to be admitted to higher level care (P < 0.05).	MNA: Good/fair MNA-SF: Good/fair	-
(Izawa et al., 2006) (131)	MNA	Community	281	Not applicable	There was a significant correlation between MNA scores and the care level of LTCI (r = -0.416, P = 0.001).	Unable to rate	-
(Odlund et al., 2008) (132)	MNA	Community (Service flat)	49	6 months	There was a significant correlation between MNA scores and care level at baseline (r = -0.52, P < 0.001).	Good/fair	-

Note: Not applicable = due to study design (cross sectional) or nature of outcome measure (i.e. LOS)

Table 9. Summary of reviewed studies investigating the ability of nutrition screening tools to predict QOL

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Vailas et al., 1999) (133)	QOL	DTERMINE	Community	155	Not applicable	Nutritional risk was negatively associated with quality of life (r= -0.44, P < 0.001)	Good/fair	-
(Yap et al., 2007) (122)		DETERMINE	Community	2605	Not applicable	Subjects at nutritional risk were more likely to be in the lowest tertile scores for SF-12 quality of life (OR 2.01; 95% CI 1.67–2.42)	Fair	Adjusted for age, sex, education, housing type, marital status, living arrangement
(Keller et al., 2004) (134)		SCREEN	Community	367	18 months	There was comparable decrease in QOL over time for all nutritional group.	Poor	-
(Gombos et al., 2008) (135)		NUFFE	Community	56	Not applicable	There was a significant association between total NUFFE scores and quality of life (r = 0.59, P < 0.001)	Good/fair	
(Torma et al., 2013) (107)		MNA-SF	Nursing home	172	1 year	There was no differences in quality of life between malnourished, at risk and well-nourished residents.	Poor	-

(Rasheed and Woods, 2013c) (136)	MNA-SF and MUST	Hospital	149	Not applicable	MNA-SF scores were significantly correlated with quality of life scores (r = 0.20 to 0.43, all P < 0.05), while MUST scores were not associated with QOL.	MNA-SF: Good/fair MUST: Poor	
(Neumann et al., 2005) (128)	MNA and MNA-SF	Rehabilitation unit (Hospital)	133	3 months	QOL was poorer at 90 days only for sub-jects with MNA-SF score <12 (P = 0.009) and total MNA score <2 4 (P = 0.001).	MNA: Good/fair MNA-SF: Good/fair	-
(Odlund et al., 2008) (132)	MNA	Community (Service flat)	49	6 months	There was a significant correlation between MNA scores HRQOL (P < 0.05)	Good/fair	-
(Smoliner, et al., 2009) (137)	MNA	Nursing home	114	Not applicable	Malnourished compared to well-nourished residents had significantly lower SF-36 scores in 'general health' and 'vitality' (P < 0.05)	Good/fair	-
(Barnabeu-Wittel et al., 2010) (138)	MNA	Hospital	196	Not applicable	MNA scores were significantly associated with "physical" and "mental health" dimensions of HRQOL (R = -0.125, P = 0.011, and R = -0.156, P = 0.001, respectively)	Good/fair	

(Johansson et al., 2009) (139)	MNA	Nursing home	579	4 years	At baseline, women at-risk of malnutrition compared to those at no risk reported more symptoms of depression and worse health-related quality of life measured by NHP (P < 0.05 – < 0.001). There were statistically significant differences between the risk group at baseline and the risk group at follow-up in the physical mobility (NHP) (P = 0.035), energy (NHP) (P = 0.023), ADL (PGC MAI) (P = 0.003) and time use (PGC MAI) (P =0.027).	Unable to rate	-

Note: Not applicable = due to study design (cross sectional) or nature of outcome measure (i.e. LOS)

Table 10. Summary of reviewed studies investigating the ability of nutrition screening tools to predict mortality

Study (Author, Year)	Clinical Outcome	Screening Tool	Setting	Sample size	Follow-up duration	Results	Rating	Note
(Brunt et al., 1999) (140)	Muscle mass and function	DETERMINE	Community	249	Not applicable	DETERMINE Checklist scores of ≥ 3 predicted at risk mid arm circumference / MAC (OR = 3.65) and triceps skin-fold (OR = 2.65). DETERMINE checklist scores ≥ 6 were predictive of at risk MAC (OR = 4.06).	Good	
(Persson et al., 2002) (103)		MNA, MNA-SF and SGA	Hospital	83	3 years	There were significant differences in fat mass (according to DXA and BIA), arm muscle circumference, triceps skinfold (TSF) between well-nourished and Protein Energy Malnourished patients as classified by SGA, MNA and MNA-SF, particularly among women. Grip strength and Katz ADL index were also significantly different according to	MNA: Good/fair MNA-SF: Good/fair SGA: Good/fair	-

					nutritional status based on SGA, MNA and MNA-SF.		
(Wakahara et al., 2007) (119)	SGA	Hospital	262	Not applicable	Percent arm muscle circumference and TSF were significantly associated with SGA scores (r = -0.326 and -0.258, both P < 0.01)	Unable to rate	-
(Norman et al., 2005) (141)	SGA	Hospital	287	Not applicable	Handgrip strength was significantly lower in malnourished than well-nourished patients (45.22 kg vs. 30.82 kg in men; 23.81 vs. 18.5 kg in women, P < 0.001).	Unable to rate	
(Wham et al., 2011) (142)	SCREEN II	Community	188	Not applicable	SCREEN II score was positively correlated with the total PASE score r = 0.20 (P = 0.042), grip strength r = 0.20 (P = 0.041), and muscle mass percentage r=0.31 (P = 0.004).	Good/fair	
(Rasheed and Woods, 2013c) (136)	MNA-SF and MUST	Hospital	149	Not applicable	MNA-SF and MUST scores were significantly correlated with mid-arm muscle circumference (MAMC) and handgrip strength (all Ps < 0.05).	MNA-SF: Good/fair MUST: Good/fair	

(Holst et al., 2012) (102)	MUST, MNA, and NRS-2002	Hospital	233	1 year	MUST, MNA-SF and NRS-2002 were significantly associated with functional parameters ($P < 0.05$). However, only MNA and NRS-2002 were associated with muscle mass (Fat free mass index) ($P < 0.05$)	MUST : Unable to rate MNA : Unable to rate NRS-2002: Unable to rate	-
(Cereda et al., 2009) (49)	GNRI and MNA	Nursing home	241	6 months	GNRI and MNA scores were positively correlated with muscle arm circumference (MAC), arm muscle are (AMA) and TSF (all Ps < 0.05).	GNRI: Unable to rate MNA: Unable to rate	-
(Cereda et al., 2008b) (50)	GNRI	Nursing home	245	3 year	GNRI scores were significantly associated with MUAC, TSF and AMA (all Ps < 0.05)	Unable to rate	Adjusted for age and sex
Cereda and Vanotti 2007) (143)	GNRI	Nursing home	153	Not applicable	There were significant differences in MUAC, handgrip strength and handgrip/AMA (kg/m^2) between residents with severe, moderate, low and no nutritional risk (all Ps < 0.05)	Good/fair	

(Cereda and Vanotti) (144)	GNRI	Nursing home	130	Not applicable	Handgrip strength and handgrip/AMA were significantly associated with GNRI (all Ps < 0.05).	Good/fair	
(Vellas et al., 2000) (145)	MNA	Hospital and community	155	Not applicable	MNA scores were significantly associated with calf circumference, MUAC, and activities of daily living (ADL) scores (all Ps < 0.001)	Good/fair	Adjusted for age
(Kuyuza et al., 2005) (146)	MNA	Hospital	226	Not applicable	MNA and MNA-SF scores were positively correlated with MUAC (r = 0.50), TSF (r = 0.37), and calf circumference (r = 0.28) (all Ps < 0.001)	MNA and MNA-SF: Unable to rate	-
(Langkamp-Henken, 2005) (147)	MNA and MNA-SF	Nursing home	23	Not applicable	MNA and MNA-SF scores were positively correlated with calf circumference, fat mass and fat free mas index (all Ps < 0.05)	MNA and MNA-SF: Good/fair	
(Charlton et al., 2007) (148)	MNA and DETERMINE	Community	283	Not applicable	MNA scores were significantly associated with MUAC, mid-thigh circumference, corrected arm muscle area (CAMA), TSF, biceps skinfold thickness, percent lean body mass, ADL (Katz and Bathel indexes)	MNA: Unable to rate DETERMINE: Unable to rate	

					and IADL (Lawton index) (all Ps < 0.05). DETERMINE score ≥ 6 was associated with MUAC, AMA and AMC (all Ps < 0.05), but not with any of the functional parameters.		
(Cereda et al., 2008c) (149)	MNA	Nursing home	123	Not applicable	MNA was significantly correlated with AMA (r = 0.42, P < 0.0001) and Barthel Index (r = 0.55; P < 0.0001).	Good/fair	
(Chevalier et al., 2008) (150)	MNA	Hospital	182	Not applicable	TSF, CAMA, lean body mass, fat mass and gait speed were significantly correlated with MNA scores (all Ps < 0.05)	Good/fair	
(Gerber et al., 2003) (151)	MNA	Nursing home	78	Not applicable	MNA scores was associated with TSF (P < 0.05), but not with handgrip strength.	Poor	-

Note: Not applicable = due to study design (cross sectional) or nature of outcome measure (i.e. LOS)

Table 11. Recommended nutrition screening tools for each clinical outcome

Clinical Outcomes	Setting	Recommended Tool	Alternative Tool
Mortality	Hospital	MNA	MUST and GNRI
	Nursing Home	GNRI and MNA	SGA
	Community	MNA	SNAQ65+
Morbidity and Complications	Hospital	GNRI	NRI
	Nursing Home	GNRI	MNA
	Community	DETERMINE	MNA
Hospitalisation and LOS		MNA	MNA-SF and MUST
LOC		MNA	MUST
Quality of Life		MNA	DETERMINE and SCREEN
Muscle Mass and Function		MNA	GNRI and MNA-SF

3.2.1 Mortality

The ability of nutritional screening tools to predict mortality has been studied the most, with nearly 29 different studies. MNA was the tool most frequently investigated. Across hospital, nursing home and community settings, MNA was the most consistent tool and showed fair to good predictive ability, followed by GNRI.

In the hospital setting, MNA predicted mortality with 'fair to good' performance (92-95). The shortened version (MNA-SF) had poorer predictive ability due to contradory results (96-98).

MUST consistently showed good predictive ability for mortality in the hospital setting with OR and HR ≥ 2 (99-101). However, one study indicated that MUST, MNA or NRS-2002 were not significant predictors of mortality after 12 months (102). GNRI strongly predicted mortality 6-months after hospital discharge with OR > 5, while SGA exhibited weaker predictive ability than MNA (103, 104).

In the nursing home setting, GNRI and MNA were the most frequently studied tools and both exhibited strong predictive ability for mortality (49, 50, 105-107). Furthermore, MNA showed stronger predictive ability compared to NRS-2002 and MUST with HR > 3.5 even after

adjustment for age (108). However, the shortened version (MNA-SF) only showed fair predictive ability (107) and SGA was slightly better than MNA-SF (109).

In the community setting, NRI, SCREEN and DETERMINE were poor predictors of mortality (110-113) whereas MNA steadily performed as a good predictor of mortality (114-116). The more recently developed SNAQ 65+ also showed comparable predictive ability to MNA (86).

3.2.2 Morbidity and complications

The ability of screening tools to predict morbidity and complications were investigated in a smaller number of studies compared to mortality (approximately 10 studies). GNRI and MNA were the most frequently studied tools for this particular outcome measure, and both performed inconsistently.

MNA failed to predict disease complications in one study (117), but larger studies indicated that MNA, NRS-2002, MUST, and SGA, successfully predicted disease complications among older patients (118, 119). In contrast, GNRI showed inconsistent performance ranging from poor to good predictive ability in several studies (49, 53, 106, 120). In fact, one study showed that GNRI was unable to predict the occurrence of complications, and instead, complications were associated with NRI score (117). Nevertheless, studies showed that both GNRI and MNA performed favourably better than other tools used in the nursing home setting with OR/HR > 3 (49, 106). Meanwhile, among community living older people, MNA and DETERMINE performed good/fair predictive ability (112, 121, 122).

3.2.3 Hospitalisation and length of hospital stay

Associations between nutrition screening tools with hospitalisation and length of hospital stay were the second most commonly investigated outcome in the studies examined. Nearly 10 different screening tools were studied in more than 15 different studies conducted in 13 countries. However, many tools showed inconsistent predictive ability.

Five studies showed that low MNA scores were strongly associated with more frequent hospitalisations and longer hospital stays (23, 94, 123-125), while two others reported no association (112, 121). Similarly, one study found that MUST failed to predict hospitalisation and LOS (98), but two other studies showed that there were trends of longer hospital stay with increased MUST category (99, 101). Furthermore, DETERMINE demonstrated similar varying predictive ability to MNA and MUST (112, 122).

Studies in several different countries further established the inconsistent predictive ability of the screening tools. A Spanish study found that MNA, NRI and GNRI were not associated with LOS (117), while two other studies from Japan and Spain showed that NRS-2002, MNA, MUST and SGA successfully predicted LOS (118, 119). Furthermore, a Germany based study found that MNA was significantly associated with LOS, but not SGA or NRS-2002 (126). On the other hand, a study from Portugal revealed that NRS-2002 was the only significant predictor of LOS of more than 8 days, while the other tools (MST, MNA and SGA) failed to predict LOS (127). MNA-SF was most consistent in predicting length of hospital stay (98, 128, 129).

3.2.4 Level of care

Nutrition screening tools have also been used to attempt to predict change in level of care (LOC), as many studies have documented that malnourished patients have an increased risk of needing to move from community or low care to high care facilities. Eleven different studies investigated the relationship of LOC with SGA, DETERMINE, MUST, and MNA scores. Of these tools, MNA and MUST showed the best predictive ability.

SGA demonstrated good predictive ability for LOC (104), while DETERMINE's performance was inconclusive (130). Additionally, MUST showed inconsistent results as one study reported that it successfully predicted LOC (101), while another comparable study indicated no association between MUST score and discharge destination among hospitalised older people,

despite more patients in the high-risk group beingdischarged to residential care/nursing home compared to the low-risk group (51% vs 40%; $P > 0.05$) (99).

Of the four tools, MNA was most widely studied for its relationship with LOC and exhibited similar performance to MUST. Two studies reported that MNA failed to predict LOC, (23, 95, 124). Conversely, four other studies found that MNA (and MNA-SF) performed well in predicting LOC as MNA score was significantly associated with discharge to nursing home (94, 128, 131, 132).

3.2.5 Quality of life

The ability of nutrition screening tools to predict quality of life was investigated in 11 studies by analysing the association between nutrition screening tools and various quality of life assessment questionnaires such as the Assessment of Quality of Life Instrument (AQoL) (152), The Quality of Life Index for Mental Health (QLI-MH) (153), EuroQol groups EQ-5D (154) and Short Form 36 (SF-36) (155). The tools studied for their ability to predict quality of life were DETERMINE, SCREEN, NUFFE, MNA, MNA-SF and MUST. The majority of these tools exhibited good/fair predictive ability and MNA performed better than the others

DETERMINE was associated with quality of life based on QLI-MH (133) and Short Form-12 questionnaires (122). Similarly, NUFFE and SCREEN were associated with quality of life but, the former performed good/fair, while the latter's performance was unable to be rated (134, 135).

MNA-SF and MUST were both poor predictors of QOL due to conflicting results, as reported by two studies (107, 136). MNA, which once again emerged as the most studied tool performed better, and was weak to moderately associated with QOL as measured by AQoL (128), the Health-Related Quality of Life (HRQOL) (132), SF-36 (137), SF-12 (138), the Nottingham Health Profile (NHP) and the Philadelphia Geriatric Centre Multilevel Assessment Instrument (PGC MAI) (139).

3.2.6 Muscle Mass and Function

The ability of nutrition screening tools to assess muscle mass was investigated in 18 studies, as measured by the association between nutrition screening results and parameters of muscle mass such as anthropometric parameters, Dual-Energy X-ray absorptiometry (DXA) scan, and Bio Impedance Analysis (BIA). Prediction of muscle function was measured through correlation with muscle function parameters such as handgrip strength (HG) and gait speed (GS). Most of the nutrition screening tools studied for their association with muscle mass and function (DETERMINE, SGA, SCREEN, NRS-2002 and MUST) were investigated in few studies ($2 \leq$ for each tool), with only GNRI and MNA examined in ≥ 4 studies.

DETERMINE successfully predicted indicators of muscle mass with OR > 2.7 (140), but no studies reported its association with muscle function. On the other hand, SGA predicted both muscle mass (103, 119) and function (141).

SCREEN version II (SCREEN II), MUST, MNA-SF, and NRS-2002 exhibited nearly identical predictive ability. SCREEN II predicted muscle mass and function among community-dwelling older adults (142). Both MUST and MNA-SF predicted muscle mass and function amongst hospitalised older adults (136). Another study however, showed that while MUST, MNA and NRS-2002 were associated with muscle function among older patients, only NRS-2002 and MNA were associated with muscle mass as measured by Fat Free Mass Index (FFMI) (102).

The two most commonly investigated tools (GNRI and MNA) again showed inconsistent association with muscle mass and function. Three studies showed that GNRI predicted muscle mass and function among institutionalised older adults (49, 50, 143), but one smaller study by the same group found that GNRI was only associated with muscle function and not muscle mass (144). Likewise, five cross-sectional studies conducted in Japan, USA, South Africa, Spain and Canada confirmed that MNA predicted muscle mass and function among older patients and nursing home

residents (145-150). Nevertheless, one study found no significant association between MNA and handgrip strength among institutionalised older adults (151).

4. Discussion

To date there remains no agreement on the best screening tool to detect malnutrition across different age groups and in various clinical settings. New screening tools, or modified version of the previous tools, are continuously emerging, but during the development of these tools studies are often not conducted to examinine the ability of the screening tools to predict significant clinical outcomes. Thus, it is difficult for many clinicians to choose the most appropriate screening tools for their particular site. This review attempted to determine the most appropriate nutrition screening tools to predict certain clinical outcomes in older population across different settings as shown in table 3, with a view to providing recommendations on which tools to use.

Based on this review, MNA and GNRI emerged as the most recommended tools to predict various clinical outcomes across different settings. The two tools performed better in predicting various clinical outcomes and were investigated in more studies than the others. The MNA in particular, has emerged as the most extensively studied screening tool in a wide range of clinical settings and in older people from various different countries (156). Hence, MNA was often used as a reference to validate other tools (46, 156), despite being more suitable for free-living than nursing home residing or hospitalised older people, as several questions in the MNA are specifically aimed at community-living older people (157). Surprisingly, the SGA which was also frequently used as a 'valid' reference (46, 158), displayed a poorer ability to predict clinical outcomes in older population than other tools such as GNRI and MUST.

Nevertheless, it must be noted that this review also found that the majority of the nutrition screening tools, including MNA and GNRI have on average fair to poor predictive ability and inconsistent performance. Most of the tools were investigated in only one or two studies and

settings. On the other hand, those investigated in multiple studies frequently showed conflicting results. Comparing the predictive ability of different tools is difficult as studies generally examined only one tool or compared two different tools, while those that evaluated multiple tools were limited in number. In addition, studies included in the present review have numerous methodological limitations including that subjects were selected by convenience sampling, small sample size, observational and cross-sectional design, and no RCT.

Nearly all tools achieved an OR or RR of < 3 for each clinical outcome and despite exhibiting significant association ($p< 0.05$), the strength of correlation to clinical outcomes were often not reported in many studies. Those that provided evidence generally demonstrated a weak correlation. Lastly, the association between nutrition screening tools and clinical outcomes was often not adjusted for other factors that potentially influence clinical outcomes such as age, sex, comorbidities and disease severity (47). Hence, the poor performance of nutrition screening tools might also be explained by the fact that clinical outcomes were not affected by nutritional risk or nutritional status alone. Many other factors such as age and disease severity might have stronger influences on clinical outcomes. This hypothesis was supported by Elia and Stratton in their review, which showed that age alone demonstrated greater ability to predict clinical outcomes than nutrition screening tools in certain circumstances (47). Furthermore, the majority of the tools were designed to detect and diagnose malnutrition rather than to predict the clinical outcomes of malnutrition (47).

The ability of nutrition screening tools to predict clinical outcomes might also be altered by the presence of nutrition interventions after the screening tool has been applied – i.e. those identified as malnourished or at risk then receive and intervention before the follow-up assessment. However, most of the studies reviewed did not report any type of nutritional intervention, consistent with reports by van Bokhorst-de van der Schueren *et al.* (45). Lastly, along with recommendations from the previous review (45), we suggest that rather than developing new tools

which will unlikely create a ‘gold standard’, conducting further research to examine and compare the predictive ability of the currently available tools in a series of well-designed nutritional intervention is more warranted and will likely provide results that are more significant to clinical practice.

Strength and limitations

The main strength of this study was the extensive search process across four different databases and includes a wide range of studies from various countries. This study also examined the use of screening tools among older people in three different settings (community, nursing home and hospital settings). However, articles reviewed in this study did not include those written in languages other than English. Articles were further restricted to those that involved subjects with mean age of ≥ 65 years. Furthermore, due to limitations in search strategy and keywords used during search process, there are potentially many studies that were unintentionally omitted from the search results and final review.

Additionally, the tools reviewed were those designed for general older populations, while screening tools designed for specific conditions and modified versions of screening tools were not included in this study. These limitations could potentially reduce generalisability of the review results. Finally, this review was limited to predictive performance of nutrition screening tools and did not provide overview or evaluation on specificity, sensitivity, validity, and reliability of the nutrition screening tools as these were available in the previous reviews (45-48).

5. Conclusion

This review showed that the majority of the nutrition screening tools performed inconsistently and relatively poorly in predicting clinical outcomes among older people. Nevertheless, there are tools that performed significantly better than the others at predicting clinical outcomes, i.e. MNA, GNRI and DETERMINE. Hence, these tools were recommended as

the preferred tools to screen and diagnose nutritional status, and to predict clinical outcomes in older population across different settings.

CHAPTER 3. BODY-WEIGHT AND NUTRITIONAL-STATUS CHANGES IN SOUTH AUSTRALIAN NURSING-HOME RESIDENTS

Abstract

Objectives: To characterise body weight and nutritional status of a cohort of older adults nursing home residents in Adelaide, South-Australia, and the factors associated with changes in these measures over 6-12 months.

Design: retrospective study.

Setting: nursing homes affiliated with a single provider of aged care

Participants: residents aged 87±8years

Measurements: Age, gender, body weight and body mass index (BMI), pain, length of stay, and nutritional status assessed by malnutrition universal screening tool (MUST), were obtained from a data base. Changes in these parameters over 6 to 12 months were determined, as were factors associated with weight change.

Results: 1,020 residents were in the 6-month retrospective analysis, and a subset of 752 residents in the 12-months sub-group. The average weight and BMI for the overall cohort were 66±16kg and 25±6kg/m^2. Almost 30% of residents were at medium or high nutritional risk (14% and 16%). Body weight decreased 0.4±4.1kg (0.5±6.4%) over 6-months (P=0.006) and 0.9±5.2kg (1.3±7.8%) over 12-months (P<0.001). 46% of residents had marked weight change (≥ 5% loss or gain) over 12-months. Residents in the lowest BMI tertile (≤23kg/m^2) were most likely to experience both marked weight change (52%) and weight reduction (30%). Weight loss was associated with higher pain scores (P=0.012) and greater length of stay in the nursing home (P=0.002).

Conclusion: On average these older people lost weight, with high rates of both substantial weight loss and gain, particularly among those in the lowest BMI tertile. Almost a third in the lowest BMI tertile lost 5% or more body weight, putting them at increased risk of undernutrition-related

morbidity, suggesting greatest attention to prevent and treat such morbidity should be focused on that group.

1. Introduction

Ageing is associated with physiological changes in body weight and composition. These changes have impacts on quality of life and life expectancy (159, 160). Weight loss is more common than weight gain in adults aged 65 years or older (160-164), and is associated with increased mortality. For example, in the prospective US Cardiovascular Health Study of community-dwelling older people, weight loss over 3 years of ≥ 5%, was more common than weight gain of ≥ 5% (17% compared with 13%), and associated with a 70% increase in mortality, whereas weight stability and weight gain were not associated with increased mortality (161). There is increasing evidence that large weight fluctuations, either up or down, are associated with poor health outcomes and increased all-cause or cardiovascular/cancer- mortality. For example, the Iowa Women's Health study found that both weight loss and weight gain of 5-10% were associated with higher incidence of chronic diseases, and weight gain ≥ 10% was associated with increased rates of myocardial infarction and breast cancer (165). Furthermore, recent evidence from the Systolic Hypertension Study in the Elderly Program (SHEP), in adults aged 60 years or more, indicated that that the extent of weight change over the previous year was a good predictor of all cause and also cardiovascular/cancer-specific mortality, better than baseline weight or body mass index (BMI, kg/m^2) (160).

One of the reasons for the association between weight change (particularly weight loss) and adverse outcomes is the development of malnutrition. This is common in older people. We have reported that 45% of 250 older, community dwelling recipients of domiciliary care services in Adelaide, South Australia were malnourished or 'at risk' of malnutrition (~5% and ~40%, respectively) (23). Higher rates of malnutrition have been reported in long-term aged-care facilities (nursing homes), sometimes as high as 85% (14, 166-168).

Knowledge is limited about the mechanisms underlying the associations between weight change, malnutrition and adverse outcomes; one possible common factor is the presence and severity of pain in older people. Eating problems or poor eating behaviour including deficient

nutrient intake are not only more prevalent in people that experience oral pain (169) but also in patients with chronic pain of any origin (170). For example ~20-30% of patients with chronic pain had energy under-consumption, with a daily caloric intakes of less than 1200 calories per day (168).

according to a food frequency questionnaire (170).

The rates of weight change (particularly weight loss) and associated malnutrition reported elsewhere suggest that such rates will also be high in our community, particularly among the institutionalised older adults. We lack good data, however, on the nutritional status, body weight and weight changes of institutionalised older people in in South Australia. The purpose of the present study was to characterise these factors, and also pain, and length of stay at nursing home, of adults aged 55 years or more, living in nursing homes affiliated with Southern Cross Care (SA&NT) Inc., South Australia.

2. Methods

Study Population

Participants were residents of 15 nursing homes in South Australia affiliated with Southern Cross Care (SA&NT) Inc. in March 2015, when "baseline" data from the Southern Cross (SA&NT) Inc. database were obtained and analysed. All residents aged 55 years or more in these 15 homes were included, except those with severe dementia living in the memory support units, those living in their facility for less than 6 months, and those with incomplete baseline body weight, height or Malnutrition Universal Screening Tool (MUST) data. 1,228 residents were screened and 1,020 included in the 6-month cohort (change from 6 months before baseline to baseline), of which 758 were also included in the 12-month cohort (change from 12 months before baseline to baseline). Residents in the 6 but not 12 month cohort had lived in their facility for more than 6 but less than 12 months.

Variables

Variables examined in this study were retrieved, after de-identification, from a computerised database used by Southern Cross Care (SA&NT) Inc. (iCare, iCareHealth, Australia). Age, height, pain score and length of stay at the nursing home were retrieved at baseline; MUST score at baseline and 6 months prior; and body weight and BMI at baseline and 6 and 12 months prior. Body weight was measured using a calibrated digital chair scale (model: HVL-CS, A&D Australasia Pty. Ltd.) and performed by a carer according to a standard weighing procedure during the residents' morning tea-time (10.00-11.30am). Before weighing, residents were asked to remove heavy clothing, such as jacket, shoes or boots. Nutritional status was assessed by one qualified dietitian for the whole 15 sites using MUST (score 0 = low risk, 1 = medium risk, 2 or more = high risk of malnutrition) (171). Pain score was measured with the Abbey Pain Scale (score 0 – 2 = No pain, 3 – 7= Mild pain, 8 – 13 = Moderate pain, and 14+ = Severe pain) (172).

Statistical Analysis

Weight change in the past 6 months was calculated by difference between the baseline weight (i.e. most current weight) and weight 6 months prior. While for the 12 months weight change, baseline weight was subtracted by weight 12 months prior. Weight change was then expressed as absolute change in (kg) and percentage of change (%). To determine predictors of weight change, three sets of analysis were performed. We used Pearson Correlation test for continuous variables, i.e., age, BMI, total pain score and length of stay at nursing home, and then ANOVA test for categorical variables, i.e., sites, sex, marital status, BMI tertiles and pain-score category. Clinically relevant variables and those with significant result (P value < 0.05) were then entered into linear regression model. To further assess whether body weight changes were associated with BMI, subjects were divided into BMI tertiles (baseline data), using the following cut-off points for BMI: 1st tertile: BMI ≤ 23.0 kg/m^2, 2nd tertile: BMI 23.01-27.49 kg/m$^{2,\ and}$ 3rd

tertile: BMI ≥ 27.5 kg/m^2. Subsequently, cross-tabulation between percentage of weight change (weight loss ≥ 5%, weight stable and weight gain ≥ 5%) and BMI tertiles was conducted to reveal the proportion of weight change according to BMI tertiles over the 6- and 12-months period. All statistical tests were performed by SPSS (v.21.0 for windows, SPSS Inc., USA). All data are expressed as descriptive data (mean ± SD). The study was approved by the Royal Adelaide Hospital Human Research Ethics Committee and registered with the Australian New Zealand Clinical Trial Registry (www.anzctr.org.au, Trial number ACTRN12615000661572).

3. Results

Baseline

Table 12 shows the characteristics of all subjects (n = 1,020; the 6-month cohort for whom there were baseline and 6-month prior data) and the 12-month cohort (n = 752; for whom there were baseline and 6- and 12-months prior data). The mean age of the 6-month cohort was 87 ± 8 years (range 55 to 105 years), with a BMI of 25 ± 6 kg/m^2 (range 12 to 48 kg/m^2) with 65% being women. The men were heavier (75 ± 15 kg vs 63 ± 16 kg, $P < 0.001$), taller 170 ± 7 cm vs 158 ± 7 cm, $P < 0.001$) and had slightly higher BMIs than the women (26 ± 5 vs 25 ± 6 kg/m^2, $P = 0.057$). Values for these parameters were similar in the 12-month cohort to those in the 6-month cohort. Men in both cohorts were younger (85 ± 8 years vs 88 ± 7 years, $P <0.001$) and had been living in the nursing home for less time than their female counterparts (32 ± 32 months vs 42 ± 37 months, $P <0.001$). Increasing age was associated with a reduction in body weight (r = -0.295, $P < 0.001$, ***Figure 10***), with the regression line indicating a decrease in body weight of 0.63 kg for each year of increased age.

Table 12. Baseline and 6- and 12-month data in men and women of the 6- and 12-month cohort

	6-months cohort				12-months cohort			
	Men (n=259)	**Women (n=761)**	**Total (n=1020)**	**P value ***	**Men (n = 178)**	**Women (n=574)**	**Total (n=752)**	**P value ***
Baseline								
Age (year)	84.8 ± 8.4	87.6 ± 7.3	86.9 ± 7.7	<0.001	85.6 ± 8.1	88.0± 7.1	87.5 ± 7.4	<0.001
Height (cm)	170.4 ± 7.2	158.1 ± 6.7	161.3 ± 8.7	<0.001	170.4 ± 6.9	158.0 ± 6.6	160.9 ± 8.5	<0.001
Pain Score †	1.9 ± 3.2	2.0 ± 3.3	1.98 ± 3.3	0.55	2.1 ± 3.4	2.1 ± 3.3	2.1 ± 3.3	0.91
Length of stay (months)	31.7 ± 31.6	41.6 ± 37.0	39.1 ± 35.9	<0.001	40.1 ± 32.8	48.7 ± 37.2	46.6 ± 36.4	0.01
Body weight (kg)	75.3 ± 14.8	63.2 ± 15.7	66.3 ± 16.4	<0.001	75.3 ± 14.4	63.1 ± 15.7	66.0 ± 16.3	<0.001
BMI (kg/m^2) ‡	26.0 ± 4.9	25.2 ± 6.0	25.4 ± 5.7	0.06	26.0 ± 4.9	25.2 ± 6.0	25.4 ± 5.7	0.09
MUST Score §	0.4 ± 0.8	0.6 ± 1.0	0.5 ± 0.9	0.01	0.4 ± 0.8	0.56 ± 0.96	0.5 ± 0.9	0.01
6 months prior								
Body weight (kg)	75.9 ± 14.5	63.5 ± 15.5	66.6 ± 16.2	<0.001	76.2 ± 14.3	63.6 ± 15.5	66.6 ± 16.1	<0.001
BMI (kg/m^2)	26.2 ± 4.9	25.4 ± 5.8	25.6 ± 5.6	0.03	26.3 ± 5.0	25.5 ± 5.9	25.66 ± 5.7	0.06
MUST Score	-	-	-	-	0.3 ± 0.7	0.5 ± 0.9	0.4 ± 0.9	0.02
Change in body weight from 6 months prior to baseline								
(kg)	-0.5 ± 4.9	-0.3 ± 3.8	-0.4 ± 4.1	0.47	-0.9 ± 4.2	-0.6 ± 3.8	-0.7 ± 3.9	0.38
(%)	-0.6 ± 6.8	-0.4 ± 6.2	-0.5 ± 6.4		-1.1 ± 5.8	-0.9 ± 6.1	-0.9 ± 6.0	0.69
12 months prior								
Body weight (kg)	-	-	-	-	76.2 ± 13.5	63.9 ± 15.4	66.9 ± 15.8	<0.001
BMI (kg/m^2)	-	-	-	-	26.3 ± 4.7	25.6 ± 5.8	25.8 ± 5.6	0.09
Change in body weight from 12 months prior to 6 months prior								
(kg)	-	-	-	-	0.0 ± 4.0	-0.31 ± 3.4	-0.2 ± 3.5	0.29

	6-months cohort				12-months cohort			
	Men (n=259)	**Women (n=761)**	**Total (n=1020)**	**P value ***	**Men (n = 178)**	**Women (n=574)**	**Total (n=752)**	**P value ***
(%)	-	-	-	-	0 ± 5.53	-0.4 ± 5.4	-0.3 ± 5.5	0.36
Change in body weight from 12 months prior to baseline								
(kg)	-	-	-	-	-0.9 ± 5.6	-0.9 ± 5.0	-0.9 ± 5.2	0.98
(%)	-	-	-	-	-1.1 ± 7.7	-1.3 ± 7.9	-1.3 ± 7.8	0.75

Data represent mean ± SD

* Independent t-test of men compared with women;

† Pain score measured with Abbey Pain Scale, 0 – 2 = No pain, 3 – 7= Mild pain, 8 – 13 = Moderate pain, and 14+ = Severe pain;

‡ BMI: body mass index;

§ MUST: Malnutrition Universal Screening Tool, 0 = low risk, 1 = medium risk, 2 or more = high risk.

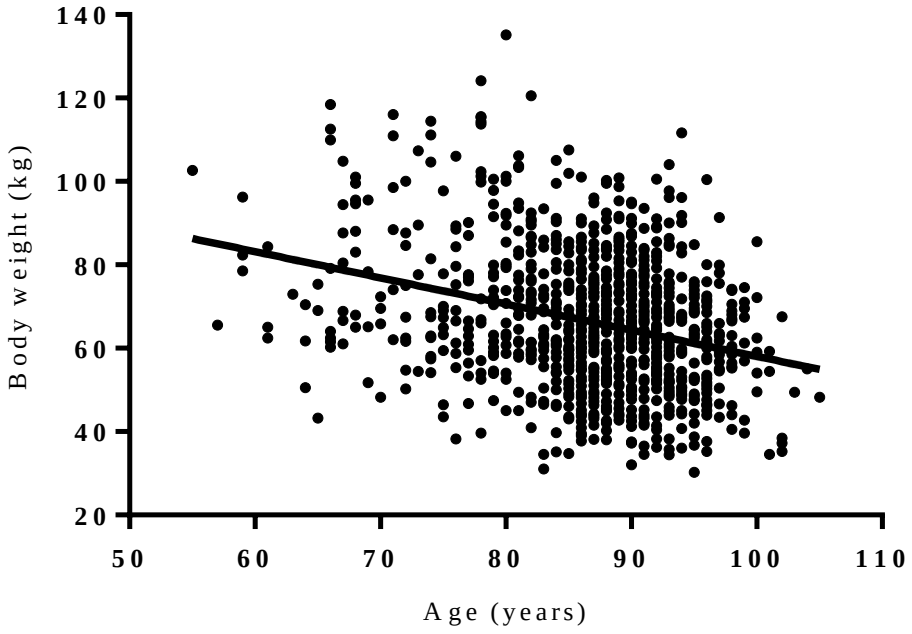


Figure 11. Body weight plotted as a function of age

Based on the MUST score, 30% of residents were classified as being at medium (score of 1) or high (score of 2) nutritional risk (14% and 16%, respectively). Women were twice as likely to be at high nutritional risk as men, with 13% of women at medium nutritional risk and 18% at high risk, compared to 19% of men at medium risk and 9% at high risk (P = 0.001). The average MUST score for women was significantly higher than male residents (0.56 vs 0.41, *P* = 0.012). Although most residents had no pain (score <2), there was a trend of higher pain scores among residents with poorer nutritional status. The mean pain score of residents with medium and high nutritional risk was 2.1 ± 3.5 and 2.6 ± 3.8, compared to 1.8 ± 3.1 for residents with low nutritional risk – although, significant difference was only observed between the high and low nutritional risk group (*P* = 0.009).

Changes over 6 and 12 months

On average, subjects lost weight during the 6- and 12-month periods before baseline (Table 7). The 6-month cohort of 1,020 residents experienced a 0.4 ± 4.1 kg weight decrease over 6 months, equivalent to 0.5 ± 6% of their starting weight ($P = 0.006$), and the 12-month cohort of 752 residents had a 0.9 ± 5.2 kg (1.3 ± 7.8%) weight reduction over 12 months ($P < 0.001$). There were no significant differences in the amount of weight lost between men and women, either in absolute or percentage terms.

A substantial minority of subjects had a reduction or increase in body weight of greater than 5% during the study period; 34% over 6 months among the subjects in the 6-month cohort (***Table 13***), and 46% over 12 months in the subjects in the 12-month cohort (***Table 14***).

Table 13. Body-weight change over 6 months

BMI-tertiles*			**Weight loss ≥ 5%**	**Weight Stable**	**Weight gain ≥ 5%**
≤ 23.00	n	354	76	211	67
	Percent		21%	60%	19%
23.01 – 27.49	n	329	68	216	45
	Percent		21%	66%	13%
≥ 27.50	n	337	53	250	34
	Percent		16%	74%	10%
Total	n	1020	197	677	146
	Percent		19%	66%	14%

* BMI: body mass index (kg/m^2)

Table 14. Body-weight change over 12 months

BMI-tertiles*			Weight loss ≥ 5%	Weight Stable	Weight gain ≥ 5%
≤ 23.00	n	252	76	121	55
	Percent		30%	48%	22%
23.01 – 27.49	n	248	70	132	46
	Percent		28%	53%	19%
≥ 27.50	n	252	67	151	34
	Percent		26%	60%	14%
Total	n	752	213	404	135
	Percent		28%	54%	18%

* BMI: body mass index (kg/m^2)

Factors associated with weight change

Weight change was associated with several variables. Pearson correlation test showed that a higher pain score at baseline (r = -0.082, *P* = 0.009) and greater length of stay in the nursing home (r = -0.102, *P* = 0.001) were significantly associated with a reduction in body weight during the 6 months before baseline. These results are supported by multiple linear-regression analysis (total pain score *P* = 0.012, β = -0.079, 95% Confidence Interval (CI) = -0.176 to -0.022; length of stay *P* =0.002, β = -0.100, 95% CI = -0.019 to -0.004). There was an association between lower initial BMI 6 months before baseline and greater weight loss over 6 months (r = -0.075, *P* = 0.017). Consistent with this, more subjects in the lowest BMI tertile (≤ 23 kg/m^2) had a decrease of 5% or more of their body weight than those in the highest tertile over the 6 months before baseline (21.5% compared with 15.7%; Table 13).

There was an apparent association between initial BMI and the magnitude of weight change, either percentage weight loss or weight gain. Subjects with lower initial BMIs consistently had greater fluctuations in body weight (increases or decreases of ≥ 5% of body weight) than those with higher BMIs over both 6 (Table 8) and 12 (Table 14) month periods. For example, 40% of

those in the lowest BMI tertile had weight change (increase or decrease) of ≥ 5% over 6 months, compared to 27% in the highest tertile; while over 12 months 52% of the lowest tertile group had weight change of ≥ 5%, compared to 40% of the highest tertile group ($P < 0.001$).

4. Discussion

The main findings of this study are that these nursing home residents had a body weight decrease equivalent to approximately 1 to 1.3% per annum (0.8 to 0.9 kg), that underweight residents were the most likely to lose weight, and that there were high rates of substantial body weight changes, both up and down, particularly in residents with initially lower body weights. The prevalence of poor nutritional status in this study, using the MUST tool, was 30%, in line with rates of 21-38% reported in recent studies of Australian and European nursing home residents using the same tool (173-176).

Various physiological and non-physiological factors have been identified as being associated with, and probably contributing to, weight loss in older people (19, 163, 177). They include dementia, depression, reduced functional status, medical conditions and medications, poor dentition, social isolation and poverty (16, 178, 179). This study was unable to investigate the role of most of those variables, but, did identify an association between higher pain scores and weight loss. The association between pain and weight loss in nursing home residents has been reported previously (180) and is likely to be mediated via multiple mechanisms, including the anorectic (181) and cachectic effects of increased cytokine action in painful conditions including malignancies. We do not have an explanation for the significant but weak association identified between greater length of residence in the nursing home and weight loss. It is possible that those admitted to the nursing home earlier started with more disabilities and poorer nutritional status and hence, the longer they live at the nursing homes, the more weight they lose irrespective of intervention provided at the nursing home.

The average decrease in body weight of approximately 1-1.3% per year in this study is consistent with the results of other studies. Longitudinal studies have shown that body weight decreases in community dwelling older people, at approximately 0.5% per year (161, 182, 183). Data on weight change among nursing home residents are more limited, but the rate of weight loss in the present study is consistent with previous findings suggesting higher rates of weight loss in nursing home residents than their community dwelling peers (162, 184, 185). A recent small Italian study reported weight loss of ≥ 5% over one year in 75% of nursing home residents (184), a large multicentre, multi-country study reported weight loss during one year of ≥ 5 kg (~7.5%) in 11% of residents (185), while a US study found substantial weight loss of 5% in 30 days or 10% in 180 days (the Minimum Data Set criteria) in ~10% of nursing home residents (162). The rate of weight decrease identified in this study is of interest, given the association between weight loss and adverse outcomes in older people (183, 185-191) . In particular, weight loss > 4-5%, probably irrespective of starting weight (161), is associated with increased mortality in older people, both community dwelling (161, 183, 186, 187) and in nursing homes (185, 188, 190).

Low body weight is also associated with adverse outcomes in older people (183, 185-191). The body weight and BMI associated with maximum life expectancy increases with increasing age (192), as does the BMI value below which there is an increase in associated mortality. Studies in older people indicate that a BMI ≤ ~ 23 kg/m^2, the upper end of the lowest tertile in our study, is associated with increased mortality (177). Furthermore, previous studies have demonstrated an interaction between low body weight and weight loss in their adverse effects on mortality in older people. Newman *et al.* reported that mortality in older people was approximately doubled by weight loss of ≥ 5% of initial body weight, irrespective of initial weight, but that mortality rates were higher in people of low body weight who lost weight (7.4 per 100 person years) than their normal weight peers who lost weight (4.6 per 100 person years) (161). Similarly, in a study of over 10,000 nursing home residents, Wirth *et al*. reported a 6-month mortality of 11% in those with a

BMI of ≥ 20 kg/m^2 who were weight stable, rising to 36% in those with a BMI < 20 kg/m^2 who lost more than 5 kg (OR 3.5, $P < 0.001$) (185). In the present study approximately 6-7% of residents were of low body weight (BMI ≤ 23 kg/m^2) and lost more than 5% of their body weight, putting them at particular risk of undernutrition-related adverse events. As recommended by Wirth *et al.*, particular attention should be focused on such people with a view to providing nutritional support (185).

Of interest, those nursing home residents in the present study who lost the most weight were those already at lowest body weight, with almost a third of residents with BMI ≤ 23 kg/m^2 experiencing a weight reduction of ≥ 5% over 12 months. Although this rate of weight loss was only marginally higher than that in the highest BMI tertile, this finding is consistent with, and supports, that of Wirth *et al.* (185). They reported that substantial weight loss (> 5 kg in that study) among nursing home residents was more prevalent in those with initially lower BMIs, with substantially higher rates of weight loss particularly if the initial BMI was < 23 kg/m^2 (185). Our finding, and that of Wirth *et al*., in nursing home residents, are at odds with that of Newman *et al*., who reported greater weight loss in community dwelling older people with *greater* baseline weight (161). The reason for this discrepancy is not clear. It may be that underweight nursing home residents, as opposed to community dwelling, are at particular risk of weight loss. In any case, our finding reinforces the need to focus particular nutritional attention on nursing home residents with low body weight.

There was a high rate of substantial weight change among the subjects in this study. Over twelve months 46.2% of residents had either a weight loss or weight gain ≥ 5%, with weight loss more common than weight gain. While the weighing techniques used were standardised as much as possible, the subjects were resident in multiple homes and not always weighed by the same person, so there would have been some variations in weighing technique that contributed to this high rate. Nevertheless, our findings are consistent with other recent reports of high levels of

weight fluctuation among older people in nursing homes. For example, a study of 6,009 nursing home residents in the United States found that 29.2% of them either lost or gained ≥ 10% body weight over 6 months (193), while in a study from the Netherlands 48% of nursing home residents with dementia lost or gained ≥ 2 kg weight over 24 weeks follow-up (194). These high rates are probably due to the high prevalence of frailty, anorexia and medical conditions such as heart failure, inflammation, and malignancy, together with the treatments used to combat them, contributing to weight loss on the one hand, with factors such as sudden immobility, glucocorticoid prescription and the identification and active nutritional support of under-nourished older residents contributing to weight gain, on the other. They are of concern, however, as weight fluctuation in either directions have been associated with poor health outcomes in older people (177, 195, 196).

This study has several limitations. Firstly, it relied solely on data recorded by the staff within each facility and it was not possible for the research team to verify the accuracy of the data. Hence, there are possibilities for variation and fluctuations in measurement results of the variables. Secondly, predictive variables for weight change used in this study were limited to only those readily available and feasible to analyse from the iCare database. Other variables that might have a stronger role in weight change such as morbidity, medication, food intake, depression, functional status [(in-) activities of daily living ADL and IADL] and mental status (cognitive performance) were not included. Thus, the role of pain in weight change could be attenuated by the presence of other factors and might become insignificant. Lastly, data for predictive variables were only available for the 6-month time point. This has limited our ability to investigate the role of these variables in a longer time frame.

5. Conclusion

In summary, the nursing home residents in this study lost weight at an average rate of 1-1.3% (0.8 to 0.9 kg) per annum, approximately double that reported previously for their

community-dwelling peers, with substantial numbers losing > 5% of their body weight in one year. Those residents with lower initial body weights were more likely to lose weight, putting them at increased risk of undernutrition associated adverse events. These findings reinforce the need to weigh nursing home residents regularly and address weight loss when detected, particularly in those already underweight.

CHAPTER 4. SIX MONTH FOLLOW UP OF BODY COMPOSITION, PHYSICAL FUNCTION, NUTRITIONAL AND MENTAL STATUS IN INSTITUTIONALISED OLDER ADULTS IN SOUTH AUSTRALIA

Abstract

Background: Weight loss is more prevalent than weight gain among people aged ≥ 65 years. Previous studies showed that weight loss, particularly fat free mass loss was associated with deleterious clinical outcomes, physical impairment and disability.

Objectives: To determine the body composition, nutrition, mental status, physical function and hospitalisation at baseline and after 6 month, and the impact of age and exercise on nutritional state, muscle mass and function among institutionalised older people.

Design: Prospective study.

Participants: Thirty six residents of nursing homes affiliated with a single provider of aged care in Adelaide, South Australia.

Measurements: Socio-demographic, medical history, anthropometry, body composition (measured by bioelectrical impedance analysis), nutritional status (assessed by five different screening tools), food intake, frailty (assessed by two frailty questionnaire), physical function (assessed by short physical performance battery, physical activity and activity of daily living questionnaires), mental status (assessed by two cognitive function tests and depression scale) and quality of life (assessed by three questionnaires on quality of life, sleep and social support), and blood parameters (assessed by complete blood count and CRP) were collected at baseline and 6-months. Changes in these parameters over 6 months were determined, as were factors associated with body composition change.

Results: Thirty two participants aged 86.1 ± 7.7 years completed the study. Weight was not changed (0 ± 2.3 kg), however, 70% participants either gained or lost >5% fat mass, 30% had gained or lost >5% fat free mass, and 82% had gained or lost more than > 5% corrected arm muscle area (CAMA) over 6 months. Nutritional status, frailty, physical function, mental status, quality of life and blood parameters were unchanged during the study. Participants who were involved in physical exercise had improved tricep skinfold thickness, SNAQb and SPPB scores compared to those who did not exercise (triceps skinfold: 1.2±2.6 vs. -0.9±2.6 mm, p=0.034; SNAQb: 0.5±1.3 vs.-0.7±1.5, p=0.024; SPPB: 0.6±1.7 vs. -0.8±1.8, p=0.027).

Conclusion: Despite no weight change over 6 months, body composition was changed dramatically among participants. Exercise appears to attenuate the effect of age and could potentially reduce fat free mass and physical function loss among institutionalised older people.

1. Introduction

The global, including Australian, population is ageing rapidly. People aged 65 years or more make up ~15% of the Australian population and those 85 years or older ~2% (197). It is projected that by 2031 these numbers of elderly people will increase by ~80% and more than 100% respectively (198). It is well recognised that after age ~65 years weight loss is more common than weight gain (160-164). For example, older people aged 75 years compared to younger aged adults (45-64 years old) were more likely to be underweight (5 vs.1%), defined as having a body mass index (BMI) lower than 18.5 kg/m^2, and substantially less likely to be overweight (47 vs. 64%), defined as a BMI higher than 25kg/m^2 (199). In a prospective US study, men aged 65 years or more lost on average 0.5% body weight per year, and 13% had involuntary weight loss of ≥4% per year (183). We reported previously, in a retrospective cohort study, that 1,020 institutionalised older people lost an average 0.4 ± 4.1kg (0.5 ± 6.4%) over 6 months and 0.9 ± 5.2kg (1.3 ± 7.8%) over 12 months (83).

Most importantly, both low body weight (particularly a BMI <22 kg/m^2) and weight loss are strong predictors of poor outcomes in older people (160, 161, 183, 190). For example, a retrospective review of 153 institutionalised older people found that weight loss of at least 5% body weight in 1 month was associated with 4.6 higher mortality risk within 1 year (190). In addition, the prospective US Cardiovascular Health Study, showed that weight loss over 3 years of ≥5% was more common than weight gain of ≥ 5% (17 vs. 13%) and associated with a 70% increase in mortality in community dwelling older adults, whereas weight stability and weight gain were *not* associated with increased mortality (161). Similarly in the Systolic Hypertension in the Elderly Program, weight loss of 1.6 kg per year compared to weight stable older adults aged 60 years or more was associated with a ~5 times greater death rate (160).

Weight loss, particularly muscle loss, leads to malnutrition and frailty, which are strongly associated with numerous adverse outcomes including reduced physical function, mental status

and quality of life and increased hospital admissions (23, 200, 201). For example, under-nourished subjects were more likely than well-nourished controls to be hospitalised in the following year (41 vs. 29% $P<0.05$) and hospital stays of more than a month were increased ~3 fold (23). In our retrospective cohort study of institutionalised older people, 28% lost ≥5% body weight over 12 months, and 30% of them were at medium or high risk of malnutrition (83).

Studies showed that strategies such as nutritional supplements and physical exercise are effective to prevent weight loss, improve nutritional status and clinical outcomes in institutionalised older people (202-204). An RCT of 100 frail institutionalised older people showed that 45 minutes high resistance exercise every other day significantly improved muscle mass and function (202). Likewise, a retrospective case control study indicated that oral nutrition support helped older nursing home residents to regain their admission weight within 9 – 10 months and improved albumin, total lymphocyte count, cholesterol, and haemoglobin, compared to non-supplemented residents. This prospective study aimed to determine in institutionalised older men and women, those arguably most at risk of malnutrition, body weight and composition, nutritional status, physical function, mental status, and hospitalisation at baseline and after 6 months, and the impact of age and participation in exercise activity on nutritional status, muscle mass and function.

2. Methods

Study population

Participants were recruited from 7 nursing homes, affiliated with Southern Cross Care (SA&NT) Inc. in South Australia, between May 2015 and June 2016. Residents aged 65 years or more were invited to partake, except those unable to understand the informed consent document, communicate with the investigator, or comply with the data collection of the study.

Thirty six participants aged 86.2 ± 7.5 years old (men: n =11, 83.7 ± 7.6 years; women: n = 25, 87.3 ± 7.4 years) participated and 32 completed the 6 months follow up (men: n =8, 82.9 ± 7.9 years; women n = 24, 87.2 ± 7.5 years). Three participants dropped out from the study due to deteriorating health and 1 due to personal reason. A majority of participants (78%) were widowed, obtained a certificate or diploma (47%) and completed higher school education (42%). Baseline measurements did not differ between completers and the total cohort (**Appendix 1**).

Outcome measures

Outcomes were determined at baseline and 6 months thereafter.

Basic demographics, including self-rated health, smoking history, consumption of nutritional supplements, alcohol consumption, hospital admission (number and length of stay) and frequency of falls over the past 6 months, and engagement in exercise activity, defined as 3 or more times/week for at least 30 minutes, were collected from the Southern Cross Care iCare database.

Body weight (kg), fat and lean mass (kg) and fat percentage (%) were measured with a body composition analyzer (Model No: SC-330, Tanita, Illinois, USA). Height (m) was measured using a calibrated portable stadiometer (Model: WSHRP, Wedderburn, NSW, Australia) and body mass index (BMI, kg/m^2) was calculated. Mid-arm and calf circumferences (cm) were measuerd with a measuring tape (Seca 203, Hamburg, Germany), and triceps skin-fold thickness (mm) with caliper (Model HSB-BI, Harpenden, British Indicators Ltd, West Sussex, UK).

Nutritional status was assessed by corrected arm muscle area, calculated using mid-arm circumference and triceps skinfold thickness (malnourished: male <21.4 cm^2, female <21.6 cm^2; severe wasting malnutrition: male <15.9 cm^2, female < 16.8cm^2 (205)), and validated screening tools i.e., the Mini Nutritional Assessment (MNA; scores <17: malnourished, 17-23.5: at risk of malnutrition, >23.5: well nourished (206)), the Malnutrition Universal Screening Tool (MUST;

scores 0: low risk of malnutrition, 1: medium risk, ≥2: high risk (171)), the Malnutrition Screening Tool (MST; scores <2: no risk of malnutrition, ≥2: risk of malnutrition (207)), the Short Nutritional Assessment Questionnaire (SNAQa; scores <2: well nourished, ≥2: moderately malnourished, ≥3: severely malnourished (58)), and the Simplified Nutritional Appetite Questionnaire (SNAQb; scores ≤14: significant risk of ≥5% weight loss within 6 months, >14: no risk of weight loss) questionnaires (208). Frailty was determined by the Fatigue, Resistance, Ambulation, Illness, and Loss of weight (FRAIL; scores 0: robust health status, 1-2: pre-frail, 3-5: frail (209)) and the Fried frailty (FRIED; scores 0: not frail, 1-2: pre-frail, 3-5: frail (205)) questionnaires. Food intake was assessed using a 3-day food record. Percent Recommended Dietary Intake (RDI) of energy and protein intake was calculated based on individual energy requirements using Schofield's euqation (210), an activity factor of 1.2 and protein requirement of 0.8 g/kg/day (211). Eating behavior was determined using the Three Factor Eating Questionnaire [TFEQ; Factor 1 'dietary restraint' i.e., the tendency of a person to restrict their food intake in order to control their body weight, consist of 21 items, scores of 0–10 = low restraint, 11–13 = high restraint and 14–21 = clinical range of restraint; Factor 2 'disinhibition (of control)' related to weight gain during depression, consist of 16 items, scores of 0–8 = low disinhibition, 9–11 = high disinhibition and 12-16 = clinical range of disinhibition.; Factor 3 '(susceptibility to) hunger' consist of 14 items, scores of 0–7 = low susceptibility to hunger, 8–10 = high susceptibility to hunger and 11-14 = clinical range of susceptibility to hunger (212)].

Physical function was determined by the Short Physical Performance Battery (SPPB; a higher scores indicates a better functioning, scores: 0-12 (213) which includes grip strength (kg; dominant hand, Jamar Dynamometer, IL, USA), gait speed (m/s; 3-m walk test), and the Instrumental Activity of Daily Living (IADL; scores 0: independent, 1-8: dependent (214)), the Physical Activity Scale for the Elderly (PASE; higher scores represents better overall activity

level, scores : 0 – 360 (215)) and Activities of Daily Living (ADL; scores 0: no dependence 0, 1-7: dependence (216)) questionnaires.

Mental function included cognitive function, determined by the Mini Mental State Examination (MMSE; scores ≤ 9: severe, 10-19: moderate, 20-24: mild, 25: no cognitive impairment (217)), Saint Louis University Mental Status (SLUMS; scores >25/30: normal, 20-24: mild neurocognitive disorder, 1-19: dementia (218)), and depression determined by the Geriatric Depression Scale (GDS; scores >5: suggestive depression, >9: depression (219)). The following questionnaires were also completed; Assessment of Quality of Life (AQoL; lower scores indicating better quality of life, scores: 0-30 (220)), Pittsburgh Sleep Quality Index (PSQI; scores ≤5: good and >5: poor sleep quality (221)) and Interpersonal Support Evaluation List (ISEL ; higher scores indicates better social support, scores 0-120 (222).

Blood pressure and heart rate of participants were measured using Omron Blood Pressure Monitor [(Model No: HEM-907), Kyoto, Japan]. Blood was collected from each participant for determination of Complete Blood Count (CBC) and C-Reactive Protein (CRP).

Statistical analysis

Statistical analysis was performed using SPSS (Version 22.0 for Windows, IBM, New York, USA). Results are presented as means and standard deviations (SD), unless stated otherwise. ANCOVA test to determine the effects of time, gender and time by gender interaction. Simple Pearson's correlation test was performed to determine the impact of age and exercise on clinical outcomes. Independent t-test was used to determine the difference in clinical outcome between exercisers and non-exercisers. Lastly, ANCOVA was performed to analyse the impact of age and exercise on fat free mass and grip strength adjusted for time and gender.

3. Results

The majority of the older men and women were non-smokers (83%), consumed at least 1 nutrition supplement per day (64%), more than 1 standard alcoholic drink per week (81%), experienced 0.7 ± 1.1 falls and were hospitalised less than once with a duration of on average 2.2 ± 8.5 days in the previous six months, and rated their health as fairly good/good (baseline and 6-month follow-up: poor: 17% and 3%, fairly good 33% and 22%, good: 22% and 44%, very good: 11% and 25%, excellent: 17% and 6%) (gender and time effect $P > 0.05$, ***Table 15***). Exercise duration was significantly higher among men than women at baseline and 6 month follow up (Baseline: 143 ± 140 vs 78 ± 103 minutes/week, 6 month follow up: 169 ± 174 vs 56 ± 73 minutes/week, P = 0.003), and there was decreasing number of participants engaged in regular exercise from both gender (baseline and 6-month follow-up: men 91% and 75%, women: 48% and 42%, (gender by time effect $P > 0.05$, Table 15).

Table 15. Effect of time, gender, and time by gender on clinical outcomes*

	Total Cohort				Completers								P value for time effect	P value for gender effect	P value for time by gender effect
	Baseline				Baseline				Change from baseline						
	Male (n =11)		Female (n = 25)		Male (n = 8)		Female (n = 24)		Male (n = 8)		Female (n = 24)				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Hospitalisation and falls															
Hospital admissions	0.2	0.4	0.2	0.4	0.3	0.5	0.2	0.4	-0.1	0.4	0.1	0.7	0.93	0.42	0.51
Hospital stay (days)	0.3	0.6	3.1	10.1	0.4	0.7	3.3	10.3	0.8	2.5	-2.3	10.5	0.68	0.40	0.40
Frequency of falls	1.5	1.5	0.3	0.7	1.8	1.6	0.3	0.7	-0.4	1.6	0.3	1.4	0.73	0.007	0.47
Body weight and composition															
Body weight (kg)	82.0	13.5	66.1	12.3	80.2	10.2	67.2	11.3	-.62	1.95	.25	2.36	0.86	< 0.001	0.56
BMI (kg/m^2)	28.1	4.2	29.0	4.9	27.5	4.3	29.5	4.5	-.17	.69	.14	1.04	0.92	0.26	0.63
Body weight BIA (kg)[#]	80.6	10.3	65.6	8.7	80.6	10.3	65.6	8.7	-.1	2.0	.5	2.2	0.95	< 0.001	0.92
BMI BIA (kg/m^2)[#]	29.0	3.8	29.4	4.2	29.0	3.8	29.4	4.2	.0	.7	.2	1.0	0.82	0.77	0.95
Fat mass BIA (kg)[#]	22.9	6.9	25.7	8.5	22.9	6.9	25.7	8.5	-.2	2.5	-.3	2.8	0.93	0.31	0.99
Fat free mass BIA (kg)[#]	57.7	3.7	40.0	3.7	57.7	3.7	40.0	3.7	.1	2.0	.8	2.5	0.73	< 0.001	0.78
Fat percent BIA (%)[#]	80.6	10.3	65.6	8.7	27.9	4.9	38.2	9.3	-.1	2.7	-.6	3.7	0.90	< 0.001	0.92
Calf circumference (cm)	36.4	2.9	34.9	4.0	36.5	2.9	35.1	3.8	.3	.9	.4	3.0	0.59	0.14	0.88
Mid-arm circumference (cm)	30.8	5.0	28.9	4.2	30.2	4.8	29.2	4.0	-.6	3.8	-.1	1.8	0.61	0.29	0.50
Skinfold triceps (mm)	13.6	8.3	17.7	7.6	11.9	5.0	18.1	7.6	-.4	2.2	.3	3.0	0.72	0.007	0.47
Nutritional status															
CAMA	46.9	14.8	37.6	10.8	46.6	17.2	38.2	10.6	-2.6	17.4	-1.0	7.6	0.58	0.008	0.68
MUST	0.4	0.8	0.2	0.6	0.3	0.7	0.2	0.6	0.0	1.1	0.0	0.6	0.77	0.73	0.73

	Total Cohort				Completers								P value for time effect	P value for gender effect	P value for time by gender effect
	Baseline				Baseline				Change from baseline						
	Male (n =11)		Female (n = 25)		Male (n = 8)		Female (n = 24)		Male (n = 8)		Female (n = 24)				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
SNAQa	0.3	0.5	0.4	0.8	0.1	0.4	0.3	0.5	0.1	0.6	0	0.5	0.41	0.73	0.82
MST	0.1	0.3	0.4	0.9	0.0	0.0	0.3	0.9	0.0	0.0	-0.3	1.0	0.16	0.29	0.43
MNA SF	12.5	1.8	12.6	1.8	12.6	1.8	12.8	1.5	0.1	1.2	0.3	0.8	0.40	0.62	0.87
MNA Total	25.0	2.8	24.9	2.6	25.5	2.2	25.2	2.2	-0.4	1.8	0.3	2.3	0.72	0.86	0.73
SNAQb	15.5	2.1	15.0	2.3	15.5	1.5	15.2	2.0	0.8	1.0	-0.4	1.6	0.041	0.36	0.17
FRIED	1.3	0.5	1.2	0.6	1.3	0.5	1.2	0.6	0.0	0.0	0.0	0.6	0.86	0.62	0.97
FRAIL	2.2	1.3	2.5	0.9	2.0	1.3	2.4	0.8	0.4	0.9	-0.1	0.7	0.99	0.67	0.45
Energy intake (kJ)	8099	1756	7577	1500	8634	1788	7577	1500	778	2930	-730	1339	0.52	0.004	0.056
Protein intake (g)	82.2	20.6	73.0	11.1	88.8	18.9	73.0	11.1	.2	27.5	1.6	16.7	0.31	0.028	0.71
TFEQ Factor 1	6.6	3.5	6.0	4.0	6.6	4.1	6.1	4.0	0.4	1.8	-0.5	5.1	0.56	0.60	0.87
TFEQ Factor 2	4.7	3.8	2.8	2.0	5.6	4.1	2.8	2.0	-1.4	3.2	-0.2	1.3	0.45	0.016	0.61
TFEQ Factor 3	3.0	3.3	2.2	1.7	3.5	3.8	2.3	1.8	-1.1	2.9	0.0	1.8	0.34	0.61	0.38
Frailty and physical function															
SPPB	4.3	2.9	4.7	2.7	4.0	2.9	4.8	2.7	.00	2.33	-.13	1.75	0.83	0.51	0.89
Grip strength (kg)	23.8	9.0	12.7	3.5	24.5	10.1	12.8	3.5	-1.3	6.5	-.5	3.5	0.73	< 0.001	0.93
Gait speed (m/s)[$]	0.43	0.17	0.47	0.17	0.46	0.13	0.48	0.17	-.04	.07	0	.10	0.87	0.33	0.87
PASE	22.7	22.1	12.8	14.8	23.7	19.8	13.3	14.9	-8.4	22.6	2.4	12.1	0.64	0.33	0.29
ADL Total	4.8	4.4	3.8	4.6	3.6	3.7	3.5	4.5	0.1	4.2	-0.4	3.8	0.18	0.70	0.54
IADL	10.5	5.9	11.5	5.8	8.8	5.1	11.3	5.8	1.0	4.6	0.8	5.1	0.29	0.07	0.24
Exercise duration (minutes/week)	167	199	75	102	143	140	78	103	26	66	-22	116	0.80	0.003	0.76
Mental status, depression, quality of life, sleep and social support															
MMSE	25.5	3.1	26.8	3.6	25.6	2.6	27.0	3.6	0.5	2.4	-0.4	2.1	0.026	0.027	0.13

	Total Cohort				Completers								P value for time effect	P value for gender effect	P value for time by gender effect
	Baseline				Baseline				Change from baseline						
	Male (n =11)		Female (n = 25)		Male (n = 8)		Female (n = 24)		Male (n = 8)		Female (n = 24)				
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
SLUMS	21.4	5.8	22.5	5.4	22.1	6.1	22.7	5.4	-0.9	5.6	1.1	3.4	0.14	0.27	0.10
GDS	2.2	1.3	2.4	2.2	2.1	1.5	2.3	2.1	0.6	1.7	0.5	2.1	0.14	0.90	0.57
AQoL	22.3	5.7	20.9	5.3	20.9	5.2	20.7	5.3	0.1	3.0	-0.2	3.6	0.021	0.37	0.10
PSQI	7.4	2.6	8.9	3.6	7.4	3.1	9.0	3.7	-0.5	1.3	-0.5	3.1	0.61	0.10	0.99
ISEL	41.6	6.9	45.0	9.6	42.5	7.2	45.5	9.5	1.6	4.8	-2.1	7.4	0.057	0.057	0.35
Blood parameters‡															
SBP (mmHg)	122.2	24.4	129.1	18.3	117.6	23.2	129.8	18.4	18.8	27.0	-4.5	13.8	0.30	0.67	0.07
DBP (mmHg)	72.1	13.6	67.3	12.8	69.3	13.8	67.8	12.8	6.3	18.7	-0.5	13.1	0.60	0.044	0.59
Heart Rate	76.4	11.9	77.0	11.4	75.4	13.8	77.4	11.5	-1.4	13.3	0.3	12.2	0.78	0.47	0.61
Hb	132.9	23.3	124.1	11.0	124.8	18.3	124.1	11.0	-4.0	6.7	-0.6	7.5	0.70	0.08	0.80
RBC	4.4	1.2	4.1	0.4	4.0	1.0	4.1	0.4	-0.1	0.3	0.0	0.2	0.53	0.45	0.52
PCV	0.4	0.1	1.9	7.2	0.4	0.1	1.9	7.2	0.0	0.0	-1.5	7.2	0.58	0.60	0.59
MCV	92.6	8.5	91.4	5.4	93.8	9.3	91.4	5.4	-2.2	3.4	-1.8	3.6	0.41	0.38	0.82
MCH	31.0	3.2	30.2	2.1	31.8	3.5	30.2	2.1	-0.2	0.8	-0.2	0.9	0.76	0.10	0.59
MCHC	334.4	8.4	329.9	12.0	338.8	9.8	329.9	12.0	6.0	4.5	4.6	9.0	0.040	0.043	0.42
RDW	15.0	3.1	14.1	1.1	14.0	0.7	14.1	1.1	-0.3	0.3	-0.5	2.2	0.10	0.57	0.38
WBC	7.3	2.6	8.9	2.7	6.1	1.5	8.9	2.7	0.7	1.2	-0.3	3.0	0.62	0.049	0.84
Neutrophils	4.8	1.9	6.1	2.6	4.3	1.4	6.1	2.6	0.7	0.9	-0.3	3.0	0.75	0.15	0.95
Lymphocytes	1.6	0.5	2.0	0.8	1.3	0.3	2.0	0.8	0.0	0.1	0.1	0.6	0.85	0.009	0.39
Monocytes	0.4	0.2	0.5	0.2	0.3	0.1	0.5	0.2	0.0	0.2	0.0	0.2	0.80	0.06	0.77
Eosinophils	0.4	0.3	0.3	0.2	0.2	0.1	0.3	0.2	0.0	0.0	-0.1	0.2	0.12	0.19	0.70
Basophils	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.016	0.21	0.58
Platelets	263.5	52.6	290.7	76.7	239.3	46.4	290.7	76.7	-19.0	23.5	-9.5	41.5	0.22	0.042	0.43
CRP	6.3	7.2	7.7	13.9	6.3	8.9	7.7	13.9	10.6	22.9	6.8	51.2	0.50	0.97	0.92

* ANCOVA test to determine the effects of time, gender and time by gender interaction; [$] n at baseline = 27 for total cohort, and 24 for completers; [#]n = 20 (6 male and 14 female); [‡]n at baseline = 31 for total cohort, and 27 for completers

Body weight and composition

Sixty two percent of the older participants were weight stable, defined as weight loss or gain less than 2.5%; while 19% lost and another 19% gained ≥2.5% of baseline body weight during the 6 months of follow up (n = 32). Of those subjects that experienced a change in body weight 3% lost and 13% gained 5% or more weight. As a result of the comparable weight changes on both ends of the spectrum on average body weight and body mass index (baseline: all: 71.0 ± 14.5 kg, 28.7 ± 4.6 kg/m2; men: 80.2 ± 10.2 kg, 27.5 ± 4.3 kg/m2; women: 67.2 ± 11.3 kg, 29.5 ± 4.5 kg/m2; gender effect: P = 0.049, P = 0.92) did not change during the 6 months of follow up (0.??? ± 2.3 kg, 0.1 ± 1.0 kg/m2, time effect: P = 0.59, P = 0.71; men: decrease of 0.62± 1.95 kg and 0.17± 0.69 kg/m2; women: increase of 0.25± 1.95 kg and 0.14± 1.04 kg/m2, gender effect: P = 0.35, P = 0.45; interaction effect of gender by time: P = 0.56 and P = 0.63).

Fat free mass was stable (less than 2.5% change) in 45% of the older people, while 10% had a stable fat mass (n = 20, ***Table 16***); 25% lost and 30% gained ≥2.5% fat free mass, while 45% lost and 45% gained ≥ 2.5% fat mass. Of those 10% lost and 20% gained ≥5% fat free mass and 35% lost and 35% gained ≥5% fat mass. On average, fat free mass (baseline: all: 45.3 ± 9.1 kg; men: 57.7 ± 3.7 kg; women: 40.0 ± 3.7 kg; gender effect: P < 0.001) did not change during the 6 months of follow up (all: 0.6 ± 2.4 kg, time effect: P =0.89; men: 0.1 ± 2.0 kg; women: 0.8± 2.5 kg, gender effect: P = 0.54; interaction effect of gender by time: P = 0.78). Similarly, fat mass and percentage (baseline: all: 24.8 ± 8.0 kg, 35.1 ± 9.4% ; men: 22.9 ± 6.9 kg, 27.9 ± 4.9%; women: 25.7 ± 8.5 kg, 38.2 ± 9.3%; gender effect: P = 0.74, P = 0.23) were stable during the 6 months of follow-up (all: decrease of 0.2 ± 2.7 kg, 0.5 ± 3.4%, time effect: P = 0.99, P = 0.96; men: decrease of 0.2 ± 2.5 kg, 0.1 ± 2.7%; women: decrease of 0.3 ± 2.8 kg, 0.6 ± 3.7%, gender effect: P = 0.97, P = 0.76; interaction effect of gender by time: P = 0.99, P = 0.92). Mid-arm and calf circumferences and triceps skin-fold thickness were comparable between genders and baseline and 6-month follow-up (P > 0.05, Table 15).

Table 16. Change in weight, CAMA, fat mass and fat free mass among participants from baseline to 6 months

Variable			Loss ≥ 5%	Loss 2.5 – 5%	Stable	Gain 2.5 - 5%	Gain ≥ 5%
Weight	n	32	1	5	20	2	4
	Percent		3	16	62	6	13
CAMA#	n	32	13	1	4	1	13
	Percent		41	3	12	3	41
Fat Mass	n	20	7	2	2	2	7
	Percent		35	10	10	10	35
FFM*	n	20	2	3	9	2	4
	Percent		10	15	45	10	20

#CAMA FFM; *Fat Free Mass.

Nutritional status

The majority of older men and women (gender effect $P > 0.05$) were well-nourished (baseline and 6-month follow-up: CAMA: malnourished: 6% and 3%, well nourished: 94% and 97%; MNA: malnourished: 0% and 3%, at risk of malnutrition: 28% and 16%, well nourished: 72% and 81%; MUST: high risk of malnutrition: 11% and 9%, medium risk: 6 % and 6%, low risk: 83% and 84%; MST: at risk of malnutrition: 6% and 0%, no risk 94% and 100%; SNAQa: malnourished: 0% and 3%, moderately malnourished: 6% and 0%, well nourished: 94% and 97%; SNAQb: at risk of weight loss: 31% and 22%, no risk: 69% and 78%), but importantly indicated as pre-frail, as measured by the FRAIL (baseline and 6-month follow-up: frail: 42% and 37%, pre-frail 53% and 59%, robust health: 5% and 3%) and FRIED (baseline and 6-month follow-up: frail: 3% and 0%, pre-frail: 92% and 94%, not frail: 5% and 6%) questionnaires.

Energy intake was higher in men than women and increased during the 6-month follow-up in men, but not women (interaction effect of gender by time: $P = 0.056$). Calculated percent recommended dietary and protein intakes for men increased from 106 ± 29% to 125 ± 41% and 127 ± 34% to 142 ± 38%; while women's protein intake increased from 137 ± 32% to 147 ± 59% but their energy intake decreased from 119 ± 27% to 110 ± 35% over the 6 months.

The majority of men and women had low dietary restraint, disinhibition and susceptibility to hunger (baseline and 6 month follow up: low restraint: 89% and 91%, high restraint: 3% and 0%, clinical range of restraint: 8% and 9%; low disinhibition: 92% and 94%, high disinhibition: 9% and 6%; low susceptibility to hunger: 94% and 97%, high susceptibility to hunger: 6% and 3%).

Physical function

Nearly all participants had difficulty with activities of daily living (baseline and 6-month follow-up: ADL: 61% and 75%, IADL: 97% and 100%). SPPB scores, grip strength, gait speed and PASE, ADL and IADL scores were comparable between genders and baseline and 6-month follow-up ($P > 0.05$, Table 15).

Mental status and quality of life

The majority of participants had no cognitive impairment/dementia (baseline and 6-month follow-up: MMSE: 78% and 84%; SLUMS: no: 42% and 50% and mild 30% and 38% neurocognitive disorder, dementia: 28% and 13%), were not depressed (GDS: no depression: 83% and 70%, suggestive of depression: 17% and 22%, depression: 0% and 8%), but had a poor sleep quality (PSQI : good sleep quality: 19% and 28%, poor sleep quality: 81% and 72%). On average, AQoL and ISEL were unchanged from baseline to 6 months (AQoL: 21.3 ± 5.4 and 20.7 ± 4.9, ISEL: 43.9 ± 8.9 and 43.6 ± 9.5, time effect $P > 0.05$). Additionally, MMSE, SLUMS, GDS, PSQI, AQoL, and ISEL scores were comparable between genders and baseline and 6-month follow-up ($P > 0.05$, Table 15).

Blood parameters

Women had higher systolic blood pressure ($P < 0.05$). Other measured blood parameters were comparable between genders and baseline and 6-month follow-up ($P > 0.05$, Table 15).

Relationships with age and exercise

There was negative correlation between diastolic blood pressure, TFEQ factor 2, ADL, and IADL with age at baseline ($r = -0.395, -0.01, -0.438, -0.353$; all $P < 0.05$), while SPPB was positively associated with age ($r = 0.354$, $P = 0.034$). At 6 month follow up, TFEQ Factor 1, ISEL, Hb, and RBC were negatively associated with age ($r = -0.419, -0.389, -0.485, -0.423$; all $P < 0.05$). Only grip strength and fat free mass showed consistent negative association with age at both time points (baseline: $r = -0.383$ and -0.564, $P = 0.021$ and 0.010; 6 months: $r = -0.426$ and -0.591, $P = 0.015$ and 0.006).

On the other hand, participation in exercise activity (exercise duration) was positively associated with grip strength, MNA, PASE and fat fee mass at baseline ($r = 0.346, 0.424, 0.435$ and 0.424, all $P < 0.05$). At 6 months, exercise duration was positively correlated with CAMA, grip strength, MNA, SNAQb, PASE, and energy intake ($r = 0.419, 0.699, 0.374, 0.356, 0.679$ and 0.496, all $P < 0.05$), while GDS, AQoL, FRAIL, IADL, and PSQI were negatively associated with exercise duration ($r = -0.370, -0.406, -0.547, -0.427$ and -0.410, all $P < 0.05$). Further analysis showed that participants who engaged in regular exercise had improved triceps skinfold thickness (1.2 ± 2.6 vs. -0.9 ± 2.6 mm, $P = 0.034$), SPPB scores (0.6 ± 1.7 vs. -0.8 ± 1.8, $P = 0.027$), and were less at risk of weight loss (SNAQb scores: 0.5 ± 1.3 vs.-0.7 ± 1.5, $P = 0.024$) compared to non-regular exercisers. Moreover, multivariate analysis adjusting for gender and time point, showed that exercise and exercise by age interaction (but not age alone) were significantly associated with FFM and grip strength (FFM: $P = 0.046$ and 0.050, Grip strength: $P = 0.001$ and 0.002). Comparison of age and exercise effects on FFM and grip strength is shown in ***Figure 11.***

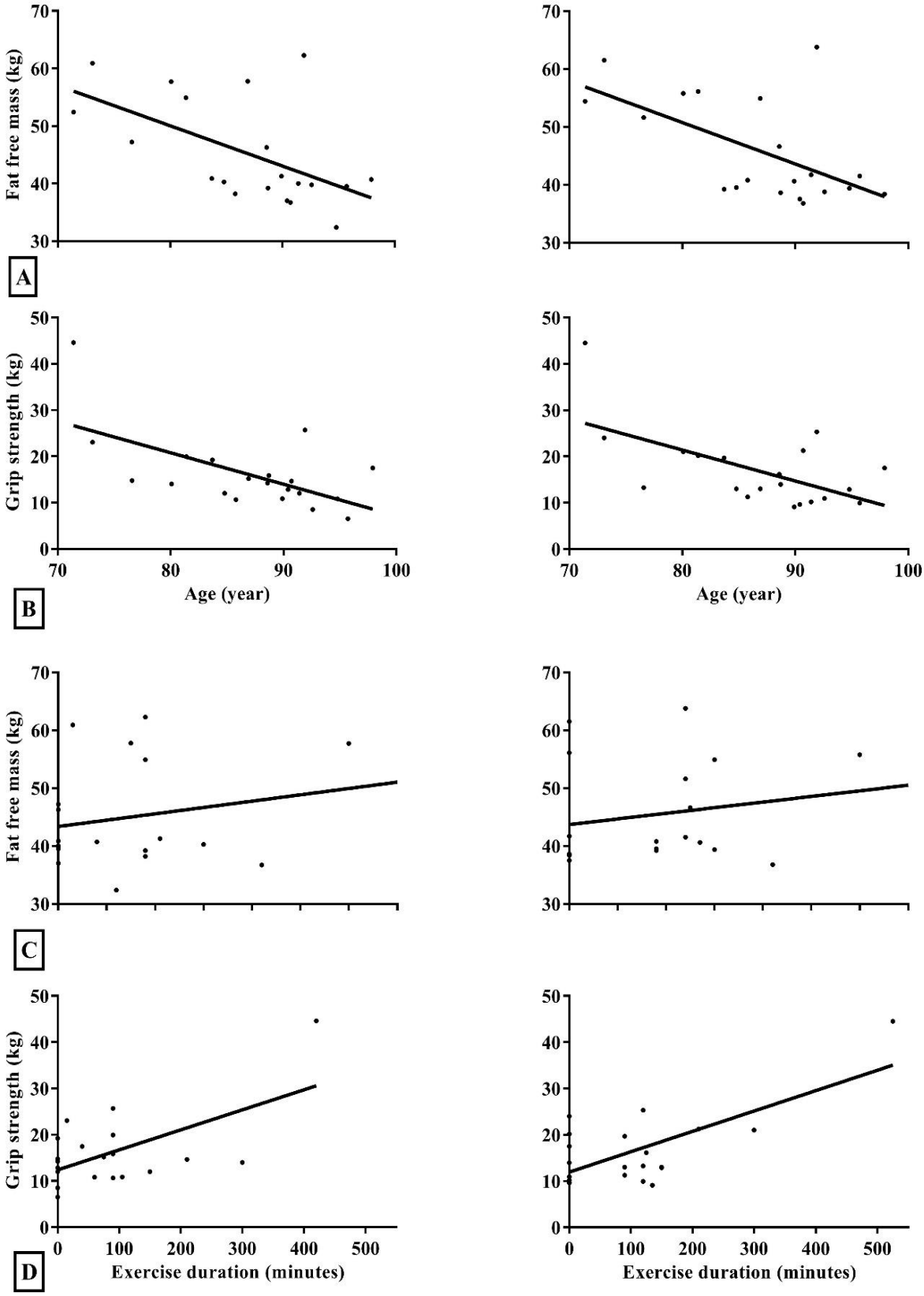


Figure 12. Association between age with fat free mass (A) and grip strength (B) at baseline and 6 months, and exercise duration with fat free mass (C) and grip strength (D) at baseline and 6 month.

4. Discussion

In the present study, the average body weight of participants did not change over 6 months. This is somewhat at odds with our previous findings from a retrospective study of the same population, which showed weight loss of 0.4±4.1kg (0.5±6.4%) over 6-months (83), in line with other nursing home based studies (162, 184, 185) where weight loss was around ≥ 5% over one year in 75% of nursing home residents (184) and ≥ 5 kg (~7.5%) over one year in 11% of residents (185). The minimal weight change observed in the present study can probably be accounted for by recruitment methods; participants had better health condition than their peers who did not take part in the study as evident by high participation in exercise activity 3 or more times/week for at least 30 minutes both at baseline (61% of participants) and 6 months (50% of participants).

Nevertheless, body composition (i.e. CAMA , fat free mass, and fat mass) changed dramatically, with 82% gained or lost more than > 5% CAMA, 70% gained or lost > 5% fat mass, and 30% gained or lost >5% fat free mass over 6 months. Additionally, fat free mass and grip strength were decreased, while fat mass increased with increasing age. These findings were comparable to a 10 year longitudinal study of 131 men and women aged 60.4 ± 7.8 years which showed that based on hydro densitometry results, fat free mass was decreased among weight stable participants, fat free mass was decreased in men by 2.0% per decade, and fat mass increased by 7.5% per decade in both gender (223). Similarly, a 2 year longitudinal study of 26 African American women aged 75.5 ± 5.1 year indicated that based on Magnetic Resonance Imaging (MRI) results, age was associated with change in body composition and there was significant losses of total skeletal muscle (−0.72 ± 0.72 kg; $P < 0.001$), while visceral adipose tissue was increased (0.19 ± 0.35 kg; $P = 0.011$) over the study period (224). Furthermore, cross-sectional study of 248 rehabilitation and nursing home residents showed that increasing age was associated with lower grip strength ($P < 0.05$) (225).

The substantial change of body composition (particularly lean mass loss and fat mass gain) is of concern as it may lead to sarcopenic obesity (226) and has been associated with poor physical

impairment, disability, and poor clinical outcomes in older people (227-230). A cross-sectional study of 4,504 adults aged 60 and over from the Third National Health and Nutrition Examination Survey (NHANES III) demonstrated that after adjustment of confounding variables, sarcopenia class I and II was associated with increased (p<0.05) ORs for having difficulty in performing various physical activity such as stooping/crouching/kneeling, climbing 10 stairs, and lifting/carrying 10 pounds (227). Another study of community-based cohort of 1,655 older women and men found that increased fat mass was associated with slower walking speed and higher probability of functional limitation (228). A study of 98 post-menopausal women showed that women with high visceral adipose tissue had a significantly higher fasting glucose (120 ± 50 vs 98 ± 39), insulin (7.9 ± 10 vs 5 ± 8), triglycerides (172 ± 69 vs 127 ± 72), apolipoprotein B (119 ± 24 vs 98 ± 32) and significantly lower HDL-C (38 ± 10 vs 46 ± 14) than those with low visceral adipose tissue (229).

It is important to note that increased physical activity could potentially attenuate the effect of age and slow the decline of fat free mass, nutritional status, and physical function as evident by improved triceps skinfold thickness, SNAQb and SPPB scores among participants who exercise regularly at 6 months follow up compared to non-exercisers (all P < 0.05). At the same time, exercise also appeared to improve quality of life, sleep quality, ability to perform daily activities, reduce depression and frailty (all P < 0.05). These findings was in line with an RCT of 100 frail institutionalised older people which showed that 45 minutes high resistance every other day improved muscle strength by 113 ± 8% (vs. 3 ± 9% in non-exercisers, P < 0.001), gait velocity by 11.8 ± 3.8% (vs. 1.0 ± 3.8 in non-exercisers, P = 0.02), stair climbing power by 28.4 ± 6.6% (vs. 3.6 ± 6.7% in non-exercisers, P = 0.01), and cross-sectional thigh muscle area by 2.7 ± 1.8% (vs. decreased by 1.8 ± 2.0% in non-exercisers, P = 0.11) (202). Another RCT conducted in three Nordic countries involving 322 nursing home residents aged > 64 years reported that after 3 months of individually tailored exercise, the intervention group had improved walking /

wheelchair speed and functional leg muscle strength compared to control group who also experienced reduced ADL, balance and transfers (231). Follow up of the same group for another 3 months without further exercise intervention, showed a reversal of previous gains in ADL function, balance and transferability (232), highlighting the importance of continuous regular exercise among long-term care residents whichhas been proven to also reduce the risk of sarcopenic obesity (233), improve physical performance and muscle strength among sarcopenic obese older nursing home residents (234). Finally, it is important to acknowledge the main limitation of this study, which are the small sample size (36% of targeted sample size) and difficult participant recruitment. Both factors might have reduce the power and significance of associations between age, exercise and other covariates. Throughout the 1.5 year duration of the study, the research team employed various strategies to recruit participants, including group presentations by senior research team member, personal approaches to potential residents identified by nursing home managers, presentations during weekly resident activities and interest groups, sending flyers to each resident through the internal mail service, and attaching posters to every notice board in the nursing homes. However, these efforts appeared to have limited impact on residents' willingness to take part in the study. Involvement in other activities in the nursing home, reluctance to commit to a long-term study and lack of perceived benefit from the research were among the most common barriers mentioned by residents and staff. Our experience is certainly not unique, on the other hand, it seems to be common in studies involving older people (235-238). Thus, there need to be attempts to develop better strategies to increase participation, such as one on one approach, and wider involvement of family / relatives, and the nursing home staff during recruitment (237).

5. Conclusion

In conclusion, nursing home residents had negligible weight change, but significant fat free mass and fat mass change over 6 months. There was a trend to increasing fat mass, and declining arm muscle area (CAMA) and fat free mass with increasing age. However, residents who participated in exercise activity had improved muscle mass and function than non-exercisers, lessening the impact of age on these parameters. Thus, nursing home providers must invest and strive to increase participation in regular exercise activities to prevent the decline of muscle mass and function, improve nutritional status, independence and quality of life of their residents.

CHAPTER 5. MEALS ON WHEELS' SERVICES ASSIST NUTRITIONALLY VULNERABLE COMMUNITY-RESIDING OLDER ADULTS MEET THEIR DIETARY REQUIREMENTS AND MAINTAIN GOOD HEALTH AND QUALITY OF LIFE: FINDINGS FROM A PILOT STUDY

Abstract:

Background: Previous studies reported that community living older people, including Meals on Wheels (MOW) recepients, did not meet recommended daily nutritional intakes (RDIs), which increases their risk of becoming malnourished. This study aimed to determine the effect of providing standard (STD) and high energy and high protein (HEHP) MOW meals on energy and protein intakes and clinical outcomes among community-living older people.

Methods: A 12-week, double blinded, parallel group, design study was conducted. Participants were randomised to either a STD (2.3 MJ and 30 g protein per meal) or HEHP (4.6 MJ and 60 g protein), group, and those who did not want MOW meals were included in the control group (CON). Energy and nutrient intake, nutritional status, physical capacity, general and psychological wellbeing, and quality of life and number and length of stay of hospitalisation were measured at baseline and week 12. Intention-to-treat analysis using multiple imputation was used in final analysis for all outcomes.

Results: Twenty-nine participants completed the study (STD=7; HEHP=12; CON=10). From baseline to week 12, the HEHP subjects increased their mean daily energy intake from 6151±376 kJ to 8228±642 kJ (P=0.002 for effect of time) and their mean daily protein intake from 67±4 g to 86±8 g (P=0.014 for effect of time). MNA score was increased significantly in HEHP by 4.0±1.1 points (P=0.001), but not in the STD and CON groups (2.8±2.1 points and 1.8±1.1 points, P>

0.05). No difference between any of the groups was found for the changes from baseline to week 12 in the other clinical outcomes (all Ps for effect of treatment were >0.05).

Conclusion: The HEHP MOW meals increased energy and protein intake and improved the nutritional status of nutritionally at-risk older people, and prevented further deterioration over 12 weeks. Further study with longer duration and involving larger number of older people with poorer intake and nutritional status will likely show greater benefit.

Trial Registration: The study was registered on the Australian New Zealand Clinical Trial Registry (www.anzctr.org.au, Trial number ACTRN12612000986875).

1. Introduction

In Asia, Europe and the US, the prevalence of poor nutrition is high among hospitalised and institutionalised older people and is increasing in community-living adults aged 65 years and older (239, 240). Similar trends are occurring in Australia (241, 242), with ~5-10% of community-living older adults identified as being malnourished and ~30-40% 'at risk' of malnutrition (166, 243, 244). Poor nutrition, particularly energy and protein malnutrition, has significant negative consequences including reduced muscle, cognitive and immune dysfunction, greater hospitalisations (number and length of stay) and premature entry into age-care homes (245, 246); all contribute substantially to increasing national health-care expenditures across the world (247-249).

Access to affordable, high quality nutrition that meets the requirements of older people is pivotal to the prevention and management of undernutrition in older people (249). Meals-on-Wheels (MOW), a community health service provider available in Australia, Canada, Ireland, United Kingdom, and United States, supports older people to live independently by providing healthy meals to their homes (250). Compliance with regulatory guidelines, and understanding the impact of these services on the health and wellbeing of their clients', provides justification for ongoing government subsidisation which is pivotal for financial viability (251).

Previously we have shown that recipients compared to non-recipients of MOW in Australia, had fewer hospital admissions and reduced length of hospital stay over a 12-month period (252). Two other Australian studies have reported that recommended daily intakes (RDIs), including for protein, iron, calcium, thiamine and riboflavin, were not being achieved even though intakes were improved by the provision of standard MOW lunchtime meals; for example, 30-45% of MOW clients still fell short of the RDI for protein despite consuming the meals (78, 253). Another study reported that significant improvements in body weight, and nutritional and functional status (over 6 months) for 'at risk' and 'malnourished' older people were related, predominantly, to body mass

index (BMI) and age, rather than to the nutrition being delivered by 'MOW' in the form of a lunchtime meal (254). The reasons why RDIs were not being met included splitting meals across the day, sharing meals, and large portion sizes that lead to food wastage.

Accordingly, the aim of the study was to determine the effect of providing at least 3 days/week of (i) standard MOW meals or (ii) high energy and high protein (HEHP) for 12 weeks on energy and protein intakes and clinical outcomes (including nutritional status, physical capacity, general and psychological wellbeing, and quality of life and number and length of stay of hospitalisation). We also aimed to determine the level of satisfaction with meals and general service provided by MOW.

2. Methods

Participants

Individuals aged 70 years or greater and perceived to be 'at risk' of poor nutrition and in need of nutritional support were recruited from MOW South Australian Inc., via advertisements on community notice boards from general practice clinics and local hospitals (particularly the dietetic departments); most individuals from the MOW Inc. South Australia database had been referred to that service within ≤3 months. Following referral, each individual was seen by a MOW client assessment officer to explain the study, obtain written informed consent to give permission for their name and contact details to be forwarded to the University research team, and to answer several short questions to determine if they met the following criteria - 1) obvious underweight/frail; 2) reduced appetite; 3) unintentional weight loss over the past year; 4) unable to shop; 5) unable to prepare food for self; 6) is unable to feed self; 7) mouth or teeth swallowing problems; 8) obvious overweight affecting quality of life; 9) unintentional weight gain over the past year; 10) special diet. Individuals identified as having 3 or more of these 10 eligibility criteria were referred a member of the research team to determine full eligibility for the trial - inclusion

criteria included a Mini Nutritional Assessment (MNA) score > 17 ≤ 23.5 and or a Body Mass Index (BMI) < 24.0 kg/m^2 plus having reported reduced appetite or unintentional weight loss over the past year and unable to shop or prepare food, and exclusion criteria included clinical diagnosis of dementia, or significant depression, or who were severely malnourished.

Individuals were allocated to the control group when they met the eligibility criteria but for personal reasons (i.e. received help with meals from family or friends, perceived themselves to be healthy, or refused assistance) did not want MOW meals. Individuals were free to withdraw from the study at any time without affecting their ongoing or future relationship with MOW or the research team.

Ninety-five older individuals who had been on the MOW database for less than ~ 3 months and were only purchasing 1 to 2 meals weekly, or intermittently, were referred to the study. An additional 22 individuals were referred from other sectors of the community including the database of the Royal Adelaide Hospital Testosterone Study (i.e. N=17) and self-referral (N=5). Of these 117 individuals, 29 did not have three or more of the key criteria and 47 did not wish to participate for various personal reasons including being too busy or waiting to be admitted to a hospital or nursing home.

Study Design

This pilot study had a 12-week, double blinded, parallel group, design. The study was conducted between September 2012 and September 2013 at Flinders University and the University of Adelaide, Adelaide, Australia. MOW recipients were randomised to either the standard-meals group (STD) or, the high energy and high protein group (HEHP). In addition, there was a Control group which contained eligible participants who declined MOW services (CON). Both the recipients of MOW services and the researchers were unaware of meal allocation; meal were allocated by MOW staff who took no part in data collection or analyses. Meals were provided for at least three days per week. The Southern Adelaide Clinical Human Research Ethics Committee and the University of Adelaide Human Research Ethics Committee approved the study. The trial

was registered with the Australia and New Zealand Clinical Trial Registry (www.anzctr.org.au, registration number ACTRN12612000986875). All participants provided written, informed consent, prior to their inclusion.

Nutritional intervention

At baseline, prior to commencing the intervention, the STD and HEHP, groups, received one hour of dietetic counselling from a qualified dietitian who estimated each individuals' energy requirements using the Schofield equation and other nutrient requirements based on Australian Nutrient Reference values (210). Individuals were given strategies on how to achieve their RDIs.

In addition to basic dietetic counselling and monitoring, participants who were randomised to either STD or HEHP received MOW meals that were cooked by one of three trained chefs who were full-time employees of MOW Inc. South Australia and, packed at a commercial kitchen facility located at Kent Town, Adelaide. All meals represented the typical 3-course hot lunchtime meal provided by MOW Inc. South Australia and as such included a soup, a main dish and a dessert. The prescribed STD meals contained ~33% estimated daily energy and protein requirements (i.e. ~2.3 MJ; 30 g protein) while the prescribed HEHP meals contained ~ 66% of estimated energy and protein requirements (i.e. 4.6 MJ; 60 g protein). The energy and protein content of the HEHP meal was manipulated by fortifying the recipes of the soups and desserts with skim milk powder, Beneprotein, Sustagen Hospital Formula (supplied from Nestlé Australia Ltd, New South Wales, Australia), cream and custard. Recipes for the HEHP main course remained largely the same as for the STD main course; the only exception being for the gravies/sauces which had extra cheese, margarine, or oil incorporated. Participants consumed their usual home-prepared food for other meal times throughout the day.

Outcome assessment methods

All outcomes were determined at baseline and week 12 by a trained research dietitian and all measurements were performed in the homes of participants.

Energy and macronutrients intake were determined at baseline and week 12 using multi-pass dietary recalls performed over 3 consecutive days by dietitian face-to-face with the subjects (2 week and 1 weekend day (255, 256).

Nutritional status was determined using indices of: 1) BMI, in which body weight was measured using Tanita digital scales (Model BF-679W, Western Australia, Australia) while participants wore light clothing and no shoes and height was measured using a portable stadiometer (Seca 213 Potable Stadiometer, Seca, CA, USA), 2) skin-fold at mid-arm, 3) the circumferences of mid-arm and calf, 4) Mini Nutritional Assessment (MNA; a score of <17 indicates that the participant is malnourished, 17-23.5: at risk of malnutrition, >23.5: well nourished) and 5) the Simplified Nutritional Appetite Questionnaire (SNAQ; a score of ≤14: significant risk of ≥5% weight loss within 6 months, >14: no risk of weight loss) questionnaires (208, 257). Physical capacity was determined from the following indices: 1) handgrip strength test using a calibrated dynamometer (Jamar Dynamometer, IL, USA) (cut of scores for frailty in women if : ≤17 kg for BMI ≤ 23 kg/m^2, ≤17.3 kg for BMI 23.1 – 26 kg/m^2, ≤18 kg for BMI 26.1 – 29 kg/m^2, and 21 kg for BMI > 29 kg/m^2, and men if: ≤29 kg for BMI ≤24 kg/m^2, ≤30 kg for BMI 24.1 – 26 kg/m^2, ≤ 30 kg for BMI 26.1 – 28 kg/m^2, and ≤ 32 kg for BMI >28 kg/m^2) and, 2) gait speed measured using the self-paced 3-meter walk test (<0.4 m/s: household ambulators, 0.4 - 0.8 m/s: limited community ambulators, and >0.8 m/s: community ambulators) (213, 258, 259). Both anthropometric and physical capacity measurements were performed in triplicate and, the average of the three values, were represented the final values used in the analysis.

General wellbeing and quality of life over the last week were determined using the Hawthorne Quality of life questionnaire (AQoL; Continuous scale between 0 and 30, with lower scores indicating better quality of life). Psychological wellbeing was determined using the Geriatric Depression Scale questionnaire (GDS; a score of >5: suggestive of depression, >9: almost always depression) (219, 220).

Hospital admission, length of hospital stay (LOS) and frequency of falls over the last three months were self-reported by participants and or their family at time of incidence and level of satisfaction with meals and general service provided by MOW including strengths and weaknesses were determined using anonymous survey at week 12.

Data analysis

The dietary recalls were analysed using FoodWorks version 6.2 (Xyris Software, Highgate Hill, Queensland, Australia) and the Australian nutrient composition database (260). Nutrient contents of the STD and HEHP meals were calculated based on recipes provided by the MOW South Australia Inc. Additionally, where participants consumed homemade meals or snacks, the nutrition information panels from all food products/ingredients used within the recipe were used to estimate the nutrient composition per serve. For each participants, measurements of each daily nutrient intake was expressed as a percentage of their RDIs. For each question in the meal and service survey, the frequency of respondents to each answer was determined.

One-way analysis of variance (ANOVA) and independent samples t-tests were used to compare differences in all baseline characteristics, and to determine differences between participants classified as completers (as per protocol) and non-completers.

There were 30% (n=12) of participants who did not complete the 12 week pilot study as per protocol, and therefore intention-to-treat analysis using multiple imputation (using 20 imputations for all outcomes) was used to determine the effect of group on the change from baseline to week 12 for all outcomes; this type of analysis reduces bias that occurs if only completers data was analysed and provides a more valid estimates (261). For each nutritional outcome a multiple imputation model was derived that included: *(1)* baseline variables that were associated with the probability of missing data at week 12, *(2)* variables that were associated with the week 12 outcome amongst participants with observed data, and *(3)* variables pre-defined to be included in the analysis model. Continuous nutrient and clinical outcomes were analysed using analysis of covariance (ANCOVA) of the change from baseline to week 12 values with fixed effects for

treatment group, age, gender, baseline energy and the baseline value of the corresponding outcome. Pairwise contrasts, adjusted for multiple comparisons by Tukey HSD, were used to test for a difference between each intervention group and control (i.e. STD vs CON and HEHP vs CON). Frequency of hospital admissions, length of hospital stay and frequency of falls were categorised and analysed using ordinal regression and included the same confounders as listed above. All statistical analyses were performed by SPSS (v.21.0 for Windows, IBM Corp, Armonk, NY, USA).

The data presented in the results sections 3.2-3.4, represent the unadjusted means and standard error of the means (SEMs) from multiple imputation model because we found consistent and comparable levels of statistical significance for both completers as per protocol and intention-to-treat analyses.

3. Results

Participants

Forty-one adults commenced the 12-week study (STD=16; HEHP=14; CON=11) and 29 participants completed the study (STD=7; HEHP=12; CON=10) – the number of participants initially allocated to STD and HEHP were unbalanced because a husband and wife were enrolled and randomised to STD but, approximately 1-week after randomisation, it was discovered the husband was ineligible as he was moving into a nursing home. Reasons for withdrawal were comparable between STD and HEHP groups (***Figure 12***). There were no differences in baseline characteristics between the STD, HEHP or CON groups or, between the completers and non-completers and (***Table 17***, $P>0.05$).

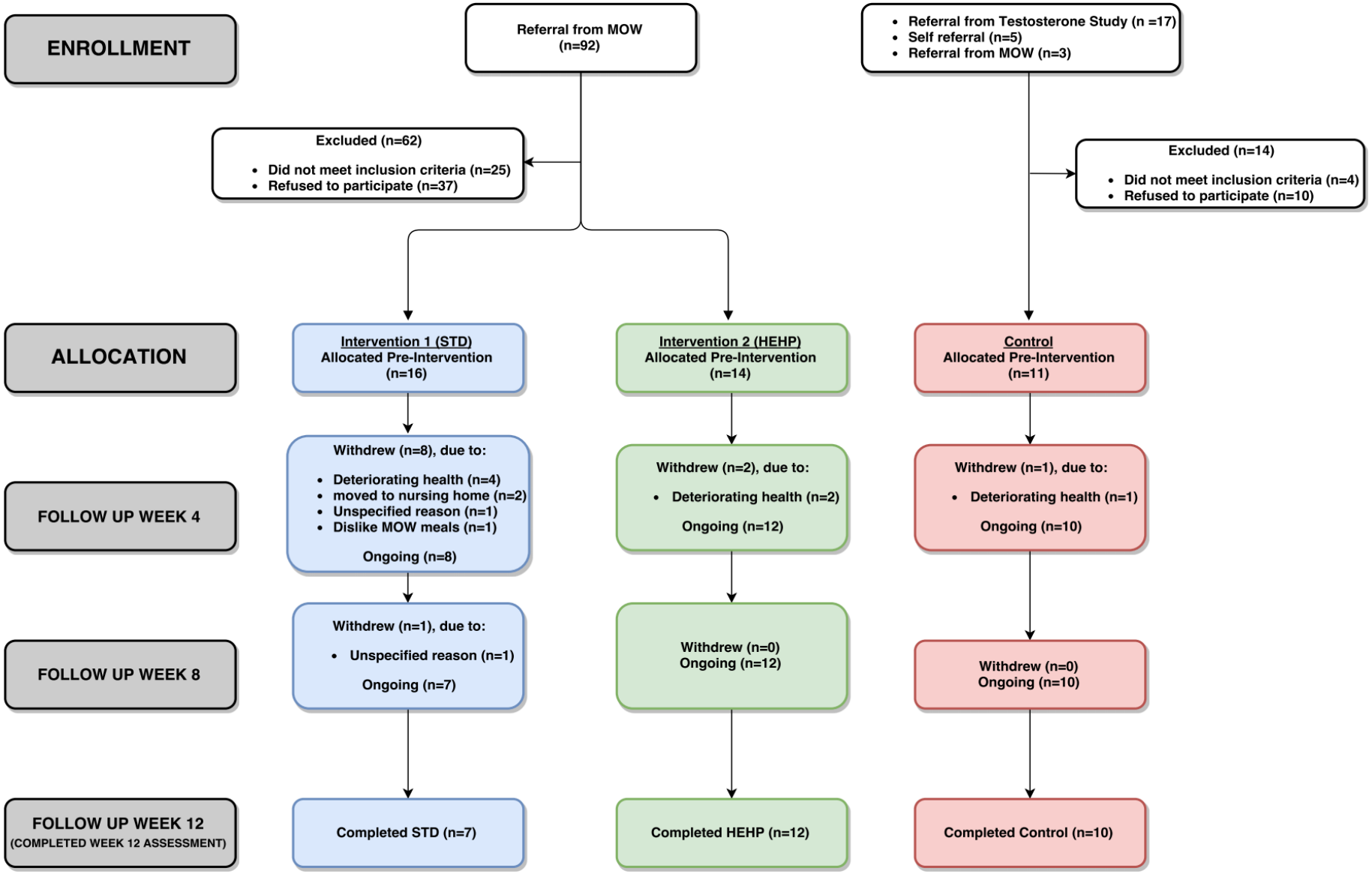


Figure 13. Flow of participants through the study

Table 17. Baseline characteristics of the total participants, completers and non-completers[^*]

	Total Enrolled (n=41)	**Completers (n=29)**	**Non-completers (n=12)**
Male/Female (n)	19/22	13/16	6/6
Age (year)	83.9 ± 0.9	83.1 ± 1.1	85.7 ± 1.9
Height (m)	1.63 ± 0.09	1.63 ± 0.01	1.63 ± 0.03
Body weight (kg)	58.0 ± 1.6	57.3 ± 1.7	59.8 ± 3.6
BMI (kg/m^2)	21.9 ± 0.6	21.7 ± 0.7	22.2 ± 1.0
Self-reported percent weight loss in the previous 3 months	4.0 ± 1.0	4.9 ± 1.3	1.9 ± 1.0
Number of medications	7.1 ± 0.6	7.2 ± 0.8	7.0 ± 0.7
Multivitamins / minerals	2.0 ± 0.3	2.2 ± 0.4	1.2 ± 0.3
Number of unmet needs based on MOW assessment	3.7 ± 0.2	3.7 ± 0.2	3.6 ± 0.4
Living status (N):			
Alone	26	17	9
With significant others	15	12	3
Require nutrition support (N)			
Yes	14	10	4
No	27	19	8
MOW referral source (N)			
Self	17	6	1
Health professional	20	3	4
Family	27	7	3
Hospital	23	5	3
Doctor	13	3	1
Friends	0	1	0
Others	0	4	0

Data presented as unadjusted Mean ± SEM or N; [^]One-way ANOVA was used to compare differences between completers against dropouts, for all baseline characteristics; [*]There were no significant differences between Completers vs Non-completers, for any of the baseline characteristics (all Ps >0.05).

Nutrient intakes

The HEHP group had significantly increased energy, protein, total fat, saturated fat and carbohydrate intake from baseline to week 12, while no significant changes were found in STD and CON groups (***Table 18*****).** In addition, for HEHP compared with CON, the magnitude of change from baseline to week 12 was greater for total fat (HEHP: 9±3 vs CON: -0.2±6 g per day), saturated fat (HEHP: 9±3 vs CON: -0.2±6 g per day), and sugar (HEHP: 9±3 vs CON: -0.2±6 g per day) (all

Ps for effect of treatment were <0.05; Table 17), whereas the change from baseline for each of these nutrients was not different between STD and CON (all Ps for effect of treatment were >0.05, Table 17).

Figure 13 shows that after 12 weeks of intervention, the HEHP compared with the CON reported greater energy intakes at morning tea, lunch and afternoon tea, and protein intakes were greater at lunch and afternoon tea (Ps <0.05 for all time-by-group interactions). Figure 2 also highlights that for both the STD and CON, there was no significant increase in either energy or protein from baseline to week 12 at any eating occasion (Ps all >0.05).

At week 12, the MOW meals provided the HEHP group with a significantly higher percentage of their RDI for energy (67±16% vs 39±16%, P=0.003) and protein (87±21% vs 51±20%, P=0.005) than the STD group. For overall intake throughout the day, all groups met their daily energy requirement and most of the nutrient requirements at baseline and week 12, except for calcium and fibre (***Table 19***). The percentage of RDIs achieved during this intervention for micro-minerals or trace elements could not be determined using the multiple imputation model because there was a large degree of variability in those data that was actually reported by the completers.

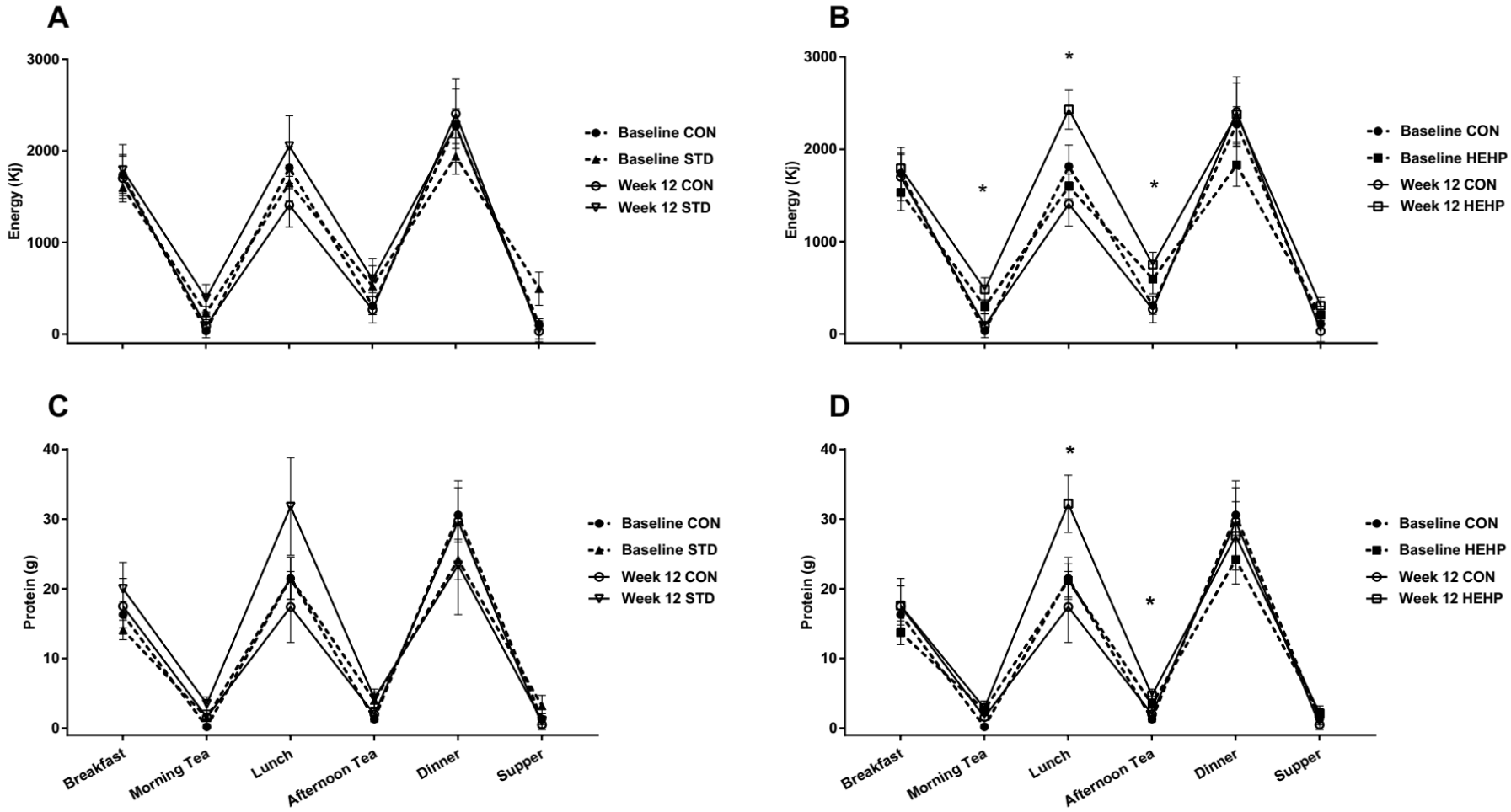


Figure 14. Patterns of energy and protein intake for STD vs CON (A and C) and HEHP vs CON (B and D)[#]

[#]Data presented as unadjusted mean energy and protein intakes at various eating occasions throughout the day at baseline and week 12; One-way ANOVA was used to compare differences in baseline parameters between the three groups and there were no significant differences between groups (all Ps >0.05); ANCOVA of the week 12 data was performed using fixed effects for treatment group, age, gender, baseline energy and the baseline value of the corresponding outcome; *Significant difference between HEHP and CON at week 12.

Table 18. Total daily nutrient intakes at baseline and change from baseline to week 12 for STD, HEHP and CON[^#]

Data presented as unadjusted Mean ± SEM derived from **intention-to-treat analysis using multiple imputation (i.e. 20 imputations per outcome)** which reduces the bias of using completers only data; [^]One-way ANOVA was used to compare differences in baseline parameters between the three groups, and there were no significant differences between groups (all Ps >0.05); [#]ANCOVA of the change from baseline to week 12 data was performed using fixed effects for treatment group, age, gender, baseline energy and the baseline value of the corresponding outcomes; [†]P values from paired t-test of baseline and week 12; [‡]P values from adjusted ANCOVA test; [*]Significant difference P < 0.05; STD: standard group, HEHP: high energy and protein fortified group, CON: control group.

Nutrients	**STD**		**HEHP**		**CON**		**P value change from baseline for STD[†]**	**P value change from baseline for HEHP[†]**	**P value change from baseline for CON[†]**	**P value STD vs. CON[‡]**	**P value HEHP vs. CON[‡]**
	Baseline (n=16)	**Change from baseline (n=16)**	**Baseline (n=14)**	**Change from baseline (n=14)**	**Baseline (n=11)**	**Change from baseline (n=11)**					
Energy (kJ)	6512 ± 376	635 ± 979	6151 ± 376	1958 ± 621	6278 ± 468	211 ± 422	0.52	0.002[*]	0.62	0.52	0.06
Protein (g)	68 ± 6	17 ± 17	67 ± 4	18 ± 7	71 ± 5	-0.5 ± 8	0.32	0.014[*]	0.18	0.61	0.34
Total fat (g)	55 ± 5	6 ± 12	51 ± 5	19 ± 8	51. ± 4	-0.2 ± 6	0.62	0.018[*]	0.97	0.26	0.021[*]
Saturated fat (g)	22 ± 2	3 ± 4	21 ± 2	9 ± 3	23 ± 2	-2 ± 3	0.50	0.007[*]	0.42	0.15	0.004[*]
Carbohydrate (g)	196 ± 17	-5 ± 29	180 ± 11	43 ± 18	173± 12	6 ± 13	0.85	0.021[*]	0.63	0.81	0.09
Sugars (g)	97 ± 12	-9 ± 16	100 ± 11	11 ± 9	85 ± 9	-5 ± 11	0.56	0.20	0.66	0.61	0.049[*]
Fibre (g)	17 ± 2	-0.1 ± 8	17 ± 2	2 ± 3	19 ± 2	5 ± 5	0.98	0.53	0.27	0.32	0.52
Vitamin C (mg)	75 ± 15	3 ± 30	74 ± 12	10 ± 19	77± 16	-2 ± 13	0.93	0.59	0.90	0.84	0.65
Calcium (mg)	824 ± 101	200 ± 211	887 ± 68	181 ± 98	801 ± 110	-32 ± 107	0.35	0.07	0.76	0.41	0.17
Iron (mg)	10 ± 1	-0.4 ± 2	7 ± 1	2 ± 1	10 ± 1	-0.5 ± 1	0.84	0.14	0.70	0.71	0.66

Table 19. Percent Recommended Dietary Intake achieved at baseline and week 12 STD, HEHP and CON[^]

Nutrients	STD		HEHP		CON	
	Baseline (n=16)	**Week 12 (n=16)**	**Baseline (n=14)**	**Week 12 (n=14)**	**Baseline (n=11)**	**Week 12 (n=11)**
Energy[#]	106	116	102	132	102	106
Protein[†]	102	125	103	124	103	102
Total fat	91	94	89	93	88	82
Saturated fat	130	138	130	140	141	115
Carbohydrate	112	98	109	102	103	105
Sugars	108	99	111	122	94	89
Fibre	68	67	68	77	74	95
Vitamin C	166	176	163	190	171	159
Calcium	63	76	68	82	62	62
Iron	119	113	108	133	126	123

Data presented as % of RDIs**;** [^]Based on Australian Nutrient Reference values; [#]Based on individual energy requirement calculated using Schofield equation; [†]Based on individual protein requirement of 1.2 g/kg body weight.

Clinical outcomes

Table 20 shows that there was significant increase in MNA score from baseline to week 12 in HEHP, but not STD and CON groups. Additionally, triceps skinfold thickness was significantly reduced in CON, but not HEHP and STD groups. There was no difference between any of the groups for the changes from baseline to week 12 for the markers of nutritional status, physical function, quality of life or psychological wellbeing (all Ps for effect of treatment were >0.05). ***Table 21*** also shows that by week 12, there was no statistically significant difference between groups for the number or length of stay for hospital admissions, or the number of self-reported falls (all P s for effect of treatment were >0.05).

Surveys

At week 12, ~50% of the 19 participants receiving STD and HEHP meals were either 'very satisfied' or 'satisfied' with the meals, while 16% was 'unsure' and 33% 'dissatisfied' with the meals. Additionally, 83% of participants were 'very satisfied' and 17% were 'satisfied' with the overall service provided by MOW and staff/volunteers who delivered the meal. Furthermore, when asked about affordability of MOW meals and services, more than half (58.5 %) of the older adults 'strongly agree' and 31.7 % 'agree' that MOW meals and services are affordable. Some notable comments from the older adults, such as:

"As a new member, I am very pleased with the quantity and standard of food supplied for $7 daily, and the quality of service is excellent."

"Enjoying MOW because of less preparation for food."

"Meals are affordable if it is actually eaten"

When all participants who completed the study were asked about their nutritional adequacy, nearly 50% perceive themselves as being 'nutritionally adequate' despite the fact that they all had an MNA score ≤ 23.5 indicating they were at-risk of malnutrition; there were more women than men (29 vs 18 %) who felt their nutritional status was not good. Although the majority of participants who received meals rated portion size of their meal as 'just right', 30% rated the

portion size as ‘too much’ (particularly those in the HEHP group [n = 5 vs 1]). Reasons for accepting or declining MOW service appear to relate to the fact that majority of the older adults (64%) are receiving shopping assistance, particularly older women (37.7% compared to 26.7% among men). Furthermore, about a third of the older adults receive support for meal preparation and cooking from family members, carer or friends and also use some types of nutritional supplements (i.e. Milo® and Sustagen®).

Table 20. Clinical outcomes at baseline and week 12 for STD, HEHP and CON[^#]

Clinical Outcomes	STD		HEHP		CON		P value change from baseline for STD[†]	P value change from baseline for HEHP[†]	P value change from baseline for CON[†]	P value STD vs. CON[‡]	P value HEHP vs. CON[‡]
	Baseline (n=16)	Change from baseline (n=16)	Baseline (n=14)	Change from baseline (n=14)	Baseline (n=11)	Change from baseline (n=11)					
MNA score	19.6 ± 0.5	2.8 ± 2.1	18.6 ± 1.2	4.0 ± 1.1	22.0 ± 0.8	1.8 ± 1.1	0.18	0.001[*]	0.10	0.83	0.65
SNAQ score	12.7 ± 0.6	1.5 ± 1.1	12.2 ± 0.6	0.9 ± 0.5	13.9 ± 0.6	0.5 ± 0.6	0.18	0.09	0.38	0.89	0.65
Body weight (kg)	58.9 ± 2.9	0.8 ± 1.3	57.4 ± 3.0	1.1 ± 1.4	57.6 ± 2.0	0.1 ± 1.0	0.56	0.44	0.94	0.28	0.37
BMI (kg/m2)	22.2 ± 0.8	0.8 ± 0.6	21.9 ± 1.3	0.3 ± 0.5	21.4 ± 0.7	0 ± 0.4	0.15	0.58	0.94	0.15	0.46
Calf circumference (cm)	32.1 ± 0.8	0.7 ± 1.1	32.0 ± 0.9	0.6 ± 0.5	32.5 ± 0.7	-0.2 ± 0.3	0.52	0.25	0.61	0.45	0.46
Arm circumference (cm)	24.0 ± 0.8	1.6 ± 1.0	25.1 ± 1.1	0 ± 0.7	25.2 ± 0.7	0 ± 0.5	0.09	0.97	0.98	0.14	0.92
Triceps skinfold (mm)	8.0 ± 1.9	-0.9 ± 1.2	7.9 ± 1.3	-2.0 ± 1.3	9.7 ± 1.5	-1.4 ± 0.7	0.46	0.14	0.032[*]	0.66	0.29
Handgrip strength (kg)	19.5 ± 1.8	0.0 ± 1.7	16.7 ± 1.8	0.4 ± 0.9	21.8 ± 1.8	0.2 ± 1.1	0.99	0.64	0.82	0.97	0.98
Gait speed (m/s)	0.62 ± 0.07	0.06 ± 0.09	0.66 ± 0.07	-0.03 ± 0.05	0.74 ± 0.07	0.05 ± 0.08	0.49	0.51	0.55	0.86	0.24
AQoL	29.7 ± 1.5	0.6 ± 1.5	30.8 ± 1.4	0 ± 1.0	30 ± 1.5	-1.0 ± 1.4	0.72	0.97	0.51	0.59	0.65
GDS	5.5 ± 0.8	0.8 ± 1.2	4.7 ± 0.6	-0.7 ± 0.8	3.9 ± 1.2	0.8 ± 1.0	0.53	0.40	0.44	0.73	0.43

Data presented as unadjusted Mean ± SEM derived from **intention-to-treat analysis using multiple imputation (i.e. 20 imputations per outcome)** which reduces the bias of using completers only data; [^]One-way ANOVA was used to compare differences in baseline parameters between the three groups and there were no significant differences between groups (all Ps >0.05); [#]ANCOVA of the change from baseline to week 12 data was performed using fixed effects for treatment group, age, gender, baseline energy and the baseline value of the corresponding outcome; [†]P values from paired t-test of baseline and week 12; [‡]P values from adjusted ANCOVA test; *Significant difference P < 0.05; STD: standard group, HEHP: high energy and protein fortified group, CON: control group.

Table 21. Hospitalisation and number of falls at baseline and week 12 for STD, HEHP and CON[^#]

Clinical Outcomes	STD		HEHP		CON		P value change from baseline for STD[†]	P value change from baseline for HEHP[†]	P value change from baseline for CON[†]	P value STD vs. CON[‡]	P value HEHP vs. CON[‡]
	Baseline (n=16)	Week 12 (n=16)	Baseline (n=14)	Week 12 (n=14)	Baseline (n=11)	Week 12 (n=11)					
Number of hospital admission (frequency)											
0 admissions	6	5	3	7	6	5	0.11	1.0	0.42	0.25	0.84
1 admission	8	3	9	3	3	2					
2 admissions	1	3	1	2	1	2					
3 or more admissions	1	5	1	2	1	2					
Total admissions	10	11	11	7	4	6					
Length of hospital stay (days)											
0 day	6	6	4	8	6	6	0.12	0.06	1.0	0.66	0.92
1 – 6 days	3	1	5	1	4	2					
7 – 13 days	4	0	2	2	0	1					
14 or more days	3	9	3	3	1	2					
Number of falls (frequency)											
0 falls	10	7	10	10	8	7	0.40	0.56	0.95	0.54	0.63
1 fall	5	5	2	3	1	2					
2 falls	0	4	1	1	2	2					
3 falls	1	0	1	0	0	0					

Data presented as unadjusted frequency derived from **intention-to-treat analysis using multiple imputation (i.e. 20 imputations per outcome)** which reduces the bias of using completers only data; [^]One-way ANOVA was used to compare differences in baseline parameters between the three groups, and there were no significant differences between groups (all Ps>0.05); [#]Frequency of hospital admissions, length of hospital stay and frequency of falls were categorised and analysed using ordinal regression using fixed effects for treatment group, age, gender, baseline energy and

the baseline value of the corresponding outcome; †P values from paired t-test of baseline and week 12; ‡P values from adjusted ANCOVA test; *Significant difference $P < 0.05$; STD: standard group, HEHP: high energy and protein fortified group, CON: control group.

4. Discussion

Our findings indicate that the energy- and protein-enhanced HEHP MOW meals significantly increased energy and macronutrient intakes, and MNA score after 12 weeks, whereas neither the CON or STD program increased these intakes over 12 weeks. However, despite these improved intakes, there was no significant differential effect of either type of MOW meal when compared with the CON, on the other markers of physical capacity, general and psychological wellbeing, quality of life or hospitalisations. This is mainly due to the fact that participants in all groups were not markedly malnourished, as evident from good nutritional intake being observed at baseline. It is likely that older people who have poorer intake and lower BMI than participants of this study, would likely see greater benefit from the intervention. Our findings indicate that energy- and protein-enhanced meals are an effective strategy to help vulnerable older adults aged 70 years and older to improve nutritional status and achieve their RDIs, especially for energy, protein, carbohydrate, and total fat. These results were unanticipated and very intriguing, considering that a review by our group indicated that older adults had 16 – 20% lower energy intake (for both postprandial state and over 24 hour), 25% (after overnight fasting) to 39% (in a postprandial state) lower hunger, and 37% (after overnight fasting) greater fullness than younger adults (262).

The magnitude of change in nutrient intakes reported here is also consistent with findings from previous studies (254, 263, 264), and especially those that have measured pre- and post-intervention intakes from consumers compared with non-consumers of MOW, assessed over 8 weeks (265, 266). For example, a quasi-experimental study by Roy and Payette reported mean daily energy and protein intakes were increased by 10 and 16 % (and provided on average 119% of RDI for protein) among frail consumers of MOW meals compared with non-consumers whose intakes remained stable (265); this is comparable to the improvement observed within the HEHP group for mean daily energy but a notable difference was that our participants were already

consuming more than 100% of their RDIs at baseline (i.e. in our study, mean daily intakes of both energy and protein increased by 10% from baseline and represented 116±17% and 188±37% of RDI by week 12). Similarly, a recent 8 week observational study conducted in the US of 51 older home-delivered meal clients (mean age of 74.11 years, 58% at risk of malnutrition and 34% malnourished) indicated that mean daily energy intake was substantially and significantly increased from 5.7 to 6.8 kJ/d and, that mean protein intake was increased from 54.1 to 73.7 g/day (266). However, a point of difference between the study by Wright *et al*. and our study, again highlights that individuals receiving MOW in US reportedly have mean baseline energy and protein intakes substantially lower than in the present study for either the STD and HEHP groups; instead, US recipients of MOW reported intakes that were comparable with our CON group. In addition to differences in nutrient intakes at baseline, 34% of the participants in the study by Wright *et al.* [33] were malnourished and therefore were probably less likely to be able to eat all the food provided, or more likely to eat less at other meals due to increased sensitivity to the gastrointestinal and hedonic effects of nutrients (79, 267). In fact, our survey data also indicated that the 30% of our participants, and particularly those in the HEHP group, reported the meal size as 'too much' and therefore consumed the main component of the 3 course meal at lunch and ate the soup and dessert for afternoon tea or dinner. In contrast, ~33% of our participants in the both STD and HEHP groups, were supplementing their intakes with other foods including sandwiches, Milo®, milk, Sustagen®, and fruit, suggesting that the provision of smaller meals and/or snacks from MOW services may be warranted to decrease older adults feeling overwhelmed by large meal size and experiencing feelings of guilt that they cannot eat it all, or that it is not affordable because the food spoils before eat it. However, a separate Australian pilot study has reported not all MOW clients at risk of malnutrition perceived the snacks to be beneficial to them after 4 weeks and concluded other strategies to improve the nutritional and health status of older adults may be more appropriate (263).

While our findings demonstrate that the CON, STD and HEHP, groups, had comparable effects on maintaining markers of nutritional status, it should be noted that the HEHP group did experience significant increases in MNA scores, and (albeit not significant) body weight that if sustained may confer a clinical benefit – i.e. total MNA score was increased by 4.0±1.1 points (P=0.001) and body weight was increased by 1.1±1.4 kg with HEHP, whereas by these outcomes were increased by 2.8±2.1 points and 0.8±1.3 kg with STD, and by 1.8±1.1 points and by 0.1±1.0 kg with CON.

Moreover, we also found that markers of physical capacity, general and psychological wellbeing and quality of life remained stable (i.e. they neither improved, nor declined, over the 12 week study) with all treatments. While there is some evidence that the benefits of increased protein intake is apparent when ~ 20-30 g of protein is consumed at each main meal, three-times per day, rather than as a large dose at a single meal (268), it is highly likely that comparable findings between the groups in this study were due, at least in part, to a number of reasons including: (i) participants in all groups adopting the dietitian's advice of consuming foods that were higher in energy and protein at both their main and mid-meal eating occasions (Figure 2); (ii) that all participants were already exceeding their RDIs for both energy and protein at baseline - in fact, protein intakes at baseline for all three groups were already reaching levels of 1.2-1.4 g/kg/day which is the new level being recommended for older adults by several international, expert, working committees (268); and/or (iii) that for some individuals, a critical nutritional deficiency was not actually overcome (i.e. some individuals despite reportedly consuming high intakes are suffering malabsorption issues. Regardless of reason(s), these comparable findings demonstrate dietetic counselling should be an additional offering provided by Australian MOW service given that some older adults and/or their carer require (and value) support from trained health professionals to increase the health knowledge and periodically assess their health and wellbeing.

A recent review has noted that major limitations of previous research in this area is that many studies do not use random allocation of treatments and/or do not have a control group is (269). Hence, major strengths of this study were that it used a randomisation design to allocate the two meal interventions and, it included a control group. Our control consisted of no provision of MOW meals throughout the 12 weeks plus one hour session of dietetics counselling at baseline; the dietetic counselling was included to ensure all participants, even the controls who were 'at risk' were as educated about the consequences of malnutrition and how energy and protein rich foods may help mitigate them. However, our data should be viewed circumspectly because it is likely that over a longer timeframe, dietetics counselling in addition to provision of nutritious meals would have the greatest impact on nutritional status and hence health. For example, a non-randomized intervention study of 355 community living participants (aged 76.7± 3.2 years) demonstrated that nutrition education and counselling when combined with the provision of meals in either a dinning-hall or home-setting, not only improved nutrition risk scores but also resulted in more participants "eating 2 or more meals per day" in home-delivered meals (76 to 81.6 %), or "consuming 5 or more servings of fruit and vegetables" (38 to 41.4 %) and reducing "more than 3 servings of alcohol drinking" in congregate meals group (8.4 to 4.8%) (270).

This study had several limitations. Recruitment of participants from only the Adelaide region of Australia, and exclusion of individuals with diagnosed with dementia and/or depression, meant we ended the pilot research with a small "final" sample size and a cohort who were possibly less sensitive to the effects of treatment. While we had a total of 117 referrals through MOW South Australia Inc. and 25 through other recruitment channel, only 35% of all referrals commenced the study and only 25% completed it. This demonstrates that many community living older adults perceive their nutritional and health status to be better than it actually is; this notion was also supported by participant' responses to the survey questions. In addition, ~21% of our eligible and allocated participants withdrew from the study within the first few weeks due to deteriorating

health or entry into a nursing home while another 5% withdrew without giving a reason or because they did not like the meal. Reasons for withdrawal at least concur with reasons previously reported by Choi et al. who found that more than 25% withdrew from MOW service within the first few weeks due to prolonged hospitalization or placement to nursing home, 15% due to improved health and 15% due to dissatisfied with MOW meals (271). However, despite using intention-to-treat (based on a customised multiple imputation) analyses for each outcome, it is likely that the 30% dropout rate in the first weeks, has caused some bias, particularly for specific micronutrients/trace elements and, the number of hospital admission, length of hospital stay and falls.

5. Conclusion

This study showed that the HEHP MOW meals increased nutrient intake and improved nutritional status in community-dwelling older people at-risk of malnutrition, whereas the control and standard meals did not have this effect. However, there was no significant effect of either type of MOW meal when compared with the CON, on the other markers of physical capacity, general and psychological wellbeing, quality of life or hospitalisations, possibly related to the good nutrient intakes and BMIs of all subjects groups at baseline, and the relatively low subject numbers. Future studies are indicated of older people with poorer intakes and nutritional status than those in this study. The results also indicated that both HEHP and STD meal types can assist in stopping further deterioration (at least over 12 weeks) of physical capacity, general and psychological wellbeing, quality of life or hospitalisations among community dwelling older people, but further research with larger numbers of MOW recipients studied for longer periods will be needed to determine the cost-effectiveness of different types of meals.

CHAPTER 6. A CROSS-SECTIONAL STUDY OF NUTRIENT INTAKE AND HEALTH STATUS AMONG OLDER ADULTS IN YOGYAKARTA INDONESIA

Abstract

Many communities around the world, particularly developing countries including Indonesia, are experiencing population ageing. There is little knowledge regarding the impact of malnutrition, or its prevalence within rural compared to urban areas, on the nutritional, functional and mental status of community-living older residents in these countries. Hence, a cross-sectional study was conducted to determine socio-demographic and anthropometric characteristics, nutritional, mental and functional, status, energy and nutrient intake, of community-dwelling Indonesians from both rural and urban areas of Yogyakarta. Older individuals were included in the study if they had been living in Yogyakarta Indonesia for the last year and were aged ≥ 65 years (n=527; mean ± SD age of 74±7 years). Rural compared with urban participants had a lower level of education and income, more hospital admissions, less dietary protein intake, lower cognitive function, poorer nutritional status and grip strength, but faster gait speed while being more dependent on assistance to perform daily activities (all $P<0.05$). Cognitive function was more strongly associated than nutritional status with physical function. Rural older Indonesians living in Yogyakarta were more likely than urban older people to be malnourished and cognitively impaired, and to have associated reductions in functional capacity and independence. Strategies to improve cognitive function and nutritional status are therefore important for the well-being of Indonesians citizens.

1. Introduction

Indonesia, with the 4th largest population in the world (272), is anticipated to have the greatest number of people aged 65 years or older in South East Asia within the next two decades (272). By 2035, Indonesia's aged population (i.e. those aged ≥ 65 years) is expected to have doubled from ~5% in 2010 to ~11% (~32 million), with the province of Yogyakarta currently having the highest proportion of older people of all 34 Indonesian provinces (i.e., ~13% compared to ~8% of the national total (3). Compared to the global average, the Indonesian population in general, has a lower level of education, lower socio-economic status and less access to health care services (273-275). The life expectancy for male and female Indonesians respectively, is 12.2 and 14.3 years at 65 years of age, and 9.4 and 11 years at 70 years; substantially lower than the global average of 15.4 and 17.9 years at 65 years and 12.3 and 14.3 at 70 years (276). Exacerbating the effects of ageing on the health and wellbeing of Indonesians, are the effects of malnutrition, which for many has its onset at an early age, and impairs mental and functional status, which can in turn lead to greater rates of hospital re-admissions, greater length of hospital stay, and increased mortality (16-18, 20, 22, 23). The prevalence and effects of malnutrition, particularly on body composition and physical function, tend to be different between men and women (277-279). Consequently, due to the double burden of ageing and malnutrition, it is anticipated an increased number of older adults from developing countries like Indonesia may be living in poor health, with associated low quality of life, over the next decades.

Both physiological (e.g., poor food intake) and non-physiological factors (environmental, social, psychological, polypharmacy) (17, 18) play a role in the development of malnutrition, regardless of ethnicity or country of residence. However, the impact of these changes is likely be more pronounced for older adults living in the most disadvantaged communities within any country. Within Indonesia, results from limited research suggest that the prevalence of malnutrition is higher in rural compared with urban areas, due to higher poverty rates and a limited food supply, which in turn, appears to reduce energy and protein intake (280). For example, a

study in West Java, showed that there was higher prevalence of malnutrition in rural when compared with urban adults aged ≥ 60 years (58 rural participants: 52% at risk of malnutrition and 16% malnourished; 54 urban participants: 35% at risk of malnutrition and 2% malnourished as defined by the Mini Nutritional Assessment / MNA) and that men but not women had substantially different nutritional status (281). In addition, a recent survey of residents of Yogyakarta Indonesia indicated that those residing in rural compared with urban areas consumed significantly less protein per day (55 vs. 66 g) and had greater food insecurity (9 vs. 1 villages) (282).

Although these two studies provide some insight into the prevalence of malnutrition in ageing Indonesians, and also provide some insight into the impact of a rural lifestyle on nutritional status, both studies included only small numbers of adults and did not collect socio-demographic information, or any data on functional and mental status, or biological markers associated with poor health. Moreover, many of these studies, including three other small studies that have been conducted in Indonesia (278, 281, 283), used screening tools that are more suited to identify nutritional status and risk among hospitalised rather than community living older people.

Given prevention, early identification and treatment of malnutrition is recognised by the World Health Organisation as a global health priority (284), the aim of this study was to determine, using a cross-sectional study design, the socio-demographic and anthropometric characteristics, and the nutritional, health, mental and functional status, of community-dwelling older men and women living in both rural and urban areas of Yogyakarta Indonesia.

2. Methods

Study design

The study had a cross-sectional design and included community-dwelling older adults living in rural or urban areas of Yogyakarta - this province is representative of Indonesia lifestyles providing a good overview with respect to the physical, demographic and socio-economic

characteristics of Indonesian citizens. For instance, Yogyakarta consists of lowland and highland areas as well as pockets of slums in the urban regions, and residents work in both modern (such as services, manufacturing/industry) and traditional (such as farming and fisheries) sectors(280). Furthermore, residents of Yogyakarta also share the multiethnic and multicultural lifestyle of the broader regions of Indonesia; for example, the province is an education hub which has 10 public and 106 private universities, colleges and institutes that brought students and their cultures from all over the country (280). Rural areas of Yogyakarta (and other Indonesian regions) are characterised by villages with low population density (703 persons/km2), lower literacy and education levels compared to the urban areas; most rural dwellers work in agriculture (280) and low socioeconomic status - 21% live below the poverty line (280, 285).

Recruitment

The rural areas sampled for this study included those from the Kulonprogo Regency which includes 'highland' and Indian Ocean beach locations (280). The urban area sampled for this study included those from the city of Yogyakarta which is located in 'lowland', characterised by high population density (12,699 persons/km2) and higher literacy and education levels compared to rural areas; most residents work in industry/ manufacturing, services and wholesale/ retail (280), with 9% of the residents living below the poverty line (285).

Two out of 12 sub-districts from the rural areas (i.e., Panjatan and Girimulyo) and two out of 14 sub-districts from the city of Yogyakarta (i.e., Gondokusuman and Jetis) were randomly selected using computer generated random numbers (GraphPad QuickCalcs, GraphPad Software Inc., CA, and USA). Then, two suburbs/ villages within the four sub-districts were selected as the final locations. The research team were then provided by the lead cadre (a small group of people specially trained to assist with community health services) a list of the residents in the villages who claimed to be 65 years and older. Finally, older people were randomly selected from the lists per suburb/village; these older individuals were invited to participate in the study.

Ethical approval for the study protocol was obtained from the Medical and Health Research Ethics Committee of the Faculty of Medicine, Universitas Gadjah Mada, Indonesia (KE/FK/1177/EC/2015, 14 September 2015) and the Human Research Ethics Committee of the University of Adelaide, Australia (H-2 016-097, 28 September 2016). The study was registered on the Australian New Zealand Clinical Trial Registry (www.anzctr.org.au, Trial number ACTRN 12616000260426). Prior to data collection, the study was explained to the older individuals by the research team, including providing a volunteer information sheet. All participants provided written informed consent prior to their inclusion in the study.

Study population

Sample size was calculated with GPower version 3.1.9.2 (Universitat Dusseldorf, Germany). With 90% power and 5% significance level, the study requires a total sample size of 522 subjects from both the urban and rural regions to detect significant interactions in a multiple linear regression of differences in nutritional status between the two populations (effect size of 0.025).

Citizens of Yogyakarta Indonesia aged ≥ 65 years or older who had been living in the region for at least 1 year were included in the study. Ten percent (n = 925) of the 9,246 older people living in the four sub-districts (rural area: Panjatan and Girimulyo, urban area: Gondokusuman and Jetis) were randomly selected. Older individuals were excluded if their medical records had General Practitioner confirmed diagnosis of severe dementia or cognitive impairment (10%), and/or when the study team identified individuals who were unable to comprehend the study protocol and give informed consent (4%). In addition, individuals whose age was found to be younger than 65 years based on birth records held by the civil registry were excluded from participating (86%) (***Figure 14***).

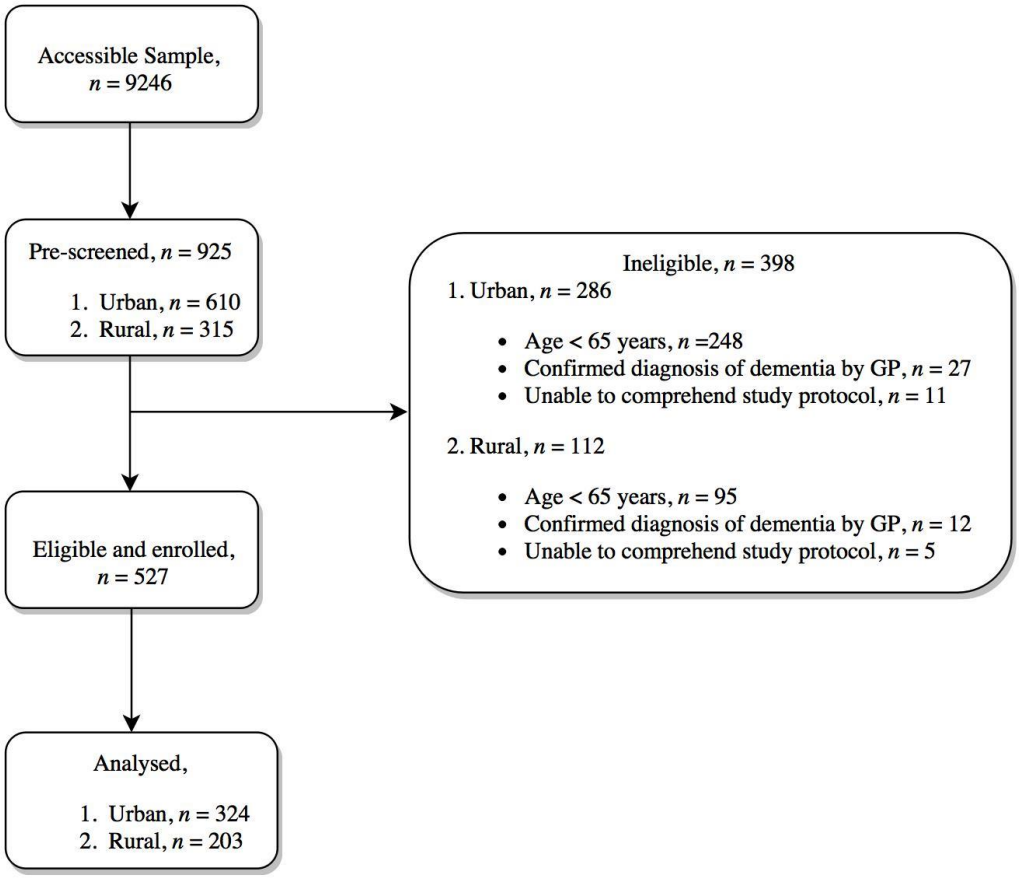


Figure 15. Participant recruitment process.

Data collection

Data collection was conducted in the dry season (to allow safe travel to the rural areas) between September and October 2015, three months after Ramadhan (fasting month) to limit changes in food variety, energy intake and body weight (e.g., weight loss during Ramadhan and regain within a few weeks thereafter of ~1 kg) (286).

Participants were instructed to meet the research team (i.e., two investigators, twelve enumerators (graduate dietitians of Department of Nutrition and Health, Faculty of Medicine, Universitas Gadjah Mada), a nurse (with phlebotomist certification from nationally accredited CITO Pathology Laboratory, Yogyakarta) and cadres at their local community centre. The trained members of the research team performed the health assessments, including blood samples and

nutrition and health questionnaires. All questionnaires, standard operating procedures, and participant information and informed consent forms, were translated into Bahasa Indonesia.

Assessments

Sociodemographic characteristics, self-reported perception of health and medical history

Age (years) was determined by the participants' identity card, the civil registry or voters list provided by the local government. A socio-demographic questionnaire included household information, level of education, occupation, and income. A health questionnaire included the participant's self-description of their health, feelings of sadness or depression, requirement of help with daily activities, receiving social support when needed, and medical history of the past 6-12 months, including smoking, alcohol consumption, hospitalisation (frequency of surgery, visit to a health centre or doctor, and admission and length of hospital stay - these data were cross-checked with the records from the community health centres that each participant attended or local government).

Anthropometric characteristics

The following parameters were determined: body weight (kg), height (m) (Wedderburn Portable Stadiometer Model: WSHRP, Auckland, New Zealand), body mass index (BMI, kg/m2), fat percentage, fat and lean mass [Bioelectrical impedance Analysis (BIA), Tanita Body Composition Analyser, Model No: SC-330, Illinois, USA), waist, hip, mid-arm and calf circumference (cm; Seca 203 measuring tape, Hamburg, Germany), and skin-fold thickness (mm; triceps, biceps, sub-scapula, supra-iliac; Harpenden Skinfold Calliper, Model HSB-BI, British Indicators Ltd, West Sussex, UK). Measurements for all parameters were taken in duplicate and the average of the two measurement were reported; the only exception being for BIA which was done once.

Nutritional status, energy and nutrient intake

Nutritional status was determined by the following validated, and widely used, questionnaires: the Mini Nutritional Assessment (MNA; a score <17 indicates that the participant is malnourished, 17-23.5: at risk of malnutrition, >23.5: well nourished (54)), the Malnutrition Universal Screening Tool (MUST; a score of 0 indicates a low risk of malnutrition, 1: medium risk, ≥2: high risk (171)), the Malnutrition Screening Tool (MST; a score <2 indicates no risk of malnutrition and ≥2: risk of malnutrition (207)), the Short Nutritional Assessment Questionnaire (SNAQ; a score <2 indicates that the participant is well nourished, ≥2: moderately malnourished, ≥3: severely malnourished (58)), and the Geriatric Nutrition Risk Index (GNRI; a score <82 indicates a major risk of malnutrition, 82-91: moderate risk, 92-98: low risk, ≥98: no risk (143)). While these nutrition screening tools have been extensively validated in Western and other Asian countries (287, 288), their use in Indonesia has to date been limited to hospital settings (289-291). However, since no similar tools are available to screen the nutritional status of community living older Indonesians, the aforementioned tools were considered the most appropriate options.

Energy and nutrient intake was determined by a single 24-hour recall, which provided a snapshot of usual energy and nutrient intake, and a Semi Quantitative-Food Frequency Questionnaire (SQFFQ) which has been validated among Yogyakarta residents and provides more detailed information of the food choices and source of nutrients consumed by an individual in the last 3 months (283). Intakes of energy, macro- (protein, fat, and carbohydrate) and micro-nutrients were determined by the Indonesian Food Database and Nutrisurvey (Version 2007, SEAMEO-TROPMED RCCN University of Indonesia).

Blood parameters

Blood pressure and heart rate of participants were measured using Omron Blood Pressure Monitor [(Model No: HEM-907), Kyoto, Japan]. Approximately 12 ml of whole blood was collected from each participant; 4 ml for determination of Complete Blood Count (CBC) and

albumin analysis, and 8 ml was converted to serum and then stored for future analysis of CRP and cytokines. CBC and albumin were analysed at CITO Pathology Laboratory, the leading accredited laboratory in Yogyakarta, Indonesia.

Frailty, physical and mental, function

Frailty was determined by the fatigue, resistance, ambulation, illness, and loss of weight questionnaire (FRAIL; a score of 0 indicates that the participant has a robust health status, 1-2: the participant is pre-frail, 3-5: frail (209)). Physical function included measurements of grip strength (kg; dominant hand, Jamar hand dynamometer, IL, USA), gait speed (m/; 3-m walk test (292)), and the following questionnaires; Instrumental Activity of Daily Living (IADL; a score of 0 indicates that the participant is independent, 1-8: dependent (293)), physical activity (International Physical Activity Questionnaire (IPAQ) (294)). Grip strength and gait speed were measured in duplicate and average score were reported. Mental function included measurements of cognitive function, determined by the Mini Mental State Examination (MMSE; a score ≤ 9 indicates severe cognitive impairment, 10-19: moderate cognitive impairment, 20-24: mild cognitive impairment, 25: no cognitive impairment (217)) and depression, determined by the Geriatric Depression Scale (GDS; a score >5 indicates a suggestive depression, >9: depression (219)).

Statistical analysis

Statistical analysis was performed using SPSS (Version 22.0 for Windows, IBM, New York, USA). Results are presented as means and standard deviations (SD), unless stated otherwise, for all participants and a breakdown by urban and rural areas. Logistic, ordinal and multinomial regressions were used to determine the effects of location, gender and location by gender interaction on socio-demographic and health characteristics. ANCOVA was used to examine the effects of location, gender and location by gender interaction on anthropometric characteristics, nutrient intake, blood parameters, frailty, physical and mental function. Spearman's Rank test was performed to determine between-participant associations between nutritional, frailty, physical and

mental function. Lastly, based on the priori knowledge presented in the introduction, ANCOVA was performed to examine the independent effects of covariates (cognitive function, nutritional status and the cognitive function by nutritional status interaction) on markers of physical function; these analyses were performed without and with adjustment for location, gender and age.

Prior to analysis, data was cleaned and checked for outliers. Two member of the research team (TA and RAH) rechecked hard copy data to clarify any identified outliers and missing values. Furthermore, skewness, kurtosis, histogram with normal curve, stem and leaf plot, and Kolmogorov-Smirnov tests were performed on numeric variables to determine normality.

3. Results

Sociodemographic characteristics, self-reported perception of health and medical history

Five hundred and twenty seven people aged 74 ± 7 years old (65 to 102 years) were included in the study; 203 (39%) total participants (83 men and 120 women) were from the rural area whereas 324 (61%) (132 men and 192 women) were from the urban area.

Rural compared with urban participants had a lower level of education ($P < 0.001$, ***Table 22***), ~3.5 times lower income ($P < 0.001$) and were less likely to be retired or unemployed (56% vs. 32%, $P < 0.001$) the findings were particularly valid for the women (gender effect all $P < 0.001$). Older women were more likely to be widowed or divorced than men (61% vs. 25%, $P < 0.001$), while the older men, compared to women, were more likely to be married (74% vs. 36%, $P < 0.001$); however, these differences were attenuated after adjustment for age (adjusted $P = 0.13$). Participants from both rural and urban areas lived on average with 4 ± 2 family members.

Table 22. Sociodemographic characteristics, self-reported perception of health and medical history of the rural and urban study participants[a]

Characteristics	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Male (*n*=132)	Female (*n*=192)	Male (*n*=83)	Female (*n*=120)			
Socio-demographic							
Age[b]	74.7 ± 6.4	74.3 ± 6.8	72.8 ± 7.1	73.8 ± 7.9	0.06	0.67	0.31
Marital Status[c]							
1. Married	91 (69)	68 (35)	68 (82)	44 (37)			
2. Widowed / Divorced	40 (30)	119 (62)	14 (17)	72 (60)	0.78	< 0.001[k]	0.11
3. Single / Never Married	1 (1)	5 (3)	1 (1)	4 (3)			
Last Education[d]					< 0.001	< 0.001	0.06
1. Uneducated	21 (16)	79 (41)	31 (37)	93 (77)			
2. Elementary School	34 (26)	23 (12)	35 (42)	24 (20)			
3. Junior High School	22 (16)	35 (18)	8 (10)	1 (1)			
4. Senior High School	30 (23)	35 (18)	8 (10)	2 (2)			
5. University / Academy	25 (19)	20 (11)	1 (1)	0 (0)			
Occupation[e,f]					< 0.001[l]	< 0.001[l]	0.38
1. Farmer/breeder/fisherman	1 (1)	2 (1)	45 (54)	40 (33)			
2. Labour/farming labour	10 (8)	3 (2)	19 (23)	24 (20)			
3. Private employee/ civil servant/military/entrepreneur	21 (15)	33 (17)	3 (3)	3 (2)			
4. Other works	50 (38)	22 (11)	2 (3)	2 (2)			
5. Unemployed / Retired	50 (38)	132 (69)	14 (17)	51 (43)			
Monthly income group[d,g]					< 0.001	0.57	0.61
1. Low	68 (52)	122 (64)	75 (91)	111 (92)			
2. Middle	23 (17)	38 (20)	2 (2)	4 (3)			
3. High	19 (14)	14 (7)	4 (5)	2 (2)			

Characteristics	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Male (*n*=132)	Female (*n*=192)	Male (*n*=83)	Female (*n*=120)			
4. Very high	22 (17)	18 (9)	2 (2)	3 (3)			
Poverty[c, h]					< 0.001	0.95	0.68
1. Poor	43 (33)	71 (37)	64 (77)	93 (77)			
2. Non-poor	89 (67)	121 (63)	19 (23)	27 (23)			
Smoking Status[c,i]					0.21	0.003	0.53
1. Yes	34 (26)	1 (0)	38 (46)	3 (2)			
2. No	52 (39)	188 (98)	20 (24)	117 (98)			
3. Smoke in the past	46 (35)	3 (2)	25 (30)	0 (0)			
Alcoholic Drink Consumption[c, j]					0.94	0.99	0.99
1. Yes	3 (2)	3 (2)	0(0)	2 (2)			
2. No	129 (98)	189 (98)	83 (100)	118 (98)			
Health and medical history							
Self-description of health[d]					0.32	0.31	0.342
1. Excellent	71 (54)	105 (55)	57 (68)	73 (61)			
2. Fair	29 (22)	44 (23)	13 (16)	26 (22)			
3. Poor	32 (24)	43 (22)	13 (16)	21 (17)			
Feel sad or depressed[c]					0.25	0.15	0.60
1. Yes	21 (16)	45 (23)	13 (16)	20 (17)			
2. No	111 (64)	147 (77)	70 (84)	100 (83)			
Requiring help for daily activities[d]					0.08	0.56	0.97
1. 0 – 1 activity	80 (60)	123 (64)	37 (45)	66 (55)			
2. 2 – 4 activities	30 (23)	43 (22)	37 (45)	32 (27)			
3. 5 – 8 activities	22 (17)	26 (14)	9 (10)	22 (18)			
Receiving social support when needed in the past year[d]					0.46	0.96	0.99
1. Always	93 (71)	137 (71)	61 (74)	89 (74)			

Characteristics	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Male (*n*=132)	Female (*n*=192)	Male (*n*=83)	Female (*n*=120)			
2. Sometimes	23 (17)	29 (15)	16 (19)	21 (18)			
3. Never	16 (12)	26 (14)	6 (7)	10 (8)			
Hospital admission in the past year[d]					0.024	0.99	0.14
1. 0 admission	17 (13)	45 (23)	11 (13)	17 (14)			
2. 1 – 2 admissions	98 (74)	130 (68)	61 (74)	86 (72)			
3. > 2 admissions	17 (13)	17 (9)	11 (13)	17 (14)			
Had surgery in the past year[c]					< 0.001	0.014	0.12
1. Yes	51 (39)	63 (33)	20 (24)	13 (11)			
2. No	81 (61)	129 (67)	63 (76)	107 (89)			
Frequency of visit to Health Centre or Doctor in the past 6 months[d]					0.55	0.25	0.90
1. 0 visit	52 (39)	68 (36)	35 (42)	45 (37)			
2. 1 – 5 visits	48 (36)	77 (40)	36 (44)	56 (47)			
3. 6 – 10 visits	26 (20)	37 (19)	11 (13)	16 (13)			
4. > 10 visits	6 (5)	10 (5)	1 (1)	3 (3)			
Length of hospital stay in the past 6 months (days)[d]					0.62	0.33	0.53
1. 0 day	120 (91)	177 (92)	80 (96)	114 (95)			
2. 1 – 5 days	4 (3)	4 (2)	3 (4)	2 (2)			
3. 6 – 10 days	6 (5)	8 (4)	0 (0)	4 (3)			
4. > 10 days	2 (1)	3 (2)	0 (0)	0 (0)			

[a]Data represent N (%);[b]Data presented is unadjusted Mean ± Standard deviation; Regression analysis to determine the effects of location, gender and location by gender interaction with [c]Logistic regression, [d]Ordinal regression, [e]Multinomial regression; [f]Based on occupation category set by Ministry of Health and Indonesian Bureau of Statistics; [g]Monthly income category set by Indonesian Bureau of Statistics where Income of < Rp.1,500,000= low, Rp.1,500,000 to Rp.2,500,000= middle, Rp.2,500,000 to 3,500,000= high, and ≥ Rp.3,500,000 = very high; [h]Poverty line as defined by Indonesian Bureau of Statistics where income of < Rp. 600,000 = poor and ≥ Rp. 600,000 = non poor; [i]Smoking status, yes=actively smoking at least 1 cigarette/day, no= non active smoker and never smoked in the past, smoke in the past= non

active smoker but smoked in the past; [j]Alcoholic drink consumption, yes= consuming at least 1 standard drink / week, no= consuming less than 1 standard drink / week or never consumed alcoholic drink; [k]Married was reference category, significant difference with widowed; [l]Unemployed / retired is reference category, significant difference to Farmer/breeder/fisherman and Labour/farming labour. *P* values were not adjusted for age, results for all age adjusted effects of location, gender and location by gender are described in the text.

Approximately one-quarter of the participants from both rural and urban areas rated their health as poor, or feeling sad or depressed (16-24%, Table 12). Approximately half of all study participants (40-55%) reported that they required help for more than one daily activity and rural compared with urban participants had significantly higher dependency (49% vs. 37%, age adjusted $P = 0.015$). The majority of participants reported that they always received social support from their relatives or neighbours when needed (71-74%).

Participants from the rural, when compared with urban, areas had more hospital admissions (86% vs. 81%, $P = 0.024$, Table 22), but were less likely to have had surgery (16% vs. 35%, $P < 0.001$), particularly the women (gender effect $P = 0.014$), in the past 12 months; however, these discrepancies were diminished after adjustment for age (hospital admission age adjusted $P = 0.12$; had surgery age adjusted $P = 0.95$). Frequency of visits to the health centre ($P = 0.55$) and length of hospital stay ($P = 0.62$) was not different between the rural and urban participants.

Anthropometric characteristics

Rural compared with urban participants had a lower body weight (44.4 ± 8.6 kg vs. 51.8 ± 11.5 kg, $P < 0.001$, ***Table 23***), were not as tall (148.3 ± 8.9 cm vs. 150.4 ± 8.5 cm, $P < 0.001$) and had a lower BMI (20.1 ± 3.2 kg/m^2 vs. 22.8 ± 4.4 kg/m^2, $P < 0.001$). Rural compared with urban participants had a lower absolute and percentage fat mass (7.8 ± 4.4 kg vs. 12.1 ± 6.7 kg, $P < 0.001$ and, 16.7 ± 7.5% vs. 21.9 ± 9.2%, $P < 0.001$) and skinfold thickness (sum of 4 sites: 37.9 ± 18.9 mm vs. 64.1 ± 28.6 mm, $P < 0.001$). They also had a lower fat free mass (36.5 ± 5.5 kg compared to 39.7 ± 7.0 kg, $P < 0.001$) and, arm (24.0 ± 3.1 cm vs.26.3 ± 4.1 cm, $P < 0.001$) and calf circumference (29.9 ± 4.0 cm vs. 31.7 ± 4.0 cm, $P < 0.001$). Age adjustment strengthen the gender by location effect for fat free mas ($P = 0.019$), but weakened the location effect for wasit-hip ratio ($P = 0.057$). Age adjustments on other anthropometric characteristics were non-significant.

Table 23. Anthropometric characteristics, nutritional, functional and mental status, and blood parameters[a, b]

Characteristics	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Men (*n* = 132)	Women (*n* = 192)	Men (*n* = 83)	Women (*n* = 120)			
Anthropometry and Body composition							
Weight (kg)	55.3 ± 11.1	49.4 ± 11.2	47.5 ± 8.5	42.2 ± 8.0	< 0.001	< 0.001	0.76
Height (cm)	157.4 ± 6.0	145.6 ± 6.4	154.7 ± 7.5	143.8 ± 6.8	< 0.001	< 0.001	0.44
BMI (kg/m^2)[c]	22.2 ± 3.8	23.2 ± 4.7	19.8 ± 2.7	20.4 ± 3.5	< 0.001	0.025	0.61
Fat percentage (%)[d]	18.4 ± 6.0	24.4 ± 10.3	14.3 ± 4.5	18.4 ± 8.6	< 0.001	< 0.001	0.20
Fat mass (kg)[d]	10.7 ± 5.0	13.1 ± 7.5	7.0 ± 3.2	8.4 ± 5.1	< 0.001	0.001	0.34
Fat free mass (kg)[d]	44.7 ± 6.9	36.3 ± 4.7	40.3 ± 5.4	33.8 ± 3.8	< 0.001	< 0.001	0.049
Waist circumference (cm)	82.1 ± 11.5	78.6 ± 12.0	73.1 ± 7.4	71.8 ± 8.3	< 0.001	0.012	0.25
Hip circumference (cm)	92.1 ± 7.8	92.9 ± 10.5	84.9 ± 5.9	84.7 ± 7.1	< 0.001	0.68	0.51
Waist – hip ratio	0.9 ± 0.1	0.8 ± 0.1	0.9 ± 0.1	0.8 ± 0.1	0.045	0.002	0.14
Arm circumference (cm)	26.6 ± 3.5	26.2 ± 4.5	24.2 ± 2.7	23.8 ± 3.3	< 0.001	0.22	0.99
Calf circumference (cm)	32.4 ± 3.7	31.3 ± 4.1	30.4 ± 3.0	29.5 ± 4.5	< 0.001	0.005	0.76
Skinfold thickness (mm)	55.7 ± 25.6	69.9 ± 29.2	31.1 ± 15.4	42.6 ± 19.7	< 0.001	< 0.001	.53
1. Biceps	9.0 ± 8.7	12.5 ± 7.6	4.4 ± 2.6	6.9 ± 7.9	< 0.001	< 0.001	0.46
2. Triceps	13.1 ± 8.7	18.9 ± 9.7	7.3 ± 4.9	12.0 ± 5.7	< 0.001	< 0.001	0.43
3. Sub-scapula	17.2 ± 8.8	19.2 ± 9.6	10.6 ± 4.9	12.6 ± 6.1	< 0.001	0.007	0.99
4. Supra-iliac	16.4 ± 9.8	19.4 ± 8.4	8.7 ± 4.9	11.1 ± 5.8	< 0.001	< 0.001	0.63
Nutritional status							
MNA[e]	23.2 ± 3.4	22.9 ± 3.5	21.6 ± 2.4	21.9 ± 2.7	< 0.001	0.97	0.39
MUST [f,g]	0.6 ± 0.9	0.5 ± 0.9	1.0 ± 1.1	0.8 ± 1.0	< 0.001	0.54	0.47
MST [f,h]	0.5 ± 0.9	0.6 ± 0.8	0.9 ± 1.0	0.7 ± 1.0	0.020	0.29	0.28
SNAQ [f,i]	0.5 ± 1.0	0.6 ± 1.1	0.3 ± 0.8	0.2 ± 0.7	0.001	0.76	0.22
GNRI[j]	98.9 ± 6.3	98.7 ± 6.3	95.2 ± 5.9	95.9 ± 6.9	< 0.001	0.60	0.30

Characteristics	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Men (*n* = 132)	Women (*n* = 192)	Men (*n* = 83)	Women (*n* = 120)			
Blood Parameters							
Systolic blood pressure (mmHg)	150 ± 23	154 ± 24	155 ± 24	167 ± 27	< 0.001	0.001	0.058
Diastolic blood pressure (mmHg)	82 ± 15	83 ± 15	79 ± 16	85 ± 15	0.63	0.023	0.055
Heart rate (beats/minute)	79 ± 14	84 ± 15	74 ± 14	82 ± 13	0.010	< 0.001	0.37
Haemoglobin (g/dL)	14.0 ± 1.7	12.8 ± 1.5	13.7 ± 1.3	12.6 ± 1.4	0.09	< 0.001	0.56
Haematocrit (%)	40.3 ± 4.5	37.6 ± 4.3	38.9 ± 3.4	36.4 ± 3.5	< 0.001	< 0.001	0.68
Erythrocytes (million cell/mL)	4.7 ± 0.6	4.5 ± 0.5	4.6 ± 0.4	4.4 ± 0.4	0.019	< 0.001	0.33
Thrombocytes (thousand/mL)	255.2 ± 65.1	286.4 ± 73.0	258.1 ± 69.9	287.2 ± 79.3	0.78	< 0.001	0.88
Leucocytes (thousand cell/mL)	6.8 ± 1.8	7.4 ± 2.1	6.6 ± 1.6	7.0 ± 1.7	0.10	0.003	0.64
Eosinophils (%)	4.1 ± 3.1	2.7 ± 2.0	4.7 ± 3.3	5.0 ± 3.8	< 0.001	0.04	0.001
Basophils (%)	0.3 ± 0.4	0.1 ± 0.3	0.2 ± 0.4	0.1 ± 0.3	0.16	< 0.001	0.16
Neutrophils (%)	55.4 ± 9.6	59.5 ± 9.2	60.3 ± 9.3	58.6 ± 9.8	0.022	0.18	0.001
Lymphocytes (%)	32.0 ± 9.0	30.2 ± 8.1	26.3 ± 7.5	28.8 ± 8.1	< 0.001	0.67	0.003
Monocytes (%)	8.1 ± 2.3	7.5 ± 2.3	8.5 ± 2.5	7.5 ± 2.6	0.39	< 0.001	0.33
MCV (fl)	85.3 ± 5.8	84.2 ± 5.9	84.7 ± 4.8	82.9 ± 6.8	0.09	0.008	0.51
MCH (pg)	29.6 ± 2.0	28.7 ± 2.1	29.9 ± 2.0	28.8 ± 2.8	0.30	< 0.001	0.84
MCHC (g/dL)	34.8 ± 1.6	34.0 ± 1.4	35.3 ± 1.0	34.6 ± 1.2	< 0.001	< 0.001	0.67
RDW (%)	14.2 ± 1.2	14.3 ± 1.8	14.3 ± 1.3	14.4 ± 1.6	0.58	0.40	0.86
Albumin (g/dL)	4.1 ± 0.3	4.0 ± 0.2	3.9 ± 0.2	4.0 ± 0.2	0.001	0.75	0.13
Frailty and physical function							
FRAIL[f,k]	0.7 ± 0.8	1.0 ± 0.9	0.7 ± 0.9	0.9 ± 1.0	0.51	0.14	0.38
Grip strength (kg)	21.4 ± 7.1	13.7 ± 4.2	18.9 ± 6.4	13.7 ± 5.0	0.017	< 0.001	0.013
Gait Speed (m/s)[d]	0.55 ± 0.22	0.49 ± 0.18	0.59 ± 0.19	0.51 ± 0.19	0.050	< 0.001	0.517
IADL[l]	3.0 ± 2.4	2.6 ± 2.4	4.1 ± 2.2	3.0 ± 2.4	< 0.001	0.001	0.09
IPAQ (MET-minutes/week)[m]	819.5 ± 321.7	852.4 ± 374	929.9 ± 266.3	896.1 ± 292.7	0.010	0.98	0.27

Characteristics	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Men (*n* = 132)	Women (*n* = 192)	Men (*n* = 83)	Women (*n* = 120)			
Mental function							
MMSE[n]	22.3 ± 5.8	21.4 ± 6.7	20.5 ± 6.2	16.3 ± 6.2	< 0.001	< 0.001	0.004
GDS[o]	2.9 ± 2.6	2.9 ± 2.3	2.8 ± 2.5	2.9 ± 2.4	0.72	0.89	0.73

[a]ANCOVA test to determine the effects of location, gender and location by gender interaction; [b]Data presented is unadjusted Mean ± Standard deviation; [c]BMI: Body Mass Index; [d]Missing data from 10 participants due to unable to stand firmly on the BIA machine and perform 3-m walk test; [e]MNA: Mini Nutritional Assessment, <17 = malnourished, 17-23.5 = at risk of malnutrition, > 23.5 = well nourished; [f]Ordinal regression test to determine the effects of location, gender and location by gender interaction; [g]MUST: Malnutrition Universal Screening Tool, 0 = low risk, 1 = medium risk, 2 or more = high risk; [h]MST: Malnutrition Screening Tool, ≥2= risk of malnutrition; [i]SNAQ: Short Nutritional Assessment Questionnaire, <2 = well nourished, ≥2 = moderately malnourished; ≥3 = severely malnourished; [j]GNRI: Geriatric Nutrition Risk Index, >98 = no risk, 92 to ≤98 = moderate risk, 82 to <92 = low risk, <82 = major risk; [k]FRAIL : Fatigue Resistance Ambulation Illnesses and Loss of weight, 0 = robust health status, 1-2 = pre-frail, 3-5 = frail; [l]IADL: Instrumental Activities of Daily Living, 0 = independent, 1 – 8 = dependent; [m]IPAQ: International Physical Activity Questionnaire, MET: Metabolic equivalent of task;[n]MMSE: Mini Mental State Examination scale, ≥25 = no cognitive impairment, 20 – 24 = mild cognitive impairment, 10 – 19 moderate cognitive impairment, ≤ 9 = severe cognitive impairment; [o]GDS: Geriatric Depression Scale, >5 = suggestive of depression, >9 = depression. *P* values were not adjusted for age, results for all age adjusted effects of location, gender and location by gender are described in the text.

Nutritional status, energy and nutrient intake

Rural compared with urban participants had poorer nutritional status according to most assessment tools (i.e. MNA: 3% vs. 6% malnourished, and 73% vs. 44% at risk of malnutrition, $P < 0.001$); MUST: 32% vs. 18% at high risk, and 17% vs. 12% at medium risk of malnutrition, $P < 0.001$); MST: 33% vs. 18% at risk of malnutrition, $P = 0.020$; GNRI: 3% vs. 2% at major risk, 22% vs. 12% at moderate risk, and 35% vs. 21% at low risk of malnutrition, $P < 0.001$). The SNAQ questionnaire however identified that nutritional status was better for rural compared with urban participants (SNAQ: 3% vs. 8% severely and 5% vs. 12% moderately malnourished, $P = 0.001$, Table 13). There was no effect of age adjustment on parameters of nutritional status.

Nutrient intake values derived from the SQFFQ methodology were not different from those derived from the 24hr recall method; hence ***Table 24*** depicts the intakes from the 24-hr recalls. Total energy, carbohydrate, fat, vitamin A, thiamine, pyridoxine, folate, vitamin E, vitamin D, magnesium, and iron intake derived from the 24-hr recall were not different between the rural and urban participants. However rural compared with urban participants, had lower intakes of protein, sugar, fiber, MUFA, vitamin C, pantothenic acid, niacine, potassium, calcium, phosphorus, zinc, and higher intakes of sodium. Adjustment for age did not change the results, the only exceptions being for magnesium intake which became significantly lower among rural participants and for niacine intake which was not different between rural and urban individuals.

Table 24. 24-hour recall nutrient intakes[a, b]

Nutrients	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Male (*n* = 132)	Female (*n* = 192)	Male (*n* = 83)	Female (*n* = 120)			
Energy (kcal)	1530 ± 500	1365 ± 445	1520 ± 447	1278 ± 402	0.24	< 0.001	0.35
Protein (g)	45 ± 21	40 ± 18	39 ± 15	34 ± 13	< 0.001	0.003	0.91
Carbohydrate (g)	229 ± 72	197 ± 64	237 ± 75.0	186 ± 60	0.77	< 0.001	0.14
Dietary fibre (g)	1 ± 24	9 ± 10	8 ± 5	7 ± 5	0.006	0.18	0.34
Sugar (g)	35 ± 18	31 ± 19	30 ± 20	23 ± 16	< 0.001	0.002	0.25
Fat (g)	51 ± 24	48 ± 22	48 ± 21	46 ± 22	0.13	0.28	0.72
PUFA (g)[c]	6 ± 4	6 ± 4	6 ± 5	6 ± 6	0.62	0.48	0.15
MUFA (g)[d]	9 ± 6	8 ± 5	7 ± 4	8 ± 7	0.040	0.92	0.11
Saturated Fat (g)	31 ± 22	29.6 ± 29.3	28.3 ± 12.9	26 ± 12	0.17	0.45	0.83
Cholesterol (mg)	117 ± 146	106 ± 136	123 ± 163	94 ± 147	0.83	0.13	0.51
Vitamin A (µg)[e]	1391 ± 866	1350 ± 1005	1575 ± 1127	1364 ± 780	0.25	0.14	0.32
Thiamine (mg)	0.5 ± 0.2	0.5 ± 0.3	0.5 ± 0.2	0.5 ± 0.2	0.81	0.049	0.26
Riboflavin (mg)	0.4 ± 0.3	0.4 ± 0.3	0.4 ± 0.3	0.4 ± 0.3	0.08	0.49	0.82
Pantothenic acid (mg)	1.6 ± 0.9	1.5 ± 0.9	1.3 ± 0.8	1.2 ± 0.7	0.001	0.17	0.99
Pyridoxine (mg)	0.7 ± 0.4	0.7 ± 0.4	0.7 ± 0.4	0.6 ± 0.4	0.83	0.19	0.58
Folate (µg)[f]	118 ± 76	119 ± 78	129 ± 145	108 ± 64	0.97	0.20	0.15
Vitamin C (mg)	41 ± 54	47 ± 46	34 ± 29	36 ± 29	0.016	0.34	0.59
Vitamin D (µg)	1.1 ± 2.8	1.0 ± 2.6	1.0 ± 2.3	0.9 ± 2.0	0.87	0.57	0.98
Vitamin E (mg)[g]	3.4 ± 3.6	3.1 ± 2.7	3.4 ± 3.5	3.7 ± 4.5	0.45	0.99	0.33
Sodium (mg)	1241 ± 566	1308 ± 619	1756 ± 888	1639 ± 722	< 0.001	0.69	0.14
Potassium (mg)	1231 ± 601	1237 ± 585	1108 ± 508	1045 ± 469	0.002	0.62	0.53
Calcium (mg)	352 ± 244	346 ± 207	309 ± 135	301 ± 181	0.017	0.70	0.95
Magnesium (mg)	168 ± 122	144 ± 75	135 ± 66	142 ± 87	0.36	0.29	0.06

Nutrients	Urban		Rural		Location effect	Gender effect	Interaction effect location by gender
	Male (*n* = 132)	Female (*n* = 192)	Male (*n* = 83)	Female (*n* = 120)			
Phosphorus (mg)	562 ± 283	517 ± 238	466 ± 171	444 ± 190	< 0.001	0.11	0.58
Iron (mg)	8.2 ± 4.2	7.5 ± 3.8	8.7 ± 10.3	7.4 ± 3.6	0.71	0.06	0.52
Zinc (mg)	3.6 ± 2.0	3.3 ± 1.7	3.0 ± 2.5	2.7 ± 1.3	0.001	0.10	0.95

[a]ANCOVA test to determine the effects of location, gender and location by gender interaction; [b]Data presented is unadjusted Mean ± Standard deviation; [c]PUFA = Polyunsaturated fatty acid; [d]MUFA = Monounsaturated fatty acid; [e]Vitamin A = retinol equivalents; [f]Folate = total folic acid; [g]Vitamin E = tocopherol equivalent. *P* values were not adjusted for age, results for all age adjusted effects of location, gender and location by gender are described in the text.

Blood parameters

Rural compared with urban participants had higher systolic blood pressure (162 ± 27 mmHg vs. 153 ± 24 mmHg, $P < 0.001$) but slightly lower heart rates (79 ± 14 vs. 82 ± 15 beats per minute, $P = 0.01$, Table 13). Adjustment for age strengthen the gender by location effect for diastolic blood pressure (P = 0.048).

Rural compared with urban participants had lower values of plasma albumin concentrations (3.9 ± 0.2 vs. 4.0 ± 0.3, $P = 0.002$), hematocrit (37.4 ± 3.7 % vs. 38.7 ± 4.6 %, $P = 0.001$), erythrocytes (4.5 ± 0.4 vs. 4.6 ± 0.6 million cell/mL, $P = 0.032$), and lymphocytes (27.8 ± 8.0 vs. 30.9 ± 8.5 %, $P < 0.001$), but higher eosinophils (4.9 ± 3.6 vs. 3.2 ± 2.6 %, $P < 0.001$), neutrophils (57.9 ± 9.6 vs. 59.3 ± 9.6 %, $P = 0.022$), and MCHC values (34.9 ± 1.2 vs. 34.3 ± 1.5 g/dL, $P < 0.001$). There was no effect of age adjustment on blood parameters.

Frailty, physical and mental function

Frailty status were comparable among rural and urban participants (8% frail and 47% pre-frail vs 5% frail and 52% pre-frail, $P = 0.51$, Table 23). Rural compared with urban participants had lower grip strength (15.9 ± 6.2 kg vs. 16.8 ± 6.7 kg, $P = 0.017$), but faster gait speed (0.55 ± 0.19 m/s vs. 0.51 ± 0.19 m/s, $P = 0.050$) and were more physically active (IPAQ = 910 ± 282 metabolic equivalent of task (MET)-minutes/week vs. 839 ± 353 MET-minutes/week $P = 0.010$). IADL scores were greater for rural compared with urban participants indicating greater dependency for assistance (IADL score: urban, 2.7 ± 2.4 vs. rural, 3.4 ± 2.4, $P < 0.001$, Table 13) and 20% compared with 6% of urban participants, indicated they were completely dependent on assistance from others to perform IADL. However, following adjustment for age, the difference in gait speed between rural and urban paticipants was no longer significant (adjusted $P = 0.20$), while other parameters remain significantly different.

Rural compared with urban participants had lower cognitive function as assessed by the MMSE scores (7% vs. 5% had severe, 51% vs. 26% moderate, and 22% vs. 28% mild cognitive

impairment, $P < 0.001$, Table 13). There was no difference in depression levels between participants from each area (GDS score: 2.8 ± 2.4 rural vs. 2.9 ± 2.4 urban, $P = 0.72$). Adjustment for age has no significant effect on parameters of mental function.

Correlations between nutrient intake with socio-demographic characteristics, nutritional status, physical and mental function

Intakes of protein, fiber, vitamins and minerals positively correlated with level of income and education (data not shown, all $P < 0.05$). Intake of potassium negatively correlated with systolic blood pressure ($r = -0.099$, $P = 0.024$). Energy and protein intakes positively correlated with body composition (fat free mass and fat mass), nutritional status (MNA, MUST, and GNRI), and both physical (grip strength, gait speed and FRAIL) and mental (MMSE and GDS) function; of these correlations, MMSE had the strongest correlation with energy and protein intakes ($r = 0.270$ and $r = 0.288$, respectively, both $P < 0.001$). Irrespective of gender, location and age, energy and protein intakes of older people with severe and moderate cognitive impairement were substantially lower than those with mild or no cognitive impairement (Energy (mean ± *SEM*) : severe CI 1195 ± 81 and moderate CI 1331 ± 34 vs. mild CI 1511 ± 39 and no CI 1496 ± 36 kcal, $P < 0.001$; Protein (mean ± *SE*): severe CI 34.3 ± 3 and moderate CI 35.6 ± 1.3 vs. mild CI 40.1 ± 1.5 and no CI 43.6 ± 1.4 g, $P = 0.001$).

Correlations between markers of physical function with nutritional status and mental function

The markers of physical function (grip strength, gait speed and IADL score) were associated more strongly with cognitive status as measured by MMSE, than with any other non-functional measure including nutritional status (**Table 25**); the correlation coefficient between MMSE score with grip strength was 0.461 ($P < 0.001$), with gait speed was 0.351 ($P < 0.001$), and with IADL was -0.440 ($P < 0.001$). There were greater increases/improvements in grip strength, gait speed and IADL as cognitive state changed from severe to moderate to mild to no impairment,

compared to changes in nutritional status from malnourished to at-risk of malnutrition to well nourished (***Figure 15***). The majority of participants classified as having severe to mild cognitive impairment were at risk of malnutrition (severe:21/30, moderate: 121/187 and mild: 85/134, respectively), while the majority (107/176) of participants with no cognitive impairment were well nourished ($P < 0.001$).

Table 25. Spearman's rank test between parameters of nutritional status, physical and mental function[a]

	Energy	Protein	MNA	MUST	MST	SNAQ	GNRI	MMSE	GDS	Grip Strength	Gait Speed	IADL
Protein	.840**											
MNA	.208**	.230**										
MUST	-.097*	-.121**	-.636**									
MST	-.074	-.075	-.474**	.208**								
SNAQ	.005	.018	-.288**	.191**	.466**							
GNRI	.082	.111*	.645**	-.722**	-.168**	-.110*						
MMSE	.270**	.288**	.383**	-.207**	-.138**	.022	.280**					
GDS	-.074	-.091*	-.356**	.107*	.247**	.209**	-.181**	-.280**				
Grip Strength	.189**	.186**	.238**	-.076	-.077	-.026	.184**	.461**	-.240**			
Gait Speed	.164**	.196**	.181**	-.092*	-.038	-.027	.110*	.351**	-.241**	.443**		
IADL	-.073	-.092*	-.335**	.186**	.100*	-.018	-.295**	-.440**	.378**	-.259**	-.324**	
FRAIL	-.121**	-.132**	-.273**	.170**	.243**	.235**	-.148**	-.168**	.330**	-.220**	-.280**	.225**

[a]Data represent *r* value; ** $P < 0.01$; * $P < 0.05$; *P* values were not adjusted for location, gender or age.

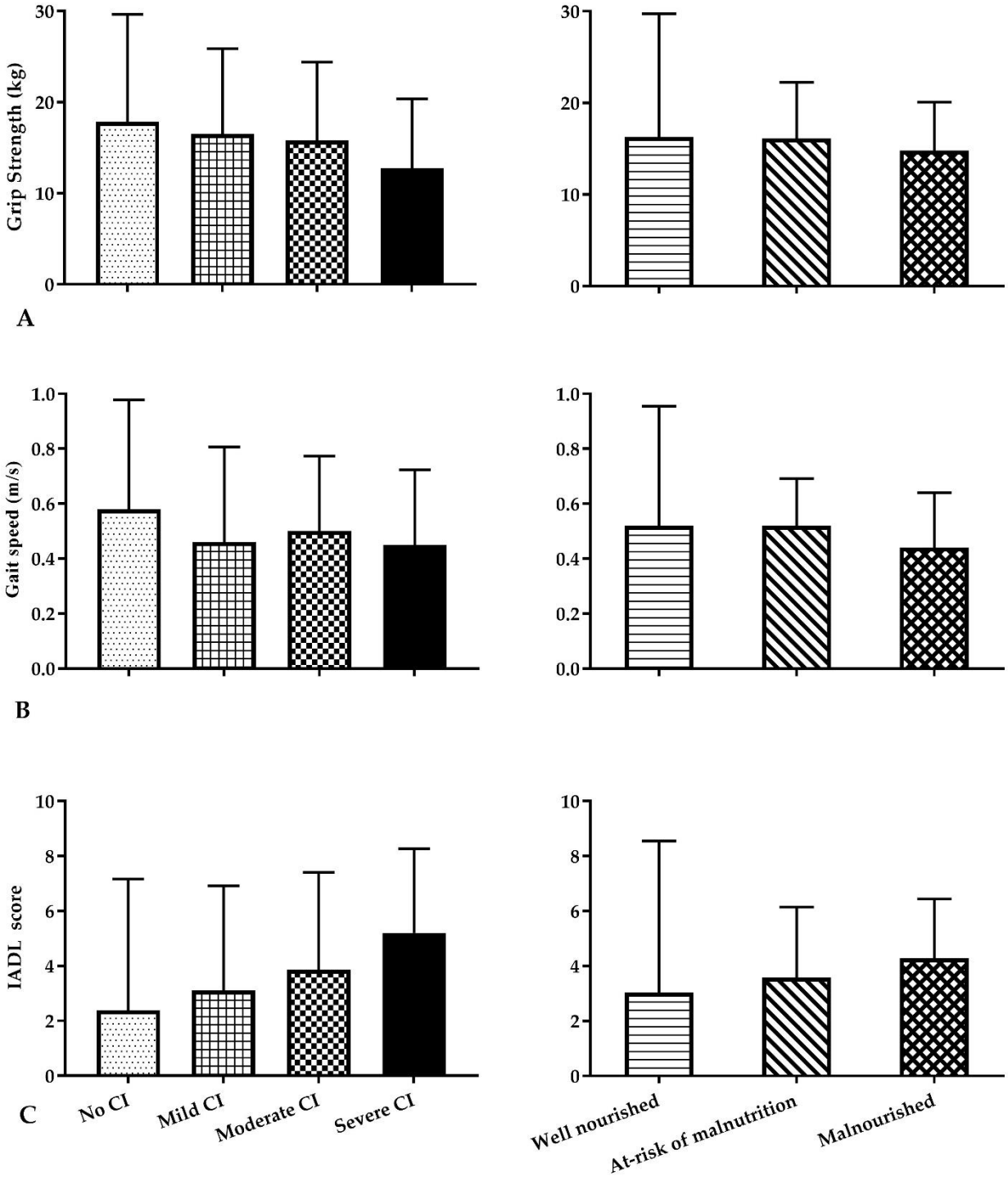


Figure 16. Grip strength (figure A), gait speed (figure B) and IADL (figure C) according to cognitive (left hand column) and nutritional status (right hand column)[#]

[#]Data presented is age adjusted Mean ± *SEM*; A. Grip strength (kg); age adjusted *P* value for cognitive function effect adjusted for age, gender and location; P value for cognitive function effect A = 0.019, B = 0.019, C < 0.01; P value for nutritional status effect A = 0.47, B = 0.15, C = 0.09; P value for interaction of cognitive function by nutritional status A = 0.62, B = 0.40, C = 0.83.

4. Discussion

This is the first study to our knowledge that has comprehesively evaluated and compared the socio-demographic and anthropometric characteristics, nutritional, cognitive and functional status, energy and nutrient intake of community-dwelling older men and women in rural and urban areas of Indonesia. The rural compared to urban participants in this study had lower levels of education and income, less dietary protein intake, more hospital admissions in the previous 6 months, lower cognitive function, poorer nutritional status (including lower body weight, height, BMI, arm and calf circumference, skinfold thickness, fat percentage, fat and fat free mass and plasma albumin concentrations), and reduced grip strength. Although they had significantly faster gait speeds, they rated themselves as being more dependent on assistance from others to perform instrumental activities of daily living including shopping, food preparation, housekeeping, transport, managing medications and finances, than did urban participants. Cognitive function was the measure that best correlated with the measured functional outcomes of grip strength, gait speed and activities of daily living, and more strongly associated with these than any measure of nutritional status in this study.

The prevalence of undernutrition (both malnutrition and at risk of malnutrition) as assessed by MNA among community-dwelling older people in this study was comparable to findings from other developing countries such as India and Iran (295-297), but significantly higher than those from more developed countries such as Japan, Taiwan, Poland and France (298-301). A French study of 692 rural- and 8,691 urban-based older people reported that undernutrition was more prevalent in the urban than rural areas (7.4% vs 18.5%) (301), while a study conducted in Poland reported that the mean MNA scores of nursing home residents (*n*=879) were significantly lower (indicating worse nutrition) than those of either urban (*n*=1003) or rural (*n*=890), community-living residents. Notably, the mean MNA score of our urban and rural Indonesian community-living residents (i.e. 24.5 ± 3.5 vs rural 23.3 ± 3.9) were comparable to the values of the Polish nursing home residents (21.3 ± 4.8) (300).

SNAQ was the only questionnaire used in this study that indicated a higher prevalence of severe and moderate malnutrition among urban than rural participants (8% vs 3% severely malnourished, and 12% vs 5% moderately malnourished). A closer look at each items of SNAQ questionnaire revealed that more of the study participants from the urban areas reported losing more than 6 kg which gave them 2 points and classified them as moderately malnourished (n = 4 vs 1, equals to 2 vs 0.5% of rural population). Additionally, there were more participants who reported taking supplemental drinks from the urban than rural area (n = 10 vs 0, equals to 5 vs 0% of rural population), which may further inflate the SNAQ score as supplemental drinks are more widely available to those living in urban than rural areas. Energy and protein intakes of Indonesian participants in this study (energy: 1411 ± 39 kcal and protein: 39.5 ± 17.6 g) were representative of the broader Indonesian population; for example, in the recent large "Total Diet Study" which involved 145,360 Indonesians from the 34 provinces, energy intake of people aged 55 years or more living in rural areas was 1615 ± 632 kcal for men and 1301 ± 509 kcal for women, whereas in urban areas they were 1676 ± 641 kcal for men and 1332 ± 516 kcal for women (21). Rural participants in the present study had substantially lower protein in their diet than urban participants (by ~ 6 ± 17 g per day), and this intake was negatively associated with income. This lower protein intake may have resulted, at least in part, in the lower nutritional status and lower body fat free mass observed in the rural participants. This finding also suggests that food security and supply are substanital issues that affect the health and nutritional status of rural older adults. Hence, improving food availability and affordability in rural areas should be a focus for the Indonesian government.

Rural participants, especially women, had higher systolic blood pressures than urban participants, and may therefore, be at greater cardiovascular risk than urban older people. The reasons for the higher systolic blood pressures in rural participants are not clear. Dietary factors may be partly responsible; for example, rural participants reported lower potassium and higher

sodium intakes and both factors are associated with blood pressure increases (302, 303). In addition, the higher blood eosinophil counts for rural participants may be caused by a higher prevalence of soil-transmitted helminth parasite infections in farmers. The prevalence of worm infections (e.g., ascaris lumbricoides, hookworm, trichuris trichura, and enterobius vermicularis) is usually higher in rural than urban areas (52-86% compared to 28%) (304, 305).

Grip strength values of our rural and urban participants from Yogyakarta (15.9 ± 6.2 and 16.8 ± 6.7 kg) were comparable to those reported from other Asian countries and Hispanic-American communities; for example, in Singapore: 362 rural and urban adults aged ≥ 65 years had a grip strength of 31.2 ± 9.2 and 24.4 ± 8.5 kg (306); in Taiwan: 558 adults aged ≥ 75 years had a grip strength of 22.3 ± 6.2 kg (307); and in Hispanic-America: 2381 adults aged ≥ 65 years had a grip strength of 23.3 ± 9.1 kg (308). In contrast, grip strength of the Indonesian participants in this study were substantially lower than community-living adults aged 65 plus years from Western countries including Belgium, Israel, Spain, UK and USA (309-312). In fact, the mean grip strength observed for the Yogyakarta participants in this study, fell within the values that have been reported for western people aged 90 years or more (11.5 ± 5.6 kg for women and 19.5 ± 8.2 kg for men) (312). The range of gait speeds observed in this study for the rural and urban participants (i.e. 0.34 to 0.72 m/s) is comparable to values previously reported for Hispanic-American older adults, but is substantially slower than for predominatly Caucasian and Afro-American older community-living adults (0.70 to 1.42 m/s), and comparable to institutionalised western people aged 90 years or more (0.49 ± 0.21 m/s for 90 years, and 0.43 ± 0.19 m/s for 95+ years) (313, 314).

Substantially lower gait speeds and grip strengths of many populations, including in Indonesia, may be related to a smaller body frame, smaller stride length, and more relaxed pace of life, particularly given that body size and weight are positively associated with both markers of physial function (315, 316). Indeed, the participants in this study had lower mean heights, weights and BMIs than “Western” populations of the same age. Therefore, the clinical significance of the

lower grip strength and gait speed within some populations compared with others remains unclear, and it is highly likely that different cut offs indicating higher risk of malnutrition, frailty and impaired physical and mental function need to be determined for specific enthnicities.

This study is the first to our knowledge to report the level and prevalence of cognitive impairment amongst Indonesians from rural compared with urban areas of Yogyakarta. The lower level of cognitive functioning observed in the rural participants is probably best explained by differenences in their level of education, but our current findings also indicate lower cognitive function may be related to their poorer nutritional status. Cognitive function appeared to be the strongest predictor of reported energy and protein intake. Previous study of 449 community-living Korean aged ≥ 60 years reported that good cognitive function as assessed by MMSE was significantly and positively associated with energy and protein intake (317). Similarly, a study of 178 Spanish adults aged ≥ 65 years showed that individuals that had no cognitive impairment compared to those with mild cognitive impairment had a higher energy intake by an average 122 kcal/day (318). An Italian based study of 1651 adults with mean age of 70 years also reported that as cognitive function decreased from 'no' to 'severe' impairment, daily energy intake tended to decrease by an average of 3.3 MJ/day; moreover, the reduction was more marked for men than women (319). Although causality cannot be determined, the data suggest that older Indonesian with an increased level of impaired cognitive function are likely to be malnourished. Hence, a malnutrition prevention program, particularly targeting older people with cognitive impairment needs more emphasis on involving other family members, considering the strong family bond and care dependancy among Indonesian older adults (320).

Our findings regarding the relationship between cognitive function and markers of physical function are consistent with previously reported associations from other countries (308, 321, 322). In a prospective study of older adults from the United States, reduced grip strength was associated with the presence of persistent, mild, cognitive impairment [hazard ratio (*HR*): 1.34, 95%

confidence interval (*CI*) 1.02–1.75], while the risk of developing mild cognitive impairment was associated with both reduced grip strength (*HR*: 1.28, 95% *CI* 1.07–1.54) and gait speed (*HR*: 1.27, 95% *CI* 1.11–1.45) (321). In a separate prospective study from the United States, reduced cognitive function with ageing was associated with decreased grip strength (308, 322), and older people who developed Alzheimer's disease had lower grip strengths than those who did not (308, 322). Our findings now extend these to a developing country, suggesting that the relationship between cognition and markers of functional status is an age-related phenomenon evident in older populations across different regions of the world. Findings of this study also confirm results from a systematic review which showed that association between cognitive function and markers of physical function were found in both cross-sectional and longitudinal studies, implying that cognitive function also predicts future decline in physical function (323).

The importance of the functional parameters, particularly gait speed and grip strength, that we measured, is their assocation in numerous studies with important clinical outcomes such as quality of life, independence, frailty, hospital admissions and survival (310-313, 321, 324, 325). In recognition of the importance of these funcational measures, they are now included in most criteria for the definition of sarcopenia (326). These functional measures are therefore important measurements of health and wellbeing of older populations, and our findings support the importance of assessing cognitive function also.

A limitation of the study was that the cross-sectional design does not allow determination of causal relationships between the nutritional, physical and mental function of older people living in rural and urban areas of Indonesia. Nevertheless, this study was amongst the first to use multiple tools to assess nutritional status, physical and mental function, and to identify Indonesian specific values for each range of these tools. However, our findings also highlight the fact that current scoring sytems within the tools used to classify frailty and sarcopenia – tools that have largely been developed in 'Western' population (326) - may not be applicable and thus there need to be

population specific criteria. This is a justified concern since urban-residing Indonesians are more aware of their health, and hence, more likely to have routine health check-ups by a GP, which in turn may lead to earlier diagnosis of disease. However, we speculate the associations found between cognitive impairment and nutritional and functional parameters may have been stronger with inclusion of more individuals with severe CI and also with the use of more sensitive tools than the MMSE to measure subtle changes in a range of cognitive abilities (327, 328).

5. Conclusion

In conclusion rural, when compared to urban, older Indonesians living in Yogyakarta were more likely to be malnourished and cognitively impaired, which were associated with reduced functional capacities, and greater dependence. Strategies to increase both health-professional and public awareness of the nutritional and cognitive issues facing older Indonesians, and the development of targeted intreventions to improve cognitive function and nutritional status, are therefore important for the health and wellbeing of older Indonesians.

CHAPTER 7. GENERAL DISCUSSION, CONCLUSIONS AND FUTURE RESEARCH

This thesis consists of five different projects including a literature review of nutrition screening tool, a cross-sectional and longitudinal study of malnutrition and its impact on Australian nursing home residents, a cross-sectional study of factors associated with malnutrition among urban and rural living older Indonesian, and a randomised control trial of the effect of high-energy and high-protein meals on nutrient intake and clinical outcomes of nutritionally at-risk community-dwelling older Australians. Findings of the studies in this thesis have provided three main crucial insights for the fields of ageing and nutrition research; these are: (i) an improved understanding on the prevalence and predictors of malnutrition among nursing home-residing South Australian and community-dwelling Indonesian, older adults; (ii) the feasibility and sensitivity of a range of recommended and/or commonly used nutrition screening tool to detect and diagnose malnutrition amongst older people across both community and residential aged care settings; and (iii) the potential for energy and protein fortification of meals to improve nutrient intake and nutritional status of community-dwelling older adults. Chapter 1 showed that malnutrition is a significant and increasingly common problem among older people in both the community and residential aged care homes, and across both developed and developing countries. It is likely that the trend of increasing prevalence of malnutrition will continue, unless awareness about this condition is raised amongst health professional and the public, and hence, early identification, prevention and management measures are implemented quickly. The chapter also provided crucial information on various strategies that are effective to prevent malnutrition among older people, particularly nutritional supplementation and food fortification. Furthermore, finding of a pilot study by our team, i.e. standard and HEHP MOW meals produced by the central MOW SA kitchen were then used as main intervention tool for study reported in Chapter 5.

Chapter 2 provided a narrative review of screening tools to identify those which are used to diagnose malnutrition and assess clinical outcomes in older adults populations across various

settings. This review showed that the majority of the nutrition screening tools performed inconsistently and poorly in predicting clinical outcomes among older people. Nevertheless, there are tools that performed significantly better than the others at predicting clini cal outcomes, i.e. MNA, GNRI and DETERMINE. Hence, these tools are recommended as the preferred tools to screen and diagnose nutritional status, and to predict clinical outcomes in older adults population across different settings. These tools were used as preferred instuments for studies reported in Chapter 4 to 6. Findings from this chapter could also potentially be useful for clinician in determining the appropriate screening tool for their particular work settings.

Chapter 3 highlighted that routine use and proper administration of currently available screening tools results in better understanding on the determinants of malnutrition among older South Australians residing in aged care homes. Around 30% of the nursing home residents were at medium or high risk of malnutrition, with women twice as likely as men to be at high nutritional risk. The prevalence of poor nutritional status in this study, using the MUST tool, was in line with rates of 21 - 38% reported in recent studies of Australian and European nursing home residents using the same tool (173-176). Overall, the total nursing home population lost approximately 1 - 1.3% body weight per annum (0.8 - 0.9 kg) , and the underweight residents were more likely than other residents to lose > 5% body weight, putting them at increased risk of malnutrition and its associated deleterious effect. In addition, in the study described in Chapter 3 pain scores were strongly associated with increased risk/severity of malnutrition, suggesting that routine measurement of pain in response to nutritional intervention may be a simple measure to help assess nutritional risk and possibly impelement strategies to improve nutritional status. The association between pain and poor nutritional status has been reported in a previous study of nursing home residents (180) and are likely to be mediated via multiple mechanisms, including the anorectic (181) and cachectic effects of increased cytokine action in painful conditions including malignancies. Nevertheless, due to limited available information, our research was unable to

explain further the role of other determinants of weight loss and malnutrition in older people which has been reported by other studies including dementia, depression, reduced functional status, medical conditions and medications, poor dentition, social isolation and poverty (16, 178, 179).

Chapter 4 details the finding that despite no change in weight and nutritional status over 6 months, there were considerable shifts in body composition among older South Australians residing in aged care homes. There were substantial changes in body composition (i.e. CAMA , fat free mass, and fat mass); i.e. 82% gained or lost more than > 5% CAMA, 70% gained or lost > 5% fat mass, and 30% gained or lost >5% fat free mass over 6 months. Moreover, increasing age of the residents was associated with decreased fat free mass and an increased fat mass at 6 month follow-up (Baseline fat free mass: r=-0.564, p=0.010; Baseline fat free mass: r=-0.591, p=0.006). These findings are consistent with those of two previous studies which showed that although having a stable weight, participants in both studies experienced significant losses of fat free mass loss and gain in fat mass (34, 35). It is important to note that the negligible change in nutritional, mental and physical function was likely caused by the fact that participants of the study were in better health than their peers who were unable to take part in the study due to ill health. Additionally, ethical approval required the researchers to report findings of abnormal nutritional (i.e. significant loss of weight and/or appetite), mental and physical function to the manager of the aged care home, which then triggered the necessary nutritional, or non-nutritional interventions to enable further decline to be addressed. In addition, the substantial change of body composition, especially fat free mass loss and fat mass gain (which are also phenotypes of sarcopenia and sarcopenic obesity), are of grave concern as these were associated with physical impairment, disability, and poor clinical outcomes in older people (329-331). Hence, the need for routine monitoring of body composition change, and early nutrition and physical exercise intervention which has been shown, in this study and in systematic reviews by other groups, to attenuate the progression of muscle mass and function loss (332, 333).

Chapter 5 showed that both the 'standard' (STD) and 'energy and protein fortified' (HEHP) lunchtime meals prepared by the aged care food service, 'Meals on Wheels', can assist older adults to meet their recommended daily intakes, especially for energy and protein which isin line with the conclusion of meta-analysis by Morilla-Herrera *et al. (80),* and further solidifies the evidence that food fortification is an effective strategy to improve nutritional intake of older adults. While the study also demonstrated that neither type of MOW meal, when compared with basic diet counselling (control), differentially improved any of the markers of physical capacity, general and psychological wellbeing, quality of life or hospitalisations, further decline in these outcomes over a 12 week period was not observed. While our screening tools identified that participants in the 'STD' and 'HEHP' groups were 'at risk of malnutrition', a major limitation of this study was that all participants had, on average, an adequate energy and protein intake at baseline, and their mean MNA scores, BMI (kg/m2), and arm and calf circumferences all indicated they were at the upper cut-off criteria indicative of being 'at risk of malnutrition'. Hence, it is possible, even likely, that studies among older people with poorer intake and nutritional state than participants of the study would show more substantial change in outcome parameters. Furthermore, nutrition counselling provided to control group helped them select the appropriate food and meet energy and protein requirements over the study period. A previous systematic review has found that dietary counselling with or without oral nutritional supplements resulted in improved weight, body composition and grip strength, but not survival (334). Lastly, the relatively short intervention period and small sample size have reduced the ability to detect a more pronounced change. Future studies will need to improve from these shortcomings and expand to a more diverse communities, including those in developing countries which currently experience rapid population ageing. The core model of food fortification should remain similar, but delivery of the intervention will likely need to be modified due to to the absence of community meal services in these developing countries.

Chapter 6 examined the prevalence rates of malnutrition/nutritional risk amongst urban and rural community-living Indonesians aged 65 years and older, and the associations between nutritional status and functional and mental status of within each of these settings. This is the first reported comprehensive study of Indonesian older adults using multiple validated tools. As expected, the rural compared to urban participants in the study had lower levels of education and income, and they were also found to have lower dietary protein intakes, more hospital admissions, lower cognitive function, poorer nutritional status and lower grip strength. Although rural participants had significantly faster gait speeds they rated themselves as being more dependent on assistance from others to perform daily activities. There were two possibly unexpected findings from the study – namely, i) cognitive function had a stronger association with functional parameters (i.e grip strength, gait speed and activities of daily living) than any measure of nutritional status, and ii) gait speeds and grip strengths of our community-dwelling Indonesian participants, both rural and urban, were substantially lower than community-living Western people, and were equivalent to those of older Westerners living in aged care homes. This finding, highlights the fact that 'normal' cut-offs for functional parameters, and criteria for diagnosis of frailty and sarcopenia need to be established for each community/country, rather than single cut-off value / criteria for worldwide older adults population currently often used in the literature (326). Overall, the studies presented in this thesis answered questions raised within the theoretical framework through the various study methodologies (including cross-sectional, longitudinal and intervention), but at the same time, raises many crucial issues which should guide furture studies. From studies conducted in Australia (Chapter 4 and 5), there was a clear pattern of difficulties with subject recruitment, with about 5% of those eligible eventually taking part. This difficulty is not unique to these two studies and has been reported by our group (235) and others (236-238). For the nursing home-based study (Chapter 4) we used extensive recruitment methods including group presentation by a senior research team member accompanied by the nursing home manager

and executives, personal approaches to potential residents identified by nursing home managers, presentations during weekly resident activities and interest groups, sending flyers to each resident through the internal mail service, and attaching posters on every notice board in the nursing homes. Moreover, the study was designed to include nearly all residents (except those with impaired cognitive function who were unable to comprehend the study protocol), but adoption of these recruitment methods did not have any apparent effect on inclusivity, despite recommendation from previous study that inclusion of minority subjects could potentially improve participations in nursing home setting (238). The study also tried to reduce access issue for the residents by conducting all assessments on-site and at times agreed to by the residents. Barriers to participation provided by other people trusted and/or related to the residents who often have the power / authority to make decision for them (gate keeper barrier) as reported in other studies (237), appeared nearly non-existent, as family and nursing home staff were actively involved in the recruitment process. Based on anecdotal information conveyed by some participants and staff, we hypothesise that reluctance to commit to a study for 3 to 6 months, and lack of perceived benefit from participating in the research, were among the main barriers.

For the community-based study of South Australian older adults (Chapter 5), recruitment methods employed included targeting MOW clients, GP and dietitian referrals, flyers, and media advertisements (weekly newspaper). However, after running for more than 2 years, recruitment remained difficult. The narrow inclusion criteria of the study which required participants to be classified as at-risk of malnutrition (based on MNA score, BMI, and weight loss history) excluded several individuals who were interested to take part due to being more severely malnourished (MNA score < 17) or well nourished (MNA score > 24). Therefore, we hypothesise that lack of inclusivity of those malnourished participants who may have benefited but who need more intensive intervention from their health care team, to some extent contributed to the low sample size. In addition, the study duration was limited to 3 months and we probably should have

conducted the follow-up assessments at 6 or even 12 months given that our findings from Chapters 4 and 6 indicate greater declines in weight with increasing age. On other hand, at the time the study was designed, our team felt this may have been too large a period and participants would withdrew if the meals did not improve participant their general sense of wellbeing.

In conclusion, the research presented within this thesis indicates that malnutrition is a real and present danger for older people around the world, and nutritional interventions through meal fortification, and or specific nutrient supplements, could potentially attenuate the progression and severity of malnutrition and related co-morbidities. However, prevention of malnutrition through early detection and diagnosis using the best of the available screening tools (i.e. MNA, GNRI and DETERMINE) is arguably better and potentially more cost effective. Further research is required to continue with the refinement of these key tools and/or develop new and more pragmatic tools and intervention strategies that are more effective to specific settings, capable of preventing, and detecting subtle changes in malnutrition and its associated health outcomes over time.

Future research

Based on findings from this theses, there are several potential lines of research that could be conducted in the future and will be pursued by our group over the coming years, including:

- Assessment of the predictive performance of established tools over long-term in hospital, nursing home and community settings. This is likely we believe to provide more clinical benefit than the development of new screening and diagnostic tools. Studies on the long-term impact and cost effectiveness of various nutrition intervention, such as food fortification, oral nutrition support, and dietetic counselling in Australian nursing home populations.
- Studies of nutritional interventions involving fortification of currently available meal services involving a wider group of community-dwelling older people in Australia, including those who were malnourished and well nourished. Additionally, collaborative

study with Nursing home providers to introduce fortified meal for residents with poor intake, at-risk of malnutrition or malnourished is warranted.

- A prospective observational study of urban and rural residing older people in Indonesia. The growing population of older people in Indonesia means there is a need for a better understanding on the long-term impact of malnutrition and impaired cognitive function on functional capacity, hospitalisation and quality of life of older Indonesians. Furthermore, understanding dietary pattern, food security and supply among older people from both region is essential to establish the appropriate nutrition intervention. Study on financial cost of malnutrition to the Indonesian health system is important to increase awareness and help the Government to formulate informed health policy.

REFERENCES

1. Australian Beureau of Statistics. Australian Social Trends. 2009. Report No.: 4102.0.
2. United Nations, Department of Economic and Social Affairs, Population Division. World Population Ageing 2015 New York, USA: United Nations; 2015. Contract No.: ST/ESA/SER.A/390.
3. BPS - Statistics Indonesia. Indonesia Population Projection 2010-2035. Jakarta, Indonesia: Statistics Indonesia; 2013.
4. Lochs H, Allison SP, Meier R, Pirlich M, Kondrup J, Schneider S, et al. Introductory to the ESPEN Guidelines on Enteral Nutrition: Terminology, definitions and general topics. Clinical nutrition (Edinburgh, Scotland). 2006;25(2):180-6.
5. Chen CC, Schilling LS, Lyder CH. A concept analysis of malnutrition in the elderly. Journal of advanced nursing. 2001;36(1):131-42.
6. Raynaud-Simon A, Revel-Delhom C, Hebuterne X. Clinical practice guidelines from the French Health High Authority: nutritional support strategy in protein-energy malnutrition in the elderly. Clinical nutrition (Edinburgh, Scotland). 2011;30(3):312-9.
7. Cederholm T, Bosaeus I, Barazzoni R, Bauer J, Van Gossum A, Klek S, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clinical nutrition (Edinburgh, Scotland). 2015;34(3):335-40.
8. Meijers JM, Halfens RJ, van Bokhorst-de van der Schueren MA, Dassen T, Schols JM. Malnutrition in Dutch health care: prevalence, prevention, treatment, and quality indicators. Nutrition (Burbank, Los Angeles County, Calif). 2009;25(5):512-9.
9. Vikstedt T, Suominen MH, Joki A, Muurinen S, Soini H, Pitkala KH. Nutritional status, energy, protein, and micronutrient intake of older service house residents. Journal of the American Medical Directors Association. 2011;12(4):302-7.
10. Russell CA, Elia M. Nutrition screening survey in the UK and Republic of Ireland in 2011. UK: British Association for Parenteral and Enteral Nutrition (BAPEN); 2012.
11. Seong TC, Ngoh, Hooi Jiun, Harith, Sakinah. Prevalence of Malnutrition among Institutionalized Elderly People in Northern Peninsular Malaysia: Gender, Ethnicity and Age-specific. Sains Malaysiana. 2012;41(1):141-8.
12. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Frequency of malnutrition in older adults: a multinational perspective using the mini nutritional assessment. Journal of the American Geriatrics Society. 2010;58(9):1734-8.
13. Charlton KE, Nichols C, Bowden S, Lambert K, Barone L, Mason M, et al. Older rehabilitation patients are at high risk of malnutrition: evidence from a large Australian database. The journal of nutrition, health & aging. 2010;14(8):622-8.
14. Gaskill D, Black LJ, Isenring EA, Hassall S, Sanders F, Bauer JD. Malnutrition prevalence and nutrition issues in residential aged care facilities. Australasian journal on ageing. 2008;27(4):189-94.
15. Rist G, Miles G, Karimi L. The presence of malnutrition in community-living older adults receiving home nursing services. Nutrition & Dietetics. 2012;69(1):46-50.
16. Chapman IM. The anorexia of aging. Clinics in geriatric medicine. 2007;23(4):735-56, v.
17. Hickson M. Malnutrition and ageing. Postgraduate medical journal. 2006;82(963):2-8.

18. Stanga Z. Basics in clinical nutrition: Nutrition in the elderly. European e-Journal of Clinical Nutrition and Metabolism. 2009;4(6):e289-e99.

19. Chapman IM. Weight loss in older persons. The Medical clinics of North America. 2011;95(3):579-93, xi.

20. Visvanathan R, Chapman IM. Undernutrition and anorexia in the older person. Gastroenterology clinics of North America. 2009;38(3):393-409.

21. Ministry of Health Republic of Indonesia. Total Diet Study : Individual Food Consumption Survey 2014. Jakarta, Indonesia2014. 232 p.

22. Miller SL, Wolfe RR. The danger of weight loss in the elderly. The journal of nutrition, health & aging. 2008;12(7):487-91.

23. Visvanathan R, Macintosh C, Callary M, Penhall R, Horowitz M, Chapman I. 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. 2003;51(7):1007-11.

24. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age and ageing. 2010;39(4):412-23.

25. Cruz-Jentoft AJ, Morley J. Sarcopenia. United Kingdom: Wiley-Blackwell; 2012.

26. Stenholm S, Harris TB, Rantanen T, Visser M, Kritchevsky SB, Ferrucci L. Sarcopenic obesity: definition, cause and consequences. Current opinion in clinical nutrition and metabolic care. 2008;11(6):693-700.

27. Zamboni M, Mazzali G, Fantin F, Rossi A, Di Francesco V. Sarcopenic obesity: a new category of obesity in the elderly. Nutrition, metabolism, and cardiovascular diseases : NMCD. 2008;18(5):388-95.

28. Benton MJ, Whyte MD, Dyal BW. Sarcopenic obesity: strategies for management. The American journal of nursing. 2011;111(12):38-44; quiz 5-6.

29. Dominguez LJ, Barbagallo M. The cardiometabolic syndrome and sarcopenic obesity in older persons. Journal of the cardiometabolic syndrome. 2007;2(3):183-9.

30. Chima CS, Barco K, Dewitt ML, Maeda M, Teran JC, Mullen KD. Relationship of nutritional status to length of stay, hospital costs, and discharge status of patients hospitalized in the medicine service. Journal of the American Dietetic Association. 1997;97(9):975-8; quiz 9-80.

31. Correia MI, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clinical nutrition (Edinburgh, Scotland). 2003;22(3):235-9.

32. Guest JF, Panca M, Baeyens JP, de Man F, Ljungqvist O, Pichard C, et al. Health economic impact of managing patients following a community-based diagnosis of malnutrition in the UK. Clinical nutrition (Edinburgh, Scotland). 2011;30(4):422-9.

33. Malnutrition Task Force. Cost of Malnutrition: Methods, Estimation and Projection. Malnutrition Task Force; 2013.

34. Elia M, Stratton RJ. Calculating the cost of disease-related malnutrition in the UK in 2007 ('public expenditure only') in: Combating Malnutrition: Recommendations for Action. BAPEN; 2009.

35. Rowell DS, Jackson TJ. Additional costs of inpatient malnutrition, Victoria, Australia, 2003-2004. The European journal of health economics : HEPAC : health economics in prevention and care. 2011;12(4):353-61.

36. Gout BS, Barker LA, Crowe TC. Malnutrition identification, diagnosis and dietetic referrals: Are we doing a good enough job? Nutrition & Dietetics. 2009;66(4):206-11.

37. Australian Institute of Health and Welfare. Australia's health 2010. Australia's health series no12. Canberra: AIHW; 2010.

38. Harris D, Haboubi N. Malnutrition screening in the elderly population. Journal of the Royal Society of Medicine. 2005;98(9):411-4.

39. Omran ML, Morley JE. Assessment of protein energy malnutrition in older persons, part I: History, examination, body composition, and screening tools. Nutrition (Burbank, Los Angeles County, Calif). 2000;16(1):50-63.

40. Winter JE, MacInnis RJ, Wattanapenpaiboon N, Nowson CA. BMI and all-cause mortality in older adults: a meta-analysis–. The American journal of clinical nutrition. 2014;99(4):875-90.

41. Garn SM. Diet and health: Implications for reducing chronic disease risk. Committee on Diet and Health, National Research Council, xiv + 768 pp. Washington, D.C.: National Academy Press. 1989, $49.95 (cloth). American Journal of Human Biology. 1990;2(5):587-8.

42. Gibson RS. Principles of Nutritional Assessment. 2 ed. New York: Oxford University Press; 2005.

43. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey (NHANES) Anthropometry Procedures Manual. Atlanta, USA: CDC; 2007.

44. Omran ML, Morley JE. Assessment of protein energy malnutrition in older persons, Part II: Laboratory evaluation. Nutrition (Burbank, Los Angeles County, Calif). 2000;16(2):131-40.

45. van Bokhorst-de van der Schueren MA, Guaitoli PR, Jansma EP, de Vet HC. Nutrition screening tools: Does one size fit all? A systematic review of screening tools for the hospital setting. Clinical nutrition (Edinburgh, Scotland). 2013.

46. van Bokhorst-de van der Schueren MA, Guaitoli PR, Jansma EP, de Vet HC. A Systematic Review of Malnutrition Screening Tools for the Nursing Home Setting. Journal of the American Medical Directors Association. 2013.

47. Elia M, Stratton RJ. An analytic appraisal of nutrition screening tools supported by original data with particular reference to age. Nutrition (Burbank, Los Angeles County, Calif). 2012;28(5):477-94.

48. Phillips MB, Foley AL, Barnard R, Isenring EA, Miller MD. Nutritional screening in community-dwelling older adults: a systematic literature review. Asia Pacific journal of clinical nutrition. 2010;19(3):440-9.

49. Cereda E, Pusani C, Limonta D, Vanotti A. The ability of the Geriatric Nutritional Risk Index to assess the nutritional status and predict the outcome of home-care resident elderly: a comparison with the Mini Nutritional Assessment. The British journal of nutrition. 2009;102(4):563-70.

50. Cereda E, Zagami A, Vanotti A, Piffer S, Pedrolli C. Geriatric Nutritional Risk Index and overall-cause mortality prediction in institutionalised elderly: a 3-year survival analysis. Clinical nutrition (Edinburgh, Scotland). 2008;27(5):717-23.

51. van Asselt DZ, van Bokhorst-de van der Schueren MA, van der Cammen TJ, Disselhorst LG, Janse A, Lonterman-Monasch S, et al. Assessment and treatment of malnutrition in Dutch geriatric practice: consensus through a modified Delphi study. Age and ageing. 2012;41(3):399-404.

52. Agarwal E, Miller M, Yaxley A, Isenring E. Malnutrition in the elderly: a narrative review. Maturitas. 2013;76(4):296-302.

53. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I, et al. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. The American journal of clinical nutrition. 2005;82(4):777-83.

54. Guigoz Y VB, Garry PJ. Mini Nutritional Assessment: a practical assessment tool for grading the nutritional state of elderly patients. Facts and Research in Gerontology. 1994;Supplement 2:15 - 58.

55. Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form mini-nutritional assessment (MNA-SF). The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(6):M366-72.

56. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. The journal of nutrition, health & aging. 2009;13(9):782-8.

57. Elia M. The 'MUST' report. UK: BAPEN; 2003.

58. Kruizenga HM, Seidell JC, de Vet HC, Wierdsma NJ, van Bokhorst-de van der Schueren MA. Development and validation of a hospital screening tool for malnutrition: the short nutritional assessment questionnaire (SNAQ). Clinical nutrition (Edinburgh, Scotland). 2005;24(1):75-82.

59. Baker JP, Detsky AS, Wesson DE, Wolman SL, Stewart S, Whitewell J, et al. Nutritional assessment: a comparison of clinical judgement and objective measurements. The New England journal of medicine. 1982;306(16):969-72.

60. Payette H, Boutier V, Coulombe C, Gray-Donald K. Benefits of nutritional supplementation in free-living, frail, undernourished elderly people: a prospective randomized community trial. Journal of the American Dietetic Association. 2002;102(8):1088-95.

61. Wouters-Wesseling W, Van Hooijdonk C, Wagenaar L, Bindels J, de Groot L, Van Staveren W. The effect of a liquid nutrition supplement on body composition and physical functioning in elderly people. Clinical nutrition (Edinburgh, Scotland). 2003;22(4):371-7.

62. Edington J, Barnes R, Bryan F, Dupree E, Frost G, Hickson M, et al. A prospective randomised controlled trial of nutritional supplementation in malnourished elderly in the community: clinical and health economic outcomes. Clinical nutrition (Edinburgh, Scotland). 2004;23(2):195-204.

63. Tieland M, van de Rest O, Dirks ML, van der Zwaluw N, Mensink M, van Loon LJ, et al. Protein supplementation improves physical performance in frail elderly people: a randomized, double-blind, placebo-controlled trial. Journal of the American Medical Directors Association. 2012;13(8):720-6.

64. Myint MW, Wu J, Wong E, Chan SP, To TS, Chau MW, et al. Clinical benefits of oral nutritional supplementation for elderly hip fracture patients: a single blind randomised controlled trial. Age and ageing. 2013;42(1):39-45.

65. Milne AC, Potter J, Vivanti A, Avenell A. Protein and energy supplementation in elderly people at risk from malnutrition. The Cochrane database of systematic reviews. 2009(2):Cd003288.

66. Neelemaat F, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Oral nutritional support in malnourished elderly decreases functional limitations with no extra costs. Clinical Nutrition. 2012;31(2):183-90.

67. Persson M, Hytter-Landahl A, Brismar K, Cederholm T. Nutritional supplementation and dietary advice in geriatric patients at risk of malnutrition. Clinical nutrition (Edinburgh, Scotland). 2007;26(2):216-24.

68. Parsons EL, Stratton RJ, Cawood AL, Smith TR, Elia M. Oral nutritional supplements in a randomised trial are more effective than dietary advice at improving quality of life in malnourished care home residents. Clinical Nutrition. 2017;36(1):134-42.

69. Lee LC, Tsai AC, Wang JY, Hurng BS, Hsu HC, Tsai HJ. Need-based intervention is an effective strategy for improving the nutritional status of older people living in a nursing home: a randomized controlled trial. International journal of nursing studies. 2013;50(12):1580-8.

70. Stange I, Bartram M, Liao Y, Poeschl K, Kolpatzik S, Uter W, et al. Effects of a Low-Volume, Nutrient- and Energy-Dense Oral Nutritional Supplement on Nutritional and Functional Status: A Randomized, Controlled Trial in Nursing Home Residents. Journal of the American Medical Directors Association. 2013;14(8):628.e1-.e8.

71. Smoliner C, Norman K, Scheufele R, Hartig W, Pirlich M, Lochs H. Effects of food fortification on nutritional and functional status in frail elderly nursing home residents at risk of malnutrition. Nutrition (Burbank, Los Angeles County, Calif). 2008;24(11-12):1139-44.

72. Gray-Donald K, Payette H, Boutier V. Randomized clinical trial of nutritional supplementation shows little effect on functional status among free-living frail elderly. The Journal of nutrition. 1995;125(12):2965-71.

73. Australian Government. Commonwealth Home Support Programme 2016 [Available from: https://www.myagedcare.gov.au/help-home/commonwealth-home-support-programme.

74. Cudmore M. A Meal a Day : A history of Meals on Wheels in South Australia 1953 - 1996. South Australia: Meals on Wheels (SA) Inc.; 1996.

75. Media Fast Facts – Meals on Wheels SA [press release]. South Australia: Meals on Wheels (SA) Inc.2014.

76. SA MoW. A complete guide to healthy eating for people using Meals on Wheels. South Australia: Meals on Wheels (SA) Inc.; 2012.

77. Pargeter KA. Meals on Wheels: A Nutritional Evaluation: National Research Institute of Gerontology and Geriatric Medicine; 1986.

78. Stuckey SJ, Darnton-Hill I, Ash S, Brand JC, Hain DL. Dietary patterns of elderly people living in inner Sydney. Human nutrition Applied nutrition. 1984;38(4):255-64.

79. Fogler-Levitt E, Lau D, Csima A, Krondl M, Coleman P. Utilization of home-delivered meals by recipients 75 years of age or older. Journal of the American Dietetic Association. 1995;95(5):552-7.

80. Morilla-Herrera J, Martin-Santos F, Caro-Bautista J, Saucedo-Figueredo C, Garcia-Mayor S, Morales-Asencio JM. Effectiveness of food-based fortification in older people a

systematic review and meta-analysis. The journal of nutrition, health & aging. 2016;20(2):178-84.

81. World Health Organization. Good health adds life to years: Global brief for World Health Day 2012. Geneva: WHO; 2012. Report No.: WHO/DCO/WHD/2012.2.

82. United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2012 Revision, Highlights and Advance Tables. 2013.

83. Arjuna T, Luscombe-Marsh N, Lange K, Kang A, Hickman P, Edwards C, et al. Body-weight and nutritional-status changes in South Australian nursing-home residents. Journal of Nursing Home Research. 2016;2:97-103.

84. Green SM, Watson R. Nutritional screening and assessment tools for older adults: literature review. Journal of advanced nursing. 2005;54(4):477-90.

85. Detsky AS, McLaughlin, Baker JP, Johnston N, Whittaker S, Mendelson RA, et al. What is subjective global assessment of nutritional status? Journal of Parenteral and Enteral Nutrition. 1987;11(1):8-13.

86. Wijnhoven HA, Schilp J, van Bokhorst-de van der Schueren MA, de Vet HC, Kruizenga HM, Deeg DJ, et al. Development and validation of criteria for determining undernutrition in community-dwelling older men and women: The Short Nutritional Assessment Questionnaire 65+. Clinical nutrition (Edinburgh, Scotland). 2012;31(3):351-8.

87. Kondrup J, Rasmussen HH, Hamberg OLE, Stanga Z. Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. Clinical Nutrition. 2003;22(3):321-36.

88. Nutrition Screening Initiative. The determine your nutritional health checklist. The Washington nurse. 1994;24(2):14-5.

89. Wolinsky FD, Coe RM, McIntosh WA, Kubena KS, Prendergast JM, Chavez MN, et al. Progress in the development of a nutritional risk index. The Journal of nutrition. 1990;120 Suppl 11:1549-53.

90. Soderhamn U, Soderhamn O. Reliability and validity of the nutritional form for the elderly (NUFFE). Journal of advanced nursing. 2002;37(1):28-34.

91. Keller HH, Hedley MR, Wong Brownlee S. The Development of Seniors in the Community: Risk Evaluation for Eating and Nutrition (SCREEN). Canadian journal of dietetic practice and research : a publication of Dietitians of Canada = Revue canadienne de la pratique et de la recherche en dietetique : une publication des Dietetistes du Canada. 2000;61(2):67-72.

92. Kagansky N, Berner Y, Koren-Morag N, Perelman L, Knobler H, Levy S. Poor nutritional habits are predictors of poor outcome in very old hospitalized patients. The American journal of clinical nutrition. 2005;82(4):784-91; quiz 913-4.

93. Soderstrom L, Rosenblad A, Adolfsson ET, Saletti A, Bergkvist L. Nutritional status predicts preterm death in older people: A prospective cohort study. Clinical nutrition (Edinburgh, Scotland). 2013.

94. Van Nes MC, Herrmann FR, Gold G, Michel JP, Rizzoli R. Does the mini nutritional assessment predict hospitalization outcomes in older people? Age and ageing. 2001;30(3):221-6.

95. Gazzotti C, Albert A, Pepinster A, Petermans J. Clinical usefulness of the mini nutritional assessment (MNA) scale in geriatric medicine. The journal of nutrition, health & aging. 2000;4(3):176-81.

96. Gentile S, Lacroix O, Durand AC, Cretel E, Alazia M, Sambuc R, et al. Malnutrition: a highly predictive risk factor of short-term mortality in elderly presenting to the emergency department. The journal of nutrition, health & aging. 2013;17(4):290-4.

97. Vischer UM, Frangos E, Graf C, Gold G, Weiss L, Herrmann FR, et al. The prognostic significance of malnutrition as assessed by the Mini Nutritional Assessment (MNA) in older hospitalized patients with a heavy disease burden. Clinical nutrition (Edinburgh, Scotland). 2012;31(1):113-7.

98. Rasheed S, Woods RT. Predictive validity of 'Malnutrition Universal Screening Tool' ('MUST') and Short Form Mini Nutritional Assessment (MNA-SF) in terms of survival and length of hospital stay. e-SPEN Journal. 2013;8(2):e44-e50.

99. Stratton RJ, King CL, Stroud MA, Jackson AA, Elia M. 'Malnutrition Universal Screening Tool' predicts mortality and length of hospital stay in acutely ill elderly. The British journal of nutrition. 2006;95(2):325-30.

100. Henderson S, Moore N, Lee E, Witham M. Do the malnutrition universal screening tool (MUST) and Birmingham nutrition risk (BNR) score predict mortality in older hospitalised patients? BMC Geriatr. 2008;8(1):1-6.

101. Rasheed S, Woods RT. Malnutrition and associated clinical outcomes in hospitalized patients aged 60 and older: an observational study in rural Wales. Journal of nutrition in gerontology and geriatrics. 2013;32(1):71-80.

102. Holst M, Yifter-Lindgren E, Surowiak M, Nielsen K, Mowe M, Carlsson M, et al. Nutritional screening and risk factors in elderly hospitalized patients: association to clinical outcome? Scandinavian journal of caring sciences. 2012.

103. Persson MD, Brismar KE, Katzarski KS, Nordenstrom J, Cederholm TE. Nutritional status using mini nutritional assessment and subjective global assessment predict mortality in geriatric patients. Journal of the American Geriatrics Society. 2002;50(12):1996-2002.

104. Covinsky KE, Martin GE, Beyth RJ, Justice AC, Sehgal AR, Landefeld CS. The relationship between clinical assessments of nutritional status and adverse outcomes in older hospitalized medical patients. Journal of the American Geriatrics Society. 1999;47(5):532-8.

105. Cereda E, Pedrolli C, Zagami A, Vanotti A, Piffer S, Opizzi A, et al. Nutritional screening and mortality in newly institutionalised elderly: a comparison between the geriatric nutritional risk index and the mini nutritional assessment. Clinical nutrition (Edinburgh, Scotland). 2011;30(6):793-8.

106. Cereda E, Pusani C, Limonta D, Vanotti A. The association of Geriatric Nutritional Risk Index and total lymphocyte count with short-term nutrition-related complications in institutionalised elderly. Journal of the American College of Nutrition. 2008;27(3):406-13.

107. Torma J, Winblad U, Cederholm T, Saletti A. Does undernutrition still prevail among nursing home residents? Clinical nutrition (Edinburgh, Scotland). 2013;32(4):562-8.

108. Diekmann R, Winning K, Uter W, Kaiser MJ, Sieber CC, Volkert D, et al. Screening for malnutrition among nursing home residents - a comparative analysis of the mini nutritional assessment, the nutritional risk screening, and the malnutrition universal screening tool. The journal of nutrition, health & aging. 2013;17(4):326-31.

109. Sacks GS, Dearman K, Replogle WH, Cora VL, Meeks M, Canada T. Use of subjective global assessment to identify nutrition-associated complications and death in geriatric long-term care facility residents. Journal of the American College of Nutrition. 2000;19(5):570-7.

110. Coe RM, Romeis JC, Miller DK, Wolinsky FD, Virgo KS. Nutritional risk and survival in elderly veterans: a five-year follow-up. Journal of community health. 1993;18(6):327-34.

111. Sahyoun NR, Jacques PF, Dallal GE, Russell RM. Nutrition Screening Initiative Checklist may be a better awareness/educational tool than a screening one. Journal of the American Dietetic Association. 1997;97(7):760-4.

112. Beck AM, Ovesen L, Osler M. The 'Mini Nutritional Assessment' (MNA) and the 'Determine Your Nutritional Health' Checklist (NSI Checklist) as predictors of morbidity and mortality in an elderly Danish population. The British journal of nutrition. 1999;81(1):31-6.

113. Keller HH, Ostbye T. Nutritional risk and time to death; predictive validity of SCREEN (Seniors in the Community Risk Evaluation for Eating and Nutrition). The journal of nutrition, health & aging. 2003;7(4):274-9.

114. Ferreira LS, do Amaral TF, Marucci Mde F, Nascimento LF, Lebrao ML, Duarte YA. Undernutrition as a major risk factor for death among older Brazilian adults in the community-dwelling setting: SABE survey. Nutrition (Burbank, Los Angeles County, Calif). 2011;27(10):1017-22.

115. Lundin H, Saaf M, Strender LE, Mollasaraie HA, Salminen H. Mini nutritional assessment and 10-year mortality in free-living elderly women: a prospective cohort study with 10-year follow-up. Eur J Clin Nutr. 2012;66(9):1050-3.

116. Saletti A, Johansson L, Yifter-Lindgren E, Wissing U, Österberg K, Cederholm T. Nutritional Status and a 3-Year Follow-Up in Elderly Receiving Support at Home. Gerontology. 2005;51(3):192-8.

117. Lopez-Gomez JJ, Calleja-Fernandez A, Ballesteros-Pomar MD, Vidal-Casariego A, Brea-Laranjo C, Fariza-Vicente E, et al. [Screening of the nutritional risk in elderly hospitalized patients with different tools]. Endocrinologia y nutricion : organo de la Sociedad Espanola de Endocrinologia y Nutricion. 2011;58(3):104-11.

118. Velasco C, Garcia E, Rodriguez V, Frias L, Garriga R, Alvarez J, et al. Comparison of four nutritional screening tools to detect nutritional risk in hospitalized patients: a multicentre study. Eur J Clin Nutr. 2011;65(2):269-74.

119. Wakahara T, Shiraki M, Murase K, Fukushima H, Matsuura K, Fukao A, et al. Nutritional screening with Subjective Global Assessment predicts hospital stay in patients with digestive diseases. Nutrition (Burbank, Los Angeles County, Calif). 2007;23(9):634-9.

120. Gamaletsou MN, Poulia KA, Karageorgou D, Yannakoulia M, Ziakas PD, Zampelas A, et al. Nutritional risk as predictor for healthcare-associated infection among hospitalized elderly patients in the acute care setting. The Journal of hospital infection. 2012;80(2):168-72.

121. Beck AM, Ovesen L, Schroll M. A six months' prospective follow-up of 65+-y-old patients from general practice classified according to nutritional risk by the Mini Nutritional Assessment. Eur J Clin Nutr. 2001;55(11):1028-33.

122. Yap KB, Niti M, Ng TP. Nutrition screening among community-dwelling older adults in Singapore. Singapore medical journal. 2007;48(10):911-6.

123. Visvanathan R, Penhall R, Chapman I. Nutritional screening of older people in a sub-acute care facility in Australia and its relation to discharge outcomes. Age and ageing. 2004;33(3):260-5.

124. Thomas DR, Zdrowski CD, Wilson MM, Conright KC, Lewis C, Tariq S, et al. Malnutrition in subacute care. The American journal of clinical nutrition. 2002;75(2):308-13.

125. Vanderwee K, Clays E, Bocquaert I, Gobert M, Folens B, Defloor T. Malnutrition and associated factors in elderly hospital patients: a Belgian cross-sectional, multi-centre study. Clinical nutrition (Edinburgh, Scotland). 2010;29(4):469-76.

126. Bauer JM, Vogl T, Wicklein S, Trogner J, Muhlberg W, Sieber CC. Comparison of the Mini Nutritional Assessment, Subjective Global Assessment, and Nutritional Risk Screening (NRS 2002) for nutritional screening and assessment in geriatric hospital patients. Zeitschrift fur Gerontologie und Geriatrie. 2005;38(5):322-7.

127. Martins CP, Correia JR, do Amaral TF. Undernutrition risk screening and length of stay of hospitalized elderly. Journal of nutrition for the elderly. 2005;25(2):5-21.

128. Neumann SA, Miller MD, Daniels L, Crotty M. Nutritional status and clinical outcomes of older patients in rehabilitation. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association. 2005;18(2):129-36.

129. Salvi F, Giorgi R, Grilli A, Morichi V, Espinosa E, Spazzafumo L, et al. Mini Nutritional Assessment (short form) and functional decline in older patients admitted to an acute medical ward. Aging clinical and experimental research. 2008;20(4):322-8.

130. Brunt AR. The ability of the DETERMINE checklist to predict continued community-dwelling in rural, white women. Journal of nutrition for the elderly. 2006;25(3-4):41-59.

131. Izawa S, Kuzuya M, Okada K, Enoki H, Koike T, Kanda S, et al. The nutritional status of frail elderly with care needs according to the mini-nutritional assessment. Clinical nutrition (Edinburgh, Scotland). 2006;25(6):962-7.

132. Odlund Olin A, Koochek A, Cederholm T, Ljungqvist O. Minimal effect on energy intake by additional evening meal for frail elderly service flat residents--a pilot study. The journal of nutrition, health & aging. 2008;12(5):295-301.

133. Vailas LI, Nitzke SA, Becker M, Gast J. Risk indicators for malnutrition are associated inversely with quality of life for participants in meal programs for older adults. Journal of the American Dietetic Association. 1998;98(5):548-53.

134. Keller HH, Ostbye T, Goy R. Nutritional risk predicts quality of life in elderly community-living Canadians. The journals of gerontology Series A, Biological sciences and medical sciences. 2004;59(1):68-74.

135. Gombos T, Kertesz K, Csikos A, Soderhamn U, Soderhamn O, Prohaszka Z. Nutritional form for the elderly is a reliable and valid instrument for the determination of undernutrition risk, and it is associated with health-related quality of life. Nutrition research (New York, NY). 2008;28(2):59-65.

136. Rasheed S, Woods RT. An investigation into the association between nutritional status and quality of life in older people admitted to hospital. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association. 2013.

137. Smoliner C, Norman K, Wagner KH, Hartig W, Lochs H, Pirlich M. Malnutrition and depression in the institutionalised elderly. The British journal of nutrition. 2009;102(11):1663-7.

138. Bernabeu-Wittel M, Jadad A, Moreno-Gavino L, Hernandez-Quiles C, Toscano F, Cassani M, et al. Peeking through the cracks: an assessment of the prevalence, clinical characteristics

and health-related quality of life (HRQoL) of people with polypathology in a hospital setting. Archives of gerontology and geriatrics. 2010;51(2):185-91.

139. Johansson Y, Bachrach-Lindstrom M, Carstensen J, Ek AC. Malnutrition in a home-living older population: prevalence, incidence and risk factors. A prospective study. Journal of clinical nursing. 2009;18(9):1354-64.

140. Brunt AR, Schafer E, Oakland MJ. Anthropometric Measures of Rural, Elderly, Community-Dwelling Women and the Ability of the DETERMINE Checklist to Predict These Measures. Journal of nutrition for the elderly. 1999;18(4):15-36.

141. Norman K, Schutz T, Kemps M, Josef Lubke H, Lochs H, Pirlich M. The Subjective Global Assessment reliably identifies malnutrition-related muscle dysfunction. Clinical nutrition (Edinburgh, Scotland). 2005;24(1):143-50.

142. Wham CA, Teh RO, Robinson M, Kerse NM. What is associated with nutrition risk in very old age? The journal of nutrition, health & aging. 2011;15(4):247-51.

143. Cereda E, Vanotti A. The new Geriatric Nutritional Risk Index is a good predictor of muscle dysfunction in institutionalized older patients. Clinical nutrition (Edinburgh, Scotland). 2007;26(1):78-83.

144. Cereda E, Vanotti A. Short dietary assessment improves muscle dysfunction identification by Geriatric Nutritional Risk Index in uncomplicated institutionalised patients over 70 years old. Clinical nutrition (Edinburgh, Scotland). 2008;27(1):126-32.

145. Vellas B, Guigoz Y, Baumgartner M, Garry PJ, Lauque S, Albarede JL. Relationships between nutritional markers and the mini-nutritional assessment in 155 older persons. Journal of the American Geriatrics Society. 2000;48(10):1300-9.

146. Kuzuya M, Kanda S, Koike T, Suzuki Y, Satake S, Iguchi A. Evaluation of Mini-Nutritional Assessment for Japanese frail elderly. Nutrition (Burbank, Los Angeles County, Calif). 2005;21(4):498-503.

147. Langkamp-Henken B, Hudgens J, Stechmiller JK, Herrlinger-Garcia KA. Mini nutritional assessment and screening scores are associated with nutritional indicators in elderly people with pressure ulcers. Journal of the American Dietetic Association. 2005;105(10):1590-6.

148. Charlton KE, Kolbe-Alexander TL, Nel JH. The MNA, but not the DETERMINE, screening tool is a valid indicator of nutritional status in elderly Africans. Nutrition (Burbank, Los Angeles County, Calif). 2007;23(7-8):533-42.

149. Cereda E, Valzolgher L, Pedrolli C. Mini nutritional assessment is a good predictor of functional status in institutionalised elderly at risk of malnutrition. Clinical nutrition (Edinburgh, Scotland). 2008;27(5):700-5.

150. Chevalier S, Saoud F, Gray-Donald K, Morais JA. The physical functional capacity of frail elderly persons undergoing ambulatory rehabilitation is related to their nutritional status. The journal of nutrition, health & aging. 2008;12(10):721-6.

151. Gerber V, Krieg MA, Cornuz J, Guigoz Y, Burckhardt P. Nutritional status using the Mini Nutritional Assessment questionnaire and its relationship with bone quality in a population of institutionalized elderly women. The journal of nutrition, health & aging. 2003;7(3):140-5.

152. Hawthorne G, Richardson J, Osborne R. The Assessment of Quality of Life (AQoL) instrument: a psychometric measure of Health-Related Quality of Life. Quality of Life Research. 1999;8(3):209-24.

153. Becker M, Diamond R, Sainfort F. A new patient focused index for measuring quality of life in persons with severe and persistent mental illness. Quality of Life Research. 1993;2(4):239-51.

154. EuroQol - a new facility for the measurement of health-related quality of life. Health Policy. 1990;16(3):199-208.

155. Ware JE, Sherbourne CD. The MOS 36-Item Short-Form Health Survey (SF-36): I. Conceptual Framework and Item Selection. Medical Care. 1992;30(6):473-83.

156. Vellas B, Villars H, Abellan G, Soto ME, Rolland Y, Guigoz Y, et al. Overview of the MNA--Its history and challenges. The journal of nutrition, health & aging. 2006;10(6):456-63; discussion 63-5.

157. Hudgens J, Langkamp-Henken B. The Mini Nutritional Assessment as an assessment tool in elders in long-term care. Nutrition in clinical practice : official publication of the American Society for Parenteral and Enteral Nutrition. 2004;19(5):463-70.

158. Young AM, Kidston S, Banks MD, Mudge AM, Isenring EA. Malnutrition screening tools: comparison against two validated nutrition assessment methods in older medical inpatients. Nutrition (Burbank, Los Angeles County, Calif). 2013;29(1):101-6.

159. Korkeila M, Rissanen A, Sorensen TI, Kaprio J. BMI, weight stability and mortality among adults without clinical co-morbidities: a 22-year mortality follow-up in the Finnish twin cohort. Obesity facts. 2009;2(6):344-51.

160. Somes GW, Kritchevsky SB, Shorr RI, Pahor M, Applegate WB. Body mass index, weight change, and death in older adults: the systolic hypertension in the elderly program. American journal of epidemiology. 2002;156(2):132-8.

161. Newman AB, Yanez D, Harris T, Duxbury A, Enright PL, Fried LP. Weight change in old age and its association with mortality. Journal of the American Geriatrics Society. 2001;49(10):1309-18.

162. Blaum CS, Fries BE, Fiatarone MA. Factors associated with low body mass index and weight loss in nursing home residents. The journals of gerontology Series A, Biological sciences and medical sciences. 1995;50(3):M162-8.

163. Morley JE, Kraenzle D. Causes of weight loss in a community nursing home. Journal of the American Geriatrics Society. 1994;42(6):583-5.

164. Wright BA. Weight loss and weight gain in a nursing home: a prospective study. Geriatric nursing (New York, NY). 1993;14(3):156-9.

165. French SA, Folsom AR, Jeffery RW, Zheng W, Mink PJ, Baxter JE. Weight variability and incident disease in older women: the Iowa Women's Health Study. International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity. 1997;21(3):217-23.

166. Banks M, Ash S, Bauer J, Gaskill D. Prevalence of malnutrition in adults in Queensland public hospitals and residential aged care facilities. Nutrition & Dietetics. 2007;64(3):172-8.

167. Guigoz Y. The Mini Nutritional Assessment (MNA) review of the literature--What does it tell us? The journal of nutrition, health & aging. 2006;10(6):466-85; discussion 85-7.

168. Suominen M, Muurinen S, Routasalo P, Soini H, Suur-Uski I, Peiponen A, et al. Malnutrition and associated factors among aged residents in all nursing homes in Helsinki. Eur J Clin Nutr. 2005;59(4):578-83.

169. Montero J, Bravo M, López-Valverde A, Llodra J-C. Clinical and sociodemographic predictors of oral pain and eating problems among adult and senior Spaniards in the national survey performed in 2010. Medicina oral, patologia oral y cirugia bucal. 2015;20(4):e393.

170. Meleger AL, Froude CK, Walker J. Nutrition and eating behavior in patients with chronic pain receiving long-term opioid therapy. PM&R. 2014;6(1):7-12. e1.

171. Stratton RJ, Hackston A, Longmore D, Dixon R, Price S, Stroud M, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. The British journal of nutrition. 2004;92(5):799-808.

172. Abbey J, Piller N, De Bellis A, Esterman A, Parker D, Giles L, et al. The Abbey pain scale: a 1-minute numerical indicator for people with end-stage dementia. International journal of palliative nursing. 2004;10(1):6-13.

173. Aukner C, Eide HD, Iversen PO. Nutritional status among older residents with dementia in open versus special care units in municipal nursing homes: an observational study. BMC Geriatr. 2013;13(1):1-7.

174. Bonaccorsi G, Collini F, Castagnoli M, Di Bari M, Cavallini MC, Zaffarana N, et al. A cross-sectional survey to investigate the quality of care in Tuscan (Italy) nursing homes: the structural, process and outcome indicators of nutritional care. BMC Health Services Research. 2015;15:223.

175. Isenring EA, Bauer JD, Banks M, Gaskill D. The Malnutrition Screening Tool is a useful tool for identifying malnutrition risk in residential aged care. Journal of Human Nutrition and Dietetics. 2009;22(6):545-50.

176. Lelovics Z, Bozo RK, Lampek K, Figler M. Results of nutritional screening in institutionalized elderly in Hungary. Archives of gerontology and geriatrics. 2009;49(1):190-6.

177. Soenen S, Chapman IM. Body weight, anorexia, and undernutrition in older people. Journal of the American Medical Directors Association. 2013;14(9):642-8.

178. Kerstetter JE, Holthausen BA, Fitz PA. Malnutrition in the institutionalized older adult. Journal of the American Dietetic Association. 1992;92(9):1109-16.

179. Gilmore SA, Robinson G, Posthauer ME, Raymond J. Clinical indicators associated with unintentional weight loss and pressure ulcers in elderly residents of nursing facilities. Journal of the American Dietetic Association. 1995;95(9):984-92.

180. Teno JM, Kabumoto G, Wetle T, Roy J, Mor V. Daily pain that was excruciating at some time in the previous week: prevalence, characteristics, and outcomes in nursing home residents. Journal of the American Geriatrics Society. 2004;52(5):762-7.

181. Bosley BN, Weiner DK, Rudy TE, Granieri E. Is Chronic Nonmalignant Pain Associated with Decreased Appetite in Older Adults? Preliminary Evidence. Journal of the American Geriatrics Society. 2004;52(2):247-51.

182. Arnold AM, Newman AB, Cushman M, Ding J, Kritchevsky S. Body weight dynamics and their association with physical function and mortality in older adults: the Cardiovascular Health Study. The journals of gerontology Series A, Biological sciences and medical sciences. 2010;65(1):63-70.

183. Wallace JI, Schwartz RS, LaCroix AZ, Uhlmann RF, Pearlman RA. Involuntary weight loss in older outpatients: incidence and clinical significance. Journal of the American Geriatrics Society. 1995;43(4):329-37.

184. Pizzato S, Sergi G, Bolzetta F, De Rui M, De Ronch I, Carraro S, et al. Effect of weight loss on mortality in overweight and obese nursing home residents during a 5-year follow-up. Eur J Clin Nutr. 2015;69(10):1113-8.

185. Wirth R, Streicher M, Smoliner C, Kolb C, Hiesmayr M, Thiem U, et al. The impact of weight loss and low BMI on mortality of nursing home residents - Results from the nutritionDay in nursing homes. Clinical nutrition (Edinburgh, Scotland). 2015.

186. Murphy RA, Patel KV, Kritchevsky SB, Houston DK, Newman AB, Koster A, et al. Weight change, body composition, and risk of mobility disability and mortality in older adults: a population-based cohort study. Journal of the American Geriatrics Society. 2014;62(8):1476-83.

187. Reynolds MW, Fredman L, Langenberg P, Magaziner J. Weight, weight change, mortality in a random sample of older community-dwelling women. Journal of the American Geriatrics Society. 1999;47(12):1409-14.

188. Sullivan DH, Johnson LE, Bopp MM, Roberson PK. Prognostic significance of monthly weight fluctuations among older nursing home residents. The journals of gerontology Series A, Biological sciences and medical sciences. 2004;59(6):M633-9.

189. Flacker JM, Kiely DK. A practical approach to identifying mortality-related factors in established long-term care residents. Journal of the American Geriatrics Society. 1998;46(8):1012-5.

190. Ryan C, Bryant E, Eleazer P, Rhodes A, Guest K. Unintentional weight loss in long-term care: predictor of mortality in the elderly. Southern medical journal. 1995;88(7):721-4.

191. Murden RA, Ainslie NK. Recent weight loss is related to short-term mortality in nursing homes. Journal of general internal medicine. 1994;9(11):648-50.

192. Decaria JE, Sharp C, Petrella RJ. Scoping review report: obesity in older adults. Int J Obes. 2012.

193. Rigler SK, Webb MJ, Redford L, Brown EF, Zhou J, Wallace D. Weight Outcomes Among Antidepressant Users in Nursing Facilities. Journal of the American Geriatrics Society. 2001;49(1):49-55.

194. Knoops KT, Slump E, de Groot LC, Wouters-Wesseling W, Brouwer ML, van Staveren WA. Body weight changes in elderly psychogeriatric nursing home residents. The journals of gerontology Series A, Biological sciences and medical sciences. 2005;60(4):536-9.

195. Corrada MM, Kawas CH, Mozaffar F, Paganini-Hill A. Association of body mass index and weight change with all-cause mortality in the elderly. American journal of epidemiology. 2006;163(10):938-49.

196. Myrskyla M, Chang VW. Weight change, initial BMI, and mortality among middle- and older-aged adults. Epidemiology (Cambridge, Mass). 2009;20(6):840-8.

197. Australian Beureau of Statistics. Australian Demographic Statistics, Dec 2016. Canberra: ABS; 2017. Report No.: 3101.0.

198. Australian Beureau of Statistics. Population Projections, Australia, 2012 (base) to 2101. Canberra: ABS; 2013. Report No.: 3222.0.

199. Schoenborn CA, Adams PF, Barnes PM. Body weight status of adults: United States, 1997-98. Adv Data. 2002(330):1-15.

200. Rolland Y, Abellan van Kan G, Gillette-Guyonnet S, Vellas B. Cachexia versus sarcopenia. Current opinion in clinical nutrition and metabolic care. 2011;14(1):15-21.

201. Chapman IM. Nutritional disorders in the elderly. The Medical clinics of North America. 2006;90(5):887-907.

202. Fiatarone MA, O'Neill EF, Ryan ND, Clements KM, Solares GR, Nelson ME, et al. Exercise training and nutritional supplementation for physical frailty in very elderly people. New England Journal of Medicine. 1994;330(25):1769-75.

203. Johnson LE, Dooley PA, Gleick JB. Oral nutritional supplement use in elderly nursing home patients. Journal of the American Geriatrics Society. 1993;41(9):947-52.

204. Simmons SF, Zhuo X, Keeler E. Cost-effectiveness of nutrition interventions in nursing home residents: a pilot intervention. The journal of nutrition, health & aging. 2010;14(5):367-72.

205. Friedman PJ, Campbell AJ, Caradoc-Davies TH. Prospective trial of a new diagnostic criterion for severe wasting malnutrition in the elderly. Age and ageing. 1985;14(3):149-54.

206. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. Nutrition reviews. 1996;54(1):S59-65.

207. Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. Nutrition (Burbank, Los Angeles County, Calif). 1999;15(6):458-64.

208. Wilson MM, Thomas DR, Rubenstein LZ, Chibnall JT, Anderson S, Baxi A, et al. Appetite assessment: simple appetite questionnaire predicts weight loss in community-dwelling adults and nursing home residents. The American journal of clinical nutrition. 2005;82(5):1074-81.

209. Morley JE, Malmstrom TK, Miller DK. A Simple Frailty Questionnaire (FRAIL) Predicts Outcomes in Middle Aged African Americans. The journal of nutrition, health & aging. 2012;16(7):601-8.

210. Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. Human nutrition Clinical nutrition. 1985;39 Suppl 1:5-41.

211. National Health and Medical Research Council. Nutrient reference values for Australia and New Zealand including recommended dietary intakes Canberra: NHMRC; 2006 [Available from: https://www.nrv.gov.au/nutrients.

212. Stunkard AJ, Messick S. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. J Psychosom Res. 1985;29(1):71-83.

213. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. Journal of gerontology. 1994;49(2):M85-94.

214. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. The Gerontologist. 1969;9(3):179-86.

215. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): development and evaluation. J Clin Epidemiol. 1993;46(2):153-62.

216. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of Illness in the Aged. The Index of Adl: A Standardized Measure of Biological and Psychosocial Function. JAMA : the journal of the American Medical Association. 1963;185:914-9.

217. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. Journal of psychiatric research. 1975;12(3):189-98.

218. Tariq SH, Tumosa N, Chibnall JT, Perry MH, 3rd, Morley JE. Comparison of the Saint Louis University mental status examination and the mini-mental state examination for detecting dementia and mild neurocognitive disorder--a pilot study. Am J Geriatr Psychiatry. 2006;14(11):900-10.

219. Yesavage JA, Brink TL, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: a preliminary report. Journal of psychiatric research. 1982;17(1):37-49.

220. Hawthorne G, Richardson J, Osborne R. The Assessment of Quality of Life (AQoL) instrument: a psychometric measure of health-related quality of life. Qual Life Res. 1999;8(3):209-24.

221. Buysse DJ, Reynolds CF, 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry research. 1989;28(2):193-213.

222. Cohen S, Hoberman HM. Positive events and social supports as buffers of life change stress. Journal of applied social psychology. 1983;13(2):99-125.

223. Hughes VA, Frontera WR, Roubenoff R, Evans WJ, Singh MAF. Longitudinal changes in body composition in older men and women: role of body weight change and physical activity. The American journal of clinical nutrition. 2002;76(2):473-81.

224. Song MY, Ruts E, Kim J, Janumala I, Heymsfield S, Gallagher D. Sarcopenia and increased adipose tissue infiltration of muscle in elderly African American women. The American journal of clinical nutrition. 2004;79(5):874-80.

225. Roberts HC, Syddall H, Butchart J, Sparkes J, Ritchie J, Kerr A, et al. Grip strength and its determinants among older people in different healthcare settings. Age and ageing. 2014;43(2):241-6.

226. Woo J. Obesity in older persons. Current Opinion in Clinical Nutrition & Metabolic Care. 2015;18(1):5-10.

227. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. Journal of the American Geriatrics Society. 2002;50(5):889-96.

228. Sternfeld B, Ngo L, Satariano WA, Tager IB. Associations of body composition with physical performance and self-reported functional limitation in elderly men and women. American journal of epidemiology. 2002;156(2):110-21.

229. Hernandez-Ono A, Monter-Carreola G, Zamora-Gonzalez J, Cardoso-Saldana G, Posadas-Sanchez R, Torres-Tamayo M, et al. Association of visceral fat with coronary risk factors in a population-based sample of postmenopausal women. International journal of obesity and

related metabolic disorders : journal of the International Association for the Study of Obesity. 2002;26(1):33-9.

230. Hughes VA, Frontera WR, Wood M, Evans WJ, Dallal GE, Roubenoff R, et al. Longitudinal muscle strength changes in older adults: influence of muscle mass, physical activity, and health. The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(5):B209-17.

231. Gronstedt H, Frandin K, Bergland A, Helbostad JL, Granbo R, Puggaard L, et al. Effects of individually tailored physical and daily activities in nursing home residents on activities of daily living, physical performance and physical activity level: a randomized controlled trial. Gerontology. 2013;59(3):220-9.

232. Frandin K, Gronstedt H, Helbostad JL, Bergland A, Andresen M, Puggaard L, et al. Long-Term Effects of Individually Tailored Physical Training and Activity on Physical Function, Well-Being and Cognition in Scandinavian Nursing Home Residents: A Randomized Controlled Trial. Gerontology. 2016;62(6):571-80.

233. Ryu M, Jo J, Lee Y, Chung Y-S, Kim K-M, Baek W-C. Association of physical activity with sarcopenia and sarcopenic obesity in community-dwelling older adults: the Fourth Korea National Health and Nutrition Examination Survey. Age and ageing. 2013;42(6):734-40.

234. Chiu S-C, Yang R-S, Yang R-J, Chang S-F. Effects of resistance training on body composition and functional capacity among sarcopenic obese residents in long-term care facilities: a preliminary study. BMC Geriatr. 2018;18(1):21.

235. Piantadosi C, Chapman IM, Naganathan V, Hunter P, Cameron ID, Visvanathan R. Recruiting older people at nutritional risk for clinical trials: what have we learned? BMC Research Notes. 2015;8(1):151.

236. Mody L, Miller DK, McGloin JM, Div M, Freeman M, Marcantonio ER, et al. Recruitment and Retention of Older Adults in Aging Research. Journal of the American Geriatrics Society. 2008;56(12):2340-8.

237. Ridda I, MacIntyre CR, Lindley RI, Tan TC. Difficulties in recruiting older people in clinical trials: An examination of barriers and solutions. Vaccine. 2010;28(4):901-6.

238. Miller K-L, McKeever P, Coyte PC. Recruitment issues in healthcare research: the situation in home care. Health & Social Care in the Community. 2003;11(2):111-23.

239. Moreira NCF, Krausch-Hofmann S, Matthys C, Vereecken C, Vanhauwaert E, Declercq A, et al. Risk Factors for Malnutrition in Older Adults: A Systematic Review of the Literature Based on Longitudinal Data. Adv Nutr. 2016;7(3):507-22.

240. Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm T, et al. Frequency of malnutrition in older adults: a multinational perspective using the mini nutritional assessment. Journal of the American Geriatrics Society. 2010;58(9):1734-8.

241. Gaskill D, Black LJ, Isenring EA, Hassall S, Sanders F, Bauer JD. Malnutrition prevalence and nutrition issues in residential aged care facilities. Australas J Ageing. 2008;27(4):189-94.

242. Charlton KE, Nichols C, Bowden S, Lambert K, Barone L, Mason M, et al. Older rehabilitation patients are at high risk of malnutrition: Evidence from a large Australian database. J Nutr Health Aging. 2010;14(8):622-8.

243. Rist G, Miles G, Karimi L. The presence of malnutrition in community-living older adults receiving home nursing services. Nutr Diet. 2012;69(1):46-50.

244. Visvanathan R, Macintosh C, Callary M, Penhall R, Horowitz M, Chapman I. 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. 2003;51(7):1007-11.

245. Rahi B, Morais JA, Gaudreau P, Payette H, Shatenstein B. Energy and protein intakes and their association with a decline in functional capacity among diabetic older adults from the NuAge cohort. Eur J Nutr. 2016;55(4):1729-39.

246. Correia MITD, Waitzberg DL. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. Clinical Nutrition. 2003;22(3):235-9.

247. Elia M. A report on the cost of disease-relared malnutrition in England and a budget impact analysis of implementing the NICE clinical guidelines/quality standard on nutritional support in adults. 2015 November 2015.

248. Association AEPLfAMoW. Cost benerfit analysis of an intervention to improve the nutritional status of community dwelling older Australians. Australia; 2011 January 2011.

249. World Health Organisation (WHO) DoNfHaDN. Nutrition for older persons. Geneva, Switzerland: WHO; 2017.

250. Wikipedia. Meals on Wheels 2016 [Available from: https://en.wikipedia.org/wiki/Meals_on_Wheels.

251. Wells Y. Review of Meal Services under the Home and Community Care (HACC) Program: Final report – Implications for Meal Services in the Commonwealth Home Support Program. . In: Ageing ADoHa, editor. Australia.: Project report prepared by the Australian Institute for Primary Care & Ageing, La Trobe University, Melbourne. ; 2013.

252. Luscombe-Marsh N, Chapman I, Visvanathan R. Hospital admissions in poorly nourished, compared with well-nourished, older South Australians receiving 'Meals on Wheels': findings from a pilot study. Australasian journal on ageing. 2014;33(3):164-9.

253. Pargeter KA, cartographer Meals on Wheels: A Nutritional Evaluation: : [Parkville, Vic.] National Research Institute of Gerontology and Geriatric Medicine; 1986.

254. Kretser AJ, Voss T, Kerr WW, Cavadini C, Friedmann J. Effects of two models of nutritional intervention on homebound older adults at nutritional risk. Journal of the American Dietetic Association. 2003;103(3):329-36.

255. Stote KS, Radecki SV, Moshfegh AJ, Ingwersen LA, Baer DJ. The number of 24 h dietary recalls using the US Department of Agriculture's automated multiple-pass method required to estimate nutrient intake in overweight and obese adults. Public health nutrition. 2011;14(10):1736-42.

256. Moshfegh AJ, Rhodes DG, Baer DJ, Murayi T, Clemens JC, Rumpler WV, et al. The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. American Journal of Clinical Nutrition. 2008;88(2):324-32.

257. Guigoz Y VB, Garry P.J. Mini nutritional assessment: A practical assessment tool for grading the nutritional state of elderly patients. Facts and Research in Gerontology. 1994;Supplement 2:15-58.

258. Bowden MG, Behrman AL. Step Activity Monitor: accuracy and test-retest reliability in persons with incomplete spinal cord injury. J Rehabil Res Dev. 2007;44(3):355-62.

259. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in older adults: evidence for a phenotype. The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(3):M146-56.

260. (FSANZ) FSAaNZ. Australian food, supplement and nutrient database 2007 for estimation of population nutrient intakes. In: FSANZ, editor. Canberra2007.

261. Pedersen AB, Mikkelsen EM, Cronin-Fenton D, Kristensen NR, Pham TM, Pedersen L, et al. Missing data and multiple imputation in clinical epidemiological research. Clinical Epidemiology. 2017;9:157.

262. Giezenaar C, Chapman I, Luscombe-Marsh N, Feinle-Bisset C, Horowitz M, Soenen S. Ageing is associated with decreases in appetite and energy intake—a meta-analysis in healthy adults. Nutrients. 2016;8(1):28.

263. Charlton KE, Walton K, Moon L, Smith K, Mcmahon AT, Ralph F, et al. "It could probably help someone else but not me": A feasibility study of a snack programme offered to meals on wheels clients. Journal of Nutrition Health & Aging. 2013;17(4):364-9.

264. Maclellan DL. Contribution of home-delivered meals to the dietary intake of the elderly. Journal of nutrition for the elderly. 1997;16:17-32.

265. Roy MA, Payette H. Meals-on-wheels improves energy and nutrient intake in a frail free-living elderly population. Journal of Nutrition Health & Aging. 2006;10(6):554-60.

266. Wright L, Vance L, Sudduth C, Epps JB. The Impact of a Home-Delivered Meal Program on Nutritional Risk, Dietary Intake, Food Security, Loneliness, and Social Well-Being. Journal of nutrition in gerontology and geriatrics. 2015;34(2):218-27.

267. Moran MB. Challenges in the meals on wheels program - Research editorial. Journal of the American Dietetic Association. 2004;104(8):1219-21.

268. Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-Based Recommendations for Optimal Dietary Protein Intake in Older People: A Position Paper From the PROT-AGE Study Group. Journal of the American Medical Directors Association. 2013;14(8):542-59.

269. Campbell AD, Godfryd A, Buys DR, Locher JL. Does Participation in Home-Delivered Meals Programs Improve Outcomes for Older Adults? Results of a Systematic Review. Journal of nutrition in gerontology and geriatrics. 2015;34(2):124-67.

270. Wunderlich S, Bai Y, Piemonte J. Nutrition risk factors among home delivered and congregate meal participants: Need for enhancement of nutrition education and counseling among home delivered meal participants. Journal of Nutrition Health & Aging. 2011;15(9):768-73.

271. Choi NG. Determinants of frail elders' lengths of stay in meals on wheels. The Gerontologist. 1999;39(4):397-404.

272. United Nations Department of Economic and Social Affairs Population Division. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. New York: United Nations; 2015. Contract No.: ESA/P/WP.241.

273. The World Bank. Indonesia Washington DC, USA2016 [Available from: http://data.worldbank.org/country/indonesia.

274. World Health Organization. WHO SAGE Survey Manual: The WHO Study on Global AGEing and Adult Health (SAGE). Geneva: World Health Organization; 2006.

275. United Nations Statistics Division. Indonesia 2016 [Available from: http://data.un.org/CountryProfile.aspx?crName=indonesia#Summary.

276. World Health Organization. Life tables: Data by country Geneva, Switzerland: World Health Organization; 2016 [Available from: http://apps.who.int/gho/data/view.main.60750?lang=en.

277. Statistics Indonesia. Statistics of Indonesian Elderly (Statistik Penduduk Lanjut Usia). Jakarta, Indonesia: Statistics Indonesia; 2014.

278. Simanjuntak E. Status gizi lanjut usia di daerah pedesaan Kecamatan Porsea, Kabupaten Toba Samosir, Provinsi Sumatera Utara Tahun 2010. Jakarta, Indonesia: University of Indonesia; 2010.

279. Rohmawati N, Asdie, AH, Susetyowati, Susetyowati. Tingkat kecemasan, asupan makan, dan status gizi pada lansia di Kota Yogyakarta. Jurnal Gizi Klinik Indonesia. 2015;12(2):62-71.

280. Statistics Indonesia. Special Region of Yogyakarta In Figures 2015. Yogyakarta, Indonesia: Statistics Indonesia; 2015.

281. Maryati Dewi. Analisis Status Gizi Lansia Menggunakan Mini Nutritional Assessment di POSBINDU Wilayah Perdesaan dan Perkotaan Kecamatan Katapang Kabupaten Bandung. Yogyakarta, Indonesia: Universitas Gadjah Mada; 2011.

282. Badan Ketahanan Pangan dan Penyuluhan DIY. Database Ketahanan Pangan D.I.Yogyakarta 2015. Yogyakarta: BKPP DIY; 2015.

283. Nurhidayati. Pola Konsumsi dan Status Gizi Lansia di Kecamatan Pajangan Kabupaten Bantul dan di Kecamatan Kraton Kota Yogyakarta. Yogyakarta: Universitas Gadjah Mada; 2005.

284. World Health Organization. Multisectoral action for a life course approach to healthy ageing: draft global strategy and plan of action on ageing and health. Geneva: World Health Organization; 2016.

285. Statistics Indonesia. Survei Sosial Ekonomi Nasional. Yogyakarta, Indonesia: Statistics Indonesia; 2012.

286. Sadeghirad B, Motaghipisheh S, Kolahdooz F, Zahedi MJ, Haghdoost AA. Islamic fasting and weight loss: a systematic review and meta-analysis. Public health nutrition. 2014;17(2):396-406.

287. Lei Z, Qingyi D, Feng G, Chen W, Hock RS, Changli W. Clinical study of mini-nutritional assessment for older Chinese inpatients. The journal of nutrition, health & aging. 2009;13(10):871-5.

288. Agarwalla R, Saikia AM, Baruah R. Assessment of the nutritional status of the elderly and its correlates. Journal of Family & Community Medicine. 2015;22(1):39-43.

289. Sari PP. Perbandingan Metode Skrining Gizi Awal Pada Pasien Rawat Inap Penyakit Dalam dan Syaraf Di RSUP DR. Sardjito Yogyakarta (Comparison of Nutrition Screening Tools Among Patients of DR. Sarjito Hospital, Yogyakarta). Yogyakarta: Universitas Gadjah Mada; 2010.

290. Andini R. Studi Komparasi Metode Skrining Pada Pasien Dewasa Rawat Inap (Comparison of Nutrition Screening Tools Among Adult Patients). Yogyakarta: Universitas Gadjah Mada; 2014.

291. Ministry of Health Republic of Indonesia. Pedoman Pelayanan Gizi Rumah Sakit (Guideline for Hospital Nutrition Service). Jakarta, Indonesia; 2013.

292. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. Journal of gerontology. 1994;49.

293. Lawton MP, Brody EM. Assessment of Older People: Self-Maintaining and Instrumental Activities of Daily Living. The Gerontologist. 1969;9(3 Part 1):179-86.

294. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Medicine and science in sports and exercise. 2003;35(8):1381-95.

295. Mathew AC, Das D, Sampath S, Vijayakumar M, Ramakrishnan N, Ravishankar SL. Prevalence and correlates of malnutrition among elderly in an urban area in Coimbatore. Indian journal of public health. 2016;60(2):112-7.

296. Vedantam A, Subramanian V, Vijay Rao N, John KR. Malnutrition in free-living elderly in rural south India: prevalence and risk factors. Public health nutrition. 2010;13(9):1328-32.

297. Aliabadi M, Kimiagar M, Ghayour-Mobarhan M, Shakeri MT, Nematy M, Ilaty AA, et al. Prevalence of malnutrition in free living elderly people in Iran: a cross-sectional study. Asia Pacific journal of clinical nutrition. 2008;17(2):285-9.

298. Chen SH, Cheng HY, Chuang YH, Shao JH. Nutritional status and its health-related factors among older adults in rural and urban areas. Journal of advanced nursing. 2015;71(1):42-53.

299. Iizaka S, Tadaka E, Sanada H. Comprehensive assessment of nutritional status and associated factors in the healthy, community-dwelling elderly. Geriatrics & gerontology international. 2008;8(1):24-31.

300. Kostka J, Borowiak E, Kostka T. Nutritional status and quality of life in different populations of older people in Poland. Eur J Clin Nutr. 2014;68(11):1210-5.

301. Torres MJ, Dorigny B, Kuhn M, Berr C, Barberger-Gateau P, Letenneur L. Nutritional status in community-dwelling elderly in France in urban and rural areas. PloS one. 2014;9(8):e105137.

302. Geleijnse JM, Kok FJ, Grobbee DE. Blood pressure response to changes in sodium and potassium intake: a metaregression analysis of randomised trials. J Hum Hypertens. 0000;17(7):471-80.

303. Sacks FM, Svetkey LP, Vollmer WM, Appel LJ, Bray GA, Harsha D, et al. Effects on Blood Pressure of Reduced Dietary Sodium and the Dietary Approaches to Stop Hypertension (DASH) Diet. New England Journal of Medicine. 2001;344(1):3-10.

304. Ministry of Health Republic of Indonesia. Disease control and evironmental health profile. Jakarta, Indonesia2015. 321 p.

305. Sumolang P, Anastasia, H, Widjaja, J and Samarang. The prevalence of helminthiasis prevalence in Palu, Central Sulawesi Epidemiology and Zoonosis Journal. 2014;5(2):75-80.

306. Lam NW, Goh HT, Kamaruzzaman SB, Chin AV, Poi PJ, Tan MP. Normative data for hand grip strength and key pinch strength, stratified by age and gender for a multiethnic Asian population. Singapore medical journal. 2016;57(10):578-84.

307. Chen PJ, Lin MH, Peng LN, Liu CL, Chang CW, Lin YT, et al. Predicting cause-specific mortality of older men living in the Veterans home by handgrip strength and walking speed: a 3-year, prospective cohort study in Taiwan. Journal of the American Medical Directors Association. 2012;13(6):517-21.

308. Raji MA, Kuo YF, Snih SA, Markides KS, Peek MK, Ottenbacher KJ. Cognitive status, muscle strength, and subsequent disability in older Mexican Americans. Journal of the American Geriatrics Society. 2005;53(9):1462-8.

309. De Buyser S, Petrovic M, Taes Y, Toye K, Kaufman JM, Goemaere S, et al. Three year functional changes and long-term mortality hazard in community-dwelling older men. European journal of internal medicine. 2016;35:66-72.

310. Garcia-Pinillos F, Cozar-Barba M, Munoz-Jimenez M, Soto-Hermoso V, Latorre-Roman P. Gait speed in older people: an easy test for detecting cognitive impairment, functional independence, and health state. Psychogeriatrics. 2016;16(3):165-71.

311. Simmonds SJ, Syddall HE, Westbury LD, Dodds RM, Cooper C, Aihie Sayer A. Grip strength among community-dwelling older people predicts hospital admission during the following decade. Age and ageing. 2015;44(6):954-9.

312. Stessman J, Rottenberg Y, Fischer M, Hammerman-Rozenberg A, Jacobs JM. Handgrip Strength in Old and Very Old Adults: Mood, Cognition, Function, and Mortality. Journal of the American Geriatrics Society. 2017.

313. Studenski S, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M. Gait speed and survival in older adults. JAMA : the journal of the American Medical Association. 2011;305.

314. Toots A, Rosendahl E, Lundin-Olsson L, Nordstrom P, Gustafson Y, Littbrand H. Usual gait speed independently predicts mortality in very old people: a population-based study. Journal of the American Medical Directors Association. 2013;14(7):529.e1-6.

315. Goodpaster BH, Park SW, Harris TB, Kritchevsky SB, Nevitt M, Schwartz AV, et al. The Loss of Skeletal Muscle Strength, Mass, and Quality in Older Adults: The Health, Aging and Body Composition Study. The Journals of Gerontology: Series A. 2006;61(10):1059-64.

316. Samson MM, Meeuwsen IB, Crowe A, Dessens JA, Duursma SA, Verhaar HJ. Relationships between physical performance measures, age, height and body weight in healthy adults. Age and ageing. 2000;29(3):235-42.

317. Lee L, Kang SA, Lee HO, Lee BH, Park JS, Kim JH, et al. Relationships between dietary intake and cognitive function level in Korean elderly people. Public Health. 2001;115(2):133-8.

318. Aparicio Vizuete A, Robles F, Rodríguez-Rodríguez E, López-Sobaler AM, Ortega RM. Association between food and nutrient intakes and cognitive capacity in a group of institutionalized elderly people. European Journal of Nutrition. 2010;49(5):293-300.

319. Leite MLC, Nicolosi A, Cristina S, Hauser WA, Nappi G. Nutrition and cognitive deficit in the elderly: a population study. European Journal of Clinical Nutrition. 2001;55(12):1053.

320. SchrÖDer-Butterfill E, Fithry TS. Care dependence in old age: preferences, practices and implications in two Indonesian communities. Ageing and society. 2014;34(3):361-87.

321. Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Bennett DA. Physical Frailty Is Associated with Incident Mild Cognitive Impairment in Community-Based Older Persons. Journal of the American Geriatrics Society. 2010;58(2):248-55.

322. Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Bennett DA. Association of muscle strength with the risk of Alzheimer disease and the rate of cognitive decline in community-dwelling older persons. Archives of neurology. 2009;66(11):1339-44.

323. Fritz NE, McCarthy CJ, Adamo DE. Handgrip strength as a means of monitoring progression of cognitive decline – A scoping review. Ageing Research Reviews. 2017;35(Supplement C):112-23.

324. Kawamoto R, Ninomiya D, Kasai Y, Kusunoki T, Ohtsuka N, Kumagi T, et al. Handgrip strength is associated with metabolic syndrome among middle-aged and elderly community-dwelling persons. Clinical and experimental hypertension (New York, NY : 1993). 2016;38(2):245-51.

325. Marengoni A, Bandinelli S, Maietti E, Guralnik J, Zuliani G, Ferrucci L, et al. Combining Gait Speed and Recall Memory to Predict Survival in Late Life: Population-Based Study. Journal of the American Geriatrics Society. 2016:n/a-n/a.

326. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosisReport of the European Working Group on Sarcopenia in Older PeopleA. J. Cruz-Gentoft et al. Age and ageing. 2010;39(4):412-23.

327. Knight A, Bryan J, Murphy K. The Mediterranean diet and age-related cognitive functioning: A systematic review of study findings and neuropsychological assessment methodology. Nutritional neuroscience. 2017;20(8):449-68.

328. Spencer RJ, Wendell CR, Giggey PP, Katzel LI, Lefkowitz DM, Siegel EL, et al. Psychometric limitations of the mini-mental state examination among nondemented older adults: an evaluation of neurocognitive and magnetic resonance imaging correlates. Experimental aging research. 2013;39(4):382-97.

329. Buch A, Carmeli E, Boker LK, Marcus Y, Shefer G, Kis O, et al. Muscle function and fat content in relation to sarcopenia, obesity and frailty of old age — An overview. Experimental Gerontology. 2016;76(Supplement C):25-32.

330. Cauley JA. An Overview of Sarcopenic Obesity. Journal of Clinical Densitometry. 2015;18(4):499-505.

331. Kalinkovich A, Livshits G. Sarcopenia – The search for emerging biomarkers. Ageing Research Reviews. 2015;22(Supplement C):58-71.

332. Cawood AL, Elia M, Stratton RJ. Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. Ageing Research Reviews. 2012;11(2):278-96.

333. Wright J, Baldwin C. Oral nutritional support with or without exercise in the management of malnutrition in nutritionally vulnerable older people: A systematic review and meta-analysis. Clinical nutrition (Edinburgh, Scotland). 2017.

334. Baldwin C, Weekes CE. Dietary advice with or without oral nutritional supplements for disease-related malnutrition in adults. Cochrane Database of Systematic Reviews. 2011(9).

APPENDICES

Table A1. PubMed search terms

Search	Query	Items found
#23	Search ((((Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL])) AND (Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL])) AND (Aged [MH] OR Elderly [ALL] OR Geriatric [ALL])) AND muscle function	189
#21	Search ((((Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL])) AND (Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL])) AND (Aged [MH] OR Elderly [ALL] OR Geriatric [ALL])) AND Muscle mass	178
#17	Search ((((Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL])) AND (Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL])) AND (Aged [MH] OR Elderly [ALL] OR Geriatric [ALL])) AND Level of care	104
#13	Search ((((Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL])) AND (Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL])) AND (Aged [MH] OR Elderly [ALL] OR Geriatric [ALL])) AND Life Quality [ALL]	212
#9	Search ((((Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL])) AND (Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL])) AND (Aged [MH] OR Elderly [ALL] OR Geriatric [ALL])) AND (Hospitalization [ALL] OR Length of stay [ALL])	461

Search	Query	Items found
#7	Search ((((Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL])) AND (Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL])) AND (Aged [MH] OR Elderly [ALL] OR Geriatric [ALL])) AND (Morbidity [ALL] OR Complications [ALL])	2345
#5	Search ((((Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL])) AND (Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL])) AND (Aged [MH] OR Elderly [ALL] OR Geriatric [ALL])) AND (Mortality [ALL] OR Survival Rate [ALL])	559
#3	Search Aged [MH] OR Elderly [ALL] OR Geriatric [ALL]	3945793
#2	Search Nutrition assessment [MH] OR Nutrition assessment* [ALL] OR Nutritional assessment* [ALL] OR Nutrition Ind*[ALL] OR Nutritional Ind*[ALL] OR Nutrition Survey*[ALL] OR Nutritional Survey*[ALL] OR INSTRUMENT* [ALL]	690465
#1	Search Malnutrition [MH] OR Nutrition Disorders [MH:NOEXP] OR Malnutrition [ALL] OR Nutrition Disorder* [ALL] OR Undernutrition [ALL] OR Nutritional Deficienc* [ALL]	130650

Table A2. Embase search terms

Search	Query	Items found
#15	'protein calorie malnutrition'/syn OR 'protein calorie malnutrition' OR 'malnutrition'/syn OR 'malnutrition' OR 'protein deficiency'/syn OR 'protein deficiency' AND ('nutritional assessment'/syn OR 'nutritional assessment' AND nutrition* NEXT/2 (ind* OR survey*) OR instrument*) AND ('aged'/syn OR aged) AND level AND of AND care	78
#14	'protein calorie malnutrition'/syn OR 'protein calorie malnutrition' OR 'malnutrition'/syn OR 'malnutrition' OR 'protein deficiency'/syn OR 'protein deficiency' AND ('nutritional assessment'/syn OR 'nutritional assessment' AND nutrition* NEXT/2 (ind* OR survey*) OR instrument*) AND ('aged'/syn OR aged) AND ('muscle function'/syn OR 'muscle function' AND ('muscle mass'/syn OR 'muscle mass') OR 'weight'/syn OR 'weight')	222
#13	'protein calorie malnutrition'/syn OR 'protein calorie malnutrition' OR 'malnutrition'/syn OR 'malnutrition' OR 'protein deficiency'/syn OR 'protein deficiency' AND ('nutritional assessment'/syn OR 'nutritional assessment' AND nutrition* NEXT/2 (ind* OR survey*) OR instrument*) AND ('aged'/syn OR aged) AND ('length of stay'/syn OR 'length of stay' OR 'hospitalization'/syn OR 'hospitalization')	56
#12	'protein calorie malnutrition'/syn OR 'protein calorie malnutrition' OR 'malnutrition'/syn OR 'malnutrition' OR 'protein deficiency'/syn OR 'protein deficiency' AND ('nutritional assessment'/syn OR 'nutritional assessment' AND nutrition* NEXT/2 (ind* OR survey*) OR instrument*) AND ('aged'/syn OR aged) AND ('quality of life'/syn OR 'quality of life')	50
#11	'protein calorie malnutrition'/syn OR 'protein calorie malnutrition' OR 'malnutrition'/syn OR 'malnutrition' OR 'protein deficiency'/syn OR 'protein deficiency' AND ('nutritional assessment'/syn OR 'nutritional assessment' AND nutrition* NEXT/2 (ind* OR survey*) OR instrument*) AND ('aged'/syn OR aged) AND ('morbidity'/syn OR 'morbidity')	50
#10	level AND of AND care	746858
#9	'muscle function'/syn OR 'muscle function' AND ('muscle mass'/syn OR 'muscle mass') OR 'weight'/syn OR 'weight'	1432308
#8	'length of stay'/syn OR 'length of stay' OR 'hospitalization'/syn OR 'hospitalization'	318508
#7	'quality of life'/syn OR 'quality of life'	297010
#6	'morbidity'/syn OR 'morbidity'	395892
#5	'protein calorie malnutrition'/syn OR 'protein calorie malnutrition' OR 'malnutrition'/syn OR 'malnutrition' OR 'protein deficiency'/syn OR 'protein deficiency' AND ('nutritional assessment'/syn OR 'nutritional assessment' AND nutrition* NEXT/2 (ind* OR survey*) OR instrument*) AND ('aged'/syn OR aged) AND ('mortality'/syn OR 'mortality' OR 'survival'/syn OR 'survival')	101
#4	'mortality'/syn OR 'mortality' OR 'survival'/syn OR 'survival'	1937475

Search	Query	Items found
#3	'aged'/syn OR aged	2883864
#2	'nutritional assessment'/syn OR 'nutritional assessment' AND nutrition* NEXT/2 (ind* OR survey*) OR instrument*	514091
#1	'protein calorie malnutrition'/syn OR 'protein calorie malnutrition' OR 'malnutrition'/syn OR 'malnutrition' OR 'protein deficiency'/syn OR 'protein deficiency'	128512

CHAPTER 4. VOLUNTEER INFORMATION SHEET AND CONSENT FORM

Government of South Australia
Central Northern Adelaide
Health Service

THE UNIVERSITY
OF ADELAIDE
AUSTRALIA

VOLUNTEER INFORMATION SHEET

Assessment of state of (under-)nutrition and its relationship with muscle mass and function over 12 months in older people

YOUR PARTICIPATION IS VOLUNTARY

You have been asked to take part in a study conducted by Dr Stijn Soenen, Mr Tony Arjuna, Dr Natalie Luscombe-Marsh, Ms Caroline Giezenaar, Mrs Rachael Tippett, Professor Karen Jones, Professor Michael Horowitz and Professor Ian Chapman. This is a research project and you do not have to be involved. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage without providing a reason.

Your decision to take part, not to take part or to withdraw will not affect your routine treatment, your relationship with those treating you, or your relationship with the Southern Cross Care.

WHAT IS THE PURPOSE OF THE TRIAL?

Quite a few older people in our community are undernourished. Prof Ian Chapman conducted a study in 2000 that found that about 40% of older people living in the community in Adelaide and receiving domiciliary care services were not well nourished, either because they were undernourished or at high risk of undernutrition. Follow-up showed that during the following year the people at risk of undernutrition and undernourished individuals were admitted to hospital more often, stayed longer in hospital, experienced weight loss and were more likely to fall than their well-nourished counterparts.

We are aiming to recruit 200 clients of the Southern Cross Care aged 65 years or older to take part in this one-year study.

We are conducting this study to improve our knowledge of the relationships between state of nutrition with level of care, hospital admissions and mortality. You may not gain any personal benefit from your involvement.

WHAT YOU WOULD HAVE TO DO?

We will visit you at three occasions at the Southern Cross Care facilities, at the start and 6 and 12 months thereafter. Each visit will take approximately 2-3 hours.

We will ask you about your health and medical history including use of medication. We will also ask you questions to assess your eating behaviour, state of nutrition and quality of life.

We will measure your height and body weight and body composition. We will make an ultrasound scan of your arm and leg and will measure the thickness of your skin and subcutaneous fat tissue with a calliper. We will also use a technique called bio-electrical impedance. This measurement is very simple to do and does not cause any pain. You will be lying on a bed. 2 electrodes are clipped to stickers that are placed on the right hand and 2 other electrodes are clipped to stickers that are placed on the right foot. A machine generates a small electrical pulse which travels through the electrode and your body. You will not feel anything and this causes no harm to you.

An automated blood pressure cuff placed around your arm will be used for measurement of blood pressure and heart rate.

We will measure your level of physical activity with some minor exercises including a 3 meter walk test, hand grip strength, repeated chair stands and standing balance test.

Also, you will have your nerve function tested. This is a very simple, painless test that involves placement of some stickers on your arms and legs, which monitor your heartbeat, and requires some deep breathing and lying/standing exercises.

We will ask you if you are willing to have a small blood sample taken to measure parameters related to your state of nutrition.

Your participation in the trial is voluntary. You may ask the researcher to stop the assessment at any time or you may withdraw from the trial completely without any consequence.

RISK AND DISCOMFORTS OF THE TRIAL

If you agree to have blood taken, the total amount will be about a quarter of a cup (~60 mL). You may experience slight bruising as a result of insertion of the needle into your arm. You should contact us if the bruising persists, or concerns you.

Your participation in the trial involves a commitment of 2 to 3 hours on three occasions. You may find this quite tiring.

RESEARCH RELATED INJURY

In the unlikely event that you have an injury during the study assessment days, and your injury is a direct result of participation in the study, the Royal Adelaide Hospital will provide reasonable medical treatment. A compensation might be paid without litigation. However, compensation is not automatic and you may have to take legal action to determine whether you should be paid.

IS THERE ANYTHING TO GAIN FROM PARTICIPATING?

This study is not directly assessing a treatment for a disease. You will therefore, not directly benefit from participating. However, we will be able to offer you information about your nutritional status.

HONORARIUM

We estimated that each assessment performed at the Southern Cross Care facilities will take approximately ~2 - 3 hours at initial, 6 months and 12 months follow up, and hence approximately 6 - 9 hours over the entire study. You will be offered $18 per hour for your time.

FINDING OF SIGNIFICANT HEALTH AND NUTRITIONAL ISSUES

At the beginning of your involvement in this study, the investigators will send a letter to your GP notifying your enrolment in the study. If the investigators found any significant health and nutritional issues during your involvement in the study, such as:

- Severe malnutrition
- Anaemia
- CRP levels of ≥ 0.3 mg/dL
- Major Depression

The investigators will notify the Southern Cross Care and your GP, and recommend them to undertake immediate and the most appropriate response to manage your health and well-being. You will still be enrolled in the study during treatment of the above issues. Your involvement in the study may be terminated if you wish to withdraw or recommended by the Southern Cross Care and your GP.

CONFIDENTIALITY

Your participation in this study is strictly confidential and will not be disclosed to other medical or research staff unless you agree or as required by law. Once you have been enrolled in our study you will be given a study participant code, and only study investigators will have access to your name and personal details. If information that we gather from this study is published, it will be done so in a manner that does not allow you to be personally identified.

All information obtained in this study will be kept by the research team for at least 5 years to allow for further analysis in the future. The information will be stored at a secure facility which can only be accessed by the investigators.

NAMES AND CONTACT NUMBERS OF INVESTIGATORS

Should you have any questions or concerns before, during or after the study, please feel free to contact Dr Stijn Soenen on 08 8313 3638 or Mr Tony Arjuna on 08 8222 5039.

IINDEPENDENT CONTACT

If you wish to talk to someone not directly involved with the study about your rights as a volunteer, or about the conduct of the study, you may also contact Dr Andrew Thornton, the Chairman, Research Ethics Committee, and Royal Adelaide Hospital on 8222 4139 during office hours.

The study has been approved by the Research Ethics Committee of the Royal Adelaide Hospital and will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research.

Government of South Australia
Central Northern Adelaide Health Service

THE UNIVERSITY OF ADELAIDE AUSTRALIA

CONSENT FORM

I the undersigned hereby consent to my involvement in the project entitled:

"Assessment of state of (under-)nutrition and its relationship with muscle mass and function over 12 months in older people" conducted by Dr Stijn Soenen, Mr Tony Arjuna, Dr Natalie Luscombe-Marsh, Ms Caroline Giezenaar, Mrs Rachael Tippett, Professor Karen Jones, Professor Michael Horowitz, and Professor Ian Chapman.

1. The nature and purpose of the research project has been explained to me. I understand it, and agree to take part.
2. I understand that I will not benefit from taking part in the trial.
3. I understand that, while information gained during the study may be published, I will not be identified and my personal results will remain confidential.
4. I understand that I can withdraw from the study at any stage and that this will not affect my medical care, now or in the future.
5. I understand the statement concerning payment to me for taking part in the study, which is contained in the Information Sheet.
6. I have had the opportunity to discuss taking part in this investigation with a family member or friend.
7. I am willing to donate a small amount of blood during the study period (three times 20 mL or a quarter of a cup in total). ☐ **YES** ☐ **NO**
8. I give permission to the investigators to notify the Southern Cross Care YES and my GP regarding significant health and nutritional issues. ☐ ☐ **NO**
9. I wish to receive results or publications arising from the study ☐ YES ☐ **NO**

Name of volunteer: ……

Date of birth: ……

Address: ……

Signed: ……

Dated: ……

I certify that I have explained the study to the volunteer and consider that he/she understands what is involved.

Signed: ……. (Investigator)

Dated: ……

CHAPTER 5. VOLUNTEER INFORMATION SHEET AND CONSENT FORM (ENGLISH)

VOLUNTEER INFORMATION SHEET

We are the research team for study titled "Determinants of Nutritional Status among Older People Living in Urban and Rural Area of Yogyakarta, Indonesia. The team is led by Tony Arjuna, S.Gz, M.NutDiet, AN, APD from Department of Health Nutrition, Faculty of Medicine, Universitas Gadjah Mada. This study is sponsored by UGM and School of Medicine, University of Adelaide. This study aims to investigate the nutritional status of older people in Yogyakarta and factors affecting the nutritional status.

We would like to invite you to participate in this study. We need around 500 volunteers for the study and each volunteer will spend approximately 2-3 hours for all assessments.

A. Your Participation Is Voluntary

Your participation in this study is completely voluntary. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage without providing a reason and there will be no repercussion.

B. Research Procedure

If you decide to take part in this study, you will be asked 2 copies of Consent Form, one for you to keep, and one for the research team. Then, we will go through the following assessments:

You will be interviewed by the Enumerator who will ask about your: Name, age, medical history, medications, allergy, smoking history, and alcohol consumption history

You will also be interviewed using several questionnaires to assess your nutritional status, frailty, daily actibities, mental health and food history.

The enumerator will measure your body frame which consist of weight, height, mid upper-arm circumference, calf circumference, hip and waist circumferences, and skinfold thickness. Lastly, your body composition will be measured with Bioelectrical Impedance Analysis (BIA).

On the assessment day, you are invited to come at 8.30am for blood collection.

Your blood sample will be taken on one occasion only by inserting a needle into the vein in your lower forearm. The blood sample will be used for complete blood count, albumin and inflammatory mediators / cytokines analysis.

A total of 12 ml sample will be taken. Around 4 ml will be collected using small tube for complete blood count and albumin analysis. While the other 8 ml will be collected using bigger tube which will be converted to serum, stored and later used for analysis of inflammatory mediator / cytokine levels in your body.

Blood collection will be conducted by trained nurse / phlebotomist from CITO Laboratory, Yogyakarta.

C. Medical Officer

In this study, all data related to medical history, laboratory tests, blood pressure, heart rate and mental status will be reviewed by Prof. Ian Chapman, MBBS, PhD, FRACP, an expert in elderly health from Royal Adelaide Hospital, South Australia.

D. Your Responsibilities As Subject

As volunteer in this study, you are required to follow the instructions given by the researchers as explained above. If you have further questions, please ask the research team.

E. Risk And Treatment

Blood collection will be conducted by a trained phlebotomist and supervised by a medical doctor. Blood collection according to the standard procedure has very minimal risk. If you experience bruises or bleeding during blood collection, the research team will help reduce the bruises by giving you ‘thrombophob ointment’. The research team also has First Aid Kits ready to treat you if there unexpected incident during blood collection.

F. Benefit

By participating in this study, you will receive direct benefit in the form of information on your nutritional status and free laboratory tests on your complete blood count and albumin levels.

G. Confidentiality

Your participation in this study is strictly confidential. All information related to your identity as research subject will only be accessible by the research team. Results of this study will be published in a manner that does not allow you to be personally identified.

All information obtained in this study will be kept by the research team for at least 5 years to allow for further analysis in the future. The information will be stored at a secure facility which can only be accessed by the investigators.

H. Honorarium

You will receive fifty thousand rupiah (Rp.50.000,-) for time spent in the study.

I. Funding

All cost incurred in this project (including laboratory tests and transport) will be covered by the research team and sponsor.

J. Additional Information

Should you have any questions or concerns before, during or after the study, please feel free to contact Tony Arjuna, S.Gz, M.NutDiet, AN, APD on 0274 - 547775 and Rasita Amelia Hasnawati, S.Gz on 085643385295.

If you wish to talk to someone not directly involved with the study about your rights as a volunteer, or about the conduct of the study, you may also contact Medical and Health Research Ethics Committee, Faculty of Medicine UGM at Gedung Radiopoetra Lt 2 Sayap Barat. Address: Jalan Farmako, Sekip Utara, Yogyakarta 55281 Phone. 0274 588688 ext. 17225, +62811-2666-869 or email: mhrec_fmugm@ugm.ac.id).

CONSENT FORM

The research team has provided adequate explanation and answered all my questions regarding the study. I understand that if I need further explanation I can ask Tony Arjuna, S.Gz, M.NutDiet, AN, APD and Rasita Amelia Hasnawati, S.Gz.

By signing this form consent to my involvement in this research project.

Signed by volunteer : ……

Full name of volunteer :……

Dated : ……

Signed by witness

Signed by witness : ……

Full name of witness :……

Dated : ……

CHAPTER 5. VOLUNTEER INFORMATION SHEET AND CONSENT FORM (BAHASA INDONESIA)

LEMBAR PENJELASAN KEPADA CALON SUBJEK

Saya, Tim Penelitian/ Gizi Lansia yang diketuai oleh Tony Arjuna, S.Gz, M.NutDiet, AN, APD dari Bagian Gizi Kesehatan, Fakultas Kedokteran, Universitas Gadjah Mada akan melakukan penelitian yang berjudul "Determinan Status Gizi Pada Lansia yang Tinggal Di Wilayah Perkotaan dan Pedesaan di Provinsi D.I.Yogyakarta". Penelitian ini disponsori oleh Peneliti Utama dari Universitas Gadjah Mada dan dana dari Fakultas Kedokteran, University of Adelaide. Penelitian ini bertujuan untuk mengetahui status gizi lansia di wilayah Provinsi DIY dan faktor-faktor yang mempengaruhi status gizi tersebut.

Tim peneliti mengajak bapak/ibu untuk ikut serta dalam penelitian ini. Penelitian ini membutuhkan lima ratus subyek penelitian, dengan jangka waktu keikutsertaan masing-masing subyek sekitar dua hingga tiga jam untuk semua pemeriksaan.

A. Kesukarelaan untuk ikut penelitian

Anda bebas memilih keikutsertaan dalam penelitian ini tanpa ada paksaan. Bila Anda sudah memutuskan untuk ikut, Anda juga bebas untuk mengundurkan diri/ berubah pikiran setiap saat tanpa dikenai denda atau pun sanksi apapun.

B. Prosedur Penelitian

Apabila Anda bersedia berpartisipasi dalam penelitian ini, Anda diminta menandatangani lembar persetujuan ini rangkap dua, satu untuk Anda simpan, dan satu untuk untuk peneliti. Prosedur selanjutnya adalah:

1. Anda akan diwawancarai oleh enumerator untuk menanyakan: Nama, usia, riwayat penyakit, riwayat penggunaan obat, riwayat alergi, kebiasaan merokok, kebiasaan minum minuman keras atau minum minuman yang mengandung alkohol.
2. Anda juga akan diwawancarai menggunakan beberapa kuesioner untuk mengetahui status gizi, tingkat kerapuhan, aktivitas sehari-hari, kesehatan jiwa dan riwayat makan.
3. Menjalani pengukuran dimensi tubuh (antropometri) oleh enumerator yang terdiri dari

pengukuran berat badan, tinggi badan, lingkar lengan, lingkar betis, lingkar pinggang, lingkar panggul, tebal lipatan lemak kulit, dan komposisi tubuh dengan alat Bioelectrical Impedance Analysis (BIA) sebanyak satu kali.

3. Pada hari dimulainya penelitian, anda diminta datang pada pukul 8.30 untuk selanjutnya dilakukan pengambilan darah.
4. Pengambilan darah dilakukan sebanyak satu kali dalam jangka waktu penelitian dengan cara memasang jarum pada pembuluh darah di lengan bawah. Pengambilan darah ini untuk pemeriksaan laboratorium mengenai keadaan darah, kadar albumin dan faktor-faktor peradangan dalam tubuh anda.
5. Jumlah sampel darah yang akan diambil adalah sebanyak 12 ml. Sebanyak 4 ml (1 tabung kecil) akan digunakan untuk analisa darah lengkap dan kada albumin. Sedangkan 8 ml sisanya (1 tabung besar) akan diolah menjadi serum untuk disimpan dan kemudian digunakan untuk analisa faktor-faktor inflamasi/peradangan dalam tubuh anda.
6. Pengambilan darah dilakukan oleh perawat dari Laboratorium Cito, Yogyakarta yang sudah terbiasa mengambil darah.

C. Penanggung Jawab Medis

Pada penelitian ini, data-data terkait riwayat medis, hasil pemeriksaan laboratorium, tekanan darah dan frekuensi denyut jantung, dan hasil pemeriksaan status mental akan ditelaah oleh Prof. Ian Chapman, MBBS, PhD, FRACP, yang merupakan dokter ahli kesehatan lansia dari Royal Adelaide Hospital, South Australia.

D. Kewajiban subyek penelitian

Sebagai subyek penelitian, bapak/ibu berkewajiban mengikuti aturan atau petunjuk penelitian seperti yang tertulis di atas. Bila ada yang belum jelas, bapak/ibu/saudara bisa bertanya lebih lanjut kepada peneliti.

E. Risiko dan Penanganannya

Pengambilan darah dilakukan oleh petugas profesional yang biasa melakukan pengambilan darah (*bleeder*) dan disertai dengan seorang dokter. Pengambilan darah sesuai prosedur tidak memberikan efek samping. Apabila terjadi kulit memar kebiruan atau perdarahan setelah pengambilan darah maka pada bagian kulit responden diberikan thrombophob. Peneliti menyediakan peralatan P3K jika terjadi hal yang tidak diinginkan selama pengambilan darah.

F. Manfaat

Keuntungan langsung yang Anda dapatkan adalah anda mengetahui secara langsung status gizi dan mendapatkan pemeriksaan laboratorium untuk mengetahui keadaan darah dan kadar albumin secara gratis.

G. Kerahasiaan

Semua informasi yang berkaitan dengan identitas subyek penelitian akan dirahasiakan dan hanya akan diketahui oleh peneliti. Hasil penelitian akan dipublikasikan tanpa identitas subyek penelitian.

Informasi yang dikumpulkan oleh tim peneliti akan disimpan selama setidaknya 5 tahun untuk memungkinkan analisa lebih lanjut di masa yang akan datang. Infromasi ini akan disimpan di fasilitas yang aman dan hanya bisa diakses oleh tim peneliti.

H. Kompensasi

Bapak/ibu akan mendapatkan uang lelah pengganti penghasilan yang hilang akibat berpartisipasi dalam penelitian ini sebesar lima puluh ribu rupiah (Rp.50.000,-).

I. Pembiayaan

Semua biaya yang terkait penelitian (termasuk biaya pemeriksaan laboratorium dan transportasi) akan ditanggung oleh peneliti dan sponsor.

J. Informasi Tambahan

Bapak/ ibu/ saudara diberi kesempatan untuk menanyakan semua hal yang belum jelas sehubungan dengan penelitian ini. Bila sewaktu-waktu terjadi efek samping atau membutuhkan penjelasan lebih lanjut, Bapak/ Ibu dapat menghubungi Tony Arjuna, S.Gz, M.NutDiet, AN, APD pada no. telepon 0274 - 547775 dan Rasita Amelia Hasnawati, S.Gz pada no. HP 085643385295.

Bapak/ ibu/ saudara juga dapat menanyakan tentang penelitian kepada Komite Etik Penelitian Kedokteran dan Kesehatan Fakultas Kedokteran UGM di Gedung Radiopoetra Lt 2 Sayap Barat. Alamat Jalan Farmako, Sekip Utara, Yogyakarta 55281 Telp. 0274 588688 pswt 17225, +62811-2666-869 atau email: mhrec_fmugm@ugm.ac.id).

PERSETUJUAN KEIKUTSERTAAN DALAM PENELITIAN

Semua penjelasan tersebut telah disampaikan kepada saya dan semua pertanyaan saya telah dijawab oleh peneliti. Saya mengerti bahwa bila memerlukan penjelasan, saya dapat menanyakan kepada Tony Arjuna, S.Gz, M.NutDiet, AN, APD dan Rasita Amelia Hasnawati, S.Gz.

Dengan menandatangani formulir ini, saya setuju untuk ikut serta dalam penelitian ini

Tanda tangan subjek: ……

Nama lengkap subjek:……

Tanggal : ……

Tanda tangan saksi : ……

Nama lengkap saksi :……

Tanggal : ……

Pilot Study - Are community dwelling older adults receiving Meals on Wheels achieving dietary targets?

This study is being undertaken by the Flinders University Department of Nutrition and Dietetics in conjunction with The University of Adelaide, Discipline of Medicine, and Meals on Wheels (SA) Inc.

Primary Investigators conducting the research are: Associate Professor Michelle Miller (Flinders University) and Dr Natalie Luscombe-Marsh (The University of Adelaide).

Invitation to participate

You are invited to participate in a pilot study which aims to explore whether MOW can improve the nutrition, health and well-being of elderly people. As part of this we want to compare average nutrient intake of meals delivered by Meals on Wheels (MOW) to your estimated nutrient requirements. We also aim to explore the barriers and facilitators for consumption of meals delivered by MOW over a 3 month period. We would also like to find out what is influencing how much of your MOW meal that you consume. Finally, we would like to provide some good scientific evidence whether the high energy and protein meal is better than the standard meal which MOW(SA) currently provide.

This information is important for many health care professionals to determine how meals provided by MOW are preventing and/or improving malnutrition.

We are seeking older adults aged over 70 years who are mentally and physically well to complete the study. You are invited to be screened for inclusion in this pilot study because you were recently referred to the MOW.

We are seeking elderly people who have been referred to MOW(SA) and who decide to receive nutritional support from the service, as well as those who may not wish to receive the service but who are still interested in participating research assessments.

Individuals who wish to receive nutritional support from MOW(SA) will be randomly allocated to either a standard MOW meals which provides 30% of your estimated daily energy and protein requirements, or to a energy and protein fortified version which will provide ~66% of your requirements.

Individuals who do not wish to receive nutritional support from MOW(SA) will be given personalised 'standard-care' education on how to achieve your nutritional requirements from our research dietician.

Your choice to participate in this study is voluntary and you can withdraw at any time. Declining participation, or withdrawal from this study, will not affect your ongoing or future relationship with Meals on Wheels.

Summary of procedures

Your decision to participate in this study is completely voluntary.

If you consent to participate in this study you will first be screened for eligibility to participate. The screening will involve determining whether you are over the age of 70 years and have recently been assessed by MOW(SA) as requiring either their standard or high energy and protein menu.

If you are younger than age of 70 years you will not be eligible to continue in this study. If you have a history of medically diagnosed dementia or short- or long-term memory loss you are not eligible to participate in the study. If you are not physically capable of completing a series of functional tests or anthropometry measurements, you will not be eligible for this research.

If you are eligible, participation will involve the following procedures:

- We will visit your home and collect any left-over meals for 5 consecutive days which we will then weigh. The weight of left overs will be subtracted from the average serving sizes to determine the amount consumed.

- We will visit your home with a portable scale and measure your weight to determine your estimated energy and protein requirements. We will also bring a stadiometer to record your height and tape measure to measure your mid-arm skin-fold. Your weight and mid-arm skin-fold will be measured at the first visit and 12 weeks after. These measurements will allow us to determine your nutritional status. This will take approximately 5 minutes.

- You will be asked to complete a series of function test at the first visit, and again, 12 weeks later. This includes hand grip strength and 3-meter walk test. This will take approximately 10 minutes.

- You will be asked to complete a Mini Nutrition Assessment (MNA) form and Short Nutritional Assessment Questionnaire (SNAQ) form at the beginning and at week 12. Additionally, you will be asked to complete a Multi-pass Dietary Recall of all foods eaten over last 24-hr on 3-days out of the 5 consecutive days and at 4, 8 and 12 weeks of the study. These dietary assessments will give us an idea of how well you are eating during the study period. These will take approximately 20 minutes.

- You will be asked to complete 2 questionnaires to determine your psychological well-being at the beginning and week 12 of the study. These are Assessment of Quality of Life (AQoL) and Geriatric depression questionnaire. These will take approximately 20 minutes at each time.

- You will be asked to complete an anonymous satisfaction survey which allows you to provide us any feedback regarding why you may or may not be completing your delivered meals. This survey will take approximately 5 minutes.

Commitments

Our dedicated and trained research staff will visit you, in your home, on 5 separate occasions at the beginning (termed baseline) of the study, and again at week 12, to collect any left-over food, measure your weight and ask you to complete functional tests, and nutritional and psychological assessments; all the information requested in the questionnaires will be collected as we interview you and will be recorded by our staff. On one occasion during the both fourth and eighth week of the study, you will also receive a call to discuss your diet in the past week.

Your time commitment will be approximately 3-4 hrs at each measurement period (i.e. baseline and week 12), and hence, approximately 8 hrs over the entire 3 month study.

Benefits

There may not be any potential benefits for you to participate in this study. It is hoped that the knowledge gained from this study will enable health care staff to better understand whether MOW meals are providing the necessary nutrition for clients. If criteria are not met then there will be some recommendations made to MOW to assist in achieving the dietary criteria. This will then help to reduce any risk of malnutrition for future MOW clients.

Risks and adverse effects

There are minimal risks associated with participating in this study. There are no invasive procedures required in this study.

For any subject that we believe may require additional specialist care, particularly those who are controls, a letter will be sent to their GP/specialist pyscian.

Compensation

If you suffer injury as a result of participation in this research or study, compensation might be paid without litigation. However, such

compensation is not automatic and you may have to take legal action to determine whether you should be paid.

Confidentiality

All records containing personal information will remain confidential and no information which could lead to your identification will be released, except as required by law.

Publication

The results of this study may be published in conference scientific journals and/or reported in conference papers at a later date. If the results are published in the future, your name or identifying information will not be used. You can request a copy of these results or any publications arising from the study are forwarded to you.

Withdrawal

Your participation in this study is entirely voluntary and you have the right to withdraw from the study at any time without giving a reason. If you do decide not to participate in this study, or if you withdraw from the study, you may do so freely, without affecting the standard care or treatment you will receive.

Disclosure of incentives

The Department of Nutrition and Dietetics (Flinders University) and Discipline of Medicine (The University of Adelaide) are sponsoring this study, with some in kind support from Meals on Wheels for staff. No-one will receive any payment for your participation.

Expenses and payments

You will not receive any payment for participation in this study and you must be willing to pay for your own meals if you have chosen to receive meals from MOW(SA).

Contact

If you wish to obtain further information about participation and the project, please contact: Dr Natalie Luscombe-Marsh on (08) 8222 5038 / 0406 674 510, or Tomoko Ueno on 0401 441 762.

Complaints

This study has been reviewed by the Southern Adelaide Flinders Clinical Human Research Ethics Committee. If you wish to discuss the study with someone not directly involved, in particular in relation to policies, your rights as a participant or should you wish to make a confidential complaint, you may contact the Executive Officer on 8204 4507 or email research.ethics@health.sa.gov.au

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CONSENT TO PARTICIPATION IN RESEARCH

I, …… request and give consent to

(first or given names) *(last name)*

my involvement in the research project*:* **Are community dwelling older adults receiving Meals on Wheels achieving dietary targets?**

I acknowledge the nature, purpose and contemplated effects of the research project, especially as far as they affect me, have been fully explained to my satisfaction by ……

(first or given names) *(last name)*

and my consent is given voluntarily.

I acknowledge that the detail(s) of the following has/have been explained to me, including indications of risks, any discomfort involved; anticipation of lengths of time; and the frequency with which they will be performed:

- Measurement of my weight to estimate my nutrient requirements.
- Measurement of my height and mid-arm skin-fold to estimate my nutritional status.
- Weighing any remaining food from my meals for five consecutive days.
- Performing of function tests to assess my physical health.
- Completing psychological questionnaire to assess my mental health.

- Provide feedback including barriers and facilitators of consumption of meals at the end of the study using an anonymous satisfaction survey.

- Completing nutritional questionnaires and dietary recall to assess my oral intake.

……
…

I have understood and am satisfied with the explanation that I have been given.

I have been provided with a written information sheet.

I understand that my involvement in this research project may not be of any direct benefit to me and that I may withdraw my consent at any stage without affecting my rights or the responsibilities of the researchers in any respect.

I declare that I am over the age of 18 years.

I acknowledge that I have been informed that should I receive an injury as a result of taking part in this study, I may need to start legal action to determine whether I should be paid.

Signature of Research Participant: ..... Date: .....

I, ... have described to .....

(first/given names)(last name) *(first/given names) (last name)*

the research project and nature and effects of procedure(s) involved. In my opinion he/she understands the explanation and has freely given his/her consent.

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

Status in Project: .....