Frailty, Nutrition & Healthy Ageing

Evaluating Nutrition Risk in Support of Healthy Ageing

Thesis Submitted in Partial Fulfilment of the requirements of Doctor Of Philosophy in Nutritional Sciences

By

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Abstract

Background: New Zealand is one of the countries experiencing a significant change in the population pyramid, characterised by an increase in the number of older adults (≥65 years old) compared to younger age groups. Worldwide, increases in the number of older adults is associated with increases in national health costs, and currently nearly half (42%) of the New Zealand's district health board expenses are being used for support services of older adults. This begs the question whether healthy ageing is being attained; and which strategies can be employed to prevent health loss with advancing age. The evidenced based literature presents an undebatable association between malnutrition (undernutrition) and adverse health outcomes among older adults, which calls for research to identify ways to prevent malnutrition.

Aim and objectives: The overarching aim of this research was to obtain evidence-based data that will help inform policy and practice on the importance of routine screening for malnutrition (risk); and to inform intervention planning towards preventing malnutrition and associated adverse health outcomes among older adults. After identifying research gaps in New Zealand, specific objectives of this thesis were 1) To investigate the associations between malnutrition risk status, body composition and physical performance among community-dwelling older New Zealanders – [*study 1*]; 2) To investigate the magnitude and potential predictors of malnutrition risk in older adults, at hospital admission – [*study 2*]. 3) To report the overlapping prevalence of malnutrition and frailty at admission to Residential Aged Care (RAC), and to evaluate the prevalence and factors associated with malnutrition and frailty – [*study 3*]. 4) To explore older adults' perspectives and experiences of food and nutrition intake, to gain new insights to factors that influence vulnerability to malnutrition risk– [*study 4*]. The findings of the four studies were then synthesised to inform recommended intervention strategies to prevent malnutrition with advancing age [*discussion*].

Methods: This research used a mixed methodology design including three cross-sectional quantitative studies and one qualitative. The three quantitative studies involved assessment of malnutrition status using the Mini Nutritional Assessment Short Form (MNA®SF) and several potential risk factors (Assessment procedure) for malnutrition including body composition (Bio-impedance analysis scale), upper body muscle strength (Hand grip strength), lower body muscle strength and mobility (Five times sit to stand test and Gait speed), Frailty status (Fried phenotype model), dental status (Dentate, non-dentate or use of dental appliances), dysphagia risk (Eating

Assessment Tool EAT-10) and cognitive status (Montreal cognitive assessment tool). In the comprehensive qualitative study, an in-depth interview lasting about an hour per participant was conducted. The in-depth interviews were recorded and transcribed verbatim. Thematic content analysis of the transcripts was conducted using the integrated approach.

Results: We found the prevalence of malnutrition and malnutrition risk respectively of 1% and 11% in the community, 26.9% and 46.6% at admission to the hospital, and 48% and 45% at admission to RAC. Nearly half (43%) of the participants were both frail and malnourished at admission to RAC. From the quantitative work [*studies 1-3*], the key predictors or risk factors identified for malnutrition were related to physiological frailty –Fried phenotype model, low muscle strength, muscle mass, gait speed, dysphagia risk, and psychological frailty – low cognition. From the qualitative work [*study 4*], thematic analysis of the participants' perspectives and experiences of food intake identified six main themes which contribute to understanding the increasing vulnerability to malnutrition with advancing age. A synthesis of the six themes indicated that the key factors that potentially increase risk of malnutrition encompasses all the three dimensions of frailty i.e. physiological – low appetite, comorbidities imposing food restrictions and physical challenges restraining food procurement, preparation or eating; psychological & social frailty – loneliness, living alone, carer stress and symptoms of depression, which altogether promote low food intake.

Conclusion: The central thesis of this research indicates malnutrition risk is highly prevalent across New Zealand settings, and may be prevented or treated through timely screening and person-centred interventions. Although a lower prevalence of malnutrition is recorded in the community, the quantitative data collected across settings provide evidence that the risk of malnutrition starts in the community, and early intervention is paramount in institutions as several older people enter hospital and RAC when already malnourished or at risk. Analysis of the qualitative data collected from older adults provided unique perspectives on factors that shape older New Zealanders eating habits. These support international recommendations for researchers to pay attention to older adults' perspectives towards designing appropriate interventions. Overall, the thesis findings indicate that policy and practice interventions should be aimed at preventing or reducing the prevalence of all three dimensions of frailty, in order to attain both optimal nutrition intake and healthy ageing. Mandatory screening for malnutrition (targeted in the community and routinely in institutions) is the first step to ensure timely intervention.

Dedication

To Naome and Newstone Chatindiara (mom and dad), you have always been my inspiration, and as you are nearing 65 years of age (currently 62yrs), this thesis is dedicated to you!

I pray that this research together with other existing literature and upcoming research projects will help identify pathways that makes healthy ageing easily attainable for your generation; so that by the time my generation and that of my unborn son turn 65 years old, old age will never be seen as a burden ☺ .

Idah Chatindiara 22/11/2019

PS: "Unborn son" Eli born 09/02/2020; 15 days before PhD viva!

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Chapter 1: Introduction

This chapter provides an introduction and justifications for this thesis, followed by the study overall aim and specific objectives. The chapter concludes by outlining the structure of this thesis.

1.1 Introduction and justification for the study.

The New Zealand's older adult (≥65 years) population is rapidly increasing, and a shift in the population pyramid shows an increase in the proportion of older adults compared to younger adults. The older adult population currently consists of about 15% of the population, and it is estimated that in about two decades almost 1-in-4 (21-26%) of the New Zealand population will be 65 years or over (Statistics New Zealand 2016). This change in population structure aligns with those of other countries in the Organisation for Economic Co-operation and Development (OECD 2018). The New Zealand life expectancy at birth is currently 81.6 years, and the life expectancy at age 65 is 19.6 years for males and 21.7 years for females –highest life expectancy to ever be estimated, indicating that people living in New Zealand are likely to live longer than earlier years (Statistics New Zealand 2018). Although life expectancy is increasing in all ethnic groups, to date, it has remained lower (approximately 6 to 7 years) for Māori (the New Zealand indigenous people) and Pacific peoples (Statistics New Zealand 2017). While this gap in life expectancy has been narrowing in the recent years, there is still need to incorporate multiple solutions in policy and practice that can help to further narrow this gap in life expectancy.

As the proportion of older adults is expected to continue to rise, there are calls to promote ageing in place, whereby adults are able to continue living independently with advancing age (Associate Minister of Health, 2016; Wiles et al. 2011). It is desirable for older adults to remain living in the community, as it is less costly and an option preferred by older adults (Jorgensen et al. 2009; Wiles et al. 2011). The New Zealand district health board (DHB) expenditures on older people services are increasing faster than the overall DHB expenses. Notably these expenses tend to increase in the absence of ageing in place or loss of independence, specifically when older adults are placed in residential aged care (RAC) (Ministry of Health 2016).

To promote healthy ageing, a myriad of factors needs to be considered. Aging is widely defined as an accumulation of deleterious time-related changes that are associated with or responsible for the increased susceptibility to disease and death

with advancing age (Harman 1981, 2003). An inborn process (the ageing process), other development or genetic defects, and lifestyle or environmental factors are key determinants of ageing, or the rate at which age-related changes may lead to adverse events (Harman 2003; Steves, Spector, and Jackson 2012). The ageing process can be modified by lifestyle and environmental factors; genetic variation only explains up to 25% of the variability of human survival (Mangino 2014). Therefore, environmental and lifestyle factors have the highest chance of increasing healthy lifespan or promoting healthy ageing. Examples of modifiable age-related changes are physiological (e.g. low physical functioning, increasing numbers of chronic conditions, and higher disability risk), psychological (e.g. cognitive impairment and depression), and poor social status (e.g. low social engagement and changes in living arrangements including loss of companionship).

While absence of disease or comorbidities is traditionally recognised as being healthy; healthy ageing encompasses one's ability to continue to function physically, mentally and socially as the body slows down its processes (Hansen-Kyle 2005). The presence of low physiological, psychological and/or and social well-being makes attainment of healthy ageing a challenge. Physiologically, degeneration in cell and tissue function contributes to a disruption in homeostasis – the body's ability to maintain a relatively stable internal environment despites changes or disturbances from the external environment (Hartl 2016). Cell malfunction leads to increased inflammation or an overall malfunctioning of the immune system hence older adults are likely to have more challenges to recover from injury or illnesses. Cumulative cellular damage results in significant declines in protein synthesis (Anisimova et al. 2018; Harman 2003), which explains why changes in body composition favouring loss of muscle mass are highly prevalent with advancing age (Anisimova et al. 2018). Low muscle mass is a common phenomenon among older adults, which leads to decline in muscle strength and function (Cruz-Jentoft et al. 2010). Therefore, older adults experiencing this change in body composition are likely to become physically challenged to live independently or undertake activities of daily living (ADL) (Landers et al. 2001).

Frailty is a widely used term that generally describes an age-related, non-specific vulnerability to adverse health outcomes (Rockwood and Mitnitski 2007). The concept of frailty considers the factors such as the age-related changes as deficits (or problems). This concept of frailty can be seen as one way to identify the level at which one is susceptible to the adverse health outcomes. For example, an older adult

experiencing multiple deficits or multiple age-related changes can be considered to be frailer and at an increased vulnerability to adverse health outcomes than someone with only one deficit. Biomedical researchers distinguish between the *broader definition of frailty*: a general state or condition of an individual, and a more specific *medical syndrome*: physical frailty (Morley et al. 2013). In the latest frailty consensus meeting, physical frailty was defined as "a medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual's vulnerability for developing increased dependency and/or death" (Morley et al. 2013). While the clinical condition of frailty has been described as the most problematic expression of population ageing (Clegg et al. 2013), it is important to note that frailty can be delayed, prevented or reversed especially when identified at pre-frailty stage. Thus, it is important to start assessing the need for intervention strategies as soon as an older adult begin to exhibit some of the age-related changes. Investigating the less explored dimension of frailty – 'social frailty' (Bessa, Ribeiro, and Coelho 2018), may help prevent physical frailty since there is a strong relationship between social frailty and low physical function (Tsutsumimoto et al. 2017; Makizako et al. 2018). Social frailty can be defined as; "a continuum of being at risk of losing, or having lost, resources that are important for fulfilling one or more basic social needs during the life span (Bunt et al. 2017)". Older adults are likely to become socially frail as the risk of losing such resources during the life span increases (Bunt et al. 2017).

Overall, without modification of the modifiable age-related changes, there is a high chance that multi-factors will conspire against attainment or maintenance of a healthy wellbeing with advancing age. One of the well-established modifiable lifestyle factors that promotes healthy ageing is good dietary behaviour or nutrition intake. In fact, positive associations exist between good nutrition, overall health and ageing processes (Kuczmarski and Weddle 2005). Accordingly, the same factors that can inhibit healthy ageing may (in) directly reduce the ability of older adults to maintain a healthy diet. For example, physiologically, the changes in body composition ensuing low muscle mass, strength and function, can make it a challenge for older adults to procure, prepare and eat food (Roberts et al. 2019; Locher et al. 2009; Schilp et al. 2011). Psychologically, the decline in cognitive function may lead to depression – one of the leading causes of poor appetite (desire to eat food) (Hays and Roberts 2006); while poor social status such as loneliness and living (eating) alone may also cause low food enjoyment which can further decrease food intake (Eskelinen, Hartikainen, and Nykänen 2016; Vesnaver et al. 2015; Whitelock and Ensaff 2018). When

individuals fail to eat enough food, they become at risk of malnutrition i.e. undernutrition. Protein requirements increase with age, yet older adults who struggle to maintain a balanced diet often fail to meet recommended daily protein intake (Wolfe, Miller, and Miller 2008). This challenge of low food intake or undernutrition is more troublesome with advancing age, when compared to challenges of overnutrition (excess food intake). However, because of the obesity pandemic (a consequence of excess food intake), there is more media information or conventional healthy eating messages targeted at preventing excess weight gain. This may make it a challenge for older people who need to gain weight to understand or follow the guidelines appropriate for meeting dietary inadequacies.

Malnutrition screening tools are helpful at identifying people at risk of malnutrition. Being identified as “at malnutrition risk” indicates the need for nutritional assessment, and potentially interventions in order to improve or maintain a good nutritional status (Lacey and Pritchett 2003). Although there are strategies designed to help older New Zealanders maintain independence including services designed to improve nutrition, increase physical activity, reduce falls, depression, social isolation and loneliness (Dyson 2002), vulnerable older adults requiring such support have an elevated risk of further physical decline and worsening nutritional status. Some older adults tend to consider themselves as healthy eaters and not at risk of malnutrition (Reimer, Keller, and Tindale 2012; Callen 2004). Accordingly, despite being identified as malnourished or at risk of malnutrition, such older adults may decline being seen by a dietitian or following the nutrition recommendations provided (Keller, Haresign, and Brockest 2007). While international evidence remains in support of timely screening, referral, nutrition intervention and monitoring per nutrition guidelines, there is a clear need for innovative and integrated approaches aimed at preventing and reversing the malnutrition process.

Timely screening is the first step towards prevention or treatment of malnutrition, as malnutrition is preceded by malnutrition risk i.e. the state of being at risk of malnutrition. Screening is a quick simple process that entails the need of a comprehensive nutrition assessment if one is identified to be “at risk” (Bales, Locher, and Saltzman 2015). Multiple screening tools have been developed and validated for use among older adults. Most of these tools are well suited for one or two settings. The Mini Nutritional Assessment-Short Form (MNA®SF), is a simple, quick, high sensitivity (89%) and high specificity (82%) screening tool that has been validated across all settings – community, hospital and RAC or nursing homes (Kaiser et al.

2011). An additional advantage of the MNA®SF is that it considers the complex nature of malnutrition at older age by examining individuals' neuropsychological, and psychological stress parameters in addition to the three domains (weight change, current food intake and risk factors for food intake) that most tools focus on. The MNA®SF is the most widely used malnutrition screening tool globally (Kaiser et al. 2010), and is a commendable tool to investigate malnutrition risk in older adults across settings (Bisogni et al. 2012).

Although screening tools are practical for identifying individuals at risk of malnutrition, they offer incomplete guidance towards an intervention pathway. To deliver targeted interventions with person-centred outcomes, there is need to develop a wider understanding of food and nutrition intake, knowledge, attitudes and sociocultural barriers to eating well. Due to the close relationship between ageing processes and decline in nutritional health, it is undebatable that all the typical age-related changes i.e. physiological, psychological and social, are potential risk factors for malnutrition and need to be investigated prior to intervention designing. Quantitative research is well suited to thoroughly assess the correlations between malnutrition and potential (objective) risk factors. Additionally, qualitative research provides a platform to explore subjective data, for example, the influence of social frailty on dietary intake. Conducting an in-depth analysis of older people's perspectives and experiences that shape their food intake will provide valuable or unique data on intervention designs that are likely to be appropriate or acceptable for the target population (Bisogni et al. 2012; Swift and Tischler 2010). Mixed methodology (quantitative and qualitative) research is therefore best suited to ensure both objective and subjective data are available prior designing intervention strategies.

In New Zealand Screening for malnutrition is not mandatory and currently, data or knowledge on malnutrition risk status and dietary behaviours of older adults in New Zealand is limited. The International Residential Assessment Instrument-Home Care (InterRAI-HC), a comprehensive geriatric assessment tool mandated by the Ministry of Health (https://www.interrai.co.nz/about/) is the primary assessment instrument in RAC and community services for older people living in the community. The InterRAI has over 20 clinical assessment instruments including "Oral and Nutritional status section" (Section K), which involves height and weight measurements to calculate BMI, documentation of any weight loss over the past one to six months, current hydration status and mode of nutritional intake used by the older adult. While this data is helpful to investigate malnutrition risk, one challenging aspect to identifying nutrition

risk is that older adults are considered to be at risk with a BMI less than 20kg/m^2, versus the more recent recommended cut-off point for older adults at 23kg/m^2 (Winter et al. 2014; Bahat et al. 2012). In a comparison of the interRAI with validated nutrition risk tools (MNA®SF and SCREENII) the malnutrition risk detection rate of interRAI was significantly lower than the validated tools (4% interRAI vs 12% MNA®SF vs 40% SCREEN11) (Radich 2014). Therefore, even though this nationwide tool aims to detect malnutrition risk it is likely to underestimate the prevalence.

A review of quantitative and qualitative scientific literature on prevalence, risk factors and/or older adults perspectives of malnutrition (risk) across New Zealand settings, published as of April 2017 (Chapter 2, Table 1) revealed that no study had assessed malnutrition risk at admission to hospital and RAC and only one qualitative study which included only men had been conducted to investigate older adults' perspectives on healthy eating. Understanding and reversing malnutrition in the older adult is complex, and studies that include assessment of multi-factors including overall health and social status are needed to better understand how age-related changes potentially affect nutritional status of specific populations. The aforementioned review (Chapter 2, Table 1) also revealed that assessments on several factors including dysphagia risk, physical performance and frailty had not been conducted in any of the New Zealand studies. Various international studies and organisations are calling for intervention strategies that aim to prevent malnutrition with advancing age. As a first step towards developing strategies, New Zealand data providing a snapshot of the malnutrition challenge across settings; and some highlights of the preliminary steps and potential strategies useful to tackle those challenges are needed. By and large, to better understand the extent of the malnutrition challenge; the rationale of the current study is underpinned by the trajectory that several older adults go through in later life i.e. from fit and well, to pre-frail, to being frail — resulting in frequent hospitalisation and then a progression to RAC.

1.2 Research Aim and Objectives.

The overarching aim of this research is to obtain evidence-based data that will help inform policy and practice on the importance of routine screening for malnutrition (risk) and to inform intervention planning towards preventing malnutrition and associated adverse health outcomes among older adults. The specific studies were chosen with an aim to include older adults from three main settings (community, hospital and RAC) where older adults may reside. While all the four studies conducted

in this research aimed to discuss the prevalence of (studies 1-3) or vulnerability to (study 4) malnutrition, the specific objectives of the studies were chosen to address the knowledge gap in New Zealand. The specific objectives were:

1. To investigate the associations between malnutrition risk status, body composition and physical performance among community-dwelling older New Zealanders [*study 1, Chapter 3]*.
2. To investigate the magnitude and potential predictors of malnutrition risk in older adults, at hospital admission [*study 2, Chapter 4]*.
3. To report the overlapping prevalence of malnutrition and frailty at admission to RAC, and to evaluate the prevalence and factors associated with malnutrition and frailty [*study 3, Chapter 5]*.
4. To explore older adults' perspectives and experiences of food and nutrition intake, to gain new insights to factors that influence vulnerability to malnutrition risk at older age [*study 4, Chapter 6]*.
5. To synthesise all the research findings (chapters 3 – 6) to inform recommended intervention strategies to prevent malnutrition with advancing age.

1.3 Thesis Structure.

This thesis was written following the Massey thesis with publication route and is composed of seven chapters. All four results chapters are presented in the form of a manuscript suitable for publication; therefore, there are some repetitions in those chapters. Three of these four results chapters are already published in international scientific journal and the final paper is currently under review. The journals where the manuscripts have been published are indicated on each chapter preface page.

Following this introduction chapter, a review of literature is conducted in chapter 2. The overall aim of this literature review is to provide literature and statistics that indicate the importance of timely malnutrition screening and early intervention, towards promoting healthy ageing, prevent frailty and reduce DHB expenses on older adults support services. In section 2.1: With national and global statistics showing significant increases in older adults' populations, the review starts by posing a question whether ageing in place or healthy ageing is being attained (2.1). In section 2.2: The review proceeds by briefly explaining how attainment of healthy ageing may be a challenge due to presence of multiple age-related changes that can work together to inhibit healthy ageing. This section 2.2 concludes by explaining how most age-related changes can be modified through environmental and lifestyle factors. In

section 2.3: The role of nutrition in health ageing is then discussed, and how nutrition intake can modify the ageing process and other age-related changes that can inhibit healthy ageing. Challenges of meeting nutritional needs of older adults due to increasing number of risk factors for malnutrition with advancing age are discussed. A review of all scientific quantitative and qualitative studies which assessed the prevalence, risk factors and/or older adults' perspectives on malnutrition risk across NZ settings (community, hospital and RAC (published studies as of April 2017) is then conducted. The last section (2.4) of the literature review discusses the important steps to be taken towards developing strategies to optimise nutrition intake and preventing malnutrition. The importance of conducting qualitative studies in addition to quantitative studies is highlighted, thus elaborating why this thesis used mixed methodologies to meet the research aims. The literature review concludes by briefly discussing the types and examples of nutrition interventions. The effectiveness of these interventions at preventing or treating malnutrition and associated health outcomes, is discussed using evidence from systematic reviews, meta-analysis and comprehensive/narrative reviews.

Chapters 3 to 5 are results chapters which report our findings from 3 quantitative studies across settings. Chapter 3 reports the associations between malnutrition risk status, body composition and physical performance among community-dwelling older New Zealanders. Chapter 4 reports the prevalence and potential predictors of malnutrition risk in older adults, at hospital admission. Chapter 5 reports the overlapping prevalence of malnutrition and frailty at admission to RAC, and evaluates the prevalence and factors associated with malnutrition and frailty. Chapter 6 is another results chapter from our qualitative study which investigated experiences and perspectives of older adults on healthy eating. All the findings of chapters 3 – 6 are synthesised in Chapter 7. This chapter 7 concludes by outlining recommendations for strategies that may be useful to prevent malnutrition through targeting frailty, thus promoting healthy ageing among community dwelling older New Zealanders. Recommendations for future research are also made.

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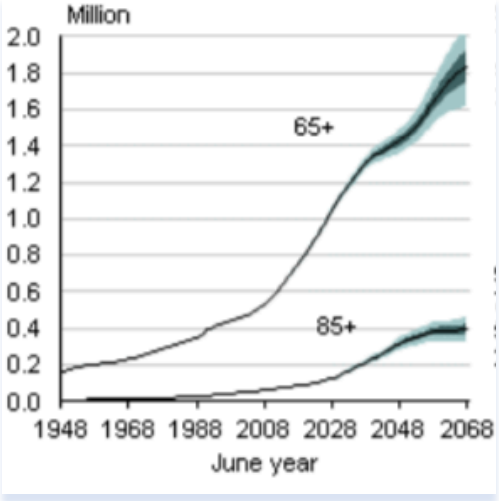
Chapter 2: Literature Review

2.1 The Ageing Population: Ageing in Place?

Globally, there has been a significant change in the population pyramid and the world health organisation (WHO) has predicted that the population of adults older than 60 years is set to double by the year 2050 (World Health Organisation 2015). New Zealand's life expectancy at birth (81.6 years), is among the top life expectancies of Organisation for Economic Co-operation and Development (OECD) countries (OECD 2018). The older adults' population is currently 15% of the total New Zealand population (Ministry of Health 2016b). Both the absolute number and percentage of populations aged 65+ and 85+ is expected to continue to rise, as there are no signs of deceleration of life expectancy, Fig.1.

Population aged 65+ and 85+

1948-2068



Percentage of population aged 65+ and 85+

1948-2068

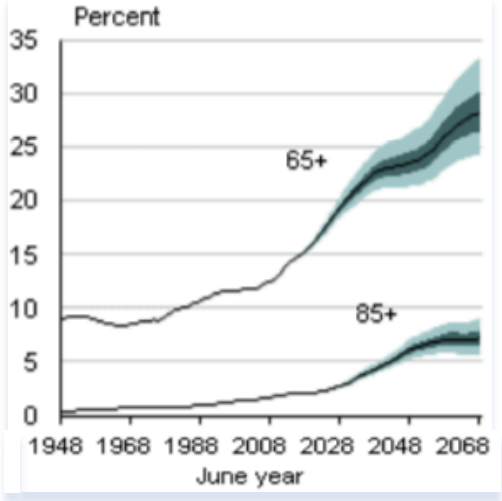


Fig.1. New Zealand older adults population projections (Statistics New Zealand 2016b).

Though increases in life expectancy have been recorded as a great accomplishment of the 20th century, concerns have been rising regarding the quality of life lived during the older ages. In fact, caring for older adults with a low socioeconomic status and a high prevalence of chronic comorbidities has been postulated as the greatest challenge of the 21st century (Silva et al. 2014). Currently, while the proportion of older adults is about 15% of the New Zealand population, they are making use of nearly half (42%) of the district health board (DHB) expenses (Ministry of Health 2016a);

which poses the questions on whether the increase in life expectancy or life span is corresponding with health span; or are our communities failing to age in place?
"Ageing in place", can be defined as the ability to live independently and comfortably in a desired place (mostly own home or community), regardless of one's age (Centers for Disease Control and Prevention 2013; Wiles et al. 2011; Associate Minister of Health 2016). With loss of independence, older people are likely to require more assistance including health and social services. Usually, the impact of this challenge escalates as older adults concurrently become unable to positively contribute to the progress of the economy; for instance because of inability to take part in the labour force (Baltes and Smith 2003). Therefore, another burning question is whether the projected increases in life expectancy will go along with good quality of life, or this will bring enormous challenges to the older people themselves, the society at large and also the economic status of nations (Christensen et al. 2009).

Different cut off points are used to classify people as older adults, and this may be based on several factors including gender, race or ethnicity and the economic status of a country. For example, in the projections above, WHO used 60+ years but on average most developed countries especially those in the OECD recognise people aged 65+ years as older adults. Of late, two subgroups of older adults have been established; the young-old (65-84 years) and the advanced age (85+ years). Research indicates that more challenges are expected in the advanced age population (Baltes and Smith 2003). The advanced age group is currently the most rapidly expanding group in New Zealand, thus higher numbers of people within this age group are projected (Statistics New Zealand 2016b). Therefore, understanding ways that promote ageing in place is a pressing public concern for the New Zealand community.

2.1.1 Heterogeneity of the older New Zealanders population

Heterogeneity of the older adults' population is an area of interest for most researchers or policy makers aiming to promote ageing in place. This heterogeneity spans across all spectrums of life, including overall health status, socioeconomic status, individuals' norms, beliefs or cultural values and some demographic factors such as country of birth or the ethnicity individuals identify with.
Despite being a relatively small population (about 4.2million) country, the New Zealand 2013 census recorded over 80 ethnic groups that each had at least 1,000 people (Statistics New Zealand 2014), indicating how ethnically diverse the nation is (Statistics New Zealand 2017c). **Fig.2** below summarises the data provided by

NZ.Stat, indicating the national ethnic population projections of adults of age 65 years and over; 2013(base)-2038 (Statistics New Zealand 2017b).

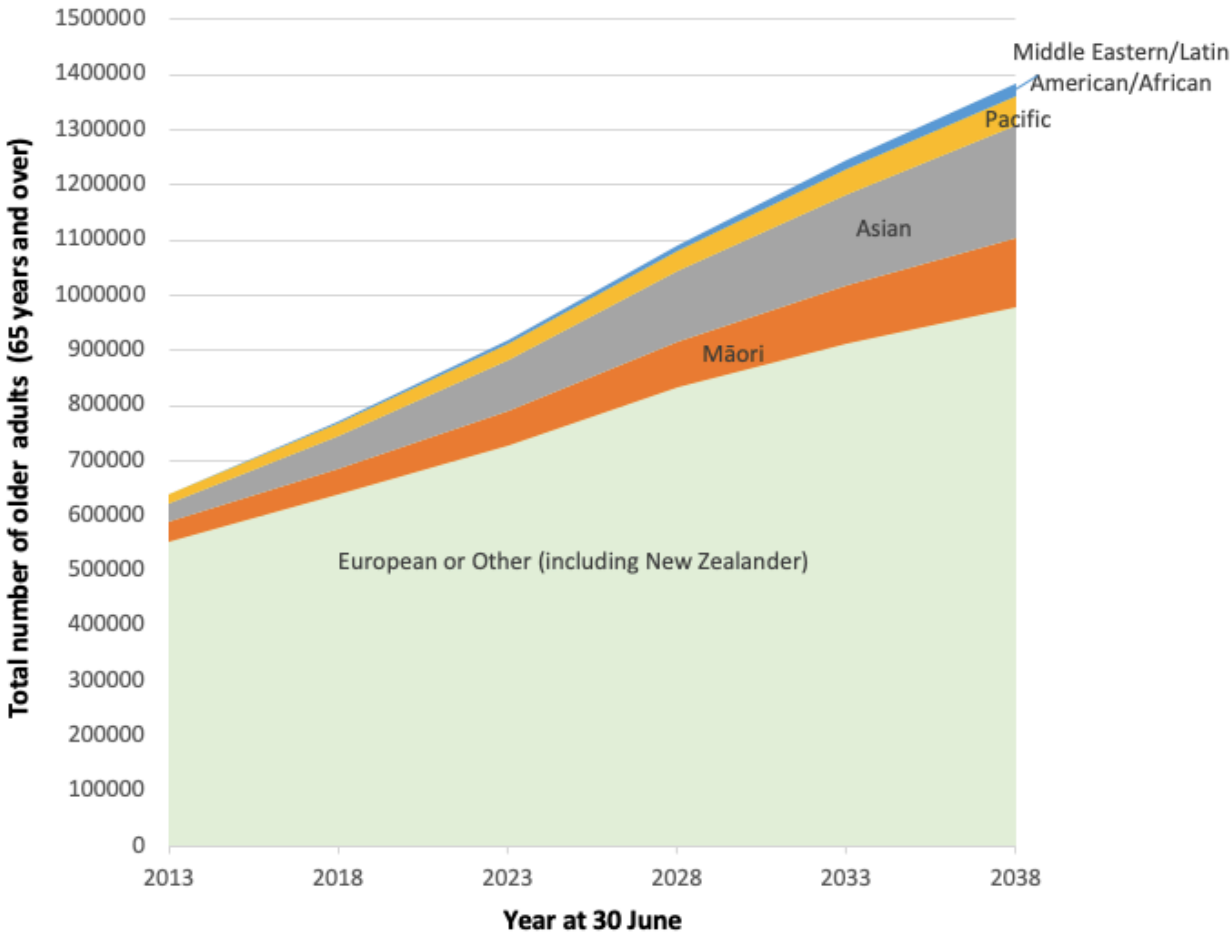


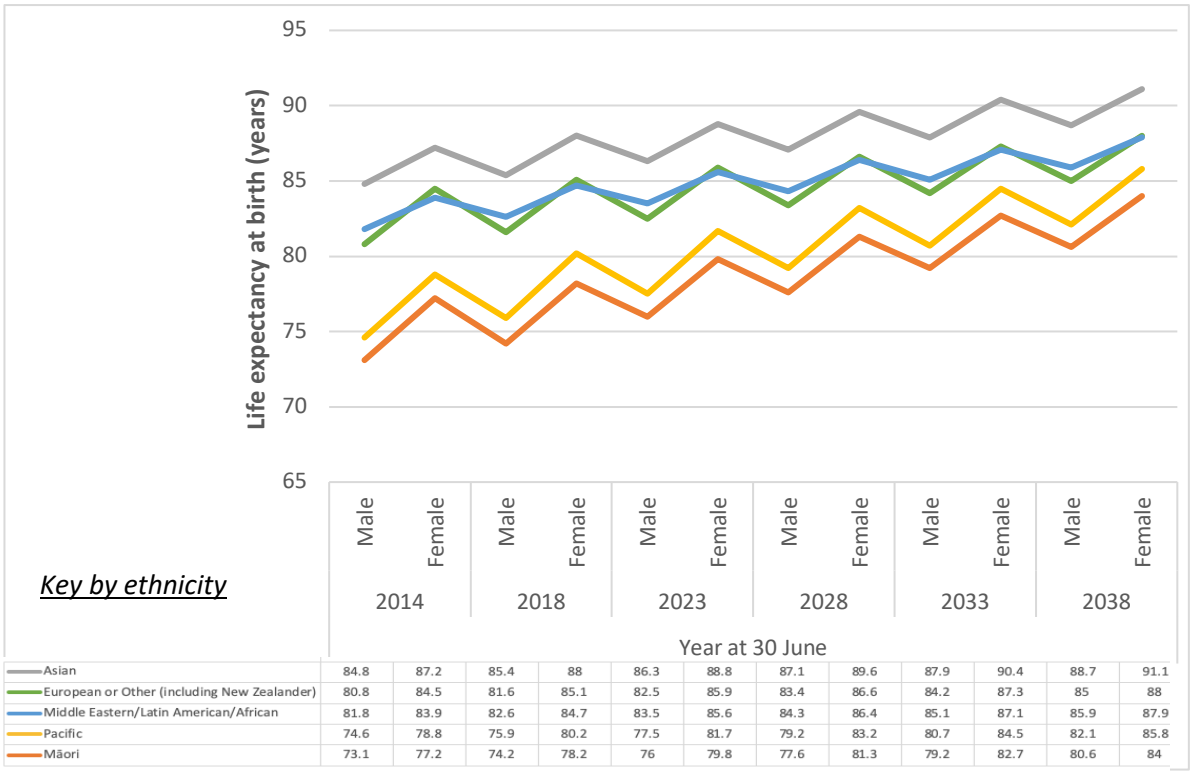
Fig.2. Total of adults of age 65 years and over: National ethnic population projections, 2013(base)-2038 (released 2017)

Data extracted on 20 Jul 2019 21:37 UTC (GMT) from NZ.Stat; http://nzdotstat.stats.govt.nz/wbos/Index.aspx?DataSetCode=TABLECODE7560#

The above figure (**Fig.2.**) shows that the total projected numbers of all the level 1 ethnicities – as per New Zealand standard classification of ethnicities (Statistics New Zealand 2017a), are all going to accelerate. Furthermore, the projections show that as the absolute number of adults over 65 years will continue to increase, so will the level of ethnic diversity (Statistics New Zealand 2017b). This ethnic diversity of the older New Zealand population calls for research that investigates specific needs of sub-ethnic groups in order to ensure efficient programs are put in place.

One of the goals of the NZ positive ageing strategy is to build communities that appreciate the diversity of cultural identity of older people (Ministry of Social

Development 2015). This goal is aimed at promoting equal chances for successful ageing across ethnicities (Ministry of Social Development 2015). Although life expectancy is increasing across all ethnic groups, the New Zealand statistics shows a clear distinction in life expectancy per ethnicity **Fig.3**. The Māori and Pacific people who had a lag in life expectancy all years leading to 2018, are projected to continue lagging in life expectancy up to year 2038 (Statistics New Zealand 2017b). Accordingly, several research studies in New Zealand employ two cut off points to classify people as older adults based on ethnicity: 55+ years for Māori and Pacific people; and 65+ for all other ethnicities. This 55+ year cut off for Māori and Pacific people is also used in the clinical setting for Ministry of Health contracts and policies; and DHB services have applied the 'alike in age and interest' principle to services for older people whereby the cut off for accessing many older persons services is 55 years for Maori and Pacific.



Asian	84.8	87.2	85.4	88	86.3	88.8	87.1	89.6	87.9	90.4	88.7	91.1
European or Other (including New Zealander)	80.8	84.5	81.6	85.1	82.5	85.9	83.4	86.6	84.2	87.3	85	88
Middle Eastern/Latin American/African	81.8	83.9	82.6	84.7	83.5	85.6	84.3	86.4	85.1	87.1	85.9	87.9
Pacific	74.6	78.8	75.9	80.2	77.5	81.7	79.2	83.2	80.7	84.5	82.1	85.8
Māori	73.1	77.2	74.2	78.2	76	79.8	77.6	81.3	79.2	82.7	80.6	84

Fig.3. Life expectancy at birth: National ethnic population projections, 2013(base)-2038 update (released 2017)

data extracted on 22 Jul 2019 13:11 UTC (GMT) from NZ.Stat http://nzdotstat.stats.govt.nz/wbos/Index.aspx?_ga=2.98349407.119226676.1563750718-961638533.1554844858

2.1.2 Lower Life expectancy for Māori

The Māori have the lowest life expectancy, and several reasons could explain the lag in life expectancy among these New Zealand indigenous people. In general, statistics show that Māori are disadvantaged across major socioeconomic indicators including income, employment, education and health status (Ministry of Health 2011; Marriott and Sim 2015), and these factors can reduce quality of life, as well as the likelihood of living longer.

Nevertheless, it is important to note that the gap in life expectancy between Māori and non-Māori (people of all other ethnicities) has been narrowing. In 2012-14Māori life expectancy was lower by approximately 7 years, while in 2000-02 it was 8.5 years lower and 9.1 years lower in 1995-97 (Statistics New Zealand 2016a). In addition to this narrowing of the life expectancy gap, a higher proportion of older Māori is expected in the upcoming years as the Māori population is growing at a faster rate than non-Māori. The Māori population is projected to increase due to high birth rates (Statistics New Zealand 2016b). Therefore, the Māori people contribution to the increasing numbers of older New Zealanders is not negligible and this raise concerns on how this may impact the nation's health system and the socioeconomic status among other factors. Overall, paying attention to ethnic diversity as part of establishing ways that promote healthy ageing is paramount.

2.2 Healthy Ageing and the influence of age-related changes.

Healthy ageing is defined as the process of developing and maintaining functional ability that enables well-being in older age (World Health Organisation 2016). The main consequences of healthy ageing are autonomy ("the ability and the desire to make decisions regarding one's care"), independence ("the ability to live on one's own terms and actively participate in one's own care") and ultimately successful ageing ("the ability to establish and maintain stated goals or lifestyles and involvement in prescribed roles") (Hansen-Kyle 2005). The World report on ageing and health indicated that functional ability can be maximised through either building and maintaining intrinsic capacity, or through enabling someone with a given level of intrinsic capacity to engage in the things that matter to them (Beard et al. 2016). Maintaining functional ability or attainment of healthy ageing, may be a challenge as there are so many age-related changes that can work together to inhibit healthy ageing (**Fig 4**)

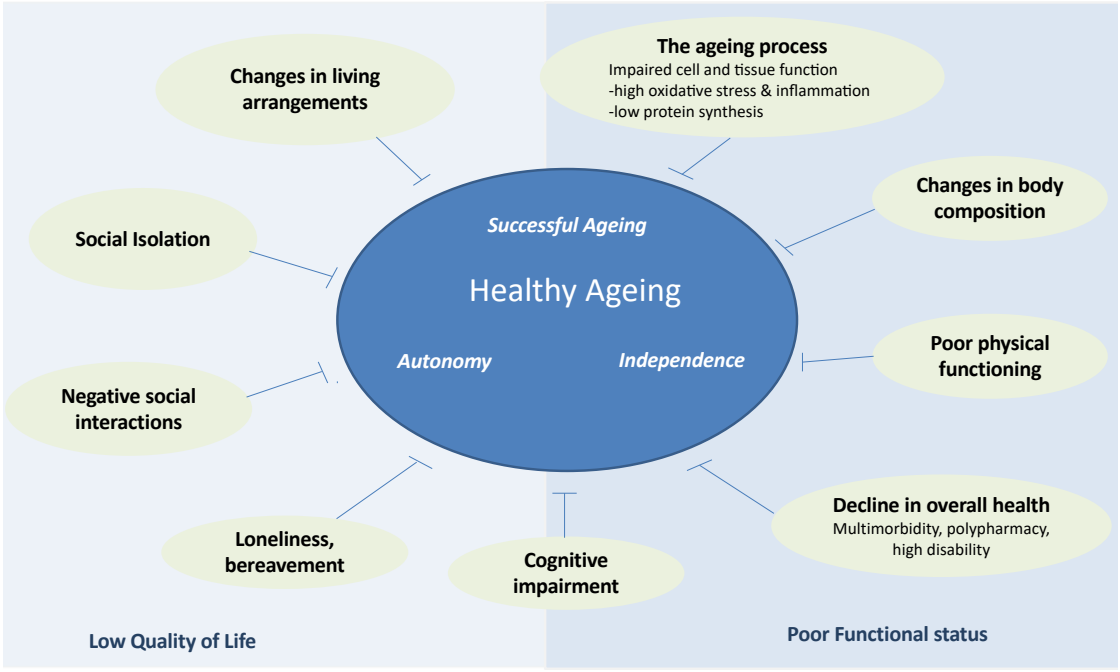


Fig.4. Age-related changes that potentially inhibit healthy ageing

Summarised from (Walker 2007; Harman 1981; Hansen-Kyle 2005; Britton et al. 2008; Steves, Spector, and Jackson 2012; Pawelec, Goldeck, and Derhovanessian 2014; Bunt et al. 2017; Harman 2003)

2.2.1 The Ageing Process.

An inborn process known as the "ageing process" can be defined as time-related changes that are associated with or responsible for the increased susceptibility to disease and death with advancing age (Harman 1981). While there are several theories of ageing (Viña, Borrás, and Miquel 2007), one of the most prominent and well-studied is the free radical theory, which explains that one common process i.e. accumulation of free radicals or reactive oxygen species (ROS) leads to increased oxidative stress ensuing cell and tissue malfunction (Harman 2003). Oxidative stress can be defined as a state of imbalance between the production of free radicals and their elimination by protective mechanisms (Ďuračková 2010). While increasing age and the intrinsic ageing process are risk factors for production of free radical, environmental and lifestyle factors may also lead to excess free radicals formation (Harman 1992; Steves, Spector, and Jackson 2012). Overall, interventions that promote adult healthy behaviours may attenuate harmful effects of less modifiable risk factors of ageing (Britton et al. 2008). In fact, previous research found that lifestyle and environmental factors explains up to 75% of the variability of human survival (Mangino 2014). Understanding and targeting the modifiable age-related changes

can therefore slow down the ageing process and promote healthy ageing (Christensen et al. 2009).

2.2.2 Physiological Age-related Changes.

Physiologically, one ageing process that underlies or contributes to all other factors is cellular malfunction – a state where cells are damaged and unable to perform their usual tasks (Harman 2003). Under normal circumstances damaged cells undergo repair or get replaced to restore normal function, but with advancing age, degeneration of cellular activities may occur which slows down the cell repair process or leads to cumulative cell damage. One of the consequences of cumulative cellular damage is a significant decline in protein synthesis (Harman 2003). Tissue growth and repair relies on protein synthesis, hence defects in protein synthesis leads to decline in muscle tissue or an overall change in body composition favouring loss of muscle mass. Decline in muscle mass is a highly prevalent condition among older adults (Hickson 2006). While this change in body composition can occur as part of the natural ageing process, ingestion of low protein diets and low physical activity are lifestyle behaviours that accelerate muscle loss (Rom et al. 2012). Decrease in muscle mass leads to poor muscle strength and function which can reduce habitual physical activity. This further worsens the changes in body composition towards muscle mass loss (Visvanathan 2003; Lee and Frongillo Jr 2001). Low muscle strength and function leads to loss of independence and impedes older adults' ability to perform activities of daily living (ADL), hence the degree of loss of muscle mass and/or function can predict whether one will be able to live independently or end up institutionalised (Verlaan et al. 2017).

The alterations in cardiovascular, pulmonary, renal and gastrointestinal physiological features associated with ageing (Aalami et al. 2003) are key causes of increasing number of illnesses (multimorbidity) and prescribed medications (polypharmacy). At a cellular level, oxidative stress triggers inflammation, and chronic inflammation is an underlying cause for many chronic conditions including cardiovascular diseases, cancer and neurological disorders (Hussain et al. 2016; Pawelec, Goldeck, and Derhovanessian 2014). Furthermore, the immune system of older adults may be compromised due to the decline in protein synthesis, making it harder for older adults to resist or recover from illnesses. This partly explains the increase in number of illnesses i.e. high prevalence (56-98%) of multimorbidity (Marengoni et al. 2011) and the associated high prevalence (≈40%) of polypharmacy (≥5 prescribed medications) observed among older adults (Kostev and Jacob 2018; Kirchmayer et al. 2016;

Charlesworth et al. 2015; Morin et al. 2018). A combination of diseases, comorbidities and poor physical functioning can all contribute to high disability.

2.2.3 Psychosocial Age-related Changes.

At older age, there is an increased risk of cognitive impairment, characterised by memory loss, Alzheimer's disease or dementia. Cognitive impairment affects one's autonomy and independence and this decreases both functional status and quality of life (Hansen-Kyle 2005). This may lead to distress or depression, and older adults with cognitive impairment tend to socially isolate themselves and/or feel lonely – both typical psychosocial age-related changes (de Boer, Ter Horst, and Lorist 2013). Multiple factors contribute to the incidence of depression at older age, including the pain and stress related to managing several illnesses, decreased physical and social functioning (Fiske, Wetherell, and Gatz 2009).

Over a decade ago, a case for examining the social context of frailty in later life in New Zealand was made (Barrett 2006). Social factors play a pivotal role in promoting health outcomes such as physical functioning (Makizako et al. 2018), cognitive functioning (Poey, Burr, and Roberts 2017; Tsutsumimoto et al. 2017), psychological factors including lowering depression risk, as well as attainment of good quality of life at older age (Hawton et al. 2011; Victor et al. 2000). To better understand social deficits among older adults, the key areas to assess include living arrangements (presence of absence of companionship or living alone), social interactions (positive or negative), perceived loneliness, and caregiving or carer stress. It is important to note that all the four aforementioned social factors are modifiable, and without modification of such factors (when needed), it may lead to social isolation, loneliness, depression among other factors that prevent attainment of healthy ageing. This may also contribute to the need for RAC (Jamieson et al. 2019). In New Zealand, a large national study of older adults (*n*= 54,345, mean age 81.9 years), found that lacking positive social interactions increased the likelihood to enter RAC (Jamieson et al. 2019). In an adjusted model evaluating the influence of social factors on admission to RAC, the study found all the four social factors (living arrangements – living alone, negative social interactions, perceived loneliness and carer stress) to be significantly associated with RAC admission (Jamieson et al. 2019). This stresses the importance of interventions that incorporate social aspects towards attaining healthy ageing.

While living alone on its own may not lead to loneliness or social isolation, it may lead to both if an older adult who is physically challenged lives alone; without access to

social support from family or community at home, or access to transport that may facilitate social engagement. On the other hand, while the association between living with others or companionship and positive health outcomes and good quality of life is well established (Victor et al. 2000), living with others may not be helpful if it leads to negative social interactions or carer stress. Such details highlight the fact that the 'one-size-fits-all' way of intervening may fail to adequately address individuals' social challenges, hence there is need to thoroughly investigate the underlying causes of poor or low social interaction at older age. In the NZ setting, promoting social interaction requires well-coordinated programmes due to, for example, the multicultural backgrounds of the older adult' population (Statistics New Zealand 2016b). In an integrative review of older adult loneliness and social isolation in NZ, loneliness was found to be significantly related to social isolation, living alone, Māori ethnicity, female gender, depression and suicidal ideation (Wright-St Clair et al. 2017). This review also found that particular populations i.e. Māori and Asian immigrants may experience loneliness differently from other groups within society and may be at higher risk of loneliness (Wright-St Clair et al. 2017).

2.2.3 Frailty in older adults.

Accumulation of physical, psychological, and social deficits (or problems) increases the risk of one being frail, hence preventing healthy ageing (van Campen 2011). Although frailty and disability frequently co-exist in older people, in some older adults frailty is considered a pre-disability stage (Xue 2011; Clegg et al. 2013); hence an understanding of the frailty concept may help prevent the high prevalence of disability observed at older age. Although frequently documented among older adults, the term frailty does not have one standard definition. However, the two most cited research work on the frailty concept (Buta et al. 2016) i.e. the Fried phenotype model (Fried et al. 2001) and frailty index or cumulative model (Rockwood and Mitnitski 2007), both describe frailty as a syndrome characterised by decreased reserve and resistance to stressors, such that one is unable to properly cope with every day or acute stressors (Fried et al. 2001; Rockwood and Mitnitski 2007).

Using the most widely used definition of frailty i.e. the Fried phenotype; frailty is characterised by having at least three of the following features: 1) unintentional weight loss, 2) low physical activity, 3) muscle weakness or low grip strength, 4) fatigue or poor endurance and 5) slowed performance or walking speed. Having one or two of these conditions is classified as being pre-frail (Fried et al. 2001). It has been argued that while the Fried phenotype model is well-suited to understand the loss of physical

health in older persons; less emphasis is placed on their psychological and social functioning (van Campen 2011). The second most cited frailty assessment procedure; commonly referred to as the frailty index considers symptoms, signs, diseases, and disabilities as deficits, and an accumulation of these deficits indicates the likelihood that frailty is present (Rockwood and Mitnitski 2007). This larger construct of frailty enables understanding of the general state of an individual, although the procedure still fails to thoroughly investigate social aspects of frailty.

Overall, while there are several frailty tools, no one tool efficiently captures all the three frailty dimensions (physical, psychological, and social). The social dimension of frailty is the least explored concept (Bessa, Ribeiro, and Coelho 2018; Bunt et al. 2017). Emerging research has defined social frailty as; “a continuum of being at risk of losing, or having lost, resources that are important for fulfilling one or more basic social needs during the life span” (Bunt et al. 2017). Examples of these resources are summarised below in **Fig 5**. Although no standard tool has been developed to cater for this continuum of risk, the definition provides a standardised basis to understand the social deficits that can be fully explored in in-depth interviews with older adults.

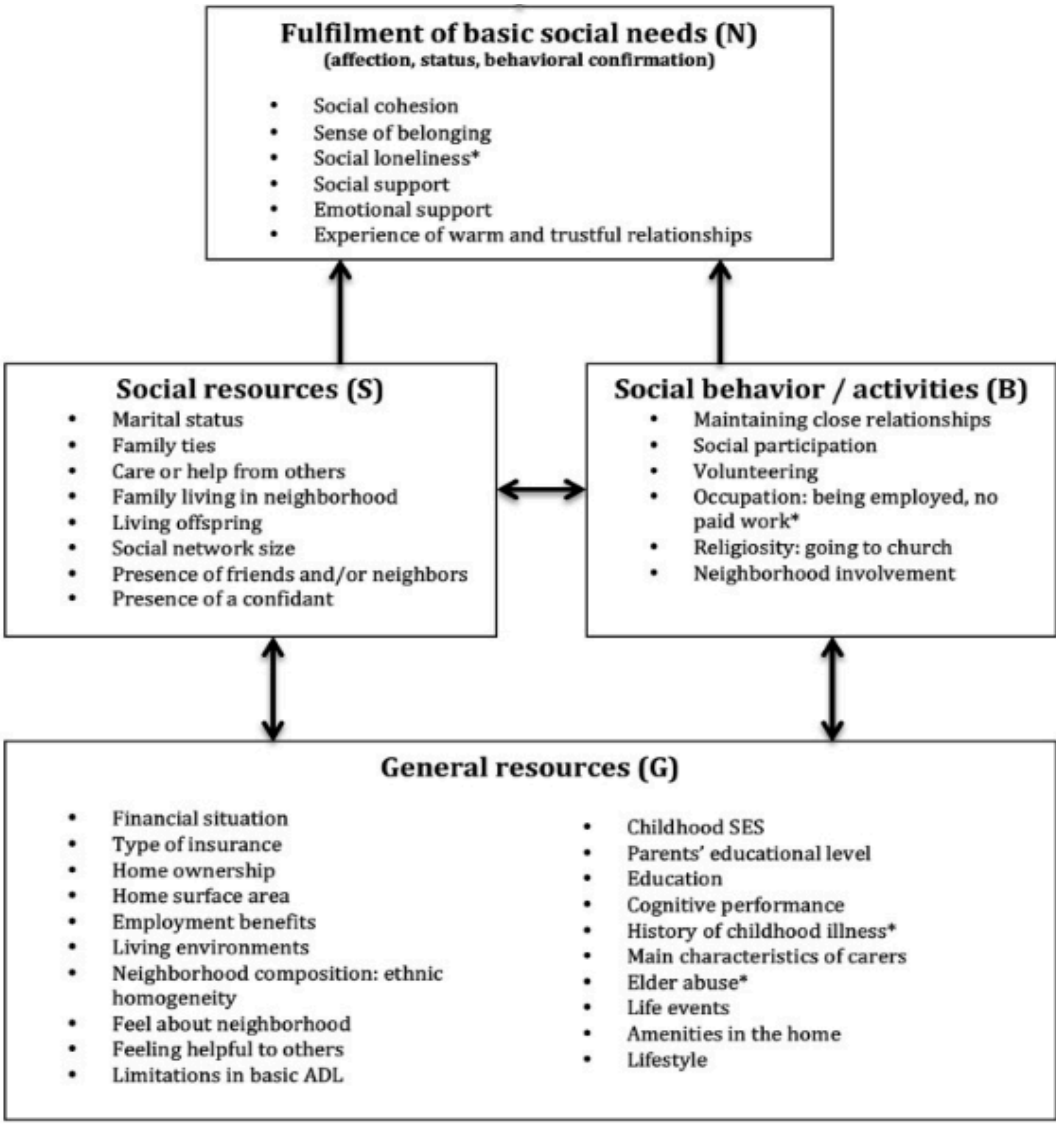


Fig.5. Resources (or restrictions) essential for fulfilment of basic social needs.

Reprinted by permission from Springer Nature, (Bunt et al. 2017)

While frailty is preventable and reversible (Caballero Mora and Rodriguez Mañas 2018), the clinical condition of frailty has been described as the most problematic expression of population ageing (Clegg et al. 2013). Timely assessment and intervention are the key steps to reduce the prevalence of the clinical state of frailty. In an effort to reduce institutionalisation and promote ageing in place, an international frailty consensus conference was held (Morley et al. 2013). The primary aim of the meeting was to come up with an operational definition of frailty, from which this group of experts agreed to distinguish between the *broader definition of frailty*: a general state or condition of an individual, and a more specific *medical syndrome*: physical frailty. A recommendation for 'screening of all persons older than 70 years and all

individuals with significant weight loss (≥5%) due to chronic disease' was made (Morley et al. 2013).

While several frailty assessment tools have been developed based on the Fried phenotype model and/or the frailty index; simple rapid screening tests such as the simple FRAIL scale (van Kan et al. 2008) have been validated for quick screening for frail older persons (Morley et al. 2013). Furthermore, some studies suggest use of one or two physical performance measures such as gait speed (Clegg, Rogers, and Young 2014), hand grip strength (Syddall et al. 2003) and timed up and go (Clegg, Rogers, and Young 2014), as adequate markers for frailty. Focus is being placed on validating rapid screening tools to promote screening and/or assessment for frailty, as frailty is significantly associated with increased risk for falls, disability, hospitalisation (hospital or RAC), multimorbidity, and mortality (Widagdo et al. 2015; Xue 2011; Torpy, Lynm, and Glass 2006).

"The importance of frailty stems from two main facts: its usefulness to stratify the risk of adverse events, such as disability, hospitalization, falls, or death, and, secondly, its reversibility.

These two facts put frailty in the center of the strategies to fight against disability in older people by detecting the early stages of functional decline and by planning and implementing interventions."

(Caballero M & Rodriguez M, 2018)

Frailty is prevalent across geriatric settings including the community, and the risk of frailty increases with increasing age. From 24 international population-based studies a 14% pooled prevalence of frailty among community-dwelling adults (≥65years) was recorded (Shamliyan et al. 2013). In the same review, it was estimated that 3–5% of deaths among older adults could be delayed if frailty was prevented (Shamliyan et al. 2013). The pooled prevalence of frailty and the estimated percentage of deaths that could be delayed through preventing frailty are both likely to be much higher when assessing institutionalised populations. However, few studies have examined the prevalence and factors associated with frailty in aged care institutions. In an international systematic review and meta-analysis, only nine studies that assessed frailty among RAC residents were identified (Kojima 2015). To prevent overall health decline and high disability with advancing age, factors that may contribute to the onset of frailty such as poor nutritional status need to be understood.

2.3 Nutrition: Healthy-eating, Healthy Ageing

2.3.1 The Role of Nutrition in Attainment of Healthy ageing.

The WHO defines nutrition as the intake of food, considered in relation to the body's dietary needs (World Health Organisation 2017). Healthy eating which is synonymous

to adequate or good nutrition is attained when one consumes food as per his/her dietary needs. Nutrition is one modifiable factor that is able to work directly on the intrinsic ageing process; as well as physiological, psychological and social age-related changes that potentially inhibit healthy ageing. Looking at the intrinsic ageing process, there is compelling evidence that cellular irradiation and oxidative stress can be reduced by adequate intake of foods containing dietary antioxidants such as Vitamins A, C and E (Lobo et al. 2010; Harman 1992). Physiologically, changes in body composition favouring loss of muscle mass can be ameliorated by adequate protein intake (Hickson 2006). Anti-inflammatory properties of diets such as the Mediterranean diet have been associated with lower risk of several chronic conditions that result from increased inflammation, including Alzheimer's and cardiovascular diseases (Davis et al. 2015; Szczechowiak, Diniz, and Leszek 2019). The Mediterranean diet is characterised by high consumption of legumes, unrefined cereals, fruits, vegetables, olive oil, moderate to high consumption of fish and low consumption of non-fish meat products (Davis et al. 2015). A meta-analysis of international studies found that nutrition interventions significantly improved older adults quality of life, particularly the physical components (Rasheed and Woods 2013). Adequate nutrition intake provides the energy required for good physical functioning which may help older adults to remain independent and socially engaged. In fact, healthful dietary behaviours are associated with positive social relationships (Conklin et al. 2014). Finally, while accumulation of age-related changes increases frailty risk, there is evidence that several effective interventions for prevention or treatment of frailty do include a nutrition component (Puts et al. 2017). Previous research concluded that effective treatment for frailty and malnutrition is based on correction of macro- and micronutrient deficits and physical exercise (Artaza-Artabe et al. 2016).

Given the fact that nutrition can (in)directly influence both intrinsic and extrinsic age-related changes, it is not surprising that inadequate nutrition is either associated with or actually leads to multiple adverse events including disability, loss of independence, hospitalisation (admission, longer length of stay and readmission), treatment costs, admission to RAC, morbidity and mortality (Ahmed and Haboubi 2010; Agarwal et al. 2013; Hickson 2006). A point to note is that good nutrition is helpful as both a preventative and treatment measure for most of the aforementioned adverse events. Those who maintain good eating habits throughout the life course are more likely to age in place (Mathers 2013). To efficiently encourage healthy eating at older age, it is important to understand the nutritional needs of older adults (section 2.3.2);

understand factors that potentially prevent optimal nutrition intake or promote malnutrition (risk) (section 2.3.3), and establish effective ways that help eliminate malnutrition risk and optimise nutrition intake with advancing age (section 2.4).

2.3.2 Nutritional needs of older people

Nutrient and energy or caloric content are the key aspects to consider when establishing human nutrient needs. The older people population is quite heterogeneous (Statistics New Zealand 2000, 2017b), and nutritional (nutrient and energy) needs depend on several factors particularly health status. In general, older people require nutrient dense foods (Lichtenstein et al. 2008). However, due to reduction in basal metabolic rate and changes in body composition among other factors; older people usually require less energy intake compared to younger people. The specific energy needs of individuals depend on several factors including general physical activity and current weight status i.e. if there is need for weight gain or loss. Therefore, for a malnourished underweight older adult, both nutrient and energy dense foods maybe more appropriate.

Macronutrients (carbohydrates, fat and proteins) provide energy, which is essential for maintenance of metabolic processes, physiological functions, and general physical and psychological performance. Thus, inadequate energy intake may stimulate ill health in older adults. Of all the macronutrients, protein intake is often deficient in older adults. A previous review discussed the importance of ensuring that recommendations for protein intake accounts for compensatory loss of muscle mass that occurs on lower protein intakes (Nowson and O'Connell 2015). Compared to the recommended 0.8g/kg/day protein intake for adults, older adults require more protein intake; approximately 1.0–1.3g/kg/day (Nowson and O'Connell 2015). Protein is the key nutrient required for counteracting the physiological and metabolic changes that occur with ageing (Bauer et al. 2013), thus it is essential to find ways that promote optimum protein intake in older adults. A lack of data is available to summarise the average macronutrient intakes of older New Zealanders. The Life and Living in Advanced Age, a Cohort Study in New Zealand (LILACS NZ) which investigated nutrition intake in octogenarians (n=578), observed the average macronutrient distribution range (AMDR) was for carbohydrates 44.2%, fat 37.6% and protein 15.9% (Wham, Teh, Moyes, Rolleston, Muru-Lanning, Hayman, Adamson, et al. 2016). The reported median protein intake per day (g/kg/day) was 0.93 (0.71–1.32) for non-Māori and for Māori 0.95 (0.77–1.18) (Wham, Teh, Moyes, Rolleston, Muru-Lanning, Hayman, Adamson, et al. 2016), thus failed to meet the average daily

recommendations (1.0–1.3g/kg/day) for protein in older adults (Bauer et al. 2013; Nowson and O'Connell 2015).

Micronutrients (vitamins and minerals) though needed in smaller quantities are essential in promoting good health. As energy needs in older adults are generally lower than for younger age groups, this may partly contribute to an unfavourable decline in micronutrient intake as food intake declines. Furthermore, the main food sources for micronutrients are high fibre foods, fruits and vegetables, which may be hard for older adults to consume with poor dental status (Marcenes et al. 2003). The commonly deficient micronutrients in older adults include calcium, magnesium and selenium, folate, zinc and vitamins A, B1 (thiamine) B2 (riboflavin), B6 and E (ter Borg et al. 2015; Wham, Teh, Moyes, Rolleston, Muru-Lanning, Hayman, Kerse, et al. 2016). LILACS NZ reported that, more than half of Māori and non-Māori had intakes below the estimated average requirement (EAR) for calcium, magnesium and selenium (Wham, Teh, Moyes, Rolleston, Muru-Lanning, Hayman, Kerse, et al. 2016). More so, the intakes were lower for; vitamin B6 in Māori women, folate in Māori and non-Māori women, vitamin E in Māori women and both ethnic groups for men and zinc in Māori and non-Māori men (Wham, Teh, Moyes, Rolleston, Muru-Lanning, Hayman, Kerse, et al. 2016). In cases of nutrient deficiencies, the use of nutrition supplements is recommended. However, excess intake of supplements can have detrimental effects including high mortality risk (Bales, Locher, and Saltzman 2015; Bjelakovic et al. 2012; Buhr and Bales 2009). Evidence around benefits and risks of nutrition supplements intake is discussed under section 2.4.3.2 of this literature review.

2.3.2.1 Conventional healthy eating vs. older people nutritional needs

Because of the obesity pandemic, there is more media information or conventional healthy eating messages targeted to prevent excess weight gain. This may make it a challenge for older people who need to gain weight to follow the guidelines appropriate for their condition. For example, while conventional healthy eating guidelines promote low calorie foods, consumption of energy dense foods is key to prevent weight loss and malnutrition (undernutrition) in older adults. Among vulnerable older adults, particularly those in long-term care, a liberalized diet approach which allows for older adults food choices instead of multiple restrictions is more likely to improve the quality of life for older adults (Niedert 2005). In fact, with increasing age a moderate increase in BMI, particularly a BMI greater than 23kg/m^2 is protective (Winter et al. 2014; Bahat et al. 2012), while dietary and calorie

restrictions have been shown to increase risk of malnutrition (Darmon et al. 2010; Zeanandin et al. 2012), frailty, morbidity and mortality (Darmon et al. 2010). In a qualitative study, older Australians reported avoidance of specific foods and calorie restrictions, regardless of their weight status and without guidance from health professionals due to their perceived healthy eating practices and/or a desire to prevent weight gain (Winter, McNaughton, and Nowson 2016). Therefore, there is absolute need to ensure older adult nutritional health perspectives are well aligned with their nutritional status.

Older New Zealanders appear to be habitual eaters who are likely to continue similar eating patterns to those they established in early life (Ministry of Health 2013). Findings from the 2008/9 NZ adult nutrition survey show that compared to younger adults, older adults consume lower added fat foods, more whole grains compared to simple carbohydrates and higher quantities of fruits and vegetables (University of Otago and Ministry of Health 2011). Overall, there is a clear knowledge gap in older New Zealanders nutrition and health status, as the current food and nutrition guidelines are based on the 2008/9 adult nutrition survey (University of Otago and Ministry of Health 2011). Furthermore, the survey aggregated data for >71 years, which may not efficiently represent the nutritional health status of the advanced age group.

2.3.3 Malnutrition and Potential Risk Factors.

Malnutrition is a chronic condition that occurs when one fails to maintain good nutrition intake, and this can be over or under nutrition. Of late, more nutrition research projects have focused on preventing over nutrition as this often leads to weight gain and the obesity pandemic. However, as people grow through the young old to the advanced age group, research indicates that malnutrition becomes more likely to occur in form of undernutrition and unintentional weight loss (Moreira et al. 2016). Undernutrition has three major syndromes; starvation or protein energy malnutrition (PEM), sarcopenia and cachexia (Agarwal et al. 2013; Yaxley et al. 2012). While all the three syndromes share similarities and are all characterised by loss of free fat mass (FFM) or muscle mass, there are some unique differences in the underlying cause (aetiology) of FFM loss in these syndromes.

In PEM, loss of FFM is a result of inadequate nutrition intake, particularly protein energy (Agarwal et al. 2013). For cachexia, while the specific cause of loss of FFM is complicated, cachexia is associated and distinguished by the presence of underlying

illness and an accompanying acute immune response (Hickson 2006; Agarwal et al. 2013). Since increased inflammation tends to occur with ageing, the pro-inflammatory cytokines which are signalling molecules that increases or promotes chronic inflammation mediates cachexia. Cachexia is often diagnosed in older adults with chronic conditions associated with increased inflammation such as cancers, rheumatoid arthritis, heart failure and chronic obstructive pulmonary disease (COPD) (Hickson 2006; Agarwal et al. 2013). Cachexia may be a component of sarcopenia (Fielding et al. 2011). Sarcopenia is defined as the age-related loss of muscle mass, strength and function, hence loss of FFM is largely attributed to ageing processes (an imbalance in muscle protein synthesis and muscle protein breakdown (Breen and Phillips 2011)). However, several factors including nutrient deficiencies, low physical activity or muscle disuse, inflammation impaired endocrine function, insulin resistance and chronic diseases are additional causes of loss of FFM (Fielding et al. 2011). This is one of the reasons why sarcopenia can also be prevalent in overweight or obese individuals – sarcopenic obesity (Stenholm et al. 2008). While high BMI values indicate lower risk for undernutrition, malnutrition may go unnoticed if assessment is sorely based on BMI (Winter et al. 2014). Body composition and muscle strength assessments are paramount to identify malnutrition, especially sarcopenic obesity (Stenholm et al. 2008).

PEM can be prevented and/or reversed through optimum nutrition intake, precisely adequate energy (protein) intake. However, sarcopenia and cachexia can be more difficult to reverse, as they can occur regardless of eating habits or energy balance (Agarwal et al. 2013). Dietary interventions are therefore insufficient, but just like any other ageing process, the incidence of sarcopenia and cachexia can be modified (delayed) by lifestyle factors particularly interventions combining physical activity and dietary behaviours (Agarwal et al. 2013; Thomas 2002; Yaxley et al. 2012). The best way to reduce or prevent the prevalence of all the three forms of malnutrition is to implement interventions when older adults are identified to be at risk of failing to maintain adequate nutrition intake.

Malnutrition is considered both a cause and consequence of the adverse events that occur at older age. While it is well established that nutrition plays a key role in attainment of healthy ageing, maintaining adequate nutrition intake at older age may be a challenge as there are multiple age-related risk factors for malnutrition (**Fig.6)** (Agarwal et al. 2013; Wham, Teh, et al. 2015; Ministry of Health 2013; Hickson 2006; Torpy, Lynm, and Glass 2006; Starr, McDonald, and Bales 2015; de Boer, Ter Horst,

and Lorist 2013; Schilp et al. 2011; Ahmed and Haboubi 2010; Roberts et al. 2019; Moreira et al. 2016). However, it is important to note that most of the nutrition risk factors are modifiable, either during or before reaching the older age. Furthermore, modification of these factors will not only promote optimal nutrition intake but will also promote healthy ageing and attenuate the intrinsic ageing process (**Fig.6**). A clear understanding of how each factor may contribute to low food intake is paramount.

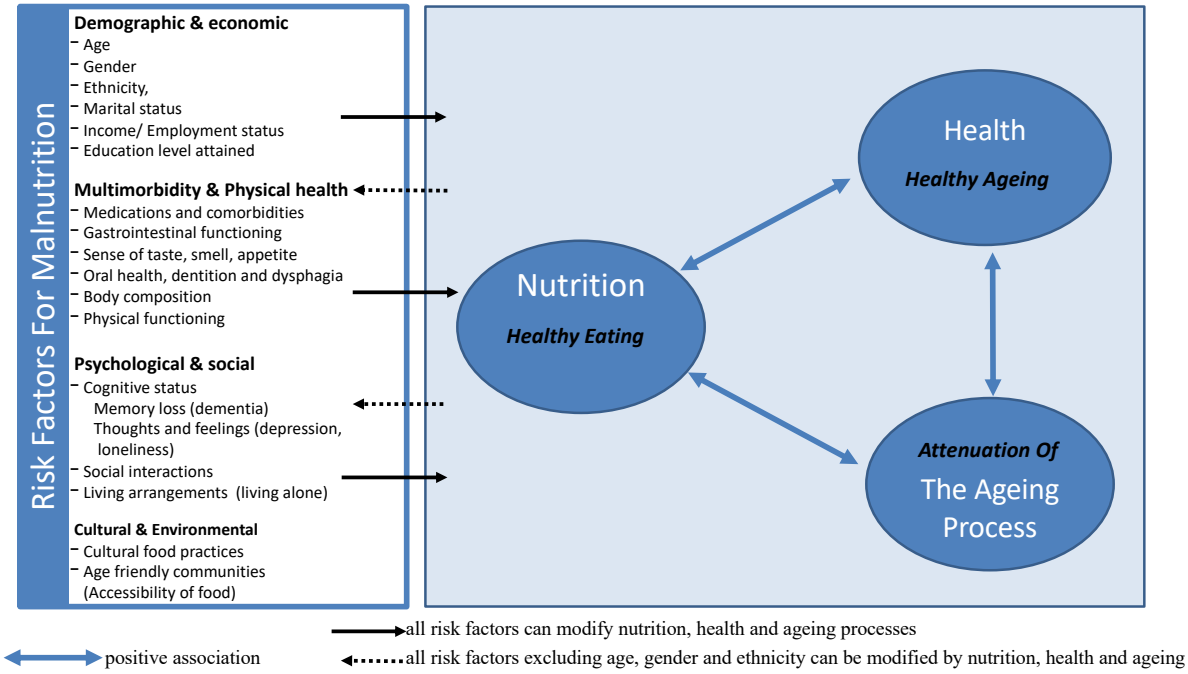


Fig.6. Malnutrition risk factors: Interactions between nutrition, health and the ageing process

Summarised from (Agarwal et al. 2013; Wham, Teh, et al. 2015; Ministry of Health 2013; Hickson 2006; Torpy, Lynm, and Glass 2006; Starr, McDonald, and Bales 2015; de Boer, Ter Horst, and Lorist 2013; Schilp et al. 2011; Ahmed and Haboubi 2010; Roberts et al. 2019; Moreira et al. 2016)

2.3.3.1 Demographic & economic factors

Challenges of maintaining good health increase with advancing age, particularly in advanced age (≥85years) (Baltes and Smith 2003; Christensen et al. 2009). The cumulative effects of decline in physical, mental and social health on food intake is the key reason why chronological age is a well-established risk factor for malnutrition (Moreira et al. 2016). These challenges tend to occur in both men and women, and conflicting results have been found on which gender is more associated with increased risk of malnutrition, with some studies reporting no association – an indication that both men and women have comparable risk of malnutrition at older

age. This could explain why in a systematic review based on longitudinal data, gender was not an independent risk factor for malnutrition (Moreira et al. 2016). In some studies, higher malnutrition risk was found among men not married or partnered, as they were found to eat a less varied diet composed of less fruits and vegetables and easy to prepare meals when compared to partnered older adults (Donkin et al. 1998). In qualitative studies, non-partnered men were also found to have low cooking skills and reported poor appetite (Hughes, Bennett, and Hetherington 2004; Wham and Bowden 2011), indicating an increased risk of malnutrition.

In multi-cultural communities, ethnicity is an important potential risk factor for malnutrition to assess, as access to different ethnic foods in communities may vary, which can influence food choice and nutrition intake. For example, the increase in migration in New Zealand has seen some people entering the country at older age – the age which may be harder to change dietary preference as older adults may prefer to eat familiar or traditional foods, as they consider them to be the 'proper foods' (McKie et al. 2000). (Un)availability of acceptable alternatives can therefore lead to low food intake. Ethnicity is also often associated with differences in education level attained and economic status. For example, in New Zealand, although the gaps are narrowing, statistics show that Māori and Pacific people are less advantaged in paid work and economic standard of living (Marriott and Sim 2015). Furthermore, Māori and Pacific people have lower percentages of people who attained tertiary education (European-19%, Māori-9% and Pacific-7%) and higher unemployment rates (European-6%, Māori-15% and Pacific-16%) which explains their lower weekly income (Marriott and Sim 2015). Worldwide, the employment status of several older adults' changes as some go into retirement, while some lose their jobs due to decline in functional status, which can lead to low income or financial instability. In the large Food for Later Life study (n=3 200, from eight European countries: Poland, Portugal, United Kingdom, Germany, Sweden, Denmark, Italy and Spain), income was found to be the most influential factor that affected the level of diet variety among older adults (Dean et al. 2009). In the absence of adequate money, older adults may fail to purchase their preferred foods, and those who feel food insecure tend to skip meals or cut down meal sizes (Klein 1996), which altogether increases the risk of malnutrition.

2.3.3.2 Multimorbidity & physical health

Multimorbidity and polypharmacy

Just like most modifiable age-related changes, the increasing number of prescribed medications and comorbidities seen with increasing age is considered both a cause and consequence of malnutrition. Focusing on how the factors increase the risk for malnutrition; intake of one or more drugs can stimulate negative nutrient-drug interactions which may lead to nutrient depletion (Akamine, Michel Filho, and Peres 2007). Comorbidities or presence of multiple chronic conditions can have cumulative detrimental effects on the individuals' metabolic processes including hormones and enzymes function, which alters food digestion, motility and absorption in the gastrointestinal tract (Akamine, Michel Filho, and Peres 2007; Roe 1985). Impaired gastrointestinal functioning characterised by slow gastric emptying and malabsorption can exacerbate anorexia, as can impaired dental status (missing teeth or not well-functioning dentures) (Wysokiński et al. 2015). Impaired dental status particularly loss of teeth is a common condition among older adults which does not only limit older adults food choices but reduces their food enjoyment which can contribute to low food intake (Petersen and Yamamoto 2005; Thomson and Ma 2014; Hickson 2006).

Dysphagia, a term used to describe presence of swallowing difficulties is another condition that can lead to low food intake (Ekberg et al. 2002). The risk of dysphagia increases with ageing partly due to the whole-body and/or region-dependent decline in muscle mass which may adversely affect the performance of the deglutitive muscles which facilitates swallowing food (Aslam and Vaezi 2013). However, dysphagia is not always assessed as part of geriatric assessments, and there are calls to screen for dysphagia risk using validated and easy to use screening tools such as the Eating Assessment Tool-10 (EAT-10) (Belafsky et al. 2008). Ageing influences senses of smell and taste (Boyce and Shone 2006), which can affect appetite or the desire to eat. The term anorexia of ageing has been used to describe the decline in appetite and food intake that occurs with ageing, and whose aetiology is multifactorial including a combination of physiological, pathological and social changes associated with ageing (Wysokiński et al. 2015; Hays and Roberts 2006).

Inflammation

Inflammation is the underlying cause of multiple chronic conditions and contributes to the high disability observed at older age. Such disabilities lead to loss of independence including ability to undertake daily routines or activities of daily living

(ADL) ranging from self-care, to management of finances, medications and ability to drive or use transport, grocery shop or prepare food. Increasing inflammation with age is not only associated with comorbidities but can also indicate presence of malnutrition. The term malnutrition-inflammation complex syndrome (MICS) has been used to describe the concurrent and common occurrence of protein-energy malnutrition (PEM) and inflammation as these conditions are related and share common symptoms including low appetite and excessive protein breakdown (Kalantar-Zadeh et al. 2003). Presence of inflammation can be assessed through quantifying serum levels of the acute phase reactants namely C-reactive protein (CRP) and prealbumin (PAB)(Kalantar-Zadeh et al. 2003). CRP is an acute phase reactant, which responds rapidly (increasing plasma levels) to severe tissue trauma. Prealbumin is a negative acute phase reactant and in addition to being an indicator of inflammation, PAB is also a short-term indicator of protein nutritional status. Consequently, some research suggest use of the biomarkers of inflammation such as pre-albumin may be helpful at identifying older adults at risk of malnutrition (Shenkin 2006).

Body composition and Physical functioning

The changes in body composition characterised by a decline in muscle mass can significantly increase the risk of malnutrition, due to the resultant poor physical functioning. Low muscle mass leads to low muscle strength and function, which hinders older adults' ability to undertake the physical ADL. One of the main characteristics of malnutrition is weight change specifically unintentional weight loss, as the change in body composition extends from loss of muscle mass to whole body weight. This is why most screening and assessment tools for malnutrition include an assessment of weight change and/or body mass index (BMI) (Green and Watson 2006). However, as it is now established that malnutrition can occur among overweight or obese older adults (sarcopenic obesity) (Stenholm et al. 2008), body composition assessments are more informative than BMI to ensure malnutrition (risk) is identified in both underweight and overweight individuals. In older adults, the bio-impedance analysis (BIA) and dual X-ray absorptiometry (DXA) are often used to assess body composition (Bales and Ritchie 2009). Additionally, a physical exam including assessments of loss of subcutaneous fat and fluid accumulation which can mask weight (muscle) loss are essential for determination of older adults nutritional status (White et al. 2012).

Assessment of muscle strength and/or muscle function can help predict decline in muscle mass (Iannuzzi-Sucich, Prestwood, and Kenny 2002; Stoever et al. 2017), while also reporting older adults' functional status particularly their level of physical functioning (Cesari et al. 2009). Muscle strength can be assessed using hand grip strength (Cruz-Jentoft et al. 2010), while muscle or physical function can be conducted through use of questionnaires or physical performance measures. Compared to physical performance assessments, questionnaires or self-reports are less effective as they are subjective, rely on participant's memory and may fail to predict onset of disability (Brach et al. 2002; Fried et al. 1996). Performance measures can predict both onset of disability and difficulties in ADL (Wennie Huang et al. 2010; Terhorst et al. 2017). Physical performance assessments such as gait speed, the five-times-sit-to-stand test (FTSTS), standing balance and the Short Physical Performance Battery (SPPB) provide robust estimates of physical functioning, which is why they are also good at predicting adverse health outcomes (Cesari et al. 2009). Overall, a thorough assessment of physical performance is essential as it provides a better understanding of one's ability to procure and prepare healthy meals and the overall risk of malnutrition.

2.3.3.3 Psychological & Social status

Decline in cognitive status increases the risk of malnutrition in several ways including a direct alteration or malfunctioning of the senses of taste and smell and early satiety feelings by the central nervous system (Morley 2001), or indirectly through psychological factors related to memory loss or dementia that influence appetite e.g. depression (Hays and Roberts 2006). In extreme cases of depression, older adults can regard avoiding eating as an 'acceptable' way to stop living (die) (Morley 1997). Low social engagement, loneliness and bereavement have detrimental effects that not only causes depression, but also make older adults lose the importance of eating food (Rosenbloom and Whittington 1993; de Boer, Ter Horst, and Lorist 2013). Overall the two main ways social status can reduce the risk of malnutrition are through promoting timely/daily availability of meals and improving appetite. The presence of social support can mean that when challenges related to undertaking ADL arises there will be less or no impact on healthy meals availability. On the other hand, companionship at meal times (rather than eating alone) can help improve appetite and food intake (de Castro 2002).

Changes in living arrangements, often associated with illness, loss of spouse or decline in income can force older adults to become institutionalised or move to RAC.

Unless extra care is taken to ensure individualised nutrition approaches are set in place (Dorner and Friedrich 2018), the move to institutions or RAC can increase risk of malnutrition as food intake may no longer be as per individual's preferences (food choices or meal times)(de Boer, Ter Horst, and Lorist 2013). For older adults who end up living alone, this can be a stressful experience and some will lose the motivation to prepare food for only one person (Moriguti et al. 2001). Compared to older adults who live in family surroundings, those who live alone are more likely to eat fewer meals per day, have significantly lower daily intake of protein, fruits and vegetables (Ramic et al. 2011), and are generally at higher risk of malnutrition (Ramic et al. 2011; de Boer, Ter Horst, and Lorist 2013; Wham et al. 2011)

2.3.3.4 Cultural & environmental factors

With advancing age, easy access to healthy, varied, and acceptable foods is paramount, given the increased risk of decline in (physical) health at older age. Absence of such access can place older adults at risk of malnutrition , especially after hospital discharge when they may be frailer (Bales, Locher, and Saltzman 2015). A fair distribution of nutrition and social programs for older adults to all communities in need is important, yet this may be a challenge for agencies offering such support (Moats and Hoglund 2012). As some older adults may become unemployed (e.g. retirement) or have limited income, ensuring communities have affordable restaurants and grocery stores nearby is therefore paramount (Keller, Dwyer, Senson, et al. 2007). With increasing risk of appetite loss, availability of meals that meet personal preferences becomes even more important. Policies that promote age friendly stores or restaurants, and transportation to and from such areas may help improve food access. Eating out is known to increase food intake hence promotion of environments or services that makes it easier for older adults to dine out can help increase food intake (Keller, Dwyer, Edwards, et al. 2007; Thomas and Emond 2017).

Furthermore, foods that are culturally acceptable can widen food choices which helps reduce the risk of low food intake. In New Zealand, a previous study found that the main factors that were significantly associated with lower risk of malnutrition for Māori people included a high rating of Māori culture to the importance of well-being and being able to access Māori food (kai) (Wham, Maxted, et al. 2015). As Māori people are more likely to be financially challenged (Marriott and Sim 2015), if access is not close by, the additional transport costs may further promote food insecurity and malnutrition risk.

2.3.4 Screening for malnutrition risk.

Malnutrition is a reversible condition that is preceded by a state of malnutrition risk. Individuals identified to be at risk of malnutrition have the best chance to benefit from intervention and regain a normal nutrition status. Screening is a simple and quick process, which can help identify the need for nutrition assessment (Bales, Locher, and Saltzman 2015).

ASPEN defines nutrition assessment as a "comprehensive approach to identifying the nutrition-related problems that uses a combination of the following: medical, nutrition, medication and client histories; nutrition-focused physical examination; anthropometric measurements; and medical diagnostic tests and procedures" (American Society for Parenteral Enteral Nutrition 2005). Nutritional assessments should be specific to the older person (Thiyagarajan et al. 2017). In summary nutrition assessment involves dietary assessments and a thorough assessment of the risk factors of malnutrition discussed above (Fig 6, section 2.3.3). Dietary assessments aim to understand an individual's dietary intake, and this can be assessed using self-reports such as food records, diet history, 24-hour food recall, and food frequency questionnaires (FFQ). However, these measures are sometimes prone to recall errors due to cognitive impairment. Three-day calorie count is a more accurate method, but this method is only applicable in health care settings (Bales, Locher, and Saltzman 2015). Using a technology-based approach for example, using computers, mobile phones or scans can be more helpful in improving data accuracy for dietary intake (Stumbo 2013; Illner et al. 2012), although this requires older adults to be interested in using such technology. Understanding dietary intake will help identify the key nutrients to target when intervening. However, to better understand the appropriate interventions to implement, a further clinical assessment of multiple risk factors of malnutrition (Fig.6) is essential. Concerning nutrition assessments, caution needs to be taken with methods to use in older adults, especially those with physical disabilities and those with cognitive impairment, to prevent falls and recall bias respectively. However, as it is time consuming and some assessments require proper training (e.g. body composition), nutrition assessment is usually considered crucial only after a quick screening procedure identifies an individual to be malnourished or at risk.

Screening is therefore the first step towards curbing malnutrition (Mueller, Compher, and Ellen 2011). Ideally, older adults should be screened for malnutrition at enrolment to community-based programs, during annual primary care visits, upon first home

care visit and at admission to hospital or RAC institutions (Bales, Locher, and Saltzman 2015). Several screening methods have been established and include the use of validated screening tools and taking anthropometric measurements. It is recommended methods used for malnutrition risk screening consider participants age group and their residential setting (Bales, Locher, and Saltzman 2015). In a comprehensive literature review of nutritional screening tools (Green and Watson 2006), twenty-one tools used in practice to detect the risk of malnutrition in older adults were identified. However, not all of these tools have been evaluated for validity, reliability, sensitivity, specificity or acceptability (Green and Watson 2006). Of the 21 tools, only four were outlined under 'acceptability considered', in addition to having high validity, reliability, sensitivity and specificity rates (Green and Watson 2006). The four tools are the Mini Nutritional Assessment (MNA), the DETERMINE checklist, the Seniors in the Community: Risk Evaluation for Eating and Nutrition (SCREEN 11), and the Nutritional Risk Assessment Scale. While the MNA, and Nutritional Risk Assessment Scale can be used across residential settings, SCREEN 11 and the DETERMINE checklist are more relevant for the community or primary care settings (Green and Watson 2006; Bales, Locher, and Saltzman 2015; Thiyagarajan et al. 2017).

Worldwide, MNA is the most frequently used tool for nutrition risk screening in older adults (Kaiser et al. 2010). With a high reliability (96%) and sensitivity (98%) the long form of the MNA is composed of 18 items. This form covers four areas of human health: anthropometric, general, dietary and subjective assessments. The MNA short form (MNA®-SF) is a shorter version of the MNA and it is composed of six items that cover assessments of food intake, weight status, mobility, psychological stress and acute disease, and neuropsychological state (Kaiser et al. 2009). Assessment of the individuals' neuropsychological and psychological stress parameters is not catered for by other nutrition screening tools, yet both parameters are crucial given the complexity of malnutrition at older age. The MNA®SF has been validated and shown to retain the accuracy of the 18 questionnaire items. In addition to having a sensitivity of 89% and specificity of 82%, the MNA®-SF is commendable because it is quick and easy to use for both older people and researchers or health workers, across settings (Bales and Ritchie 2009). The MNA®SF is one of the few screening tools validated across all settings, which makes it the best option for studies that aim to assess malnutrition risk across settings.

Given the crucial part screening for malnutrition plays for preventing malnutrition and related adverse events, malnutrition screening is mandatory in several developed countries such as the USA, UK, Netherlands and some parts of Denmark, on patient admission to and routinely in hospitals and other institutions; and a recommendation for screening of all new patients registering with a GP has been made (Elia, Zellipour, and Stratton 2005). However, mandatory screening is not yet standard practice across NZ health care settings. This makes it difficult to understand the impact of malnutrition on individuals' health and the nation's (NZ) economic status overall. Evidence from overseas studies indicates the cost effectiveness of malnutrition screening and timely intervention (Elia 2015; Hugo et al. 2018). Previous findings show that significant nutrition risk factors differ per study population, for example the country from which the study is performed and the residential or health care setting.

2.3.5 Malnutrition Risk across NZ settings: Community, Hospital and Residential Care.

While prevalence of malnutrition tends to increase as people get older, findings suggest that prevalence rates may also differ by the living setting (Kaiser et al. 2011). In NZ, the three well established settings for older adults are community (own home or retirement homes), hospital and residential aged care (RAC). In the community, when older adults live with family members and/or are still independent, they can prepare meals and enjoy meal times compared to those who live alone (Locher et al. 2005; Hays and Roberts 2006). When people move to the RAC setting, the environment may affect eating habits leading to low nutrition intake, as changes in living or eating arrangements may increase the risk of malnutrition (Wham et al. 2011; Vesnaver et al. 2015). The prevalence of malnutrition therefore varies marginally by setting. Based on the MNA®, the mean prevalence of malnutrition per setting are 2%-community, 23%-hospitalized and 21%-institutionalized (Guigoz 2006). In addition, higher prevalence values have been found for older adults at risk of malnutrition: 24%-community, 45%-hospitalized and 51%-institutionalized (Guigoz 2006). The mean prevalence among institutionalised patients was obtained from a wide prevalence range (5%-70%) as the studies included participants of different levels of care i.e. retirement homes (5%) vs. nursing homes (20%) vs. long term care (70%) (Guigoz 2006). A combination of the latter two can be considered more or less equivalent to New Zealand RAC setting, as retirement homes are considered under the community setting.

Screening studies in New Zealand have suggested that overall about a third of community living older adults show high nutritional risk (Watson, Zhang, and Wilkinson 2010b; McElnay et al. 2012; Wham et al. 2011; Wham, Carr, and Heller 2011). Although not much research has been undertaken in New Zealand RAC settings, research suggests that nutrition risk is higher in RAC compared to community setting. For example, in a study conducted in 22 UK care homes, only 14% of the subjects had a normal nutritional status (Gordon et al. 2013), thus routine screening in residential care may be essential. Older adults at high nutrition risk or malnourished often end up in hospitals and they tend to have longer stays in hospitals (Agarwal et al. 2013), as malnutrition hinders the functioning of the human immune system. In fact, while malnutrition causes hospitalisation and longer hospital stay; hospitalisation can also affect food intake, for instance through loss of appetite or effects of depression that often comes with being hospitalised (Kagansky et al. 2005; Allison 2000; Hiesmayr et al. 2009; Correia and Waitzberg 2003; Agarwal et al. 2013). Malnutrition is therefore highly prevalent (up to 60%) in adults admitted to hospitals (Barker, Gout, and Crowe 2011; Agarwal et al. 2013; Kaiser et al. 2010). Screening at hospital admission may be a prudent way to prevent both the causes and consequences of malnutrition, during and after hospitalisation, yet again this is not mandatory in NZ.

Table 1 provides a review of quantitative and qualitative scientific literature on prevalence, risk factors and/or older adults' perspectives of malnutrition (risk) across New Zealand settings, published as of April 2017. From this table, it is clear there is limited quantitative data published on prevalence and risk factors of malnutrition, especially among institutionalised (hospital or RAC) older adults. No data have been published at admission to the hospital or RAC. Furthermore, several risk factors (Fig. 6) including dysphagia risk, physical performance and frailty have not been assessed in any of the NZ studies. The published data are mainly from the community-dwelling older adults, hence there is need for more quantitative studies in hospital and RAC settings. Availability of qualitative studies is even more scarce, as only one study which included only men was found (Table 1).

**To date (August 2019) only 2 studies which are part of this thesis have been conducted at admission to New Zealand hospital and RAC settings and one qualitative study across gender and ethnicity (part of this thesis) has also been conducted*.

Table 1: Quantitative and qualitative studies of prevalence, risk factors or older adults' perspectives on malnutrition (risk) across New Zealand settings: Published studies as of April 2017

Key: Number of quantitative studies published from the community-**7**, hospital-**2, none at admission** and RAC-**none**; Qualitative studies from all settings n=**1 from men only**.

Region of data collection (Author & Year of publication)	**Study Setting, sample size, mean age (or age included)**	**Nutrition risk screening tool used**	**Prevalence of Nutrition risk**	**Risk factors assessed**	**Significant Risk factors identified**
Christchurch **(Watson, Zhang, and Wilkinson 2010a)**	Community n=152, 79.5 years	SCREEN 11	Nutrition risk: 54% (At risk 23%, at high risk 31%)	Only SCREEN 11 tool items	Significance not reported but the most frequently observed factors in participants at nutrition risk were: -unintentional weight change -eating alone -perception of own weight -and low milk product intake.
Auckland **(Wham, Carr, and Heller 2011)**	Community n=51, 82.4 years	SCREEN 11	Nutrition risk: 31%	As per SCREEN 11 tool	Significance not reported but the most frequently observed factors in participants at nutrition risk were: -Eating alone -Milk Product Intake Meal Preparation -Meat & Alternatives Intake -Weight Change -Frequency of Eating
Northland and Bay of Plenty	Community, n=108, 75-85years	SCREEN 11	Nutrition risk: 52%	-Age, -Gender -Ethnicity -Marital status	-widowed -living alone

(Wham et al. 2011)				-Education -Smoking status -Alcohol consumption -Living arrangement -physical activity -BMI, Waist circumference, Waist hip ratio -Grip strength -Fat and muscle mass % Albumin, Hb, ferritin and serum zinc levels	-low levels of haemoglobin and serum zinc. -lower muscle mass and strength -high body fat, -consumed alcohol less frequently -less physical activity.
Hawkes Bay **(McElnay et al. 2012)**	Community, n=473, 74years	SCREEN 11	Nutrition risk: 56.5% (At risk 23.7%, at high risk 32.8%)	-Age -Gender -Ethnicity -Living situation	-Ethnicity -Living situation From SCREEN 11, the most frequently observed nutrition risk factors were: -eating alone frequently -a low intake of meat/ alternatives -finding meal preparation not enjoyable -perception of own weight being too high or low
Multi centres (n=60) from 3 District Health Board: Canterbury (n=24), Bay of Plenty (n=12) and Capital/ Coast (n=24) **(Wham et al. 2014)**	Community n=3480, >65years	Australian Nutrition Screening Initiative (ANSI)	Nutrition risk: 62%	-Age -Gender -Ethnicity -Marital status -Education -Living situation -*WHOQOL -Services use: Dietitian, meals on wheels -Number of medications -Number of comorbidities	-Female gender -Māori and other ethnicities versus European -Marital status: not married -Taking multiple medications -having more depressive symptoms, cardiovascular disease and diabetes.

Bay of plenty **(Wham, Redwood, and Kerse 2014)**	Community, n=45, 85-86years	SCREEN 11	Nutrition risk: 60% (At risk 27%, at high risk 33%)	As per SCREEN 11 and: -Gender -Marital status -Education -Living situation -Self-reported health -Ability to do daily activities -Depression -Number of medications	Significance not reported but the most frequently observed nutrition risk factors were: -eating alone -a low intake of meat/ alternatives -low intake of milk -unintentional weight change
Bay of plenty and lakes region of the north Island **(Wham, Teh, et al. 2015)**	Community, n=655, 83years	SCREEN 11	Nutrition risk: 43.5 (49% of Māori and 38% of non-Māori)	-Age, -Gender, -Ethnicity -Marital status -Education -Smoking status -Alcohol consumption -Living situation -physical, mental and depression status -difficulty getting to shops -pension only income	Risk factors assessed per ethnicity: Māori - younger age -lower education -living alone -depressive symptoms Non- Māori -female gender -living alone -lower physical health related quality of life -depressive symptoms
Christchurch **(Hanger et al. 1999)**	Hospital n=55 - patients admitted for hip fracture only	Nutritional indices: Triceps skinfold thickness, Mid-upper arm circumference, serum albumin and pre- albumin	42% had at least 2 indicators of protein energy malnutrition		

Middlemore, Auckland **(Van Lill 2002)**	Hospital n = 71 -admitted for at least 1 week	MNA-SF	Nutrition risk: 68% (32% well-nourished 44% at risk of malnutrition 24% malnourished)	-Age -Gender -BMI	Significance not reported but malnutrition was high: -with increasing age -In females -with decreasing BMI
	Residential aged care (RAC)				None published.
Auckland **(Wham and Bowden 2011)**	Qualitative study Community n=12	SCREEN 11	Nutrition risk: 50% (A qualitative study)	Only SCREEN 11 tool items	Significance not relevant for study design The most frequently observed nutrition risk factors were: -eating alone frequently -a low intake of meat/ alternatives -finding meal preparation not enjoyable -perception of own weight being too high or low

*MNA-SF - Mini Nutritional Assessment short-form, SCREEN 11- Seniors in the Community: Risk Evaluation for Eating and Nutrition, Version II,

*WHOQOL- The World Health Organization Quality of Life

2.4 Optimising Nutrition Intake and Preventing Malnutrition

As discussed, age-related changes contribute to high prevalence of malnutrition (risk) in older adults. Moreover, the significant impact of malnutrition on stimulation of age-related changes has been highlighted. A vicious cycle exists between malnutrition and age-related changes, which prevents attainment of healthy ageing. Establishing interventions that optimise nutrition intake (healthy eating) will help prevent and/or eliminate malnutrition and promote healthy ageing.

2.4.1 Needs Assessment and Development of Intervention Strategies

Because of the heterogeneity of the older people population, several factors need to be considered towards establishing an efficient nutrition intervention. A needs assessment can be undertaken at an individual or community level to understand the main nutrition risk factors (Fig 6, page 28.) that affect a specific population and tailor nutrition interventions accordingly. This will not only help in formulating the appropriate intervention for that specific population, but will also provide a baseline to understand how the population may (not) be able to comply with certain interventions (Sheats, Winter, and King 2015). It is important to ensure that the intervention designed is quite easy for the target population to comply for example; it should not be burdensome, unaffordable, inaccessible or unsustainable (Freudenberg et al. 1995). Furthermore, it is essential to design an intervention that considers special populations including ethnicity, socio-economic and health status. Finally, studying both local and global trends is paramount (Bales, Locher, and Saltzman 2015).

The use of the framework for mapping interventions by Bartholomew et. al (Bartholomew Eldredge et al. 2016) is recommended for designing and implementing nutrition interventions across settings (Sheats, Winter, and King 2015). The Bartholomew framework emphasises the importance of conducting a needs assessment as a pre-requisite to intervention designing. The framework second step recommends creating and preparing matrices of change objectives (personal, social, cultural and environmental factors) (Bartholomew Eldredge et al. 2016) and this stage requires understanding the target population perspectives and experiences that shape their eating behaviours (Bisogni et al. 2012). This calls for well-designed qualitative research which includes a heterogeneous group of older adults, to ensure different or multiple viewpoints are captured. The immense contributions of qualitative research in understanding people's perspectives of healthy eating has been previously reported (Bisogni et al. 2012); hence the use of qualitative methodology in

nutritional science research is increasing. It is recommended that findings from qualitative research be part of the decision-making processes that direct the development of policy and practice (Swift and Tischler 2010). In addition to understanding older adults' perspectives (qualitative research), conducting quantitative research is paramount to enable thorough assessments of correlations between malnutrition and potential (objective) risk factors. Such objective assessment will help inform the key risk factors necessary to target when designing interventions for a specific population. Mixed methodology research (quantitative and qualitative), is therefore best suited to objectively and subjectively assess the needs for a population and potential ways to optimise nutrition intake with advancing age.

2.4.2 Types of Nutrition Interventions.

Nutrition interventions can be broadly categorised into two types – clinical and social. Through understanding population specific challenges, researchers developing intervention designs can get an idea of the type of intervention that is more likely to be efficient to the target group. While interrelated, these are aspects of clinical and social interventions that make either more appropriate for a specific target group or individual. In general, clinical interventions include screening and monitoring dietary approaches through food and/or the provision of nutritional supplements where appropriate, while social interventions usually take a whole person approach to encourage adequate food intake. Social interventions often involve addressing multi-factors associated with malnutrition including lack of access to food, difficulties cooking, isolation, ill health, poverty or depression.

There is evidence from systematic reviews, meta-analyses and comprehensive narratives outlining several examples of interventions shown to prevent or treat malnutrition (Table 2). As there is no one gold standard to assess malnutrition, studies that test the efficacy of interventions on ameliorating malnutrition (risk) report different outcome measures (Laur et al. 2017), but as indicated in Table 2 several studies often include primarily an assessment of whether dietary intake (energy, protein and/or micronutrients) and clinical outcomes such as weight change, muscle strength, physical function, complications during or post-hospitalisation, morbidity or mortality risk, were improved post-intervention.

While both clinical and social interventions may be implemented across geriatric settings, certain interventions are more appropriate for either community, hospital, or RAC setting. For most interventions, there is an overlap between social and clinical

aspects. Some examples of nutrition interventions designed to prevent or reduce malnutrition include: manipulation of diet quality and/or quantity (food/meal modification, enhancement or enrichment), use of nutrition or dietary supplements, nutrition education or counselling, improving access to food or healthy meals (including promotion of age friendly communities, use of home delivery meal services, and provision of cooking classes) and finally improving social status or averting social isolation (Table 2). **T**able 2 shows that most types of these intervention studies have been studied in multiple studies hence systematic reviews were identified. However, for averting social status and improving access, results are less conclusive as they are dependent on narrative reviews or a few studies.

Table 2: Effectiveness of nutrition interventions at preventing or treating malnutrition and associated health outcomes: Evidence from systematic reviews, meta-analysis and comprehensive/narrative reviews

Setting **Author & date**	**Type of review**	**Types of nutrition interventions included**	- **Results (**summarised effect of intervention *vs.* control/standard**)** *Authors' Conclusions*
Community (Sauer et al. 2018)	Systematic, n=20 studies included in subjects who either had or were at risk of malnutrition.	- ONS - counselling, dietary advice - home visits	- ↑ energy intake - ↑ protein intake - ↑ anthropometrics (body weight) - ↑ nutritional status - ↑ functional status - ↑ muscle strength (handgrip strength). - Impact was inconclusive for body composition, quality of life, readmissions, complications or morbidity, and mortality, mainly due to a limited number of studies. *Nutrition interventions were found to improve health and nutrition outcomes among community-dwelling adults.*
Hospitals or rehabilitation centres. (Mills et al. 2018).	Systematic, n=10 studies included (546 patients, mean age 60–83 years)	Food or Meals enrichment (via fortification) - Fortified foods and snacks	- ↑ energy intake - ↑ Protein intake *Compared with usual nutritional care, energy- and protein- based fortification and supplementation could be employed as an effective, well-tolerated and cost-effective intervention to improve dietary intake amongst older inpatients. This strategy may be particularly useful for patients with cognitive impairment who struggle with ONS, and clinical trials are required to compare these approaches and establish their impact on functional outcomes.*
RAC (Agarwal et al. 2016)	Narrative	- Meal enrichment - Therapeutic diets - Texture modified diets - ONS	- Overall the narrative findings indicate that all the types of intervention outlined in this review can help improve nutrition intake and clinic outcomes, although further research is required to improve the evidence base.

		- Mealtime ambience - Enteral and parenteral nutrition	*A number of food and nutrition strategies have demonstrated positive nutritional and clinical outcomes in the RAC setting. These strategies extend beyond simply enhancing the nutritional value of foods and hence necessitate the involvement of a range of committed stakeholders. Implementing a nutritional protocol in RAC facilities that comprises routine nutrition screening, assessment, appropriate nutrition intervention, including attention to food service systems, and monitoring by a multidisciplinary team can help prevent decline in residents' nutritional status. Food and nutritional issues should be identified early and managed on admission and regularly in the RAC setting.*
Hospitals or rehabilitation centres. (Collins and Porter 2015)	Systematic Review with Meta-analysis, n=10 trials included	Oral nutrition interventions - ONS - foodservice interventions to create energy dense meals - enhanced clinical care processes	- ONS and energy dense meals improve energy and protein intake significantly - ONS also showed some improvements in anthropometry and hospital length of stay. - Opposing results in studies investigating enhanced clinical care processes. *The provision of oral nutrition supplements and energy dense meals improved energy and protein intake and therefore may comprise effective strategies for addressing malnutrition in rehabilitation. The effect of these strategies on other nutritional and functional outcomes should be explored further.*
All settings (Bjelakovic et al. 2012).	Cochrane Systematic Review & meta-analysis, n= 78 trials with 296,707 randomised participants	Micronutrient – antioxidant supplements (beta-carotene, vitamin A, vitamin C, vitamin E, and selenium) Investigation of the relationship between antioxidant supplements intake and mortality only.	- ↑ mortality with intake of beta-carotene & selenium - Vitamins A, C and E did not significantly affect mortality, but the dose of vitamin A was significantly associated with increased mortality *No evidence to support antioxidant supplements for primary or secondary prevention. Beta-carotene and vitamin E seem to increase mortality, and so may higher doses of vitamin A. Antioxidant supplements need to be considered as medicinal*

		No other health outcome assessed.	*products and should undergo sufficient evaluation before marketing.*
All settings (Buhr and Bales 2009) -Part 1 and (Buhr and Bales 2010) - Part 11	2x reviews of evidence from meta-analyses and randomized controlled trials	Micronutrients supplements and Omega-3 fatty acids: - Vitamin D - Calcium - antioxidants vitamins - B-vitamins (B9/folate, B6 and b12) - Omega-3 fatty acids from fish intake or fish oils supplementation	- Vitamin D and calcium improves bone heath and reduces the risk of falls - Evidence does not support a recommendation for vitamins A, C, E, or antioxidant combinations in the prevention of CVD or cancer - Little or no evidence of B vitamins supplementation to CVD or cognitive function. - Modest consumption of fish or fish oil supplements (<1g/day) reduces the risk of sudden cardiac death. - High doses (1–6g/day) of fish oil supplements have been shown to reduce serum triglyceride levels
All settings (Nieuwenhuizen et al. 2010).	Narrative review	- Meal fortification, - variety, - between meal snacks - ONS - dietary advice	- Meal fortification, variety, between meal snacks and ONS are all helpful at improving nutrition intake. Limited evidence for dietary advice alone. *The product factors identified here suggest that especially small volume, energy and nutrient dense ONS can be effective to improve nutritional intake.*
Community, hospitals and RAC (Milne et al. 2009)	Cochrane Systematic Review & meta-analysis, n= 62 trials with 10,187 randomised participants	ONS, protein and energy supplementation	- ↑ energy intake - ↑ Protein intake - ↑ body weight - ↓ mortality (among malnourished older adults) - ↓ Complication rates *Supplementation produces a small but consistent weight gain in older people. Mortality may be reduced in older people who are undernourished. There may also be a beneficial effect on complications which needs to be confirmed. However, this updated review found no evidence of improvement in functional benefit or*

			reduction in length of hospital stay with supplements. Additional data from large-scale multi-centre trials are still required.
All settings (Baldwin, Parsons, and Logan 2001)	Cochrane Systematic Review & meta-analysis including 37 trials with 2,714 randomised participants.	Dietary advise	- ↑ body weight when dietary advise is combined with nutritional supplements - Dietary advise alone less effective - No significant difference in mortality. *This review highlights the lack of evidence for the provision of dietary advice in managing illness-related malnutrition. Dietary advice plus nutritional supplements may be more effective than dietary advice alone or no advice in enhancing short-term weight gain, but whether this is sustainable, or whether survival and morbidity are improved remains uncertain. A large adequately powered randomised controlled trial is needed comparing the efficacy of different therapies to increase dietary intake in people with illness-related malnutrition and examining the impact of this on clinical function and survival.*
All settings (Policy) (Brambila-Macias et al. 2011)	Synthesis of systematic reviews, academic papers, and institutional reports.	Nutrition awareness; Policy interventions to promote healthy eating - Public information campaigns - Advertising controls - Nutrition education - Nutritional labelling	- Reducing or banning unhealthy food advertisements generally have a weak positive effect on improving diets - Public information campaigns raise awareness of unhealthy eating but fails to translate the message into action. - Nutritional labelling allows for informed choice but does not necessarily result in consumption of healthier foods. *Overall, measures to support informed choice have a mixed and limited record of success. On the other hand, measures to target the market environment are more intrusive but may be more effective*

↑ indicates an increase or improvement, ↓ indicates a decrease or prevention. ONS: oral nutrition supplement

2.4.3.1 Manipulation of diet quality and/or quantity

In all settings, one of the major challenges observed in older adults is inability to consume adequate nutrients due to ill health specifically gastrointestinal problems, poor dentition, loss of appetite etc. (Wells and Dumbrell 2006). Concerning this, some effective nutrition interventions include manipulating diet quality or quantity e.g. modifying textures of foods or introducing energy dense meals respectively (Nieuwenhuizen et al. 2010). Interventions that focus on meal enhancement e.g. use of additional flavours or appetizing smells are also beneficial as this can counteract the decline in sensory function (taste, sight and smell) and the resultant loss of appetite that often occurs with ageing (Nieuwenhuizen et al. 2010). As older adults experiencing loss of appetite often fail to cope with large meal sizes, one way of increasing diet quantity without significantly changing meal sizes is meal enrichment or food fortification. There are several foods that can be fortified including bread, soups, protein and dairy-enriched main meals and snacks or desserts such as biscuits, yogurt and ice cream (Mills et al. 2018). Food fortification is a useful strategy for older adults who struggle to cope with oral nutrition supplements, and has been shown to increase both energy and protein intake (Mills et al. 2018).

2.4.3.2 Nutrition or dietary supplements

When dietary intake alone fails to maintain adequate nutrition intake, the use of nutrition supplements is recommended. Nutrition supplementation is the most well studied nutrition intervention as it aims to directly correct energy, protein and/or micronutrient (vitamins and minerals) intake using specially formulated energy or nutrient dense foods or pills.

Oral Nutrition Supplements (ONS)

ONS are foods – mostly liquids containing relatively high amount nutrients per small volume that are used to improve nutritional intake in older adults and patients with nutritional health problems. While the primary aim of ONS is to correct energy and protein intake, typical ONS also provides the commonly deficient micronutrients in older adults. Some ONS variations also provide high fibre. Complete ONS are a version of ONS that contain both macro- and micronutrients in quantities sufficient to meet daily nutritional needs (when consumed in adequate volume) (Uí Dhuibhir, Collura, and Walsh 2019).

There is compelling evidence to support that ONS significantly improve energy and protein intake (Milne et al. 2009). However, research also shows that effectiveness of ONS use heavily relies on adherence or compliance, i.e. if individuals consume the

ONS as prescribed (Agarwal et al. 2016; Hubbard et al. 2012). A systematic review of compliance to oral nutritional supplements found positive correlations between high compliance and a couple of properties of the ONS namely high energy density and availability of a variety of flavours (Hubbard et al. 2012). To meet taste preferences, variations in flavours have been introduced in recent years, and some commercial ONS are now available in several flavours (mocha, strawberry and vanilla). Highly energy density is an important property of ONS as this enables the ONS to be supplied in low volumes (50-125ml) (Agarwal et al. 2016) which older adults with low appetite can handle. Identifying older adults preference may help improve adherence, for example, among hospitalised older New Zealanders, a preference for the Fortisip and Ensure ONS was documented (Hanger et al. 1999). The integrated care for older people (ICOPE) also states that ONS together with dietary advice should be recommended for older people affected by undernutrition (World Health Organization 2017a).

In addition to improving energy and protein intake, ONS have been shown to improve body weight, reduce complications during or post-hospital discharge and prevent mortality (among malnourished older adults); although mixed results are reported for physical function (Agarwal et al. 2016; Milne et al. 2009). Increased physical activity may be required to attain improvements in functional status during ONS intake (Agarwal et al. 2016; Milne et al. 2009). For example, in one randomised trial, use of a homemade ONS in a multifaceted intervention involving group (physical) exercises and oral care, the intervention group maintained its physical function while a significant decrease was observed in the control group (Beck, Damkjær, and Sørbye 2010).

Micronutrients Supplementation: Vitamins and Minerals

Micronutrients supplements are usually provided in pill form and may contain one or more vitamins and/or minerals. Although intake of these supplements is recommended only when intake through diet is not optimal (Buhr and Bales 2009), usage of nutrition supplements among older adults in developed countries such as the USA and Australia has been increasing (Goh et al. 2009; Qato et al. 2016; Gahche et al. 2017). Research investigating both usefulness and potential risk for (over) use of micronutrients supplements is increasing, and findings indicate that caution needs to be exercised when (self) prescribing nutrition supplements. Overall, to date there is more evidence in support of ONS combining energy, protein and selected micronutrients, compared to use of single micronutrients. As far as single

micronutrients supplementation is concerned, there are only a few where evidence supports their use especially Vitamin D and calcium for bone health (Bales, Locher, and Saltzman 2015; Buhr and Bales 2009). Unlike other nutrients, dietary sources are often insufficient for vitamin D requirements in older adults, therefore, frequent supplementation of vitamin D is recommended (Buhr and Bales 2009).

As the increased usage of nutrition supplements among older adults is coupled with concurrent use of interacting medications (Goh et al. 2009; Qato et al. 2016; Gahche et al. 2017), this can lead to multiple adverse health outcomes. There is less evidence for beneficial effects of routine intake of antioxidant supplement e.g. beta-carotene, vitamin A, vitamin C, vitamin E, and selenium. In fact, excess intake of vitamin A, beta-carotene and selenium has been associated with increased mortality (Bjelakovic et al. 2012; Buhr and Bales 2009). Furthermore, there is limited evidence to support use of B vitamins (B9/folate, B6 and B12) for cardiovascular health (Bales, Locher, and Saltzman 2015; Bjelakovic et al. 2012; Buhr and Bales 2009). However, both the antioxidant vitamins/minerals and B vitamins are part of the supplements which (single nutrient) usage is increasing. In the most recently published systematic review and meta-analysis which included studies that tested efficacy of various types of nutrition supplements, the authors concluded; 'nutritional supplementation can improve a number of physical performance outcomes in older people, particularly when they include multi-nutrients (Veronese et al. 2019). Micronutrients are essential for promoting good health, but they are needed in smaller quantities. It is therefore important to ensure recommendation to supplement any micronutrient is only done after deficiency is noted. The risk for excess intake is high if an individual is taking fortified food, ONS or other multi-nutrient supplements containing some of the micronutrients, or when dietary intake is optimal.

Finally, apart from energy, protein and micronutrients supplementation, consumption of fish oils supplement or modest intake of fish is effective at preventing cardiovascular diseases and treatment of hypertriglyceridemia (Buhr and Bales 2010).

2.4.3.3 Nutrition education or counselling

Another intervention type applicable to all settings is raising nutrition awareness (Polonen et al. 2017; Moats and Hoglund 2012; Stroebele-Benschop, Depa, and de Castro 2016). This includes having nutrition education or counselling sessions, providing education materials (pamphlets, newsletters) and use of media like television adverts. In a review of policy interventions to promote healthy eating, reducing or banning unhealthy food advertisements was found to have a weak

positive effect on improving diets. While public information campaigns manage to raise awareness of unhealthy eating, they however fail to decipher the message into action. Finally, the review noted that nutritional labelling allows for informed choice but does not necessarily result in consumption of healthier foods (Brambila-Macias et al. 2011).

Although some research shows that nutritional counselling/education alone can improve nutritional status, a systematic review and meta-analysis of data concluded that dietary advice alone is less effective, but more positive results including weight gain are obtained when dietary advice is combined with nutritional supplements (Baldwin, Parsons, and Logan 2001). This more or less agrees with Brambila-Macias, Shankar et al. findings that mere awareness may not lead to changes in eating behaviours (Brambila-Macias et al. 2011).

2.4.3.4 Improving access to food or healthy meals

In community settings, some of the interventions that may help prevent malnutrition include improving access or availability of food. This can be done at individual level e.g. provision of subsidised support that help in daily activities (grocery shopping, cooking etc.), which are essential for making balanced diets available to older adults daily (Campbell et al. 2015). Home delivery meal services are one of the most studied ways of promoting access to healthy meals. The services such as meals on wheels are helpful for homebound older adults who are unable to partake ADL nor go out to dine in restaurants. Such meals can also be helpful as back-up plans for less frail older adults to use during 'hard' days. Although there are limited data from intervention studies which limits the ability to conclude the effectiveness of home delivery meals (Campbell et al. 2015), use of home delivery meals is generally associated with improved nutrient intakes, food security, quality of life, and promotes socialisation opportunities (Campbell et al. 2015; Zhu and An 2013). For more independent older adults, cooking classes are one way of improving access to healthy meals among those who lack cooking skills. In a Canadian study, majority of the older men who participated in a cooking and nutrition education program gained cooking confidence, developed healthy cooking skills, improved cooking variety and increased their cooking activities at home (Keller et al. 2004).

Finally, access and availability of food can be improved at community or national level through policy change towards age-friendly communities, which may make it easier for older adults to go for grocery shopping and/or go to eat at healthy restaurants (Stroebele-Benschop, Depa, and de Castro 2016). These age friendly communities

range from transportation, structure of stores – easy to manoeuvre for all older adults including frailer ones who may use walking aids. Since access to food or healthy meals can be reduced by poverty, policy promoting subsidised meal prices may also help. Previously the use of food coupons or food assistance programs were identified as helpful for overall intake especially for people with lower economic status (Davis 1982).

2.4.3.5 Improving social status

Some types of nutrition intervention can focus on social aspects for example averting social isolation and/or loneliness, as these factors increase the risk of malnutrition by stimulating depressive symptoms or reducing appetite (Moats and Hoglund 2012). Social issues are best investigated in qualitative research, hence there is limited data from systematic reviews with meta-analyses identified in Table 2. However, some well structure randomised controlled trials indicate that social support can effectively promote nutrition intake, especially when incorporated in multi-domain interventions. For example, in a multifaceted intervention including social interaction through group exercises in addition to ONS and oral care interventions, the intervention group maintained its social function and significant increases in weight, BMI, energy and protein intake were obtained (Beck, Damkjær, and Sørbye 2010). In another randomised controlled trial, a home-based and lay volunteer-administered multi-domain intervention including physical training, nutritional and social support effectively improved quality of life (Kapan et al. 2017) malnutrition and frailty in older people (Luger et al. 2016). In this study, the control group received social support only, which involved a home visit by a lay volunteer who could go out, have a chat, or share interests and had also the opportunity to perform cognitive training with the older persons. The comparison group received similar social support in addition to physical training and nutrition support. It was quite remarkable to note that the control group which had just this social support obtained comparable decreases in prevalence of malnutrition and frailty (Luger et al. 2016). This study calls for more well designed randomised controlled trials to further ascertain the effectiveness of social support on nutritional health.

Overall, there is evidence to support the effectiveness of interventions at improving dietary intake (energy, protein and/or micronutrients), ameliorating malnutrition and associated adverse health outcomes including weight change, muscle strength, physical function, complications during or post-hospitalisation, morbidity and mortality risk; although the effect of the interventions on muscle strength and functional status

was significant in independent living or community participants only (Sauer et al. 2018). While some evidence is now available, it is important to note that in all the cited systematic reviews, meta-analyses and comprehensive narratives the authors call for more robust or randomised control studies to assess the efficacy of interventions.

2.5 Summary of the Literature Review

This literature review is divided into four sections (2.1 to 2.4). The review begins with summarising the national and global statistics which shows significant increases in older adults' populations. While acknowledging that this has been a great achievement, the review poses a question whether ageing in place or healthy ageing is being attained, and if yes is this occurring across ethnicities (2.1). In a quest to understand ways to promote healthy ageing, section 2.2 of this review proceeds by briefly explaining and acknowledging how attainment of healthy ageing may be a challenge due to presence of multiple age-related changes that can work together to inhibit healthy ageing. This section concludes on a positive note by explaining how most age-related changes can be modified through environmental and lifestyle factors including nutrition intake. In section 2.3, the role of nutrition in health ageing is then discussed, and how nutrition intake can modify the ageing process and other age-related changes that can inhibit healthy ageing. Challenges of meeting nutritional needs of older adults due to increasing number of risk factors for malnutrition with advancing age are discussed. A review of all scientific quantitative and qualitative studies which assessed the prevalence, risk factors and/or older adults' perspectives on malnutrition risk across NZ settings was then conducted, from which the main research gap that this thesis addresses is noted. To be specific, no data had been published at admission to the hospital or RAC, as most published data was obtained from the community-dwelling older adults. Only one qualitative study which recruited men only had been conducted in 2011. Several risk factors including dysphagia risk, physical performance and frailty had not been assessed in any of the NZ studies. The last section (2.4) discusses the important steps to be taken towards developing strategies or interventions to optimise nutrition intake and preventing malnutrition. The first step which involves needs assessments was discussed highlighting the importance of both objective and subjective data, thus elaborating why this thesis used mixed methodologies to meet the research aims. This section ends by briefly discussing the types of nutrition interventions that can help prevent or treat malnutrition.

It is undebatable that interventions that successfully optimise nutrition intake and prevent malnutrition can prevent loss of independence and promote healthy ageing. Overall, this review highlights the importance of timely nutrition screening and early intervention towards promoting healthy ageing, which can help reduce the burden on older adults as well as the financial budget for older adult health.

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Chapter 3: Preface

This first results chapter presents findings from the quantitative study conducted among older adults living in the community

The chapter is presented in manuscript format and has been published in the Australian and New Zealand journal of public health*: Impact Factor 1.91.*

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Author Contributions

IC wrote the manuscript, conducted statistical analysis, interpretation of the data and handled publication correspondences. CW and JA designed the study and participated in manuscript preparation. MR, VW and ES participated in data collection. All authors participated in the manuscript proof reading and approved the final manuscript.

Formatting of the text font and references has been done to meet that of the complete thesis

Associations between nutrition risk status, body composition and physical performance among community-dwelling older adults (Results paper 1)

3.1 Abstract

Objective: To investigate the associations between nutrition risk status, body composition and physical performance among community-dwelling older New Zealanders.

Methods: This cross-sectional study enrolled 257 community-dwelling older adults (median age 79 years). Assessments included the Mini Nutritional Assessment-Short Form (MNA®-SF) for nutrition risk; the Eating Assessment Tool-10 for dysphagia risk; bioimpedance analysis for body composition (free fat mass (FFM) and percentage body fat) and gait speed for physical performance. A multiple logistics regression analysis was conducted, to determine factors associated with lower odds [OR (95% CI)] for nutrition risk.

Results: Every yearly increase in age was associated with higher odds 1.09 (1.01–1.17) for nutrition risk. Additionally, nutrition risk was less likely to occur among participants of age <85 years 0.30 (0.11–0.79), with no dysphagia 0.29 (0.09–0.97) and those with a healthy gait speed 0.29 (0.09–0.97). Lower odds for nutrition risk were also found with increasing values of FFM index 0.51 (0.34–0.77), and percentage body fat 0.81 (0.72–0.90). Gait speed was positively correlated with FFM index (r=0.19 p<0.022), percentage body fat (r=0.23, p=0.006) and BMI (r=0.29, p<0.001).

Conclusion: Among these participants, associations between nutrition risk, body composition and physical performance were found.
Implications for public health: Routine screening of nutrition risk and/or physical performance among vulnerable older adults is key towards identifying those in need of assessment and dietary intervention. Alongside strategies to encourage physical activity, this may help to slow losses of FFM and protect physical performance.

Key words:
Nutrition risk, body composition, physical performance, BMI

3.2 Introduction

The number of community-dwelling older New Zealanders in need of care and requiring residential care has increased (Ministry of Health 2016; Broad et al. 2015),

and concerns are arising as to how to ensure older adults remain healthy and independent in the community (ageing in place). Decline in health status with ageing is often associated with changes in body composition and loss of functional status (Hickson 2006). Maintaining good health is more challenging for those in advanced age (≥85years) (Baltes and Smith 2003) who are the most rapidly expanding age group in New Zealand (Statistics New Zealand 2016a). A decline in health with advancing age is partly attributable to increased inflammation and number of comorbidities, many of which may be irreversible (Fougère et al. 2016; Salive 2013).

Decline in nutritional status is a modifiable risk factor directly affecting development of malnutrition and in most cases is amenable to intervention (Watterson et al. 2009; Splett, Roth-Yousey, and Vogelzang 2003; Australian and New Zealand Society for Geriatric Medicine 2017). It is important to identify nutritional vulnerability among community-dwelling older adults, so that preventative or supportive strategies may be implemented timely (Starr, McDonald, and Bales 2015). The Mini Nutritional Assessment Short Form (MNA®-SF) is the most frequently used tool for nutrition risk screening in older adults (Kaiser et al. 2010). As body mass index (BMI) is incorporated into the MNA®-SF tool, use of additional body composition assessments may help elucidate the association between individuals' nutrition risk and measures of body mass. Similar to younger adults, early undesirable changes in body composition in older adults can be indicated by a decline in muscle mass or fat-free mass (FFM) (Davidson and Getz 2004). In older adults, evidence suggests that not only FFM but a higher total body mass, particularly a BMI ≥23kg/m^2 is protective against all-cause mortality (Winter et al. 2014). However, the protective effect of greater BMI against mortality in relation to physical function is still not clear (Winter et al. 2014).

Despite being acknowledged as a significant indicator of decline in health status and life expectancy in older adults; physical functioning assessments are not always conducted in geriatric assessment settings (Studenski et al. 2011; Studenski et al. 2003). Compared to self-reports, physical performance assessments such as gait speed and the five-times-sit-to-stand test (FTSTS) provide more robust estimates of physical functioning (Brach et al. 2002; Fried et al. 1996). Gait speed and the FTSTS are two of the three components of the short physical performance battery (SPPB) tool, which was developed to assess lower extremity function in older adults (Guralnik et al. 1994). Gait speed is an independent predictor of adverse health events including falls, morbidity, long-term residential care admission, and mortality (Cesari et al.

2009; Cruz-Jentoft et al. 2010). The FTSTS is an adequate substitute to gait speed assessment (Cruz-Jentoft et al. 2010; Cesari et al. 2009; Tiedemann et al. 2008), and a validated predictor of dynamic balance in older adults (Goldberg et al. 2012; Berg et al. 1989).

Nutrition screening studies in New Zealand have reported that about a third of community- dwelling older adults are at nutrition risk (Watson, Zhang, and Wilkinson 2010; McElnay et al. 2012; Wham et al. 2014; Wham et al. 2015). While prevalence has been determined, the association between nutrition risk and physical performance remains unknown. The aim of this study was to evaluate the associations between nutrition risk status, body composition and physical performance (gait speed and FTSTS).

3.3 Methods

Study design and recruitment

A cross-sectional study conducted among 257 community-dwelling older adults living in Auckland, New Zealand. Older adults aged ≥75 years or ≥65 for Māori or Pacific ethnicity, living within the Waitemata District Health Board catchment area were recruited. A younger age group was included for Māori and Pacific participants as they have a lower life expectancy compared to other ethnicities (Statistics New Zealand 2016b). Participants were excluded if they had any known swallowing impairment*, known pre-existing cognitive impairment, presented with a voice box tumour, were receiving psychiatric care' for conditions affecting nutritional intake (e.g. Anorexia nervosa), enteral/parenteral nutritional support or palliative care or if they had any malabsorption syndromes.

Two medical centres in Auckland provided a confidential list of 1028 registered patients aged ≥75 years (≥65 for Māori or Pacific ethnicity). Both medical centres are geographically located in one district health board (Waitemata) and serve the same communities and overall population. These urban general practices were selected because of their size (medium to large practices serving over 5000 patients), and proximity to each other (about 2.1km apart). A total of 549 older adults were invited to participate in the study by phone call or a letter, 278 agreed to participate and 257 completed the study (Fig 1). Written consent was obtained prior to data collection.

*Participants were excluded if they had any known swallowing impairment because the original study design aimed to exclude participants who were obviously malnourished as a result of this cause.

Ethical approval was gained from the Health and Disability Ethics Committee: Northern A (Application 14/NTA/70).

Data collection

Trained nutrition researchers conducted face to face interviews, body composition and physical performance assessments at the participants' home. A questionnaire consisting of validated tools to screen for malnutrition risk, (Mini Nutritional Assessment short form (MNA®-SF)), dysphagia risk (Eating Assessment Tool-10 (EAT-10)) and cognitive status (Montreal Cognitive Assessment (MoCA)) was used. Participants were asked if they required help with activities of daily living (ADL) such as shopping, cleaning and cooking. A list of co-morbidities, medications and nutrition supplements was collected from medical files and from the participants.

For consenting participants, arrangements were made for a blood sample to be taken at a laboratory of the participants' convenience to assess for inflammatory status. Participants needed to fast for >10 hours but <16 hours (water only taken) and refrain from smoking. Collection of samples occurred via venepuncture by a trained phlebotomist, with processing of samples and analysis occurring according to Canterbury Health Laboratories procedures (Canterbury health laboratories 2013).

Assessments

Nutrition risk status

Using the MNA®-SF cut-off points, nutrition status was defined as well-nourished (MNA®-SF score ≥12), at risk of malnutrition (MNA®-SF 8-11) or malnourished (MNA®-SF score 0-7). Nutrition risk status was categorised as: 'at nutrition risk' (MNA®-SF score ≤11) and 'not at risk or well nourished' (MNA®-SF score ≥12). All assessments were performed according to the MNA®-SF user guide (Rubenstein et al. 2001).

Dysphagia risk

The Eating Assessment Tool-10 (EAT-10) is a self-reported validated questionnaire that assesses perception of swallowing difficulty and was used to evaluate dysphagia risk. An increased EAT-10 score indicates increased dysphagia risk or swallowing difficulties; an EAT-10 score ≥3 is suggestive of swallow impairment (Belafsky et al. 2008).

Cognitive status

Cognitive status was determined using the validated Montreal Cognitive Assessment (MoCA) (Nasreddine et al. 2005). A standardised protocol was used to conduct the MoCA to screen for mild cognitive impairment (MCI) (Nasreddine 2004). Out of a possible score of 30 points, a score ≤26 indicates some level of cognitive impairment (Nasreddine et al. 2005).

Anthropometry and Body composition

Body weight and composition was assessed using a bioimpedance analysis (BIA) scale (Tanita Body Composition Analyser SC-330, Wedderburn, Sydney, Australia). Body weight (kg), muscle mass (kg), free fat mass (FFM), fat mass (kg), and total body fat percentage measures were collected. Participants with a pacemaker or other internal electronic or metal medical device were excluded from the full assessment and were weighed using the 'weigh only' mode. A portable stadiometer (Seca 213, Hamburg, Germany) was used to measure height and BMI was calculated (kg/m^2). As previously described (Bahat et al. 2016), Free fat mass index (FFMI) was calculated using the equation: FFMI (kg/m^2) = [FFM (kg)/height squared (m^2)]

Muscle strength

Muscle strength was assessed using hand grip strength (Cruz-Jentoft et al. 2010). A hand grip dynamometer, Jamar Hydraulic Dynamometer (model #5030J1, Sammons Preston, USA) was used. The measurement procedure used conformed to the standard approved by the American Society of Hand Therapists (ASHT) (Roberts et al. 2011; Fess and Moran 1981) and the mean of three measurements from the dominant hand was recorded. A cut-off point of <20kg for women and <30kg for men indicated low muscle strength and risk for sarcopenia (Cruz-Jentoft et al. 2010).

Physical performance: Gait Speed

The 2.4m (8 foot) walk test was performed twice and the fastest walk was used for gait speed (m/s) analysis (Guralnik et al. 2000). Gait speed is a validated measure of physical performance, which assesses the lower extremity muscle function (Cruz-Jentoft et al. 2010; Guralnik et al. 2000). A cut-off point of <0.8 m/s indicated low physical performance and risk for sarcopenia (Cruz-Jentoft et al. 2010).

Physical performance: Five-times-sit-to-stand test (FTSTS)

The FTSTS was performed according to the standard protocol (Guralnik et al. 1994). FTSTS is a validated measure of physical performance which assesses the lower

extremity muscle strength (Cruz-Jentoft et al. 2010) and predicts dynamic balance (Goldberg et al. 2012). Completion of the FTSTS in ≥17 seconds indicated low physical performance (Cesari et al. 2009).

Inflammatory status

Presence of inflammation was assessed through quantifying serum levels of C-reactive protein (CRP) (Kalantar-Zadeh et al. 2003). Serum CRP levels were determined by rate nephelometry for a quantitative measurement and a CRP ≥10 mg/L was considered an indicator for inflammation (Stenvinkel et al. 2002).

Statistical analysis

Continuous data were assessed for normality using Shapiro Wilcoxon tests. As none of the continuous data was normally distributed, all descriptive statistics for the non-parametric data are presented as median and interquartile range (IQR), while categorical data are presented as frequencies and percentages. Differences between non-parametric data were analysed using the Mann Whitney U test, while the Chi-square test of independence was used for categorical data. Fisher exact test was used instead of Chi-squared test of independence whenever a cell had an expected count less than five. Additionally, to investigate factors associated with nutrition risk status, univariate and multiple logistics regression analyses were conducted. For the multiple regression model, all factors were adjusted for age (continuous variable), gender, ethnicity, marital status, living arrangements (alone, with spouse or others), income source (pension ± additional) and education level attained. Spearman's rho was used to examine the correlations between body composition and physical performance. All statistical analyses were completed using SPSS version 24. Results were considered significant at $p<0.05$.

3.4 Results

Overall, there were 257 community-dwelling participants, median age 79 (IQR 7) years. About 47% were men. Fig.1 summarises the participant recruitment process.

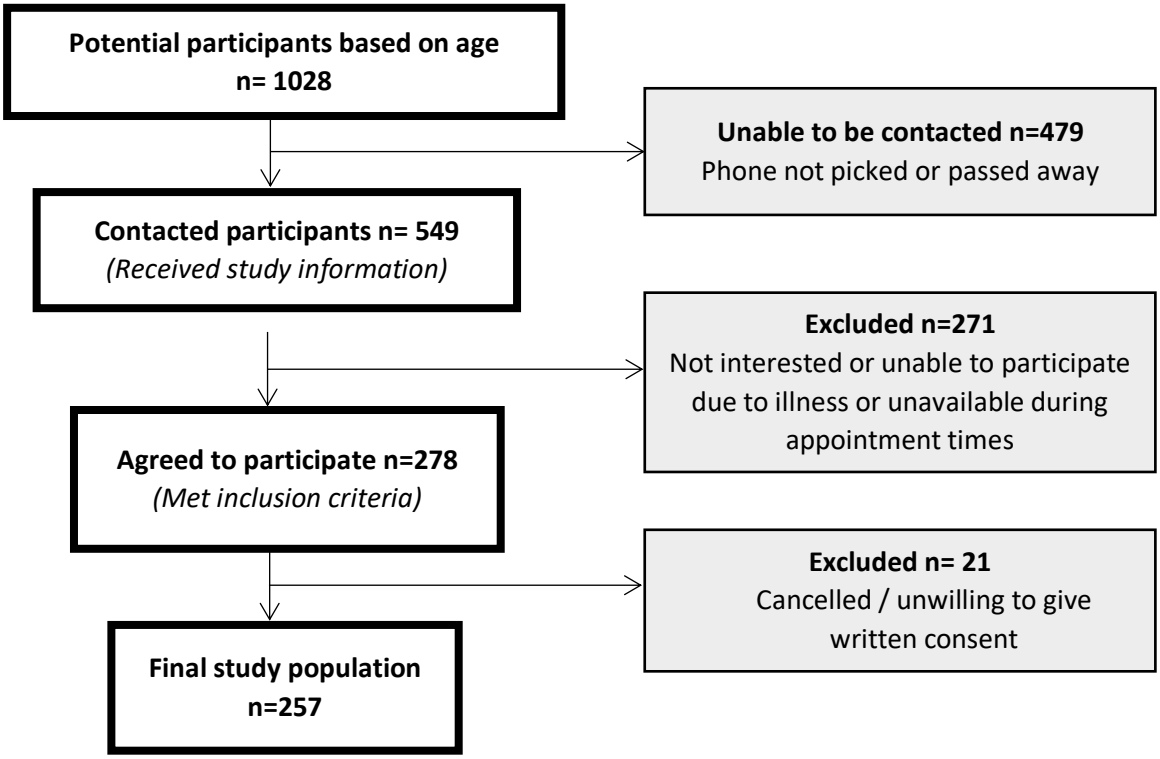

Fig.1 Participants recruitment flow chart

Participant characteristics

The demographic, health and physical characteristics of the participants are summarised in Table 1. Participants had a median BMI of 26.8kg/m^2 with 17% below the healthy cut-off ≥23kg/m^2. Presence of inflammation was identified in 10% of the participants (CRP ≥10 mg/L). Forty-one percent were dentate and about 7% were at dysphagia risk (EAT-10 ≥3). A third (31%) of the participants had at least five comorbidities (mainly cardiovascular and blood disorders, diabetes and other endocrine disorders, musculoskeletal disorders including osteoarthritis and rheumatoid arthritis). Half (51%) were taking five or more medications, and a quarter (26%) had normal cognitive status according to the MoCA. About one-in-ten participants (11%) demonstrated low gait speed (<0.8m/s) and about 16% required help with activities of daily living (ADL). About 71% had low hand grip strength.

Table 1. Participants Characteristics by Nutrition Risk Status

		*Nutrition Risk Status		
	*Total	Well nourished	At Nutrition Risk	
Sociodemographic Characteristics	***n (%)***	***n (%)***	***n (%)***	***p Value*** [a]
All participants	257	227 (88.3%)	30 (11.7%)	-
Age (years)				

<85	218 (84.8)	197 (90.4)	21 (9.6)	0.016**
≥85	39 (15.2)	30 (76.9)	9 (23.1)	
BMI (kg/m²)				
≥23	210 (82.7)	200 (95.2)	10 (4.8)	<0.001**
<23	44 (17.3)	25 (56.8)	19 (43.2)	
Gender				
Men	120 (46.7)	110 (91.7)	10 (8.3)	0.119
Women	137 (53.7)	117 (85.4)	20 (14.6)	
Marital status				
Married/ Partnered	149 (58.0)	133 (89.3)	16 (10.7)	0.584
Single [b.]	108 (42.0)	94 (87.0)	14 (13.0)	
Ethnicity				
NZ European	172 (66.9)	153 (89.0)	19 (11.0)	0.656
All Other Ethnicities [c.]	85 (33.1)	74 (87.1)	11 (12.9)	
Living Arrangements				
Living with others	45 (17.5)	39 (86.7)	6 (13.3)	0.784
Living with partner only	118 (45.9)	106 (89.8)	12 (10.2)	
Living alone	94 (36.6)	82 (87.2)	12 (12.8)	
Income Source				
Pension plus other income	130 (50.6)	116 (89.2)	14 (10.8)	0.648
Pension only income	127 (49.4)	111 (87.4)	16 (12.6)	
Education				
Tertiary	53 (20.6)	48 (90.6)	5 (9.4)	0.943
Secondary	187 (72.8)	164 (87.7)	23 (12.3)	
Primary	17 (6.6)	15 (82.2)	2 (11.8)	
Health and physical performance	***n (%)***	***n (%)***	***n (%)***	***p Value [a]***
Dental status				
Dentate	106 (41.2)	92 (86.8)	14 (13.2)	0.051*
Edentulous	8 (3.1)	5 (62.5)	3 (37.5))	
Dental Appliance	143 (55.6)	130 (90.9)	13 (9.1)	
Dysphagia				
Normal swallowing	240 (93.4)	215 (89.6)	25 (10.4)	0.035**
At dysphagia risk	17 (6.6)	12 (70.6)	5 (29.4)	
Inflammation				
No (Serum CRP<10 mg/L)	118 (90.1)	103 (87.3)	15 (12.7)	0.677
Yes (Serum CRP≥10 mg/L)	13 (9.9)	11 (84.6)	2 (15.4)	
Number of Comorbidities				
<5	177 (68.9)	161 (91.0)	16 (9.0)	0.050*
≥5	80 (31.1)	66 (82.5)	14 (17.5)	

Polypharmacy [d.]				
No	126 (49.0)	110 (83.7)	16 (12.7)	0.616
Yes	131 (51.0)	117 (89.3)	14 (10.7)	
Nutrition supplements				
Not taking	124 (48.2)	107 (86.3)	17 (13.7)	0.326
Taking	133 (51.8)	120 (90.2)	13 (9.8)	
Cognitive status				
Normal	66 (26.3)	53 (80.3)	13 (19.7)	0.058
≥ mild cognitive impairment	162 (64.5)	148 (91.4)	14 (8.6)	
Incomplete MoCA	23 (9.2)	21 (91.3)	2 (8.7)	
Requires help with ADL?				
No	217 (84.4)	193 (88.9)	24 (11.1)	0.432
Yes	40 (15.6)	34 (85.0)	6 (15.0)	
Muscle strength (kg) [e.]				
Healthy muscle strength	57 (29.2)	49 (86.0)	8 (14.0)	0.626
Low muscle strength	138 (70.8)	123 (89.1)	15 (10.9)	
Physical performance: Gait speed				
Healthy (gait speed ≥0.8m/s)	174 (88.8)	157 (90.2)	17 (9.8)	0.028**
Low gait speed (gait speed <0.8m/s)	22 (11.2)	16 (72.7)	6 (27.3)	
Physical performance: FTSTS				
Healthy (FTSTS <17sec)	107 (62.9)	94 (87.9)	13 (12.1)	0.600
Low physical performance (FTSTS ≥17sec)	63 (37.1)	57 (90.5)	6 (9.5)	

Body composition	n [Median (IQR)]	Median (IQR)	Median (IQR)	p Value [a]
BMI (kg/m^2)	254 [26.9 (6.5)]	27.2 (5.8)	21.5 (8.3)	<0.001**
Fat Mass (kg)	144 [23.1 (10.0)]	23.5 (9.8)	15.6 (17.3)	0.007**
Percentage Body Fat (%)	144 [32.5 (14.0)]	32.8 (13.5)	23.3 (17.7)	0.003**
Free Fat mass index (kg/m^2)	144 [17.8 (3.2)	18.1 (3.1)	14.9 (3.0)	<0.001**

ADL, activities of daily living, BMI, body mass index; CRP, C-reactive protein; MNA®-SF, Mini Nutritional Assessment Short-Form; FTSTS, five times sit-to-stand test

*Well nourished -MNA®-SF ≥12; At nutrition risk -MNA®-SF ≤ 11 (malnourished or at risk of malnutrition)

*The percentages (%) in the total column are percentage of all participants (257). All other percentages are percentage total within a category (raw percentages).

[a.] p value significant at **p<0.05, or at borderline significance *p=0.05, Mann Whitney U test, Chi-square or Fisher's exact

[b.] Marital status single: Widowed 71, Divorced n=20, Never married n=3

[c.] Other ethnicities: Māori n=9, Pacific n=7, others n=58

[d.] Polypharmacy: "Yes" taking 5 or more medications (Gnjidic et al. 2012)

[e.] Low muscle strength: handgrip strength <20kg women and <30kg for men (Cruz-Jentoft et al. 2010)

Nutrition risk status associations with participants' characteristics

Twelve percent of the participants were malnourished (1%) or at risk (11%). From a multiple logistics regression analyses, every yearly increase in age was associated with higher odds 1.09 (1.01 – 1.17) for nutrition risk. Additionally, nutrition risk was less likely to occur among participants of age <85 years 0.30 (0.11 – 0.79), with no dysphagia 0.29 (0.09 – 0.97) and those with a healthy gait speed 0.29 (0.09 – 0.97). Lower odds for nutrition risk were also found with increasing values of FFM index 0.51 (0.34 – 0.77), and percentage body fat 0.81 (0.72 – 0.90), (Table 2).

Table 2. Factors associated with nutrition risk: Univariate and multiple logistics regression analyses

Independent Factors	Unadjusted OR (95% CI)	p Value	Adjusted* OR (95% CI)	p Value
Age (years)	1.06 (1.00 – 1.14)	0.069	1.09 (1.01 – 1.17)	0.033**
Age <85 years	0.36 (0.15 – 0.85)	0.020**	0.30 (0.11 – 0.79)	0.015**
Normal swallowing (EAT-10 >3)	0.28 (0.09 – 0.86)	0.026**	0.29 (0.09 – 0.97)	0.045**
Healthy Physical performance (gait speed ≥8m/s)	0.29 (0.10 – 0.84)	0.022**	0.22 (0.07 – 0.71)	0.012**
BMI (kg/m^2)	0.81 (0.73 – 0.90)	<0.001**	0.82 (0.74 – 0.91)	<0.001**
Fat Mass (kg)	0.88 (0.81 – 0.96)	0.002**	0.86 (0.78 – 0.94)	0.002**
Percentage Body Fat (%)	0.90 (0.84 – 0.96)	0.002**	0.81 (0.72 – 0.90)	<0.001**
Free Fat mass index (kg/m^2)	0.65 (0.48 – 0.87)	0.003**	0.51 (0.34 – 0.77)	0.001**

Adjusted* for sociodemographic factors: age (continuous variable), gender, ethnicity (x4 categories), marital status (x4 categories), living arrangements (alone, with spouse or others) and income source (pension ± additional) and education level; Multiple logistics regression. **Only factors significantly ($p<0.05$) associated with nutrition risk reported.

Physical performance and associated factors

Based on gait speed and FTSTS, low physical performance was identified in 11% and 37% of the participants respectively (Table 1). The two measures of physical performance gait speed and FTSTS were positively correlated, ($r=0.52$, $p<0.001$). Gait speed was positively correlated with all body composition measurements

including FFMI (r=0.19 p<0.001), percentage body fat (r=0.23, p=0.006) and BMI (r=0.29, p<0.001), (Table 3).

Statistically significant correlations between hand grip strength and FTSTS (r=0.24, p=0.002), FFMI (r=0.48, p<0.001), and EAT-10 (r=-0.14, p=0.044) were observed (results not shown in table 3).

Table 3: Physical performance correlations with body composition measures

	Gait speed m/s	
	r	p Value [a]
FTSTS(s)	0.52	<0.001**
BMI (kg/m^2)	0.29	<0.001**
FFMI (kg/m^2)	0.19	0.022**
Percentage body fat	0.23	0.006**

BMI, body mass index; FFMI, free fat mass index; FTSTS, five times sit-to-stand; MNA®-SF, Mini Nutritional Assessment Short-Form. [a.] p value significant at **p<0.05, Spearman's rho

3.5 Discussion

Among 257 community-dwelling older adults (median age 79 years, 46.7% men), 12% were either malnourished (1%) or at risk of malnutrition (11%). Meta analyses of studies on community-dwelling older adults using the MNA® (Short Form and Long Form) observed a higher prevalence of malnutrition (2-3%), and at risk of malnutrition (26%) (Cereda et al. 2016; Verlaan et al. 2017). Our study is the first to use the MNA®-SF among community-dwelling older New Zealanders. Findings differ from previously reported nutrition risk prevalence rates (30-60%) in New Zealand using the Australian Nutrition Screening Initiative (ANSI) and the Seniors in the Community: Risk Evaluation for Eating and Nutrition (SCREEN-II) tools (Watson, Zhang, and Wilkinson 2010; McElnay et al. 2012; Wham et al. 2014; Wham et al. 2015). These three tools focus on three domains: weight change, current food intake and risk factors for food intake. In addition to these factors, the MNA®SF also considers individuals' neuropsychological, psychological stress and acute disease parameters. Therefore, while our study is not a population representative (due to the smaller sample size), the lower prevalence observed in the current study may be a result of a difference between the nutrition screening tools used. Additionally this may reflect a healthy volunteer effect or recruitment bias (Groves 2006; Sackett 1979). Half of

the participants declined to participate and indicated that they were not interested, not available at appointment times, or were too unwell.

The prevalence reported in our study is however similar to that reported in two previous studies, which included similar sample sizes and also used the MNA®SF; where older participants (mean age 81 years) were described as healthy and/or functional (Winter et al. 2013; Kaiser et al. 2011). In these studies of 225 Australian and 272 German participants, less than 1% were malnourished and 11-16% were at risk of malnutrition (Winter et al. 2013; Kaiser et al. 2011). In our recently published study which assessed nutrition risk of older adults (mean age 84 years) at hospital admission, about 27% were identified as malnourished and 47% at risk of malnutrition (Chatindiara et al. 2018). Most (88%) participants were admitted from the same community (Auckland) as the current study, suggesting that prevalence of nutrition risk among community-dwelling older New Zealanders is especially high among those who are unwell (Chatindiara et al. 2018).

Nutrition risk was less likely to occur among adults less than 85 years old when compared to those of advanced age, and the odds for nutrition risk increased with every yearly increase in participants' age. This finding agrees with previous studies that report a significant increase in community nutrition risk with advancing age (Smoliner et al. 2013; Söderhamn et al. 2012). With advancing age, food intake tends to decline due to a combination of factors including anorexia of ageing, poor oral health, change in taste sensitivity, depression, increasing number of comorbidities and medications taken, which altogether influences appetite (Cabrera et al. 2007; Gougeon 2014; Moreira et al. 2016; Jyrkkä et al. 2011). Therefore, as the 85+ years population is growing fast (Statistics New Zealand 2016b), identifying those at risk is a priority. We found vascular disorders and diabetes were the most frequently observed conditions, which complements a previous report where cardiovascular disease and diabetes were independent predictors of nutrition risk in older new Zealanders (Wham et al. 2014).

A healthy physical performance (gait speed ≥0.8m/s), was associated with lower odds for nutrition risk. While this supports findings from several longitudinal studies which indicate that a decline in physical functioning is a key risk factor for malnutrition in older adults (Moreira et al. 2016), the exact direction of the association between malnutrition and low physical performance remains unclear. Inadequate nutrient intake, particularly protein can lead to sarcopenia or loss of muscle mass, which

influences physical functioning (Robinson, Cooper, and Aihie Sayer 2012; Drewnowski and Evans 2001). However, regardless of direction, this finding supports the importance of conducting physical performance assessments in geriatric assessment settings (Studenski et al. 2003; Cesari et al. 2009). We found that at least one-in-ten (11%) participants had low gait speed indicative of low physical performance. Inadequate space is reported to be one of the challenges towards performing physical performance tests such as gait speed (Studenski et al. 2003). Space limitations can be overcome by conducting the FTSTS which is a consistent determinant of gait performance (Bohannon et al. 1995) and an adequate substitute to gait speed for physical performance assessment (Cesari et al. 2009; Cruz-Jentoft et al. 2010; Tiedemann et al. 2008). We observed a correlation between these two measures, ($r=0.52$, $p<0.001$). Notably, the FTSTS performance tends to depend on multiple psychological and physiological processes including sensation, speed and balance (Lord et al. 2002). Additionally, compared to gait speed, performing the FTSTS requires more motor activity and muscle performance (Bohannon et al. 1995). This may elucidate our finding for lower participant performance on FTSTS compared to gait speed i.e. low physical performance was identified through the FTSTS in 37% of the participants. However, both gait speed and FTSTS are efficient and cost-effective methods of assessing physical performance (Cesari et al. 2009; Cruz-Jentoft et al. 2010; Tiedemann et al. 2008), and may help identify older adults at risk for inability to perform ADL (Wennie Huang et al. 2010). Identifying risk is a key preventative measure to ensure older adults are able to undertake food related activities which are key to ensuring adequate food intake and preventing malnutrition (Schrader et al. 2014).

We found that gait speed was positively correlated with all body mass measurements i.e. muscle mass, percentage body fat and BMI. This is in line with previous studies which report the protective action of a moderate increase in BMI (Donini et al. 2012), and positive associations between increasing BMI and improved functional status (Bahat et al. 2012). Indeed, in younger adults focus is placed on increasing muscle mass, and in some cases, dietary restrictions. However, in older adults, it may be important to devise strategies that promote whole body mass maintenance and/or gain, to achieve optimum health. In fact, with increasing age, restrictive diets tend to be less effective towards preventing morbidity or promoting quality of life (Darmon et al. 2010). Since weight loss is a defining characteristic of malnutrition (Chen, Schilling, and Lyder 2001), it appears paramount to at least conduct nutrition screening among underweight older adults. The protective effect of a higher BMI

against morbidity and mortality in older adults (Donini et al. 2012; Bahat et al. 2012), may be due to its association with healthier physical performance.

We found greater muscle mass positively correlated with muscle strength, which is important in preventing swallowing difficulties (Sura et al. 2012). Our data shows that participants who reported normal swallowing (no dysphagia), had lower odds of being at nutrition risk, as has been previously reported (Takeuchi et al. 2014; Wakabayashi and Matsushima 2016). The findings indicate the existence of a vicious cycle between poor physical functioning, body composition (muscle mass) and nutrition risk status. Although it is well-known that impaired swallowing can cause decline in food intake, swallowing problems are not often assessed among ambulatory patients, and older adults may not report problems as they consider swallowing difficulties a normal part of aging (Chen et al. 2009). In many cases, those who struggle with swallowing self-modify their diet, often resulting in exclusion of foods that prevents the individual experiencing choking events or discomfort. Adults with swallowing difficulties tend to report low meal enjoyment and low food intake (Ekberg et al. 2002). Altered diet contributes to incomplete nutrition and particularly muscle loss. Resultant weakness may further diminish swallow strength and reduce overall dietary intake (Jaradeh 2006). Muscle strength as measured by hand grip strength is a marker for nutrition status (Norman et al. 2011). Unexpectedly, we found no association between low muscle strength and nutrition risk. In comparison to the other measures of physical functioning we assessed, the high prevalence of low muscle strength (71%), we observed appears to be an anomaly. Our assessments for grip strength conformed to the ASHT protocol (Fess and Moran 1981), and the ASHT considers the Jamar hand dynamometer as the gold standard for assessing hand grip strength (Roberts et al. 2011). However, previous research indicated the recording errors that can occur when using this dynamometer (Roberts et al. 2011), some of which cannot be ruled out in the current study. For example, about 1.4kg to 1.8kg of force is required to produce an accurate reading (Roberts et al. 2011). Although not specified in the ASHT protocol, some studies have reported the importance of including verbal encouragement as a way to ensure the optimum hand grip strength is recorded (Jung and Hallbeck 2004; Roberts et al. 2011).

This study has several strengths. This study incorporated objective physical performance tests, which are more robust in assessing physical functioning, compared to questionnaires (Brach et al. 2002; Fried et al. 1996). Furthermore, the physical assessments enabled us to evaluate both upper and lower body functioning

(Guralnik et al. 1994; Goldberg et al. 2012). Several factors were used to assess decline in health status including blood biomarkers, physical functioning, body composition, comorbidities, medication and participants' self-reports which provides a platform to better understand associations between nutrition and health status. Body composition (not just BMI) was assessed, with the aim of counteracting the limitations of using BMI alone in older adults. The main outcome measure (nutrition risk status) was assessed using a validated and widely used tool (MNA®SF). Limitations of this study include the smaller sample size, recruited from one district health board, which may be inadequate to detect the true nutrition risk status of older New Zealanders. The sample could demonstrate clustering in participants characteristics due to the practice-based recruitment method used. The cross-sectional nature of the study limits the ability to detect causality, hence only associations were discussed. The distribution of the study sample across ethnicities was not even; hence it is difficult to generalise study findings to other ethnic groups particularly Māori and Pacific.

3.6 Conclusion

The current study is the first to report an association between low nutrition risk and better physical performance among community-dwelling older New Zealanders. A positive correlation between improved physical performance and higher BMI adds to the body of evidence for the protective effect of a higher BMI in older adults. In addition to better physical performance, low nutrition risk status was associated with a younger age, particularly <85 years, healthier body composition, and low dysphagia risk. Collectively, these findings can assist in designing nutrition-related interventions aimed at supporting ageing in place. Screening and/or assessment of nutrition and physical performance status are both cost effective and efficient procedures, which may enable timely implementation of appropriate interventions for attaining or maintaining independence with ageing.

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Chapter 4: Preface

This second results chapter presents findings from the quantitative study conducted at admission to the hospital.

The chapter is presented in manuscript format and has been published in the Biomedical Central (BMC) Geriatrics: Impact Factor 3.0.

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Author Contributions

IC wrote the manuscript, conducted statistical analysis, interpretation of the data and handled publication correspondences. CW and JA designed the study and participated in manuscript preparation. AP and DP participated in data collection. MR and MK provided input for statistical design, analysis and interpretation. All authors participated in the manuscript proof reading and approved the final manuscript.

Formatting of the text font and references has been done to meet that of the complete thesis

Dysphagia risk, low muscle strength and poor cognition predict malnutrition risk in older adults at hospital admission (Results paper 2)

4.1 Abstract

Background: Malnutrition in patients admitted to hospital may have detrimental effects on recovery and healing. Malnutrition is preceded by a state of malnutrition risk, yet malnutrition risk is often not detected during admission. The aim of the current study was to investigate the magnitude and potential predictors of malnutrition risk in older adults, at hospital admission.

Methods: A cross-sectional was study conducted in 234 older adults (age ≥65 or ≥55 for Māori or Pacific ethnicity) at admission to hospital in Auckland, New Zealand. Assessment of malnutrition risk status was performed using the Mini Nutritional Assessment Short-Form (MNA®-SF), dysphagia risk by the Eating Assessment Tool (EAT-10), muscle strength by hand grip strength and cognitive status by the Montreal Cognitive Assessment (MoCA) tool.

Results: Among 234 participants, mean age 83.6 ± 7.6 years, 46.6% were identified as at malnutrition risk and 26.9% malnourished. After adjusting for age, gender and ethnicity, the study identified [prevalence ratio (95% confidence interval)] high dysphagia risk [EAT-10 score: 0.98 (0.97-0.99)], low body mass index [kg/m^2: 1.02 (1.02-1.03)], low muscle strength [hand grip strength, kg: 1.01 (1.00-1.02)] and decline in cognition [MoCA score: 1.01 (1.00-1.02)] as significant predictors of malnutrition risk in older adults at hospital admission.

Conclusion: Among older adults recently admitted to the hospital, almost three-quarters were malnourished or at malnutrition risk. As the majority (88%) of participants were admitted from the community, this illustrates the need for routine nutrition screening both at hospital admission and in community-dwelling older adults. Factors such as dysphagia, unintentional weight loss, decline in muscle strength, and poor cognition may indicate increased risk of malnutrition.

Keywords:

Older adults, hospital malnutrition risk, dysphagia risk, muscle strength, MNA®-SF

4.2 Introduction

The current life expectancy at birth (81.7 years) for New Zealand is among the top life expectancies within the Organisation for Economic Co-operation and Development countries (OECD 2018). This raises the issue of whether efficient

strategies have been put in place to ensure this growth in life expectancy will go along with good quality of life (Christensen et al. 2009; Dalziel 2001). Since ageing is a well-documented risk factor for hospitalisation (Boult et al. 1993; Dorr et al. 2006; Inouye et al. 2008), there is great need to come up with strategies that help older people to continue living healthily in the community. Although ageing is inexorable, several factors contributing to hospital admission in older adults can be modified, for example, nutrition status. Despite being well documented as a preventable condition, hospital malnutrition is highly prevalent among older adults (20-60%) (Barker, Gout, and Crowe 2011; Agarwal et al. 2013; Kaiser et al. 2010). It remains unclear whether malnutrition occurs before or after admission since at hospital admission, nutrition screening is not mandatory and is conducted infrequently (McWhirter and Pennington 1994; Tappenden et al. 2013; Starr, McDonald, and Bales 2015).

Malnutrition is preceded by a state of malnutrition risk thus nutrition risk screening may identify those who show nutritional compromise before they reach a state of malnutrition, enabling intervention and prevention. Although several international studies assessed malnutrition risk at hospital admission (Pablo, Izaga, and Alday 2003; Allard et al. 2016; Imoberdorf et al. 2010; Amaral et al. 2007; Korfalı et al. 2009; Planas et al. 2004; Rasmussen et al. 2004; Amaral et al. 2010; Kyle et al. 2003), the wide range of malnutrition risk prevalence (15-78%) observed from these studies raises questions. Differences in methodology used to assess malnutrition risk may partly explain the reported discrepancies. Several methods of malnutrition risk screening have been established and the choice of method used should consider participants age and setting (Bales and Ritchie 2009; Guaitoli, Jansma, and de Vet 2014). The Mini Nutritional Assessment Short-Form, (MNA®-SF) is a validated tool for assessment of malnutrition risk in older adults in multiple settings, including the hospital (Rubenstein et al. 2001). The MNA®-SF is used globally and has a sensitivity of 89% and specificity of 82% for assessing malnutrition risk in older adults (Bales and Ritchie 2009; Mueller, Compher, and Ellen 2011).

Studies suggest that malnutrition risk factors are multidimensional. These include sociodemographic (e.g. age, gender, living arrangements and employment status), psychological (e.g. individuals' thoughts and feelings), and health status (e.g. functional ability, presence of comorbidities, polypharmacy, impaired chewing and swallowing) (Moreira et al. 2016; Tamura et al. 2013; Vanderwee et al. 2010; Pirlich et al. 2006; Wham, Redwood, and Kerse 2014). Understanding these factors may be helpful for identifying those at malnutrition risk and providing timely preventative

interventions. Levels of cognitive impairment often increase with ageing (Glisky 2007), and have the potential to influence nutrition status. Previous studies have reported positive associations between satisfactory dietary intake and better cognition (Ortega et al. 1997). Furthermore, older adults are more vulnerable to dysphagia (swallowing difficulties) (Humbert and Robbins 2008), which can lead to malnutrition through decline in food intake. Among healthy community-dwelling older adults, a positive correlation between posterior tongue strength (swallowing strength) and hand grip strength (a measure of muscle strength) was observed (Butler et al. 2011). This suggests that loss of muscle strength at one site e.g. hand grip, may be indicative of weakness at other sites e.g. oral cavity. To date, there is limited literature supporting a strong association between tongue strengthening and swallow outcomes. However, among older adults in long term care, reduced tongue strength was found to be associated with observable signs of swallowing difficulty and reduced food consumption (Namasivayam, Steele, and Keller 2016). Therefore, exploring associations between muscle strength, dysphagia and malnutrition appears warranted.

In New Zealand, malnutrition risk screening is not mandatory and knowledge of prevalence of malnutrition in older adults is lacking. Using the MNA®-SF, the aim of the current study was to investigate the magnitude and potential predictors of malnutrition risk in older adults, at hospital admission.

4.3 Methods

Setting and sample

A cross-sectional study was conducted in two hospitals in Auckland, New Zealand. The study included a non-randomised convenience sample of 234 older adults. Recruitment was at hospital admission between July 2014 and September 2015. Ethics approval was granted by the Health and Disability Ethics Committee: Northern A region 14/NTA/70/AMO1.

At hospital admission, participants were provided with an information sheet, the study procedures were explained and written consent was obtained. The inclusion criteria were: age ≥65 or ≥55 for Māori or Pacific ethnicity, admission to hospital rehabilitation wards within the preceding five days, able to comprehend study requirements and give consent. A younger age group was included for Māori and Pacific participants as they have a lower life expectancy compared to other ethnicities (Statistics New Zealand 2016). Furthermore, findings on health disparities related to ethnicity in New

Zealand indicates that Māori and Pacific populations are more likely to biologically age earlier due to poor health (Bramley et al. 2004; Dyall 2014). Participants were excluded if they presented with dysphagia, known gastrointestinal disease, known pre-existing cognitive impairment, malignancy or tracheostomy.

Assessments

Sociodemographic data including age, gender, ethnicity, marital status, living arrangements, pension-related income and highest education level attained were obtained from participants and clinical notes. Participants were asked if they required help with activities of daily living (ADL) to understand if individuals may be limited in physical functioning. Comorbidities, use of medications and nutritional supplements were evaluated from participant reports and clinical notes. Self-reported dental status was recorded as either dentate (able to chew food without appliances), edentulous (missing teeth contributing to chewing problems and not using dental appliance) or use of dental appliances. Validated tools for screening malnutrition (MNA®-SF), dysphagia risk (Eating Assessment Tool-10 (EAT-10)) and cognitive status (Montreal Cognitive Assessment (MoCA)) in older adults were used. Furthermore, physical measurements specifically weight, height, body mass index (BMI) and muscle strength were done.

Malnutrition risk status

The MNA®-SF is comprised of six items that assess food intake, weight loss, mobility, psychological stress, neuropsychological problems, and BMI. Using the previously validated MNA®-SF cut-off points; nutrition status was defined as the state of being either well-nourished (MNA®-SF score ≥12), at malnutrition risk (MNA®-SF score 8-11) or malnourished (MNA®-SF score 0-7). Furthermore, malnutrition risk status was categorised as: 'at risk' (MNA®-SF score ≤11) and 'not at risk' (MNA®-SF score ≥12). Lower MNA®-SF score indicate increased malnutrition risk. All assessments were performed per the MNA®-SF user guide (Rubenstein et al. 2001).

Dysphagia risk

EAT-10, a self-reported validated questionnaire that assesses perception of swallowing difficulty was used to evaluate dysphagia risk. Increase in the EAT-10 score is indicative of increased dysphagia risk or swallowing difficulties, and an EAT-10 score ≥3 is suggestive of dysphagia (Belafsky et al. 2008).

Cognitive status

Cognitive status was determined using the MoCA tool. This tool is a multi-domain test which enables detection of mild cognitive impairment through several assessments including memory, attention, conceptual thinking and orientation. Low MoCA scores indicate decline in cognitive status and a score ≤26 indicates cognitive impairment (Nasreddine et al. 2005).

Muscle strength

Muscle strength was assessed using hand grip strength (Cruz-Jentoft et al. 2010). A hand dynamometer (Jamar Hydraulic Dynamometer, model #5030J1, Sammons Preston, USA) was used. The measurement procedure used conformed to the standard approved by the American Society of Hand Therapists (Roberts et al. 2011). The mean of six measurements, three from each hand was recorded. In participants (n=8) who could only provide measurements from one hand, a mean of three measurements was used from the dominant hand (Coldham, Lewis, and Lee 2006; Roberts et al. 2011).

Statistical analysis

The main outcome measure was malnutrition risk indicator score (MNA®-SF). Continuous data was assessed for normality using Shapiro Wilcoxon tests and through visual analysis of the normality plots. Descriptive statistics for normally distributed data were presented as mean ± standard deviation (SD) and categorical data were presented as frequencies and percentages. Chi-square test of independence or Fisher exact tests was used to analyse the association between participants' demographic characteristics and malnutrition status. As the prevalence of malnutrition risk was higher than 10%, Poisson regression with robust variance estimation was used to quantify the magnitude of the associations between potential predictors and malnutrition risk (MNA®-SF score) (Barros and Hirakata 2003). Each characteristic was added to the Poisson regression model adjusting for the major non-modifiable human factors (age, gender and ethnicity), medications and comorbidities, as these factors are related to malnutrition risk. The magnitudes of associations were reported as prevalence ratio (PR) and 95% confidence interval (95% CI). Results were considered significant at $p<0.05$. All statistical analyses were done using IBM SPSS Statistics version 24.

4.4 Results

Study population and prevalence of malnutrition risk

Malnutrition risk assessment was completed in 234 participants aged (mean years ± SD) 83.6 ± 7.6, of whom 40.6% were women. Eighty-eight percent of participants were admitted from the community and 41% had a BMI less than 23kg/m^2, which is below the proposed healthy cut-off point (BMI ≥23kg/m^2) for older adults (Winter et al. 2014). Data collection was conducted within five days of hospital admission, regardless of admission reason. No adverse events were encountered during the study data collection. Table 1 shows the participants characteristics by nutrition status.

The study identified 109 participants (46.6%) at malnutrition risk (MNA®-SF score 8-11) and 63 participants (26.9%) as malnourished (MNA®-SF score 12-14).

Table 1. Participants' demographic characteristics by malnutrition status: MNA®-SF

Characteristics	*Total n (%)	Malnutrition status		
		Well-nourished n (%)	At malnutrition risk n (%)	Malnourished n (%)
All participants'	234 (100)	62 (26.5)	109 (46.6)	63 (26.9)
Admission source				
- Community	156 (88.1)	46 (29.5)	70 (44.9)	40 (25.6)
- Aged care [a.]	21 (11.9)	5 (23.8)	7 (33.3)	9 (42.9)
Age				
- <85 years	122 (52.1)	32 (26.2)	58 (47.5)	32 (26.2)
- ≥85 years	112 (47.9)	30 (26.8)	51 (45.5)	31 (27.7)
BMI				
- <23kg/m^2	95 (40.6) **	9 (9.5)	45 (47.4)	41 (43.2)
- ≥23kg/m^2	139 (59.4)	53 (38.1)	64 (46.0)	22 (15.8)
Gender				
- Men	95 (40.6)	25 (26.3)	46 (48.4)	24 (25.3)
- Women	139 (59.4)	37 (26.6)	63 (45.3)	39 (28.1)
Marital status				
- Married/partnered	95 (40.6)	26 (27.4)	42 (44.2)	27 (28.4)
- Single [b]	139 (59.4)	36 (25.9)	67 (48.2)	36 (25.9)
Ethnicity				
- All other ethnicities [c]	87 (37.2) 147 (62.8)	21 (24.1) 41 (27.9)	38 (43.7) 71 (48.3)	28 (32.2) 35 (23.8)

- New Zealand European				
Living arrangements				
- Living alone	104 (44.4)	31 (29.8)	49 (47.1)	24 (23.1)
- Living with partner only	73 (31.2)	21 (28.8)	32 (43.8)	20 (27.4)
- Living with others	57 (24.4)	10 (17.5)	28 (49.1)	19 (33.3)
Income source				
- Pension only income	152 (65.0)	37 (24.3)	69 (45.4)	46 (30.3)
- Pension plus other income	82 (35.0)	25 (30.5)	40 (48.8)	17 (20.7)
Education				
- Primary	52 (22.2)	11 (21.2)	28 (53.8)	13 (25.0)
- Secondary	144 (61.5)	38 (26.4)	62 (43.1)	44 (30.6)
- Tertiary	38 (16.2)	13 (34.2)	19 (50.0)	6 (15.8)

BMI, body mass index; MNA®-SF, Mini Nutritional Assessment Short-Form

*The percentages (%) in the total column are percentage total. All other percentages are percentage total within a category. All values are reported after rounding up to 1 decimal place, therefore percentages add up to 100 ± 0.1 **Only BMI was statistically significant across nutrition status groups: $p<0.05$ Chi-square test of independence

[a] Aged care: admitted from long term residential care (n=16) or private hospital interim care (n=5)

[b.] Marital status single: widowed n=110, divorced n=15, single/never married n=14

[c] Other ethnicities: Māori n=6, Pacific n=6, others n=75

Physical and health predictors of malnutrition risk

Table 2 summarises the descriptive data for predictive factors evaluated in relation to malnutrition risk, and the respective magnitudes [PR (95% CI)] of association with malnutrition observed. From the descriptive data, participants showed a general decline in physical and health status. Only a third maintained full dentition and an increased risk of swallowing problems was suggested by the elevated mean EAT-10 score of 3.0 (± 5.8). A majority of the participants had reduced muscle strength (hand grip), reduced cognitive functioning scores, required daily help with ADL and had approximately six comorbidities. Hypertension (and other vascular diseases), osteoporosis and chronic obstructive pulmonary disease were the most frequently observed conditions.

After adjusting for age, gender and ethnicity, analysis from Poisson regression with robust variance estimation identified [PR (95% CI)] high dysphagia risk [EAT-10 score: 0.98 (0.97-0.99)], low muscle strength [hand grip strength (kg): 1.01 (1.00-1.02)], low BMI (kg/m^2) [1.02 (1.02-1.03)] and decline in cognition [MoCA score: 1.01 (1.00-1.02)] as significant predictors of malnutrition risk in older adults at hospital admission (Table 2).

Table 2: Physical and health predictors of malnutrition risk indicator score (MNA®-SF)

	Descriptive statistics [a] (n=234)			Malnutrition risk score [b] (MNA®-SF)	
	Total	**Not at risk (n=62)**	**At risk (n=109)**	**Prevalence ratio (95% CI)**	***p* value**
***Dental status* n (%)**					
Dentate	46 (19.7)	13 (28.3)	33 (71.7)	1	
Edentulous	51 (21.8)	13 (25.5)	38 (74.5)	0.95 (0.84-1.07)	0.384
Dental appliance	137 (58.5)	36 (26.3)	101 (73.7)	1.00 (0.91-1.09)	0.956
Dysphagia risk					
EAT-10 score (mean ± SD) [c]	3.0 ± 5.8	1.4 ± 2.2	3.6 ± 6.5	0.98 (0.97-0.99)	<0.0001**
BMI					
(mean ± SD)	24.7 ± 5.3	27.4 ± 5.2	23.7 ± 5.0	1.02 (1.02-1.03)	<0.0001**
Muscle strength					
Hand grip, kg (mean ± SD) [d]	14.5 ± 7.0	16.0 ± 7.5	13.9 ± 6.7	1.01 (1.00-1.02)	0.006**
***Requires help with ADL* n (%)**	77 (32.9)	25 (32.5)	52 (67.5)	1	
No	157 (67.1)	37 (23.6)	120 (76.4)	0.93 (0.86-1.00)	0.061
Yes					
Cognitive status					
MoCA score (mean ± SD) [e]	18.5 ± 5.8	20.3 ± 5.4	17.8 ± 5.8	1.01 (1.00-1.02)	0.025**
Number of medications					
(mean ± SD)	7.5 ± 4.4	7.1 ± 3.5	7.7 ± 4.6	1.00 (0.99-1.01)	0.537
Number of comorbidities					
(mean ± SD)	5.7 ± 2.7	5.6 ± 2.9	5.7 ± 2.7	1.00 (0.98-1.02)	0.683
***Nutrition supplements* n (%)**	82 (35.0)	25 (30.5)	57 (69.5)	1	
Taking [f]	152 (65.0)	37 (24.3)	115 (75.7)	0.95 (0.87-1.02)	0.163
Not taking					

MNA®-SF, Mini Nutritional Assessment Short-Form; Eating Assessment Tool, EAT-10; BMI, body mass index; ADL, activities of daily living; MoCA, Montreal Cognitive Assessment

[a] Descriptive statistic for continuous data were presented as mean ± standard deviation (SD) and categorical data presented as frequencies (n) and percentages (%)

[b] Poisson regression with robust variance estimation. Each parameter was adjusted for age, gender, ethnicity, number of comorbidities and medications; PR (95% CI) ** *p* value significant at $p<0.05$

[c] Missing data n=2

[d] Missing data n=66

[e] Missing data n=69

[f] Average number of supplements taken n=1

4.5 Discussion

This is the first study in New Zealand to assess prevalence and predictors of malnutrition risk in older adults at hospital admission. Almost three-quarters were either malnourished (26.9%) or at malnutrition risk (46.6%), congruent with previously published international findings (15-78%) (Pablo, Izaga, and Alday 2003; Allard et al. 2016; Imoberdorf et al. 2010; Amaral et al. 2007; Korfalı et al. 2009; Planas et al. 2004; Rasmussen et al. 2004; Amaral et al. 2010; Kyle et al. 2003). Dysphagia risk, low BMI, decreased muscle strength and cognitive decline, were identified as statistically significant predictors of malnutrition risk, at hospital admission. As 88% of participants were admitted from the community, this suggests that the high prevalence of hospital malnutrition may be a result of unrecognised community malnutrition; hence routine screening is essential on hospital admission. Furthermore, it suggests that community-based assessment and intervention may be important for identifying at-risk adults and providing early supportive measures.

The prevalence of malnutrition (26.9%) observed in this study is congruent with previously reported hospital malnutrition prevalence (20-60%) internationally (Barker, Gout, and Crowe 2011; Agarwal et al. 2013; Kaiser et al. 2010). This suggests that both malnutrition risk and malnutrition are present in older adults prior to hospital admission. This study is an extension of our pilot investigation that reported malnutrition risk prevalence in adults (n=88) of advanced age (85+ years), wherein a similar prevalence of malnutrition risk was observed (Popman et al. 2017). Previously, malnutrition has been identified in New Zealand older adults (n=55) hospitalised for hip fracture; where 42% were found to have at least two indices of protein energy malnutrition as evidenced by low triceps skinfold thickness, reduced mid-upper arm circumference, and low serum pre-albumin (Hanger et al. 1999). Moreover, using the MNA®-SF, a New Zealand hospital audit of older adults (n=72) found 24% were malnourished and 44% were at nutrition risk (Van Lill 2002). The insights from the aforementioned reports and findings from our study suggest the need for routine screening at hospital admission in New Zealand.

Previous studies reported chewing and swallowing problems as common phenomena in older people, which may lead to decline in food intake (Petersen and Yamamoto 2005; Thomson and Ma 2014; Hickson 2006). Reduced food intake is one of the main causes of malnutrition. Thus, understanding both dental status and dysphagia risk may be helpful in devising strategies intended to prevent malnutrition. In contrast to previous studies (Poisson et al. 2014; Saarela et al. 2014), no significant association

between dental status and malnutrition risk status was observed in the current study. However, as expected, we observed that with increasing risk of dysphagia (increasing EAT-10 scores), the prevalence ratio of malnutrition risk also increased. This concurs with findings of a previous study that assessed the association between swallowing difficulties and hospital malnutrition (Vanderwee et al. 2010). In the current study, 22% of the participants demonstrated EAT-10 scores ≥3 which suggests that in older people who are malnourished or at malnutrition risk, consideration of swallow assessment would be prudent. This may identify contributory problems and define treatment targets. Furthermore, for treatment of malnutrition, it may be helpful if future studies investigate the clinically relevant cut-off points for the EAT-10 associated with malnutrition risk, since an EAT-10 score ≥3 is merely suggestive of dysphagia (Belafsky et al. 2008).

Greater muscle strength as indicated by greater hand grip strength was associated with lower malnutrition risk. Similar findings were observed in an Australian study that explored the potential of hand grip strength to independently predict nutrition status in a hospital population (Flood et al. 2014). A Canadian study that assessed malnutrition at hospital admission observed hand grip strength to be an independent factor associated with hospital stay (Allard et al. 2016). Several factors explain the occurrence of poor muscle strength in older adults and how they may create a vicious cycle resulting in malnutrition. Reduced physical activity and functional decline commonly observed in older adults contribute to muscle atrophy and poor muscle strength (Baumgartner et al. 1999; Sakuma and Yamaguchi 2012; Colón-Emeric et al. 2013). In addition, malnutrition promotes body weight loss (low BMI), particularly muscle mass loss, including the deglutitive muscles, which consequently increases swallowing problems and hence malnutrition risk (Visvanathan 2003; Lee and Frongillo Jr 2001).

Muscle weakness and low BMI often occur together in undernourished people (Norman et al. 2005; Norman et al. 2011). Our study supports this association, as a positive correlation ($r=0.236$, $p<0.046$) between BMI and muscle strength was observed. BMI is an integral part of the MNA®-SF and in older adults high BMI values are associated with low malnutrition risk (Vanderwee et al. 2010; Hogue et al. 2009), better functional status (Bahat et al. 2012) and may be protective against mortality (Hogue et al. 2009; Donini et al. 2012; Thinggaard et al. 2010). Accordingly, a BMI ≥23kg/m^2 has been proposed as the healthy cut-off point for older adults (Winter et

al. 2014). In the current study, 41% of the participants had a BMI <23kg/m^2 which may explain the high prevalence of malnutrition risk observed.

Two-thirds of participants required daily help with various tasks such as cooking, cleaning, showering and dressing. This may suggest loss of physical function among these participants which may contribute to the low muscle strength and high malnutrition risk observed. Previous studies reported that malnutrition risk is higher in older adults who rely on others for assistance with daily activities like grocery shopping and cooking (Allard et al. 2016; Agarwal et al. 2013; Moreira et al. 2016). Although not statistically significant (p=0.061), our data demonstrated an increased risk of malnutrition among older adults who required help with ADL. Whether this incremental decrease in nutrition status can be detected clinically is not clear from this study.

Medications and comorbidities are well documented factors associated with malnutrition (Moreira et al. 2016; Agarwal et al. 2013). In the current study, on average each participant had six comorbidities and was taking seven medications. Although these factors were not significantly associated with malnutrition risk in this study, they may contribute to decreased physical activity, decline in muscle mass and consequently poor muscle strength. These factors negatively influence malnutrition risk (Visvanathan 2003; Lee and Frongillo Jr 2001). Two-thirds (65%) of the participants did not take any nutritional supplements and among those who took supplements, on average only one supplement was taken. This may explain why taking nutrition supplements did not impact malnutrition risk. A recent study in New Zealand observed low micronutrient intake in older adults and noted that with some of the micronutrients, those who took nutritional supplements were less likely to be nutrient deficient (Wham et al. 2016). Further education in this area may assist older adults in determining whether supplementation is appropriate.

In agreement with previous studies (Moreira et al. 2016), malnutrition risk was associated with decline in cognitive status. Cognitive impairment is associated loss of independence which may negatively affect older adults' lifestyle, specifically food intake and physical activity. Malnutrition and cognitive impairment have been reported as predictors of all-cause mortality among hospitalised adults (>70 years) (Farid et al. 2013). In the current study, 62% of the participants indicated some level of cognitive impairment (MoCA score ≤26). Although about a quarter of the participants declined taking the MoCA test, the high prevalence of cognitive impairment among

the test takers suggests the importance of performing cognitive assessments in older adults.

The strengths of this study include the use of validated screening tool MNA®-SF and the use of a critical time point for data collection i.e. at hospital admission. These factors enable understanding of malnutrition risk in older New Zealanders at hospital admission, which provides helpful insights towards promoting good nutritional status not only during hospitalisation but also prior in the community and after discharge. However, the use of an observational study design hinders us from determining causality. Additionally, investigations were done using a convenience sample (n=234), which limits generalisability of the findings. Hand grip strength and cognitive status assessments were undertaken with about three-quarters of the participants, therefore interpretation of these results should be made with caution, as the missing data may have introduced bias in our findings. Overall, the participants had low MoCA scores which may have influenced the malnutrition risk outcome, since some of the MNA®SF items rely on memory. Due to poor physical strength and/or presence of metals in the body, only 16 participants completed muscle mass measurement using bio-impedance analysis scale, thus we could not report muscle mass findings. As significant changes in body composition occur with ageing, inability to assess muscle mass in this study limited our ability to understand the impact of body composition on malnutrition risk. To understand participants' general health status, the current study recorded comorbidities and medications taken. However, the study did not capture reason for admission, which would have helped clarify participants' health upon admission.

4.6 Conclusion

Among older adults recently admitted to hospital rehabilitation wards, almost three-quarters were malnourished or at malnutrition risk. This illustrates the need for timely screening, as early identification is one of the most important and effective ways to prevent and reduce the prevalence of malnutrition and malnutrition risk. As 88% of the participants were admitted from the community, this illustrates the need for routine nutrition screening both at hospital admission and in community-dwelling older adults. Routine screening, especially at hospital admission, would identify those that may benefit from intervention or nutritional support during hospitalisation. Interventions that focus on increasing muscle strength and/or preventing dysphagia risk, while considering the cognitive functioning of older adults may reduce malnutrition risk. This

cross-sectional study indicates the need for robust intervention studies to investigate the efficacy of prevention or reversal of malnutrition risk factors on nutritional status.

Abbreviations

ADL, activities of daily living; BMI, body mass index; CI, Confidence Interval; EAT-10, Eating Assessment Tool; MNA®-SF, Mini Nutritional Assessment Short-Form; MoCA, Montreal Cognitive Assessment; PR, Prevalence Ratio; SD, Standard Deviation.

Author Contributions

IC wrote the manuscript, conducted statistical analysis and interpretation of the data. CW and JA designed the study and participated in manuscript preparation. AP and DP collected the data participated in pre-final manuscript editing. MR and MK provided input for statistical design, analysis and interpretation. All authors participated in the manuscript proof reading and approved the final manuscript.

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Availability of data and materials

All original data is available at Massey University College of Health, Auckland campus, New Zealand. The corresponding author can share this data upon request.

Ethics approval and consent to participate

Ethics approval was granted by the Health and Disability Ethics Committee: Northern A region 14/NTA/70/AMO1. Participants were provided with the study information and the study procedures were explained. Written consent was obtained before data collection.

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no competing interest.

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Chapter 5: Preface

This third results chapter presents findings from the quantitative study conducted at admission RAC

The chapter is presented in the format of a manuscript prepared for submission to the Australian and New Zealand journal of public health.

***Authorship**:* Chatindiara Idah, Allen Jacqueline, Hettige, Dushanka, Senior Stacey, Richter Marilize, Kruger Marlena and Wham Carol (2019). Overlap of malnutrition and frailty at admission to long-term residential aged care.

Author Contributions

IC edited of the study design (added frailty assessment), collected the data, conducted statistical analysis, interpretation of the data and wrote the manuscript. CW and JA designed the study, supervised data collection and participated in manuscript preparation. DS and SS participated in data collection. MR and MK supervised data collection and participated in manuscript preparation. All authors participated in the manuscript proof reading and approved the final manuscript.

Formatting of the text font and references has been done to meet that of the complete thesis

Overlap of malnutrition and frailty at admission to long-term residential aged care (RAC) (Results paper 3)

5.1 Abstract

Aim: Coexistence of malnutrition and frailty is likely to cause loss of independence and consequently placement to residential aged care (RAC). The aim of this study was to report the overlapping prevalence of malnutrition and frailty at admission to RAC, and to evaluate the prevalence and factors associated with malnutrition and frailty.

Methods: A cross-sectional study including 174 older adults at admission to RAC. Clinical assessments included the Mini Nutritional Assessment Short Form for nutrition status, Fried phenotype for frailty status, and physical performance assessments of gait speed and muscle strength. Questionnaires capturing sociodemographic and health factors were administered. A Cox regression analysis was conducted to identify the factors associated with malnutrition and frailty.

Results: Of the 174 participants (mean age 85.5 years, 61% women), four in ten (43%) were both malnourished and frail. Overall, 76% of participants were frail and 24% were pre-frail. Forty-eight percent were malnourished and 45% were at risk of malnutrition. Low risk of malnutrition was associated with unit increases in muscle strength [0.96 (0.93-0.99)], gait speed [0.27 (0.10-0.73)], and pre-frailty status [0.32 (0.12-0.83)].

Conclusion: The high overlapping prevalence (43%) highlights the importance of early and ongoing screening of malnutrition risk in RAC for timely dietary intervention; and considering the overlap with frailty to design appropriate complementary interventions.

Keywords

Malnutrition; Frailty; Long-term residential aged care

5.2 Introduction

Malnutrition and frailty are related and frequently observed geriatric syndromes (Verlaan et al. 2017; Laur et al. 2017; Hu et al. 2017; Cruz-Jentoft et al. 2017; Jeejeebhoy 2012), which are associated with loss of independence, poor quality of life (Rasheed and Woods 2013; Kojima et al. 2016) and high mortality risk (Laur et al. 2017; Hu et al. 2017; Kamo et al. 2017). Loss of independence is a key factor that necessitates placement to residential aged care (RAC) (Wiles et al. 2011; Jorgensen

et al. 2009). Compared to living in the community, RAC placement is a less preferred option for several older adults (Wiles et al. 2011; Jorgensen et al. 2009), as well as an economic burden to the health system. Currently, older adults utilise approximately 42% of district health board expenses, of which over half (60%) is used for support services in RAC (Ministry of Health 2016). In New Zealand about half of older adults enter RAC before they die (Broad et al. 2015) and almost 13% die within the first six months of placement – all cause mortality (Connolly et al. 2014). Multidimensional health status screening at admission to RAC can enable early diagnosis of conditions and implementation of appropriate interventions, which may help improve the quality of life of residents after RAC admission, and moderate RAC health expenses.

A high prevalence (30-50%) of malnutrition i.e. inadequate nutrient and energy intake, among older adults living in RAC setting has been reported (Gaskill et al. 2008; Suominen et al. 2005). Malnutrition at an older age is complex, and the elevated prevalence of malnutrition observed in RAC could be the reason for or consequence of RAC placement. For example, as older adults move to RAC, the changes in social status can impact nutritional status (Ramic et al. 2011; Wham et al. 2015; Eskelinen, Hartikainen, and Nykänen 2016). This highlights the importance of malnutrition screening at admission to RAC. Those who are malnourished experience a significant decline in muscle mass, which leads to physical frailty. The age-related loss of muscle mass and strength (sarcopenia) (Cruz-Jentoft et al. 2017), is considered to be both a component (Morley et al. 2013) and an additional cause of frailty with advancing age (Cruz-Jentoft et al. 2017). Frailty is a multifaceted syndrome. By definition, frailty is a framework which provides a means to identify increased vulnerability resulting from failure of multiple physiologic systems (Fried et al. 2001). The Fried phenotype criterion (Fried et al. 2001) is a robust and most frequently used frailty assessment instrument (Buta et al. 2016; Dent, Kowal, and Hoogendijk 2016). Older adults in nursing homes are frequently considered frail, but few studies have objectively reported the prevalence of frailty in this setting. In a systematic review and meta-analysis, only nine studies that assessed frailty among RAC residents were identified, reporting a wide range of frailty prevalence (19-76%) (Kojima 2015).

Both malnutrition and frailty have been linked to a general decline in health status, including increasing number of medications and comorbidities, poor dentition, swallow difficulties, low cognition (Agarwal et al. 2013; Moreira et al. 2016; Pegorari and Tavares 2014), loss of independence and poor quality of life (Rasheed and

Woods 2013; Kojima et al. 2016). Similarities in symptoms and factors associated with malnutrition and frailty explains why sometimes similar treatment strategies are implemented for those who appear malnourished or frail (Laur et al. 2017). However, given the differences in aetiology of these conditions (Jeejeebhoy 2012), it is important interventions are tailored specifically for malnutrition or frailty. For those with both conditions, provision of interventions that considers the intersection between malnutrition or frailty maybe more suitable (Laur et al. 2017). While emerging research indicates the importance of considering the overlap and distinctiveness of these conditions in research and clinical practice (Laur et al. 2017; Verlaan et al. 2017), studies which have reported the overlap of malnutrition and frailty in the RAC setting are limited (Laur et al. 2017). Understanding the magnitude of the overlap at admission to RAC is key for early intervention planning and to help identify those 'at risk' – the group which may benefit most from early intervention. The aim of this study was to report the overlapping prevalence of malnutrition and frailty at admission to RAC, and to evaluate the prevalence and factors associated with malnutrition and frailty.

5.3 Methods

Study design

A cross-sectional study was conducted among 174 adults aged ≥65 years (≥55 years if of Maori and Pacific descent), within the first week of admission to RAC. A younger age group was included for Māori and Pacific participants as they have a lower life expectancy compared to other ethnicities (Statistics New Zealand 2018). The details about RAC services and the types of care offered in New Zealand is provided elsewhere (Ministry of Health 2012). In short, there are four main types of RAC depending on the level of care required; rest home, long-stay hospital, dementia and psycho-geriatric units (Ministry of Health 2012). The study included residents admitted for either rest home or hospital level of care, at facilities under the Waitemata District Health Board (WDHB) region of Auckland, New Zealand. Participants were excluded if they were under palliative care, or if previously diagnosed with dementia, swallow disorders, malabsorptive disorders, cancer of the larynx or psychiatric eating disorders.

Ethical approval was gained from the Health and Disability Ethics Committee: Northern A (Application 14/NTA/70).

Recruitment and Data collection

Forty-one out of 63 RAC facilities registered with the WDHB, agreed to participate. Weekly calls to RAC facility managers were made to check for new admissions. Investigators visited potential participants to provide study details and seek written consent. A family member served as a proxy if participants were unable to provide written consent. Demographic and health data were recorded from medical files and from the participants. The health data included a list of co-morbidities, medications and nutritional supplements taken. Participants were asked if they were able to perform activities of daily living (ADL) such as shopping, cleaning and cooking, prior to RAC admission. Self-reported dental status was recorded as either dentate (able to chew food without appliances), or non-dentate (missing teeth contributing to chewing problems and/or usage of dental appliance). All data were collected during a single visit between April and October 2017, and all assessments were conducted by three trained nutrition and dietetics researchers (IC, DH, SS).

Malnutrition status

Using the Mini Nutritional Assessment Short Form (MNA®SF) cut-off points (Kaiser et al. 2009); nutrition status was defined as well-nourished (MNA®SF score ≥12), at risk of malnutrition (MNA®SF 8-11) or malnourished (MNA®SF score 0-7). Consequently, malnutrition status was categorised as malnourished (MNA®SF score 0-7) and non-malnourished (MNA®SF score 8-14). All assessments were performed per the MNA®SF user guide (Rubenstein et al. 2001).

Dysphagia risk

The Eating Assessment Tool-10 (EAT-10), is a 10 item self-reported validated questionnaire that assesses perception of swallowing difficulty (dysphagia). An increased EAT-10 score indicates increasing dysphagia risk or swallowing difficulties and an EAT-10 score ≥3 is suggestive of swallow impairment (Belafsky et al. 2008).

Cognitive status

Cognitive status was determined using a validated questionnaire – the Montreal Cognitive Assessment (MoCA) (Nasreddine et al. 2005). A standardised protocol was used to conduct the MoCA to screen for mild cognitive impairment (MCI) (Nasreddine 2004). The total possible score is 30 points, and a score ≤26 indicates some level of cognitive impairment (Nasreddine et al. 2005).

Muscle strength

Muscle strength was assessed using hand grip strength (Cruz-Jentoft et al. 2010). A hand dynamometer, Jamar Hydraulic Dynamometer (model #5030J1, Sammons Preston, USA) was used. The measurement procedure conformed to the standard approved by the American Society of Hand Therapists (ASHT) (Roberts et al. 2011). The mean of three measurements, from the dominant hand was recorded. A cut-off point of <20kg for women and <30kg for men indicates low muscle strength and risk for sarcopenia (Cruz-Jentoft et al. 2010), thus it was used to indicate a positive score for the frailty low muscle strength criterion.

Gait Speed

Mobility was assessed using a 2.4 meter (8 foot) walk test. Using a retractable tape measure, two cones were placed 0.6m apart at one end of an unobstructed area of floor. A third cone was placed 2.4m from the second cone, and a fourth cone was placed 0.6m from the third. A stopwatch (Accusplit, Survivor, Pleasanton, CA) was used to obtain the time taken to complete the 2.4m walk, i.e. between the second and third cone (Guralnik et al. 1994). The 2.4m walk was performed 3 times and the mean and fastest time taken to complete the walk were recorded in seconds. The fastest 2.4m walk (*secs*) was converted to a 2.4m gait speed (*m/s*) and the 2.4m gait speed was converted to a 4m gait speed (m/s) using the following validated equations (Guralnik et al. 2000):

For 2.4m gait speed ≤ 1.0 m/s

- 4-m gait speed = 0.01 + (2.4m gait speed) (1.052).

For 2.4m gait speed > 1.0 m/s

- 4-m gait speed = 0.481 + (2.4m gait speed) (0.581)

From the 4m gait speed, a cut-off point of ≤0.8 m/s indicates low gait speed and sarcopenia risk (Cruz-Jentoft et al. 2010), thus it was used to indicate a positive score for the frailty low gait speed criterion. Additionally, participants who were chair bound or whom clinical notes indicated a recent fall or 'risk of fall' were not asked to perform the walk test and were also recorded as having a low gait speed.

Frailty Status

Frailty assessment was based on the Fried phenotype criterion, which describes frailty as having three or more positive frailty scores of the following: low gait speed, low muscle strength, low physical activity, extreme exhaustion and unintentional weight loss (UWL) (Fried et al. 2001). Having one or two of the conditions was considered pre-frail (Fried et al. 2001). In participants whom it was not feasible to

record a score for one or two components, the data was recorded as "not scored", and the total frailty score was recorded from the remaining criterions (Bieniek, Wilczyński, and Szewieczek 2016).

Positive frailty scores for **low gait speed** and **low muscle strengt**h were recorded based on the assessments described in detail above. A positive score for the frailty '**low physical activity**' criterion was recorded in participants responding: "one to three times a month" or "hardly ever or never" to the question: *"How often do you engage in activities that require a low or moderate level of energy such as gardening, cleaning the car, or going for a walk?"* (Santos-Eggimann et al. 2009). [*Responses: 1 = "More than once a week"; 2 = "Once a week"; 3 = One to three times a month" and 4 = "Hardly ever or never"]*. As recommended by Fried et al. (Fried et al. 2001), **exhaustion** was assessed using the two statements from the Centre for Epidemiologic Studies Depression (CES-D) Scale (Orme, Reis, and Herz 1986). A positive score for the frailty exhaustion criterion was recorded, if a participant answers "moderate or most of the time" to either of the two questions: *1) "How often in the last week did you feel that everything you did was an effort 2) "How often in the last week did you feel that you could not get going" [Responses: 1 = Rarely or none of the time (<1 day); 2 = Some or little of the time (1 to 2 days); Moderate amount of the time (3 to 4 days); 4 = Most of the time (5 to 7days)]*. Finally, **unintentional weight loss (UWL)** was self-reported; or if previous weight was available on the clinic portal, UWL was calculated through subtracting the 'current body weight' as weighed on the data collection day from the previous 3 months record. A positive score for the frailty UWL criterion was met for participants who had lost more than 3kg within the preceding 3 months.

Statistical analysis

All statistical analyses were completed using SPSS version 24. Results were considered significant at $p<0.05$. Analyses compared participants characteristics by malnutrition status: non-malnourished *vs* malnourished, and by frailty status: non-frail *vs* frail. Continuous data were checked for normality. Independent t-test was performed to compare the differences between normally distributed data (mean ± SD) and non-parametric data (median and interquartile range (IQR)) were analysed using the Mann Whitney U test. Categorical data are presented as frequencies and percentages, and Chi-square test of independence or Fisher exact test was used to compare the differences between categories. To assess for factors associated with malnutrition and frailty a series of Cox regression analyses adjusting for non-

modifiable human factors (age, gender and ethnicity), number of medications and comorbidities were performed as these factors are known to influence institutionalisation. All models were adjusted for these factors as they influence malnutrition and institutionalisation. To assess whether an independent association existed between malnutrition and frailty, an additional Cox regression analyses adjusting for all variables assessed was conducted. Prevalence ratio (PR) and 95% confidence interval (CI) were reported from the regression analyses.

Due to the high prevalence of malnutrition and frailty, a Cox regression with equal follow-up time was conducted, as there was a high chance for logistic regression to overestimate PR and inadequately control for confounding factors (Barros and Hirakata 2003). Findings from the logistic regression analyses confirmed the overestimation of the PR, and when adjusting for similar confounding factors used in the Cox regression model, more factors were identified as statistically associated with malnutrition and frailty.

5.4 Results

Participants' characteristics

A flow chart for recruitment of the participants is provided in Figure 1. A total of 174 older adults were recruited, of whom 75% were entering RAC as permanent residents while 25% were short-term (interim or respite) care. Participants were of mean age 85.5 ± 7.5 years and median BMI 22.1 (6.8) kg/m^2. About 61% were women, 66% were single, widowed or divorced and 64% were of New Zealand European ethnicity. A large proportion (%) of these participants demonstrated a low gait speed (90%), low muscle strength (93%), ≥mild cognitive impairment (69%), non-dentate dental status (71%), polypharmacy (70%) and ≥5 comorbidities (65%). Over half (64%) of the participants were taking nutrition supplements – on average, just one supplement. These were mostly vitamin D, an oral nutrition supplement or multivitamins. The participants' characteristics by malnutrition and frailty status are provided in Table 1.

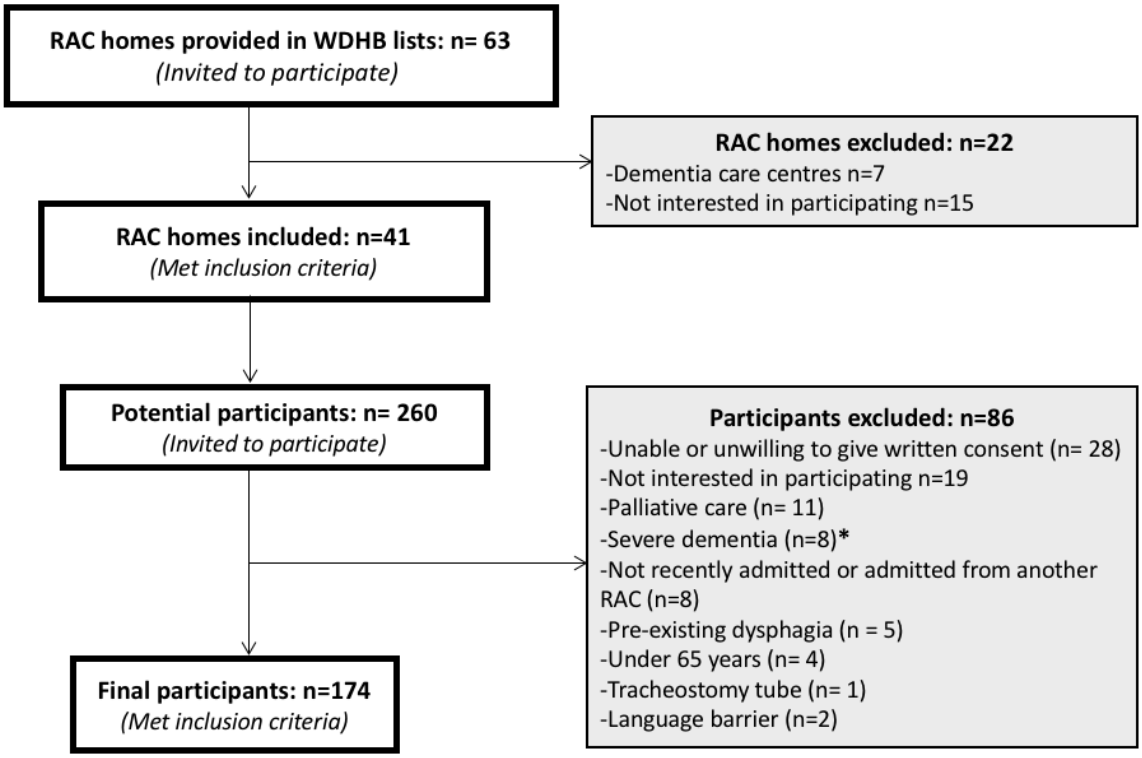

Fig.1 Participants recruitment flow chart

*Additional numbers of participants who got admitted with dementia not captured as the RAC clinical managers screened and excluded these when providing the weekly list of newly admitted older adults.

Table 1. Participants Characteristics by Malnutrition and Frailty Statuses

Characteristics	Total	Malnutrition Status			Frailty Status		
		Non-malnourished [a.]	Malnourished	*p* Value	Non-Frail [a.]	Frail	*p* Value
	N=174	91 (52.3%)	83 (47.7)		42 (24.1%)	132 (75.9%)	
Gender							
Men	68 (39.1%)	37 (54.4%)	31 (45.6%)	0.655	19 (27.9%)	49 (72.1%)	0.348
Women	106 (60.9%)	54 (50.9%)	52 (49.1%)		23 (21.7%)	83 (78.3%)	
Age (years)							
Mean ± SD	*85.5 ± 7.5*	*84.7 ± 7.5*	*86.4 ± 7.4*	0.133	*83.5 ± 7.5*	*86.1 ± 7.4*	0.044**
BMI (kg/m²) [b.]							
Median (IQR)	*22.2 (6.8)*	*23.1 (6.5)*	*20.5 (7.3)*	*0.002***	*22.2 (7.7)*	*22.1 (6.7)*	*0.632*
Ethnicity							
NZ European	111 (63.8%)	56 (50.5%)	55 (49.5%)	0.517	22 (19.8%)	89 (80.2%)	0.077
'Other' Ethnicities [c.]	63 (36.2%)	35 (55.6%)	28 (44.4%)		20 (31.7%)	43 (68.3%)	
Marital status							
Married/ Partnered	59 (33.9%)	29 (49.2%)	30 (50.8%)	0.552	10 (16.9%)	49 (83.1%)	0.112
Single [d.]	115 (66.1%)	62 (53.9%)	53 (46.1%)		32 (27.8%)	83 (72.2%)	
Education							
Tertiary	41 (23.6%)	18 (43.9%)	23 (56.1%)	0.319	7 (17.1%)	34 (82.9%)	0.349
Secondary	104 (59.8%)	55 (52.9%)	49 (47.1%)		29 (27.9%)	75 (72.1%)	
Primary	29 (16.7%)	18 (62.1%)	11 (37.9%)		6 (20.7%)	23 (79.3%)	
Income Source							
Pension plus other income	42 (24.3%)	16 (38.1%)	26 (61.9%)	0.030**	9 (21.4%)	33 (78.6%)	0.621
Pension only income	131 (75.7%)	75 (57.3%)	56 (42.7%)		33 (25.2%)	98 (74.8%)	
Living arrangements prior admission							
Lived with others	84 (48.3%)	39 (46.4%)	45 (53.6%)	0.134	14 (16.7%)	70 (83.3%)	0.026**
Lived alone or spouse only [e.]	90 (51.7%)	52 (57.8%)	38 (42%)		28 (31.1%)	62 (68.9%)	

ADL disability prior admission							
Not disabled	47 (27.0%)	32 (68.1%)	15 (31.9%)	0.011**	18 (38.3%)	29 (61.7%)	0.008**
Disabled for ≥1 ADL	127 (73.0%)	59 (46.5%)	68 (53.5%)		24 (18.9%)	103(81.1%)	
Prior setting							
Community	114 (65.5%)	66 (57.9%)	48 (42.1%)	0.042**	33 (28.9%)	81 (71.1%)	0.041**
Hospital	60 (34.5%)	25 (41.7%)	35 (58.3%)		9 (15.0%)	51 (85.0%)	
Type of admission							
Short term [f.]	44 (25.3)	28 (63.6%)	16 (36.4%)	0.082	10 (22.7%)	34 (77.3%)	0.800
Permanent	130 (74.7%)	63 (48.5%)	67 (51.5%)		32 (24.6%)	98 (75.4%)	
RAC level of care							
Rest home	98 (56.3%)	66 (67.3%)	32 (32.7%)	<0.001**	32 (32.7%)	66 (67.3%)	0.003**
Hospital	76 (43.7%)	25 (32.9%)	51 (67.1%)		10 (13.2%)	66 (86.8%)	
Dental status							
Dentate	50 (28.7%)	30 (60.0%)	20 (40.0%)	0.197	12 (24.0%)	38 (76.0%)	0.978
Non-dentate [g.]	124 (71.3%)	61 (49.2%)	63 (50.8%)		30 (24.2%)	94 (75.8%)	
Dysphagia							
No Dysphagia	108 (62.1%)	62 (57.4%)	46 (42.6%)	0.084	31 (28.7%)	77 (71.3%)	0.072
At dysphagia risk	66 (37.9%)	29 (43.9%)	37 (56.1%)		11 (16.7%)	55 (83.3%)	
MoCA score [h.]							
Mean ± SD	*14.6 ± 6.1*	*14.9 ± 6.7*	*14.3 ± 5.4*	*0.555*	*14.2 ± 7.3*	*14.8 ± 5.7*	*0.657*
Cognitive status [h.]							
Normal cognition	4 (2.4%)	4 (100%)	0 (0.0%)	0.008**	3 (75.0%)	1 (25.0%)	0.036**
≥mild cognitive	115 (68.5%)	66 (57.4%)	49 (42.6%)		29 (25.2%)	86 (74.8%)	
impairment	49 (29.2%)	18 (36.7%)	31 (63.3%)		8 (16.3%)	41 (83.7%)	
Incomplete MoCA							
Number of prescribed medications *Mean ± SD*	*6.1 ± 2.9*	*5.6 ± 2.3*	*6.6 ± 3.3*	*0.023***	*5.5 ± 2.4*	*6.3 ± 3.0*	*0.096*
Polypharmacy							
≥5 prescribed medications	53 (30.5%)	29 (54.7%)	24 (45.3%)	0.673	15 (28.3%)	38 (71.7%)	0.396
<5 prescribed medications	121 (69.5%)	62 (51.2%)	59 (48.8%)		27 (22.3%)	94 (77.7%)	

Number of Comorbidities *Mean ± SD*	*5.7 ± 2.3*	*5.5 ± 2.2*	*5.8 ± 2.3*	*0.457*	*5.6 ± 2.4*	*5.7 ± 2.2*	*0.738*
<5 comorbidities	61 (35.1%)	30 (49.2%)	31 (50.8%)	0.545	16 (26.2%)	45 (73.8%)	0.636
≥5comorbidities	113 (64.9%)	61 (54.0%)	52 (46.0%)		26 (23.0%)	87 (77.0%)	
Nutrition supplements							
Not taking	63 (36.2%)	41 (65.1%)	22 (34.9%)	0.011**	16 (25.4%)	47 (74.6%)	0.770
Taking [i.]	111 (63.8%)	50 (45.0%)	61 (55.0%)		26 (23.4%)	85 (76.6%)	
Muscle strength [j] *(kg)*							
Median HGS (IQR)	*12.3 (10.5)*	*14.0 (9.3)*	*10.4 (11.5)*	*0.003***			
Healthy muscle strength	12 (7.5%)	8 (66.7%)	4 (33.3%)	0.375			
Low muscle strength	149 (92.5%)	76 (51.0%)	73 (49.0%)				
Gait speed [k.] (m/s)				*<0.001***	*Not analysed: variables are components of the outcome measure.*		
Median (IQR)	*0.01 (0.5)*	*0.28 (0.61)*	*0.01 (0.23)*				
Healthy gait	16 (9.8%)	15 (93.8%)	1 (63.3%)	0.001**			
Low gait	148 (90.2%)	74 (50.0%)	74 (50.0%)				
Frailty Status							
Non-frail	42 (24.1%)	34 (81.0%)	8 (19.0%)	<0.001**			
Frail	132 (75.8%)	57 (43.2%)	75 (56.8%)				

ADL, activities of Daily Living; BMI, Body Mass Index; HGS, Hand grip strength; MNA®SF, Mini Nutritional Assessment Short-Form; SD, Standard deviation
Results reported as frequencies n (%), unless otherwise indicated. Percentages (%) in the total column are percentage of the total study sample. All other percentages are percentage total within a characteristics' category.
***p* value significant at p<0.05, mean ± SD, independent T-test; median (IQR), Mann Whitney U test; n (%), Chi-square or Fisher's exact.
[a.] Non-**malnourished**: well-nourished n=13, at risk of malnutrition n=78. **Non-frail**: Robust n=0, pre-frail n=42.
[b.] BMI missing data n=32, unwilling or unable to stand on scale
[c.] Other ethnicities: Māori/Pacific n= 5, others n=58
[d.] Single: widowed n = 8, divorced n = 18, single/never married n = 13
[e.] n=54 lived with spouse only
[f.] Short term: Interim care n=15 Respite care=29
[g.] Non-dentate: n=12 were edentulous, n=112 used dental appliances
[h.] n=29 missing data, unwilling to complete the MoCA
[i.] average number of nutrition supplements taken n=1
[j.] n=10 missing data
[k.] n= 13 missing data

The overlapping prevalence of malnutrition and frailty

Almost half [75 (43.1%)] of the participants had coexisting malnutrition and frailty, 65 (37.4%) were either frail or malnourished and the remaining 34 (19.5%) were neither malnourished nor frail. Figure 2 illustrates the coexistence or overlap between malnutrition and frailty. Nine in 10 (90%) of the malnourished participants were identified as frail, and about 6 in 10 (55%) of frail participants were malnourished.

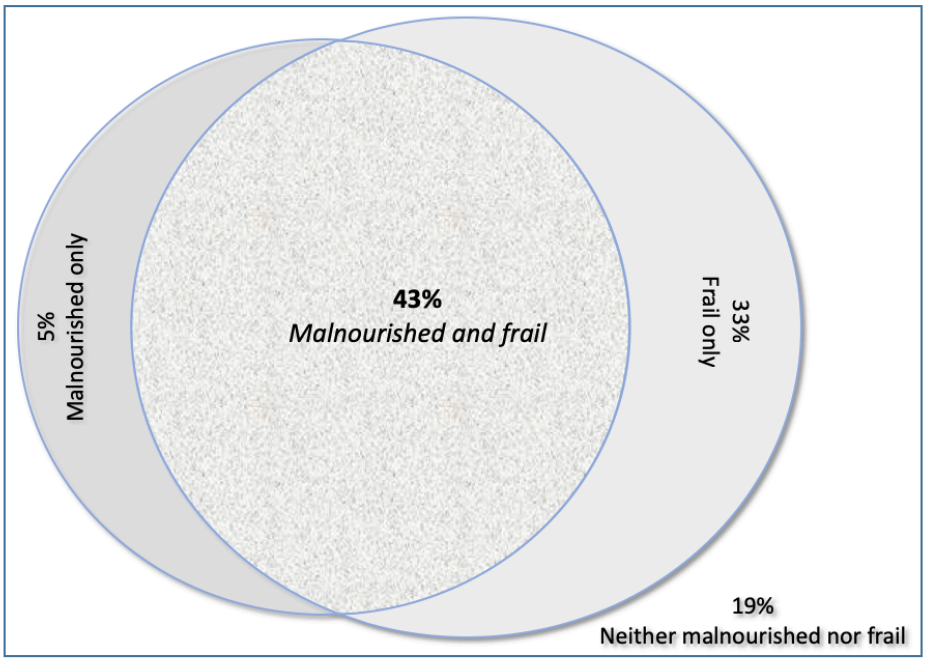

Fig. 2. Overlap between malnutrition and frailty at admission to RAC.

Prevalence and factors associated with malnutrition and frailty.

About half [83 (47.7%)] of the participants were identified as malnourished. A further 78 (44.8%) were at risk of malnutrition and 13 (7.5%) were well-nourished. Three-quarters of the participants were frail, 42 (24.1%) were pre-frail and none were robust. Table 2 shows the results from a Cox regression analysis of factors associated with malnutrition and frailty. After adjusting for age, gender, ethnicity, number of medications and comorbidities, lower risk for malnutrition was associated with RAC level of care: rest home (vs hospital) [0.52 (0.33-0.83)], unit increases in participants muscle strength (kg) [0.96 (0.93-0.99)] and gait speed (m/s) [0.27 (0.10-0.73)], and frailty status: non-frail (vs frail) [0.37 (0.17-0.77)]. An independent association between malnutrition and frailty was found after adjusting for several additional factors (full Cox regression model[£], Table 2), whereby non-frail older adults had about 68% lower risk for malnutrition [0.32 (0.12 – 0.83)], when compared to frail participants (Table 2).

Table 2. Factors associated with malnutrition and frailty at admission to RAC: Cox regression model

	Malnutrition		Frailty	
Factors	**Adjusted* PR (95% CI)**	***p* Value***	**Adjusted* PR (95% CI)**	***p* Value***
ADL disability				
Not disabled (*vs*. Disabled for ≥1 ADL)	0.60 (0.34 – 1.06)	0.079	0.75 (0.50 – 1.14)	0.787
Prior setting				
Community (*vs*. Hospital)	0.82 (0.52 – 1.29)	0.382	0.89 (0.62 – 1.29)	0.538
Type of admission				
Short term (*vs*. Permanent)	0.66 (0.38 – 1.15)	0.138	0.99 (0.67 – 1.48)	0.966
RAC level of care				
Rest home (*vs*. Hospital)	0.52 (0.33 – 0.83)	0.005**	0.81 (0.57 – 1.15)	0.236
Dental status				
Dentate (*vs*. Non-dentate)	0.84 (0.50 – 1.39)	0.492	1.05 (0.72 – 1.55)	0.789
Dysphagia risk: *EAT-10 score*	1.02 (0.98 – 1.06)	0.263	1.00 (0.97 – 1.04)	0.954
Cognitive status *(MoCA score)*	0.99 (0.95 – 1.03)	0.703	1.01 (0.97 – 1.04)	0.719
Number of nutrition supplements	1.16 (0.95 – 1.43)	0.148	0.99 (0.83 – 1.19)	0.922
Muscle strength *(kg)*	0.96 (0.93 – 0.99)	0.017**		
Gait speed *(m/s)*	0.27 (0.10 – 0.73)	0.010**		
Frailty status				
Non-frail (*vs*. Frail)	0.37 (0.17 – 0.77)	0.008**		
Full model[£]				
Frailty Status				
Non-frail (*vs*. Frail)	0.32 (0.12 – 0.83)	0.019**[£]		

Not analysed: variables are components of the outcome measure

*p-value significant at p<0.05, Cox regression analyses. All factors adjusted for Age, Gender, Ethnicity, number of Medications and Comorbidities.

[£]**Full model**: Frailty status adjusted for Age, Gender, Ethnicity, Marital status, Education, Pension income, Living arrangements, ADL disability, Prior setting, Admission type, Level of care, Dentate or Non-dentate, EAT-10 final score, MoCA final score, Number of regular prescription medications, Number of comorbidities.

5.5 Discussion

Our study shows that 4 in 10 (43%) participants were both malnourished and frail at admission to RAC. These participants were older (mean age 85.5 years) and more vulnerable, as a larger proportion (%) demonstrated low gait speed (90%), low hand grip strength (93%), ≥mild cognitive impairment (69%), non-dentate dental status (71%), polypharmacy (70%) and ≥5 comorbidities (65%).

Our study is the first to report this overlapping prevalence (43%) of malnutrition and frailty at admission to RAC. The findings are congruent to the 47% prevalence reported among all (n = 160) older adults ≥85 years who lived in two nursing homes of Japan, where coexistence of malnutrition and frailty was found to predict mortality (Kamo et al. 2017). The overlap we observed is higher when compared to findings from a systematic review and meta-analysis of community-dwelling older adults (Verlaan et al. 2017). While we found 9 in 10 malnourished older adults were frail, and almost 6 in 10 (55%) of frail participants were malnourished, the cited systematic review and meta-analysis found 7 in 10 malnourished older adults were frail, and almost 1 in 10 (8%) of frail participants were malnourished (Verlaan et al. 2017). The higher prevalence of overlap in malnutrition and frailty in RAC admissions when compared to community dwelling participants can be explained by the older age and presence of multiple chronic conditions among RAC admissions.

The prevalence of malnutrition (48%) and frailty (76%) in the current study is similar to other observations among RAC residents, where up to 50% of older adults have been reported to be malnourished (Gaskill et al. 2008; Suominen et al. 2005) and up to 76% as frail (Kojima 2015). We also found nearly half (45%) of the participants were at risk of malnutrition and about a quarter (24%) were at risk of frailty (pre-frail). This indicates a significant proportion of older adults where risk for malnutrition and/or frailty could potentially be lowered with early screening and effective nutrition and/or frailty interventions. Our data shows no significant difference in the prevalence of malnutrition or frailty, between those requiring short term versus permanent admission to RAC. Although adults entering RAC for short term care are usually considered more independent than those entering RAC for permanent residence, this finding suggests that both groups had significant declines in physical functioning and nutritional status. During the seven-month data collection period we identified several participants initially admitted for a short-term placement, who returned for permanent RAC placement. Screening for malnutrition and/or frailty at admission to RAC regardless whether short or long-term placement may help reduce unrecognised malnutrition and/or frailty among community-dwelling older adults. This will enable early intervention to occur, reducing health burden and risk of complications for both community-dwelling older adults and RAC residents.

The current study demonstrates that after adjusting for several factors, non-frail older adults had about 68% lower risk for malnutrition [0.32 (0.12 – 0.83)], when compared to frail participants. An independent association between malnutrition and frailty has

previously been reported among older adults (mean age 67 (Wei et al. 2017) and 76 years (Boulos, Salameh, and Barberger-Gateau 2016)) residing in the community. In our study, malnutrition was found to be associated with low gait speed and low muscle strength (hand grip strength), which are both components of the Fried phenotype (Fried et al. 2001). Although the Fried phenotype is the most widely used frailty assessment tool, a full consensus has not been reached on the gold standard for frailty assessment in older adults (Morley et al. 2013). Some studies suggest use of one or two physical performance measures such as hand grip strength (Syddall et al. 2003), timed up and go and gait speed (Clegg, Rogers, and Young 2014), as adequate markers for frailty. A bi-directional hazardous relationship exists between malnutrition and frailty. While malnutrition is a major cause of muscle loss and frailty (Kaiser, Bandinelli, and Lunenfeld 2010; Goisser, Guyonnet, and Volkert 2016), there are several mechanisms by which frailty can also lead to inadequate nutrient and energy intake. Frail older adults may have inadequate muscle strength or mobility (Fried et al. 2001) needed for meal preparation, and are likely to have low appetite (Martone et al. 2013) and swallowing difficulties (Payne and Morley 2018), which reduces food intake. Although no other study has reported an association between malnutrition and frailty among older New Zealanders, associations between malnutrition and some of the individual components of physical frailty including lower physical health related quality of life (Wham et al. 2015), low muscle strength (Chatindiara, Allen, et al. 2018) and low gait speed (Chatindiara, Williams, et al. 2018) have been reported. The aforementioned studies and the current study findings provide support for co-existence of malnutrition and frailty among older New Zealanders across residential settings.

When adjusting for covariates (Table 2), no statistically significant associations were found between malnutrition/frailty and potential risk factors including dental status, dysphagia risk, taking nutrition supplements and cognitive status. This is inconsistent with previous observations, where the aforementioned factors have been associated with malnutrition (Agarwal et al. 2013; Moreira et al. 2016) and frailty (Pegorari and Tavares 2014; Bahat et al. 2018). Since our study design included an in-person clinic visit at the RAC centre, with assessments lasting for about an hour, older adults with dementia, terminal illnesses or under palliative care were excluded, and we acknowledge prevalence ratios would have been higher with the inclusion of those conditions. Initial exclusion criteria reduced the number of participants who would have shown pre-existing dysphagia complaints or cognitive impairments, thus limiting

the ability to directly observe correlations to the malnutrition/frailty axis. In future we would like to examine associations of malnutrition/frailty with these high-risk factors.

The following study limitations are noted. While a snapshot of prevalence and coexistence of malnutrition and frailty at admission to RAC is provided, the sample size may not be statistically powered for external generalisability, nor preventing type two errors (failure to reject a false null hypothesis which stated that there is no association between the risk factors and malnutrition/frailty). This may explain some of the non-statistically significant associations reported. Two-thirds of the participants showed some level of cognitive impairment; hence, the possibility of recall bias cannot be completely ruled out for the assessments that relied on participant's memory. To increase reliability and accuracy of the subjective data collected from participants with some level of cognitive impairment, the data was cross-checked with clinical notes, a family member, or a registered nurse at the RAC. Although the study design included body composition assessment using bio-impedance analysis (BIA) scales, only 42 participants completed this assessment as most participants had metal implants or were unable to standstill on the BIA scale. In future studies, the use of body composition assessment equipment where older adults lie prone may assist with measurement.

To the best of our knowledge, no other study has reported coexisting malnutrition and frailty at admission to RAC, and this study is one of the first few studies to focus on understanding this overlapping prevalence among individuals with high risk of chronic diseases. In our study, the two main outcome measures were assessed using validated and widely used screening and assessment tools for malnutrition (MNA®SF (Kaiser et al. 2009)) and frailty (Fried phenotype (Fried et al. 2001)). Previous research reported the MNA®SF as the most appropriate screening tool for older adults in long-term geriatric settings (Donini et al. 2016). The Fried phenotype assessment procedure is both robust and objective (Fried et al. 2001; Dent, Kowal, and Hoogendijk 2016).

5.6 Conclusion

This study demonstrates that coexisting malnutrition and frailty is prevalent at admission to RAC, affecting 4 in 10 older adults. Furthermore, nearly half (45%) of the participants were at risk of malnutrition and about a quarter (24%) at risk of frailty (pre-frail). This indicates a significant proportion of older adults where risk for malnutrition and/or frailty could potentially be lowered with early screening for

malnutrition and/or frailty, and effective intervention. Therefore, overall this study provides evidence that helps inform policy and practice on the importance of mandatory routine screening for malnutrition from RAC admission date – as a first step to ensure timely intervention. Among these vulnerable older adults, distinct prevalence ratios were observed (48%-malnutrition *vs* 76%-frailty); supporting emerging research which highlights the importance of understanding the overlap and distinctiveness of malnutrition and frailty, in order to design the most appropriate complementary interventions.

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Chapter 6: Preface

This forth results chapter presents findings from the qualitative study conducted among vulnerable older adults living in the community

The chapter is presented in manuscript format and has been published in the Appetite Journal: Impact Factor 4.1.

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Author Contributions

IC was responsible for all aspects of the manuscript including study conceptualisation, study designing, data collection, transcription of the transcripts, transcripts coding, data analysis, manuscript drafting and handled publication correspondences. NS participated in data analysis and coding. NS, CW and MK participated in study designing, supervised data collection and participated in manuscript preparation. All authors participated in the manuscript proof reading and approved the final manuscript.

Formatting of the text font and references has been done to meet that of the complete thesis

Eating less the logical thing to do? Vulnerability to malnutrition with advancing age (Results paper 4)

6.1 Abstract

The aim of this qualitative inquiry was to explore older New Zealanders perspectives and experiences of food and nutrition intake, to gain insights to factors that influence vulnerability to malnutrition risk at older age. Participants represented an ethnically diverse group of nutritionally vulnerable older adults (five malnourished and nine at risk), with most participants identifying as having an illness severity of moderate or severe. Thematic content analysis was performed using an integrated approach and took into account participants' nutritional status as determined using the Mini Nutritional Assessment-Short Form. Six key themes emerged. Almost all participants reported they had reduced their food intake and felt that eating less, was the **'logical'** thing to do as they were now undertaking less physical activity. They described eating as a **chore;** they ate because they 'had to keep going', but hardly ever felt hungry (low appetite); they had lost interest in eating, and no longer found food fanciful. Being in the **company** of others encouraged eating except in stressful situations such as caring for an ill spouse. They had a **preference** for foods they had grown up with but could no longer readily access or needed to **avoid** some foods because of coexisting conditions or illnesses, food intolerance and chewing difficulties. Finally, participants tried to eat foods best for their **health**. The notion of healthy eating as consuming "more vegetables" was widely held, with some participants explaining this meant "less fat and less sugar". Overall, the low food intake reported by these participants appears shaped by a myriad of sociocultural and health related factors. The findings can be used as a foundation to develop strategies for preventing vulnerability to malnutrition with advancing age.

Keywords

Nutritional vulnerability; community; older adults; eating less; qualitative study

6.2 Introduction

With advancing age, meeting the recommended daily energy and nutrient intake may be a challenge, as several factors combine to increase older adults' vulnerability to malnutrition (undernutrition) (Hickson 2006). Malnutrition tends to occur as a continuum, starting with the presence of risk factors that promote low food intake and unintentional weight loss (Keller 2007). Studies have reported that about one in three community living older New Zealanders is at risk of malnutrition (McElnay et al. 2012; Wham et al. 2015). The risk increases with age and is particularly high among those

of advanced age (85 years and over) (Chatindiara, Williams, et al. 2018). Several changes that promote low food intake occur with advancing age, for example a decline in overall health including the ability to chew and swallow food (Hickson 2006). Changes in sense perceptions including sight and taste can lead to a significant decline in desire to eat (appetite) (Hays and Roberts 2006). Appetite can also be further inhibited by changes in social status, particularly if older adults experience loneliness and/or bereavement for example due to loss of a spouse or friends of the same age-group (Wham et al. 2015; Wham et al. 2011). Older adults may end up living alone and become socially isolated which may lead to depression (Fiske, Wetherell, and Gatz 2009). Both living alone and depression are considered independent risk factors for malnutrition (Wham et al. 2015). Decline in muscle mass can lead to low physical function, and can make it more difficult for older adults to partake in activities required to procure, prepare and cook meals (Moreira et al. 2016; Agarwal et al. 2013; Starr, McDonald, and Bales 2015).

Access to a variety of preferred foods is important towards optimising food intake of older adults. Māori and Pacific peoples value traditional food and practices, and traditional foods form an essential part of their daily intake (Ministry of Health 2013). The New Zealand older population is becoming more multi-cultural (Statistics New Zealand 2018). Differences in country of birth and/or ethnicity can influence food preference and overall nutritional intake. However, most risk factors related to malnutrition risk such as social frailty (e.g. decline in social interaction or absence of companionship), the ability to afford or physically access adequate food, are all modifiable factors which can be targeted for prevention. Given the heterogeneity of the older population (Statistics New Zealand 2018), a qualitative inquiry can support researchers to better appreciate the types of interventions that are needed. Qualitative findings may also help to elicit intervention features that maybe perceived as unacceptable, unaffordable, inaccessible, unsustainable or burdensome (Freudenberg et al. 1995; Bartholomew Eldredge et al. 2016). The qualitative description approach is a method of choice to understand what shapes eating behaviours where a flexible way of conversing can facilitate collection of data relevant to practitioners and policy makers (Sandelowski 2000, 2010). This method can also incorporate narrative or phenomenological hues which enables researchers to pay more attention to certain phrases or experience as described by participants (Sandelowski 2000).

The aim of this qualitative inquiry was to explore older adults' perspectives and experiences of food and nutrition intake, and to gain new insights to factors that influence vulnerability to malnutrition risk at older age. The in-depth analysis took into account the participants nutrition risk status as determined using the Mini Nutritional Assessment Short Form (MNA®SF) (Kaiser et al. 2009) on data collection day.

6.3 Methods

Participant recruitment

This qualitative study recruited older adults enrolled with a medium sized urban general practice (>5,000 patients) located in Auckland, New Zealand. This practice serves a diverse socio-economic and multi-ethnic population, including indigenous Māori and Pacific peoples. Participants were purposively selected on the basis of: ethnicity (Māori, Pacific, New Zealand [NZ] European or other); gender (both men and women); age 75 years and over, except for Māori or Pacific who were 65 years or over; living in the community; and presence or absence of chronic conditions. Based on pilot interviews, we decided that we were likely to get rich data on factors that increase vulnerability to malnutrition from participants living with chronic conditions. We also included participants with few or no health conditions because healthier participants can provide perspectives on maintaining a good nutritional status (Vesnaver et al. 2012). As nutrition risk among older adults living in the community has been observed at a later age, the current study aimed to recruit adults aged 75 years and over; a 10 year younger age group for Māori/Pacific participants was included as they have a lower life expectancy compared to other ethnicities (Statistics New Zealand 2018).

Study protocol and Ethics approval

Researchers met with the general practice staff to explain the study and the recruitment of participants from their practice, and the practice agreed to support the research. Posters were displayed in the practice waiting room inviting patients to take part. The poster outlined the eligibility criteria for the study. A 'recruitment plan' was developed (Appendix 4) to guide the purposive selection of participants with diverse sociodemographic and health characteristics. Potential participants could ask the receptionist to pass their name and phone number on to the researcher (IC) or they could contact the researcher directly. Copies of the participant information sheet (PIS) and the consent form were available from the practice. The researcher (IC) phoned interested potential participants to confirm that they met the inclusion criteria, further explain the study protocol, and scheduled a face-to-face interview. All participants

were recruited and visited between March and May 2018. Before data collection began, the researcher clarified the study procedures and provided the participants with an Information Sheet to give the participants further opportunity to ask any questions. Participants were advised that all data would be saved in a de-identifiable form and no details revealing their identity will be published. Written consent was obtained ahead of the interview.

Ethical approval was gained from the Massey University Human Ethics Committee, Southern A (Application Ref. 17/74). The participating general practice was provided with a copy of the study proposal and the ethics application and used its own research ethics processes.

Data collection and analysis

The present study is best described as qualitative description (Sandelowski 2010, 2000), although narrative and phenomenological approaches were partly employed. The qualitative description approach was seen to best suit the current study, as we aimed to understand how older adults' experiences influence vulnerability to malnutrition, as part of a larger study that aims to identify intervention strategies that can inform policy and practice to encourage healthy eating at older age. A face-to-face in-depth interview was undertaken to allow for intense and detailed exploration of individuals perspectives, thoughts, behaviours and experiences (Boyce and Neale 2006). Based on previous international research (Moreira et al. 2016) and findings from our quantitative studies on key factors associated with nutrition risk among older New Zealanders, (Chatindiara, Allen, et al. 2018; Chatindiara, Williams, et al. 2018), an interview guide was designed. Two pilot interviews were conducted to test the content and language of questions, and the flow and timing of the interview. Two women aged 75 and 76 years and living alone participated in the pilot interviews. These pilot interviews were not included in the study sample. Adjustments were made to the interview guide to ensure complete coverage of the four topic areas (Table 1). For each interview, the interview guide was used as a simple guide to ensure important topics were covered, but the conversation was flexible and involved use of probes, which allows rich detail to be gained (Britten 1995). One interviewer (IC) conducted the interviews. When she began to hear the same comments again and again, which was confirmed by co-authors reading transcripts – after 13 interviews, the authors considered the data collected to have been approaching saturation (Morse 1995; Sandelowski 2008). Nevertheless a further three interviews were undertaken to "stretch diversity of data as far as possible" (Glaser and Strauss 1967)

and to ensure that saturation was based on the widest possible range of data from this multi-ethnic sample.

All interviews were conducted in the participants' homes. Data were collected on participants' demographic characteristics together with their body weight, height and nutrition risk status. A Tanita bathroom scale (Model THD-646) was used for weighing the participants and the Mini Nutritional Assessment Short Form, MNA®SF was used to assess nutrition risk status (Kaiser et al. 2009). In-depth interviews were about 60 minutes long, except on two occasions where couples were interviewed together, and the interview was about 100 minutes. While the majority of participants were interviewed alone, one frail older woman (P#012) requested that her daughter be present. All conversations were audio taped and transcribed verbatim. Transcripts formed the basis of coding and classification of themes. All thematic analysis and data coding were conducted using NVivo for mac 12 software, after all interviews were completed. To efficiently generate themes for this study (thematic content analysis), an integrated approach (Bradley, Curry, and Devers 2007) was used for code structure development. This approach retains the benefits of inductive reasoning (i.e. transcripts were read line-by-line), while also allowing the predetermined codes to help ensure key factors were considered during data analysis and interpretation (Chenail 2012). Initially, transcripts were coded under four segments/clusters as per the four topics covered in the interview guide. Additionally, new codes were added during de-novo coding. This was then followed by merging and splitting the initial segments leaving a descriptive theme for eating routines, and six main themes relating to vulnerability to malnutrition. Two researchers (IC and NS) drafted the code structure after reading the first three transcripts. All transcript coding was performed by IC and confirmed by NS. All authors agreed on the final codes.

Illness severity assessment

Given the complex information available for each patient, the current study conducted a summary assessment of illness severity, as an attempt at communicating clearly with the reader. Our assessment was principally weighted to current symptoms, i.e. functional severity in Stein's classification (Stein et al. 1987). This assessment offers the opportunity to explore data for differences between differently categorised patients (which would support theory-building). Four categories – Nil, Mild, Moderate or Severe were used to present each participant's severity of Illness. Appendix #1 and #2 provide the participant details that were considered in the categorisation of each individual's illness severity.

Table1. Interview topics

Inquiry Logic: The interview topics and questions sought to identify how past and present experiences influence food intake and potentially increase vulnerability to malnutrition

1. Eating routines – Current food and nutrition intake.

Can you tell me your usual or normal eating routine/habits?

- Types of foods and drinks regularly consumed
- Frequency: Usual number of meals consumed daily
- Eating arrangements (alone vs. with others)

2. Vulnerability to nutrition risk factors– Changes with advancing age

How would you describe your appetite?

Are you noticing or would you say there are any changes in:

- your food preferences and selection
- the amounts or portion size you eat
- your frequency of meal intake (skipping vs. not skipping meals, snacking)

How do you go about:

- grocery shopping?
- food preparation and/or cooking?

Would you say you have some challenges eating certain foods?

3. Perceptions and value placed on healthy eating

Personal rating of current eating habits (healthy, average, could be better)

Perspectives and understanding of healthy eating

Perspectives on the importance of healthy eating

Perspectives and attitude towards using nutrition information or seeking nutrition advice

Perspectives on the importance of doing some physical activity (e.g. walks, gardening etc.)

4. Approaches to improve food and nutrition intake

- Flexible questioning based on the interview. Not discussed with all participants.

6.4 Results

Participants' characteristics and eating routines

Of 16 participants included, mean age 81 years (range 65-93 years) seven were men; six were of either Māori or Pacific descent. A total of nine older adults were living alone or with a spouse only. Table 2 summarises the key characteristics for the sixteen study participants. Appendix #1 summarises the complete breakdown of characteristics per participant. The majority of participants (n=13) took more than five medications and 12 had more than five comorbidities. Based on a combination of factors considered as proxies for illness severity (Appendix #1 and #2), most (n=14) of the participants had significant health issues as indicated by an illness severity of moderate or severe. Using the MNA®SF, five participants were identified as malnourished and nine were at risk of malnutrition. Based on BMI, six participants were overweight (BMI>28 kg/m^2), but one of these (p#002) had experienced unintentional weight loss. This participant (P#002) and the remaining 10 participants with a BMI <28kg/m^2 needed to either gain weight (n=5) or prevent weight loss (n=6).

Table 2: Participants' Characteristics

Characteristics	Number of participants (n)
Gender	
Men	7
Women	9
Age (years) Median (range): 81(65-93)	
65-74	3
75-79	2
80-84	7
85-93	4
Ethnicity	
NZ/European	10
Māori	3
Pacific	3
Marital Status	
Married	7
Widowed	8
Single (never married)	1
Living Arrangements	
Live with 'others'	7
Live with spouse only	5
Living alone	4
Education Attained	
Primary	2
Secondary	11
Tertiary	3
Income source	
Pension only	12
Pension plus other income	4
Receiving home help	
Yes	6
No	10
BMI (kg/m^2) Mean (range): 25.8 (17- 43)	
BMI <23	5
BMI 23-28	5
BMI >28	6
Illness severity	
Nil/Mild	2
Moderate	9
Severe	5
Malnutrition Status	
Well-nourished	2
At risk of malnutrition	9
Malnourished	5

In general, participants described the inclusion of all major food groups within their eating routines. There was a tendency to prioritise the intake of fruit and vegetables, while limiting consumption of meat and high fat foods such as cheese or standard milk. Participant descriptions generally indicated that breakfast consisted mainly of cereal with more variety evident in the weekends. Most participants reported eating three meals a day and skipping meals was uncommon. They rarely ate between-meals and when they did, snacks mostly consisted of a cup of tea and plain biscuits. Half of the participants took a vitamin supplement, mostly Vitamin D3, while some took Vitamins B9, B12, and C. Three participants had been prescribed oral nutrition supplements (ONS), Ensure or Complan. One of these participants (*P#015)* enjoyed the ONS and had started to gain weight; another took the ONS once and although she thought it might be helpful, preferred to eat meals.

While the displacement of food groups was not evident among these participants, the major change noted with regards to eating habits was a reduction in the amount (portion size) of food consumed at mealtimes. Several participants specifically said they probably ate only half of what they had eaten in the past. A thematic analysis of the participants' perspectives and experiences of food intake identified six main themes which contribute to understanding the increasing vulnerability to

malnutrition with advancing age. The themes relate to 1. Lower food intake as a result of declining physical function (***eating less the logical thing to do***), 2. Lack of appetite and loss of interest in food (***eating is a chore***), 3. Enjoyment of eating with others except when caring for spouse (***Companionship can encourage eating while carer stress might limit benefi****t*), 4. Conditioned food preferences and habits (***We prefer foods we grew up with and we trust***), 5. Food restrictions as a result of ill health (***There are foods that need to be avoided***) and 6. Perceptions of healthy eating influence on eating behaviours (***We try to eat foods that are best for our health***). The chosen ***theme title*** served to illuminate the main message from participants descriptions.

Theme 1: Eating less, the 'logical' thing to do.

Almost all (*n*=14) participants reported reduced mobility; with six older adults dependent on a walker to be mobile. Overall, participants indicated they didn't want to take risks by overdoing physical activity. One couple indicated that they were comfortable and confident to do the osteo- exercises organised in collaboration with the local hospital, as there was someone to offer guidance. Several participants indicated concerns over falls with some explaining that they are as active as possible, but have to take extra care with tasks. Their decline in physical functioning had forced most to reduce their physical activity even though they wished to be more active.

> *I'd like to be able to do more. For a while there I was going walking, but then I had another fall, and then the, I didn't, couldn't get my walker outside (P#0001, 94 years old, NZ European woman)*

> *Like physically, I can feel in my body is the [problem], like I go for walks, you can sort of feel the urge to walk, you know. And I think once you start falling off, no, no, I don't want to do that, I don't want, I think there's something lacking (P011, 74 years old, Māori man)*

There are several ways with which the decline in physical functioning indicated a direct or indirect influence on food and nutrition intake. First, as older adults reported a reduction in the amount of food they consumed, they were not concerned because they saw this as a reasonable thing to do, now that they were less physically active. For these older adults, eating less or smaller portions than before was a 'logical' thing to do.

> *Like that, you don't feel like eating as much as you used to. But you can see, often can see reason for it, that I don't do as much as I used to, you know, physically. (P#015, 83 years old, NZ European man)*

> *… I don't eat as much as I used to. Well, I'm not doing any work, am I? I don't get hungry, no! … I just don't get hungry, I suppose. Whereas when you're younger, you're working, you get hungry, don't you? Something to do with old age, I think. (P#0001, 94 years old, NZ European woman)*

One couple even complained that the food provided at the hospital was too much and not necessary when they were not undertaking much physical activity.

> *I mean the fact that we've both been in and out of hospital is not a lack of food in what we're eating. Certainly not lack of food when you're in hospital. No, that's terrible there. The amount they give you there. It's disgusting. You do not need that amount of food. It's awful. Not when you're lying in bed all day, doing nothing. (P#009 & P010, 82 & 84 years old, NZ European couple)*

There was an overwhelming sense of tiredness with several older adults describing themselves as 'lazy". Participants actively made decisions to reduce activities related to grocery shopping, food preparation and cooking. Several participants mentioned that they often eat whatever was easy to prepare and that they cooked less often because they felt lazy. This tended to lead to eating the same foods during the week and small quantities of food.

> *I eat anything that's easy. (Laughter)... I guess I'm lazy when it comes to cooking. I suppose you get into the habit of cooking the same things…. I like all the things I used to like, but I don't get to cook them very often, coz it's too hard. (P#008, 88 years old, NZ European woman)*

> *…by now you've probably realised I'm basically lazy. When I ate my sandwich, we've run out of tomatoes and that, so I've been having cheese for my lunch. Which, sometimes I'll have a bit of ham. I'm not very keen but … at the moment I've been eating cheese nearly every day this week but it's not normal. (P#009, 82 years old, NZ European woman)*

Theme 2: Eating is a chore.

Several participants described a significant decline in their appetite. While some older adults indicated they felt they should eat more, they explained that they just didn't get hungry and to most of these participants, eating was almost seen as a chore.

> *… the eating's just changed. Not interested. Whereas food was main priority, now not bothered one way or the other… I know I've got to eat to keep me going, and I just eat it and I'm not really fanciful. If it's too big on the plate, it really puts me off. And the idea then is to shovel it in as quick as I can, which is wrong, because now I'm trying to eat slower and last a bit longer… (P#009, 82 years old woman)*

> *… even my kids tell me I'm not eating enough that's why I'm tired but I don't say anything because I know I just don't feel like it. (P014, 82 years old, Māori man)*

Although participants were sure that their appetite had been declining and they now eat less than they used to, they could not pinpoint the main cause of this decline. Participants often paused, trying to work out the cause, but often ended up saying "*I just don't feel like eating … I don't know, it [appetite loss] just happened… I just don't get hungry*". The unknown cause of appetite loss made it hard for participants to identify ways to stimulate their appetite, although one woman recovering from extreme weight loss found watching cooking shows made her hungry.

> *I do watch a cooking thing…all the time. [I.C: Ohh yeah and do you find it helpful to watch those (shows)] Ohh I get hungry! [Mrs P#12's daughter: Yeah and then she goes like I want one of those, I want my muffin.] (P#012, 65 years old, Māori woman)*

One older man who had a very low appetite and had involuntarily lost weight in the last year consulted his GP and was told it was probably a consequence of his heavy medication regime. This man also considered appetite loss a normal part of ageing.

> *I think it [involuntary weight loss] was because I had a fractured vertebra and my own doctor… he gave his opinion. He said well I think it's just that when people get this there's a lot of pain with it, and the pain puts them off, dissuades them from eating very much, and the medicine, you're on fairly heavy medicine against pain.… I have not recovered my full appetite, but for all I know that's what happens when you're getting older, you know. (P#015, 83 years old, NZ European man)*

In several cases, low appetite was also linked to changes in sensory perception. In fact, as older adults reported perceived changes in food taste, texture, smell, they debated whether there had been changes in the way foods taste nowadays, or whether age or use of dentures led to a low sense of taste.

> *I have a limited appetite, I can't fit a whole lot in. And I think when you get older, things don't taste the same either. I think that's partly because you have a denture, … and it covers the taste buds in your mouth, because I think the taste buds are at the roof of your mouth. And I think that makes a difference too (P#008, 88 years old, NZ European woman).*

> *Well some things you eat, you hardly taste at all. I mean whether that's the food now or me. Age? (P#009, 82 years old woman)*

One participant who had experienced a recent decline in appetite linked this to a change in weather, while another participant explained her appetite varied over the course of the day.

> *[Appetite] it's been really poor lately, not as good as what it used to be. But only the last month I'd say, but before that I was eating well. I feel all right, just not eating as much, probably the hot weather you don't eat so much. (P#0001, 94 years old, NZ European woman).*

> *[Appetite] Not as good as it could be. It depends what part of the day it is. In the mornings I don't eat very much. I have my meal in the middle of the day and I enjoy that generally. (P#013, 90 years old, NZ European woman).*

Theme 3: Companionship can encourage eating while carer stress might limit benefit.

Nine older adults were living alone or with a spouse only; two were living with a son or daughter, and the remaining five were living with two or more family members. Most participants indicated a strong desire to continue living in own home rather than move into a residential aged care (RAC) home.

> *you know, everybody is different. I'd rather be in here on my own, with [wife's name] doing her thing, [rather] than sitting in the village [RAC] watching other people go down fast. (P#002, 81 years old, European man)*.

All four participants who lived alone were experiencing or recovering from unintentional weight loss and were either malnourished (n=2) or at risk (n=2). In the previous year, one of the four (*P#015)* had been deeply concerned about the weight loss and started to gain weight after taking an ONS. In contrast, another participant (P#013) did not consider her weight loss a problem because she had not been feeling and eating well. The loss of a spouse affected the desire to eat. One man (P#014), despite living with his daughter, reflected that since becoming widowed he ate less. A woman aged 94 years (P#001), said she had become used to living and eating alone after her husband died 30 years earlier. Nonetheless, when asked if there are any changes in her current living arrangements that could help improve her food intake; she explained that she felt better when her niece came to live with her. Another woman who was also widowed, expressed deep sadness with living alone, which she associated with her low food intake (P#008).

> *[I.C: you said you feel that eating well for your case is being able to eat more. So, what do you think might help you, or encourage you, to eat more?] Maybe if there were a few more people around. Coz it's awful lonely living on your own. [I.C: have you thought about moving to a residential care home; because there are always people around there?] Oh, no thank you. My grandson suggested. I've lived here for a long time, I've lived here for 20 years, I know the area, which is important. Familiar things, and familiar people and events and places, they build a sense of security in you when you're older. I hope to drop dead here. (P#008, 88 years old, NZ European woman)*

Four participants had moved to community retirement villages. One woman, a widow, was still distressed by the move, while another, a retired priest, was struggling to gain his appetite and had unintentional weight loss. However, for all four participants, the retirement village offered opportunity for social interaction, village restaurants, and

staff who could help with tasks such as gardening. One woman who lived with her spouse indicated that eating out would be a good way to get together with others but also explained she was not included in social groups.

> *And a lot of people, well a lot of the single ladies, which is good, they get together and they go out and stuff like that, where they don't ask the married women. Well, not me anyway… [I.C: So for you, eating out would be more for social reasons?] Yes, up here, is to mix with the other people and be around. But outside, it would just be the two of us so there's no point really. I must admit, if we go for dinner up here, very often what's on the menu I don't like so I'll stick with fish and chips if I have to. If they have a buffet, where you help yourself, I like that a lot better. There's more choice of stuff and that's nice. (P#009, 82 years old, NZ European woman)*

Companionship made eating pleasurable. Enjoying mealtimes was described by those who had a spouse or lived with their children/others. Participants also spoke of getting help to prepare meals. Despite having company, three participants who were the primary carer of a spouse with multiple conditions, such as dementia and diabetes, reported feeling depressed.

> *He's got arthritis, he's got high blood pressure, he's got diabetes, he's got everything. And he's a bit dementia, yeah. So, I'm having a problem myself looking after coz he's stubborn. He do things he likes instead of me, so what can I do? I can't help it, but that's what I said to the nurse when she comes around, I said I'm getting sick because of him (P#004, 74 years old, Pacific woman).*

One man who cared for his wife explained that her conditions influenced what they both ate (*P#007*). He aligned his diet to that of his spouse because it was easier to manage in regard to cost.

> *… well you can't always afford not to have them at the same time because it costs too much money having separate meals. (P#007, 76 years old, NZ European man)*

Theme 4: We prefer foods we grew up with and we trust.

Over half (n=9) of the participants reported preferences for foods they commonly ate at a younger age. The remaining seven participants said their current food preference had changed over time and although they enjoyed foods they ate when younger, their health and financial status now influenced what they ate. A decline in food intake was reported by those who ate the same foods they had at a younger age and those whose food preferences had shifted. Three participants who were Island-born and had moved to New Zealand from Tonga and Samoa in early adulthood said they preferred eating foods grown on the Island and prepared at home "*…We eat yam, taro, tapioca, we eat a lot, that's our main eat in Tonga p#003*".

One woman described foods she would not eat because she considered they were foods "rich people" ate. She had not eaten 'energy dense foods' as a young person and although she could now afford these foods, felt they were not (good) value for money. This woman was severely underweight (BMI 16.9), had numerous food allergies and gastrointestinal problems, and might have benefited from a wider range of foods.

> *I've just gone through life having plain food. I've never been one to have rich food, you know. People like Christmas cake and stuff like that, I can't take that … No, I just don't like that sort of thing. I'm not a rich person, I don't like rich food. (P#005, 85 years old, NZ European woman)*

A strong preference for fruits and vegetables was displayed, although most participants complained about the high cost. Eating smaller servings of vegetables, buying frozen vegetables, vegetables in season, or buying vegetables when reduced in price were practical strategies, they used to keep costs down.

> *The round cabbage, the old days used to be 50 cents, but nowadays $5. Even if I wanted, I never buy. But when you go back to the shop some other time it's gone down, I think because it's been there for a week or two weeks, so I bought. It's a hard life, it's not easy (P#004, 74 years old, Pacific woman).*

> *"I buy vegetables even if they are expensive, but I just eat smaller servings of it. (P#013, 90 years old, NZ European woman)*

Another woman expressed a preference for food prepared or cooked at home. She prepared her meals and cut the vegetables – she did not trust the food prepared in restaurants and 'take-aways' fearing a lack of hygiene.

> *I'd rather cook my cabbage and meat or something, or whatever I cook. I don't trust the food that they sell in the shops, I just don't like it, I don't know why. It's like I'm buying something, I'm giving my money and I eat something I don't know if it's clean, or did they wash it before they cook. So that's why, and even the Chinese [take-aways] and even if I'm hungry, when I look at it, I don't buy it (P#004, 74 years old, Pacific woman).*

Some participants perceived foods such as meat and milk were processed differently compared to their childhood days. Several participants demonstrated a growing preference for fish over meat, with some specifying that they doubted the quality of the meat. Two men, one who had worked in a dairy factory and the other in a freezing works, had significantly reduced their milk and meat intake, respectively indicating that nowadays there is unnecessary use of additives.

> *That's the other thing, I don't like to drink milk all the time.... Yeah, I saw them, I saw them in a factory. The milk, when they had a drum of milk from the farmers,*

they put some stuff inside to attract the people to drink. Not like the island milk, only milk, nothing else to put in. (P#016, 81 years old, Pacific man).

Theme 5: There are foods that need to be avoided.

Participants described dietary restrictions in relation to comorbidities or conditions they experienced. Often, they had multiple conditions such as hypertension, arthritis, gout, high blood sugar or cholesterol. Most of their comments indicated that they were setting their own restrictions, while other times a health practitioner had prescribed the dietary restriction. Older adults with previous heart disease reported fat and/or dairy restrictions.

Well I used to, before I had the heart failure, dairy products, meat, some veges, everything, you can think of! I have gone easy on meat now, and dairy products … even pork sausages, I don't eat that either. A bit fussy you think? (P014, 82 years old, Māori man)

One man who had diabetes and hypertension dreaded the thought of a heart attack. He avoided eating foods with a high fat content, which included meat and cheese, and was concerned about "sugar", although he continued to eat sugary foods including ice cream.

I get more frightened of heart disease than I do of, you know [diabetes]. Like cheese, I always mentally picture myself having heart attacks eating too much cheese, you know…. In the past you [he] had more fat in your meat, and like the wife would boil something with fat in it, you know… not anymore (P011, 74 years old, Māori man).

Participants reported a few allergic reactions to a number of foods. In one extreme case an 85-year-old woman who was underweight described her reaction to the multiple foods she was allergic to.

I'm allergic to dairy products, you know, cheese, milk, eggs. I have to have enzymes. If I don't have them I can't eat, because it affects my stomach. And fish is included in that…my mouth swells up. I don't ever have much on a plate. My stomach can't cope with too much. It's my skin too, I have a lot of trouble with my skin. It's very sensitive. (P#005, 85 years old, NZ European woman)

Another woman had no specific dietary restrictions and had a good appetite, but due to her stomach illness needed to limit the amount of food she consumed each meal.

Well it's quite nice and tasty when I'm eating it, but I don't know what changed in me, from being sick nearly two years ago, something changed. When my stomach has had enough, it's had enough. Because if I keep pushing it down, I'll end up being ill all night and uncomfortable (P#009,82 years old, NZ European woman).

Half (n=8) of the participants avoided foods that were hard for them to chew and eat. These included fruits, vegetables, nuts and undercooked meat. This was an issue for those who had missing teeth and dentures. For those affected, several coping strategies had been put in place including substituting fresh fruit with tinned or eating steak pie instead of steak.

> *Maybe I'll have a pie, one or two pies throughout the week. I don't go for steak or anything like that., I don't, my teeth are all old now, and these are false teeth. [I.C: So you normally eat the meat which is in the pie?] Yeah. If I bought a chow mein with meat in it, that's the type of thing. (P011, 74 years old, Māori man).*
> *Anything that's really soft I can eat, but like, apples, I can't. False teeth. They're just old, probably not up to standard … it's very hard when it's not tinned stuff. (P#006 & P#007, 75years and 76yrs old couple)*

Participants did not directly associate food avoidance or overall food intake with their psychological health, although some participants descriptions indicated that they would probably eat better if they were not feeling awful or distressed due to living alone or caring for an ill spouse respectively. Six participants reported symptoms of mild dementia, mainly forgetfulness, and an additional eight participants reported symptoms of depression (Appendix #3). One woman did discuss her forgetfulness and how it affected her grocery shopping.

> *I've been missing out on my orange vegetables because I'm a wee bit, I haven't had them to hand, though carrot at the moment and pumpkin. Mostly coz … I'm getting old, and I don't always do the best shopping that I could, and sometimes I would forget. (P#008, 88 years old, NZ European woman)*

Theme 6: We try to eat foods that are best for our health.

All but one participant described their eating as either reasonably healthy or very healthy. This participant said she found it difficult to eat healthily and explained this was due to her illnesses. Although the majority had more than two chronic conditions, a strong sense of eating what was "best", was apparent. Participants associated healthy eating with living longer. Despite their fatigue, they valued eating well and were trying their best to manage their low energy levels including use of frozen meals.

> *… I think it's [losing weight] an old person's problem, because sometimes when you get to the night-time, you're just too tired, you just can't do it. But see I'm being very good; I've got six frozen meals in that box … So, I'm trying hard., I try hard, because the reason I've survived so long is because I've always taken care of my diet. (P#008, 88 years old, NZ European woman)*

> *[I.C: So how healthy do you think your eating habits are, just in general?] I don't think we could get any healthier food. Thank God for frozen food. (P#002, 81 years old, European man)*

Ten (of 16) participants described eating fruits and vegetables as a key aspect of healthy eating. Of these, four had a BMI of less than 20 and were experiencing unintentional weight loss. Participants indicated that meals delivered by (social) services would be more acceptable if they included vegetables.

> *[home delivered meals] they're all the same, and they don't have a great variety of vegetables. I mean, I know we're supposed to have green vegie, there's never any green vegetables. Might be one little piece of broccoli like that. So they're okay up to a point, but I would sooner prepare my own when I can (P#008, 88 years old, NZ European woman).*

The quality of food was fundamental to consumption. Quality was described in terms of freshness, ingredients, and method of cooking and influenced what was purchased, even when the cost was high. Participants indicated a preference for cooking their meals at home. Home-cooked meals were associated with "healthier" ways of cooking food, avoidance of fried foods, and use of "healthy" ingredients.

> *Cook your own food. As you get older you need good, fresh food I always think…so the fresher the better (P#005, 85 years old, NZ European woman).*
> *… we make our own food, that's the main thing. You understand when you make your (own) food … if you want to eat a good meal you can make nice food and put everything you know is good. (P#016, 81 years old, Pacific man)*

Seven (of 16) participants described reducing portion size and the overall consumption of sugary and/or fatty foods. Based on BMI, three were overweight; the remaining four participants needed to gain, or at least maintain their current weight. All seven participants had similar perceptions of healthy eating and they sought to eat small portions and avoid sugary or fatty foods.

> *The plain ones (biscuits) are better for you, they haven't got any sugar in them. (P#013, 90 years old, NZ European woman, BMI 19.9)*

> *That's why I like fish because I know it is healthy fish, and fruits and vegetable, I like lettuce. [I.C: What would you say is unhealthy to eat?] … don't need to eat too much. And not to eat fatty things. I like vegetables and not really like meat. I like yoghurt, I cut down ice cream coz I know it's too fattening. (P#003, 84 years old, Pacific woman, BMI 37)*

While several participants experiencing unintentional weight loss focused on eating small portions, and/or more vegetables, three participants were certain that healthy eating meant eating more (larger portions) of food. Two participants had received advice from their health practitioner and/or family.

> *We're supposed to be putting weight on. Anna (registered nurse) told us we've gotta, especially [his wife], she's got to put weight on. All that stuff you didn't want,*

> *we were told not to eat because it would make you fat, we've been told to eat them. (P#002, 81 years old, European man)*

> *I was really tired because I didn't eat properly, I didn't know how to eat properly. … I think the more you eat the better, because I can have my energy when I eat. I have discovered that now. She [her daughter] has taught me that. (P#012, 65 years old, Māori woman)*

Most participants were satisfied with their knowledge about healthy eating from magazines, television or radio. A few participants said their nurse or doctor had offered advice. In general, most participants did not seek nutrition advice because they felt they were already doing their best to eat healthily.

> *No, just if I see it, I'll read it…in magazines… Hard to say whether it goes in or not. [I.C: Do you sometimes talk to your doctors about nutrition and food?] No, generally have too many other things to complain about (laughter). (P#0001, 94 years old, NZ European woman)*

While it was not clear which eating behaviours were guided by participant preference or practitioner prescription, it was apparent that there was some confusion regarding dietary recommendations due to the presence of coexisting conditions. In an effort to eat only foods best for their health, participants tended to categorise foods as healthy or unhealthy and restrict foods accordingly. In some cases, perceptions of healthy eating did not differ between participants who were overweight or those who were underweight. The notion of healthy eating as consuming "more vegetables, less fat and less sugar" was widely held, including by those who, for example, did not need to restrict their energy intake. Furthermore, knowledge related to nutrition did not always influence personal behaviour in a way that might have been expected. For example, one woman (*P#013)* described several food and nutrient sources and explained in physiological detail how they influenced health. Despite her considerable knowledge she reported continuing to lose weight, and only sometimes eating foods higher in protein or carbohydrate – her focus was on eating more vegetables.

> *[I.C: What would you classify as healthy eating in this state that you are in now; now that you are trying to stop losing weight?] I still eat the vegetables as much as I can, and sometimes I make a baked egg custard which is eggs beaten up and milk mainly, a little bit of sugar. (P#013, 90 years old, NZ European woman)*

6.5 Discussion

This study explored older adults' experiences of food and nutrition intake to understand the key concepts that influence vulnerability to malnutrition with advancing age. Participants were ethnically diverse and nutritionally vulnerable with most (14 of 16) experiencing moderate or severe illness. Of the 14 participants, 12

had more than five comorbidities, 13 took more than five medications, and 5 were underweight (BMI <23). Using the MNA®SF, five participants were malnourished and nine were at risk of malnutrition. Typically, older adults with multiple comorbidities and polypharmacy are at higher risk of malnutrition (Moreira et al. 2016) and eat too little food (Wysokiński et al. 2015).

Almost all participants reported they consumed less food at meal times, while several indicated they probably ate only half of what they would have eaten in the past. A decline in food intake did not seem to be of concern to most participants who commonly rationalised this as appropriate because they were doing less physical activity. For these participants '*Eating Less was the Logical thing to Do'.* Older adults in the Netherlands who were undernourished, also reported eating less in response to reduced physical activity. (van der Pols-Vijlbrief, Wijnhoven, and Visser 2017). In the current study two participants remarked on the large meals they were offered while in hospital. They felt the large portion size was unnecessary when they were lying in a hospital bed all day. A qualitative enquiry where hospitalised older Australians were observed to eat less than half of their meals, also found the participants validated their low food intake due to a lack of physical activity (Hope et al. 2017).

Despite eating less food, most of the study participants expressed the need to eat a varied diet. They mostly ate three times a day and rarely skipped meals. Older Australians have reported similar eating routines; they valued eating well and rarely skipped meals (Winter, McNaughton, and Nowson 2016). Snacking or eating between meals was not a common practice in the current study, as has been similarly observed among Swedish older adults who related snacking to social gatherings or activities (Edfors and Westergren 2012). Older adults from London avoided snacking as they perceived it to be an unhealthy practice (Avgerinou et al. 2019). However, nutritious snacks in addition to three meals a day, especially for those who are underweight or have a small appetite, are recommended for older adults (Ministry of Health 2013), especially when eating three main meals a day might prove difficult. Among older Americans it is well documented that those who do not snack tend to have lower energy intakes (Zizza, Tayie, and Lino 2007), and for people with a poor appetite eating a nutrient dense diet can be a challenge. Despite being aware of the need to eat a little and often, undernourished older adults have said they find it difficult to eat at more frequent intervals (Beelen et al. 2017).

Almost all (*n*=14) participants reported reduced mobility; while they wanted to do more walking, they were fearful of falling and expressed an overwhelming sense of tiredness including being 'lazy'. This impacted on food related activities such as grocery shopping, food preparation and cooking. As a result, some participants reported "eating the same foods", while others made the use of frozen meals, a strategy characteristic of resilient eating (Vesnaver et al. 2012).

Most participants described eating as a 'chore' and expressed a low enjoyment of food. They explained they ate because they 'had to keep going', but hardly ever felt hungry, had lost interest in eating, and no longer found food fanciful. As food enjoyment reduces food apathy and promotes regular eating (Vesnaver et al. 2012), this finding is not unexpected. Participants were unable to pinpoint the main cause for their decline in appetite. One older man considered appetite loss as a normal part of ageing, while two participants described how their appetite fluctuated in relation to the weather or over the course of the day. British seniors have explained that keeping an eating routine was important to overcome appetite fluctuations (McKie et al. 2000) and this may be an important strategy for those with a poor appetite. Changes in sensory perception (taste and smell of foods) were described by some participants as a further reason for low appetite; they debated whether it was the way foods were produced or whether it was part of ageing. Loss of appetite and sensory decline is common among older adults (Hays and Roberts 2006) and some regard their loss of appetite loss as a direct cause of malnutrition (van der Pols-Vijlbrief, Wijnhoven, and Visser 2017). However resilient eaters condition themselves to maintain regular eating patterns despite a lack of hunger (Vesnaver et al. 2012) and this was evident among some of our participants.

The presence of a spouse or other family members encouraged participants to eat. They reported enjoying companionship and having meals prepared for them. Scottish older adults who lived alone but ate with others at a communal lunch club similarly reported that dining with others was a pleasurable experience (Thomas and Emond 2017). The positive influence of companionship on food intake has been reported in other studies (Locher et al. 2005; Stroebele-Benschop, Depa, and de Castro 2016). In the current study four participants who lived alone and were malnourished or at nutrition risk said their enjoyment of meals had decreased especially after becoming widowed. Both living and eating alone are well-established risk factors for malnutrition (Tomstad et al. 2012; Vesnaver et al. 2015; Vesnaver and Keller 2011) and loss of commensality in widowhood results in irregular meal intake (Vesnaver et al. 2015).

Poor appetite has previously been reported in older men who live alone (Hughes, Bennett, and Hetherington 2004; Wham and Bowden 2011) and this may adversely impact food intake (Hughes, Bennett, and Hetherington 2004). Despite the importance of companionship, the burden of caring for a spouse with multiple illnesses led to three participants expressing feelings of depression. Spouses are the most common informal carer of older people in New Zealand (Statistics New Zealand 2009) and experience elevated levels of distress (Swain 2018). As this may lead to poor appetite and malnutrition among carers (Donini et al. 2013), urgent strategies are needed for carer support. We found the 'caregiving' spouse aligned their own food intake to the needs of their spouse as they were unable to justify the cost of preparing different meals.

Preferred foods were often the "foods we grew up with and we trust". Three participants born in the Pacific Islands held a strong preference for foods grown in Tonga and Samoa although they had been in New Zealand since early adulthood. Similarly, British seniors report a preference for 'proper meals' which tend to be traditional in composition, contain familiar foods (McKie et al. 2000), and prepared in similar ways to their upbringing and past experiences (Bloom et al. 2017). In the current study, half the participants expressed a preference to have meals prepared at home. Some participants doubted the hygiene of food prepared elsewhere and some considered restaurant food to be less healthy. Similarly, investigations of food choice among older adults in New York and Australia show a preference for homemade meals, as participants considered them to be superior and more healthful (Falk, Bisogni, and Sobal 1996; Winter, McNaughton, and Nowson 2016). We found participants' food preferences were altered by their health perceptions. For example, those who reported fat wasn't good for their health ate fish more regularly and had a lower preference for meat. A growing preference for fish over meat has also been reported among community living older adults in Australia (Brownie and Coutts 2013), UK (Whitelock and Ensaff 2018) and Ireland (Delaney and McCarthy 2011), although little is known on how such preferences influence diet quality. Two men expressed a lack of trust in the quality of meat and milk due to modern processing and this had altered their preference for these foods. Australian older adults have reported similar concerns over changes in the quality of the food supply, perceiving foods to be now of inferior quality and containing too many additives (Host et al. 2016). Although participants indicated a strong preference for fruit and vegetables, access was limited by affordability. Older men in New Zealand who live alone also identified cost as a

barrier to their fruit and vegetable intake (Wham and Bowden 2011), which may compromise nutrient intake.

Co-existing conditions or illnesses led to food avoidance or restriction among twelve participants. Ill health is a known barrier to food choice (Locher et al. 2009; Winter, McNaughton, and Nowson 2016) and in the current study participants restricted foods such as meat, dairy and cheese due to their 'high fat content' and fear of heart conditions. Foods are more likely to be consumed by older adults if they are perceived as being good for health (van der Zanden et al. 2014; Provencher, Polivy, and Herman 2009). Food allergies and intolerance were further reasons for excluding specific foods. One woman who was malnourished and underweight had excluded eating dairy products, eggs, fish, and meat. This woman, and another woman, ate only small portions of food explaining that their stomach "could not handle large amounts of foods anymore". Food allergies are a growing but underdiagnosed problem in older adults (De Martinis, Sirufo, and Ginaldi 2017) and food intolerance, including slower gastric emptying, tends to negatively impact older adults eating behaviours (Drewnowski and Shultz 2001). In addition, chewing and eating difficulties led to avoidance of fruit and meat, consistent with data reported from in-depth interviews with Irish and British older adults (Delaney and McCarthy 2011; Whitelock and Ensaff 2018).

Participants tried to eat foods best for their health. Although food enjoyment was low, participants understood eating was important for wellbeing. In-depth interviews with older adults engaged in the eight country EU project Food in Later Life study found healthy eating was regarded as an investment to ensure independence, as a means to avoid becoming ill or to control existing disease; and the notion of "looking after oneself" drove this motivation (Lundkvist et al. 2010). In the current study, most participants were satisfied with their understandings of healthy eating and almost all participants described their eating as either "reasonably" or "very healthy". Eating more fruit and vegetables was associated with a shift to "very healthy". In general, participants tended to categorise foods as healthy or unhealthy and restricted foods accordingly, regardless of whether they needed to gain or lose weight. Similarly, participants in the Food in Later Life study reported categorising foods as solely (un)healthy, which led to avoidance of these foods (Lundkvist et al. 2010). Among older Australians, specific foods were often restricted regardless of weight status; participants adopted restrictive dietary practices without specific guidance, as a result of childhood weight gain concerns (Winter, McNaughton, and Nowson 2016). In the

current study, participants held several perceptions of healthy eating and did not seek nutrition advice as they felt they were already doing their best. Similarly, older Canadians perceived that they were eating well and when advised that they were at nutrition risk, denied the results and found ways to explain away the risk because it contradicted their strongly held beliefs (Reimer, Keller, and Tindale 2012).

The principal limitation of this study is that study participants were recruited from a single general practice in a poorer region, more vulnerable than the general NZ older population and were purposively selected by ethnicity and older age. The specificity of the study population is also a principal strength of the study in that it supports greater depth and analysis. We make no claims to generalisability. The qualitative research design allows for transferability of study findings, which may be applicable in other contexts, situations, times, and populations. It is possible that self-selection of participants may have occurred, and the recruited participants may be more keenly interested in nutrition. We assessed the participants' severity of illness and malnutrition status (MNA®SF), which provided some context in the analysis and interpretation of study findings. The ethnic diversity, range in body mass index and nutritional status of participants allows transferability to different groups of older adults. To our knowledge this is the first qualitative enquiry within a New Zealand population of older adults that seeks to understand factors that influence vulnerability to malnutrition with advancing age.

6.6 Conclusion

In conclusion, the data from participants' experiences indicated that vulnerability to malnutrition can be minimised through focusing on individual perceptions and behaviours. Participants were not concerned about eating less food, they rationalised this was because they were undertaking less physical activity. The cycle between malnutrition and low physical status (Jeejeebhoy 2012) suggests it is important for older adults to continue to eat regularly and maintain habitual physical activity. Participants valued activity, particularly walking, but were hindered by mobility challenges. Given they perceived they should eat less because they were not undertaking much physical activity, strategies to improve physical function among vulnerable older adults may be paramount in preventing a decrease in food intake. Although eating less was also related to low appetite, low food enjoyment, limited access to preferred foods and comorbidities which imposed food restrictions, the participants valued eating well and ate regular meals. Encouragement with appetising energy dense drinks or snacks may also help to address low food intake. Some of

the participants appeared to exercise resilient eating habits even when food was less fanciful, and those who lived alone or who cared for an ill spouse faced additional stresses. Social support to maintain the health and resilience of older carers is critical to ensuring their food intake is not compromised whilst they undertake this important role.

These results contribute to an increased understanding of older adults' perceptions towards eating among those who are vulnerable to malnutrition. The findings can be used as a foundation to develop strategies for preventing vulnerability to malnutrition with advancing age. Identifying those who are at risk of malnutrition is an important first step. Interventions which focus on modifiable objective factors as well as subjective factors (such as tiredness) may help improve the overall eating experience.

Conflict of interest

None.

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Chapter 7:

Planning intervention strategies to prevent malnutrition with advancing age: Discussion and synthesis of thesis findings.

7.1. Introduction

The overarching aim of this research was to obtain evidence-based data to help inform policy and practice on the importance of routine screening for malnutrition (risk) and to inform intervention planning towards preventing malnutrition and associated adverse health outcomes among older adults. A comprehensive review of the literature was conducted in chapter 2, followed by a series of quantitative studies (chapters 3 to 5) and a comprehensive qualitative enquiry (chapter 6) to better understand the factors that influence nutrition status and dietary behaviours of older New Zealanders. Findings, strengths and limitations of all the studies are discussed (chapters 3 – 6). The objective of this final chapter is to synthesise all the research findings to inform recommended intervention strategies to prevent malnutrition with advancing age. A discussion of implications for policy, practice and future research regarding recognition, prevention and/or treatment of malnutrition follows. The synthesis specific research questions are:

> 5a. From the statistical analysis conducted, is malnutrition prevalence a challenge across NZ/Auckland settings and are there any factors consistently associated with increasing risk?
>
> 5b. From the thematic analysis of older adults' experiences and perspectives, what are the salient factors contributing to increased vulnerability to malnutrition with advancing age?
>
> 5c. To reduce the prevalence of malnutrition, what recommendations can be drawn to inform key strategies to prevent malnutrition with advancing age?

7.2. Summary of study findings and methodological considerations.

7.2.1. Prevalence of malnutrition (risk) across settings

> ***RQ: Is malnutrition prevalence a challenge across NZ/Auckland settings?***

In chapters 3, 4 and 5, we found the prevalence of malnutrition and malnutrition risk of 1% and 11% in the community, 26.9% and 46.6% at admission to the hospital, and 48% and 45% at admission to RAC. Although the main limitation of our studies is the sample size which limit generalisability of the prevalence values, all but one of these findings are congruent with findings from international studies conducted using the MNA®SF among older adults living in the community, or in institutions (hospital and RAC) (Guigoz 2006). The only discrepancy noted was in the prevalence of malnutrition risk among community participants where we found a lower prevalence of 11% vs. 24% reported in a review of 21 studies of community-dwelling older adults (Guigoz 2006). This discrepancy is also seen when we compare the findings to previous studies conducted in the community setting in NZ whereabout 1-in-3 community dwelling older adults were at risk of malnutrition (Watson, Zhang, and Wilkinson 2010; McElnay et al. 2012; Wham et al. 2014; Wham et al. 2015). However, a direct comparison cannot be made as these NZ studies used different malnutrition screening tools. The lower prevalence reported among our community participants may be explained by the fact that the participants were generally healthy and independent (potentially a result of healthy volunteer effect or recruitment bias (Groves 2006; Sackett 1979)); hence the prevalence values are congruent with other overseas studies where participants were described as mostly healthy (11-16%) (Winter et al. 2013; Kaiser et al. 2011).

Overall, our findings across the three settings align with the trend seen in previous international research whereby almost none (0%) to 2% of community participants are identified as malnourished. However, an unacceptable and alarming prevalence of malnutrition is observed in institutions (hospital and RAC settings). This may explain why more intervention programmes aimed at reducing malnutrition prevalence are designed for institutionalised older adults. The infamous statement; '*malnutrition the skeleton in the hospital closet*', originated from early research which indicated malnutrition was a hidden problem in hospitals (Butterworth Jr 1974). The research deliberated on health care worker or physician induced malnutrition; listing 14 examples of undesirable practices that affects nutritional health of hospitalised patients (Butterworth Jr 1974). This early work is considered as one of the starting points that helped shape the improvements seen in prevention of hospital malnutrition (Souza, Sturion, and Faintuch 2015). However, despite some developments, unacceptable prevalence rates of malnutrition (risk) in the hospitals and other institutions such as RAC continue to be recorded. This raises the question whether these rates are only a consequence of hospitalisation/institutionalisation, or '*there is*

another skeleton i.e. more undesirable practices or hidden malnutrition problems in the community'? Data that provide insights on whether the high prevalence of malnutrition often documented in institutions is a contributing cause for such admissions or malnutrition tends to arise after admission is paramount to answer that question. Our studies are well designed to help answer this as they provide evidence for the proportion of older adults that get admitted to institutions when already malnourished or at risk. Worth noting, while our studies were conducted at admission to the hospital and RAC, the findings for malnutrition prevalence are comparable to those of older adults who had been living in the hospital and RAC (Guigoz 2006). This suggests routine screening among all vulnerable community dwelling older adults may be prudent in primary care as we found only up to a quarter (7.5-26.9%) of older adults move from the community to institutions while still having a normal nutritional status (Chatindiara, Allen, et al. 2018) [Chapters 4 and 5]. When we combined all the data from the 3 settings (chapters 3-6), of the 665 older adults 608 had their prior setting documented. An analysis of these 608 participants showed that 527(87%) were living or moving from the community, and the average prevalence of malnutrition for this combined dataset was 22% in addition to 30% who were at risk. Therefore, regardless of the low prevalence observed among the study of community participants alone, this combined dataset or the combined findings of chapters 3-5 helps provide evidence that malnutrition is a challenge across settings.

7.2.2. Risk factors for malnutrition

RQ: Which key factors are associated with increasing risk for malnutrition?

Demographic

Of all the demographic factors, age was the only significant risk factor for malnutrition. The risk tends to increase with every yearly increase in age, particularly among those in advanced age, 85 years and over (Chatindiara, Williams, et al. 2018). We found this association between age and malnutrition among the community participants only, who were mostly healthy. Although age is a well-established risk factor for malnutrition (Moreira et al. 2016), our finding across settings suggest that age maybe a more important factor to consider among independent or less vulnerable groups e.g. in community, but screening should be undertaken among all vulnerable older adults (e.g. those with multiple illnesses, homebound or institutionalised) regardless of age. In fact, previous research established institutionalisation as an independent predictor of malnutrition (risk) (Moreira et al. 2016), hence routine screening for all

institutionalised older adults regardless of age seems prudent. Across settings we found no significant associations between malnutrition and all other demographic factors assessed – gender, ethnicity, marital status, education and income. All the demographic groups, except for ethnicity (fewer Māori/Pacific people included) were well represented in our studies. Mixed results have been reported in previous studies and none of these demographic factors were also identified as significant risk factors in a systematic review of risk factors for malnutrition (Moreira et al. 2016). Therefore, as our results also show no evidence of association between malnutrition and the demographic factors, this can be seen as a way to encourage screening across demographic characteristics.

Inflammation, multimorbidity and polypharmacy

Given that decline in health is a key determinant of nutritional status; one of the strengths of our studies was the assessment of several factors to better understand participants health status including blood biomarkers, physical functioning, body composition, comorbidities, medication usage, cognitive functioning, dental status and dysphagia risk. All assessments were included in the study designs across settings, except for inflammation (blood biomarkers) which for logistical reasons was only assessed among the community participants. Given the health profile of the community participants, it is not surprising that no association between inflammation and malnutrition risk was found. This finding supports previous research which explained that the use of blood biomarkers may fail to identify older adults who are at risk, as changes in biomarkers level is likely to be detected when older adults are already severely malnourished (Zhang et al. 2017). This emphasises the importance of using screening tools which have high validity and specificity to detect older adults at risk of malnutrition such as the MNA®SF and SCREEN 11 (Green and Watson 2006).

In bivariate analyses (test for independence), we found associations between malnutrition and number of comorbidities and prescribed medications (chapter 3 and 5). Based on the MoCA tool, up to a quarter of older adults had a normal cognitive status (MoCA score >26). Bivariate analysis showed a significant association between low cognition and high malnutrition risk across settings (chapters 3-5); and even after adjusting for covariates low cognition was found to be a key predictor of malnutrition prevalence at admission to hospital (chapter 4). All our studies specifically excluded older adults with pre-existing or known dementia, hence this high prevalence is an indication of unrecognised decline in cognitive functioning

among older New Zealanders. The MoCA tool is validated for use among older adults (Nasreddine et al. 2005) and the main resource required to administer this tool is time. However, it is also important to note that nearly a quarter of our participants declined to complete the MoCA test. Shorter validated tools may be needed to promote completion. Our studies were the first to report associations between dysphagia risk and malnutrition among older New Zealanders, indicating the importance of swallowing difficulties as part of routine geriatric assessment. While several assessments of overall health were conducted, we acknowledge that it would have been prudent to include sensory assessment – taste, smell, appetite, as these factors are key contributors to the anorexia of ageing (Hays and Roberts 2006).

Physical functioning and Body composition

Across all settings, we consistently found a decline in physical performance as determined by gait speed, hand grip strength, FTSTS and frailty – phenotype model, a significant risk factor for malnutrition in both unadjusted and adjusted models (multiple regression analyses). Borderline significance of association was obtained between malnutrition and ADL ability (an indicator of low physical functioning/frailty). It is important to note that our one question method to assess ADL ability, whereby we simply asked older adults if they needed help with ADL such as shopping, cooking and cleaning is not validated, and validated questionnaires could have yielded a different result. However, given that physical assessments are a more objective way of understanding participant's physical functioning (Brach et al. 2002; Fried et al. 1996), by conducting multiple physical performance measures, this was considered sufficient. Addition of a long subjective questionnaire to assess physical functioning or performance would have likely made the data collection process burdensome for these older adults. Our assessments of physical performance were extensive including both upper (hand grip strength), lower body muscle strength and mobility (FTSTS and gait speed) (Guralnik et al. 1994; Goldberg et al. 2012). Our study was the first to report an association between physical frailty (Fried phenotype model) and malnutrition risk among older New Zealanders. In general, our findings provide an overall indication that the pre-frailty state (having one or 2 indicators of low physical function (Fried et al. 2001)) should be considered a sufficient reason to evaluate the need for nutrition intervention(s).

The main indicator of poor nutritional status is unintentional weight loss; hence it is not surprising that we found an association between low BMI and high risk of malnutrition. This indicates the importance of weighing older adults on regular basis

for example at each GP visit so that unintentional weight loss is noted and acted upon. BMI is an integral component of the MNA®SF (Kaiser et al. 2009). To counteract the limitations of using BMI alone in older adults, our study design included body composition assessments using BIA scales. However, among vulnerable participants at admission to hospital and RAC, most were unable to safely stand on the scales for the BIA reading to be completed. Use of body composition analysers where patients lie prone are recommendable for future studies. None the less, from the community participants where body composition assessments were successful, our study found muscle mass was positively correlated with better nutritional and physical status, and even increased fat mass had a protective effect. The use of BIA scales in general practice would be an additional advantage to allow changes in skeletal muscle mass to be tracked over the life course. Unlike younger adults where recommendations are to reduce fat mass and only increase muscle mass, our findings adds to the body of evidence for the protective effect of a higher BMI (whole body mass) in older adults against malnutrition and functional status (Donini et al. 2012; Bahat et al. 2012).

7.2.3. Vulnerability to malnutrition with advancing age: Older adults' perspectives

> ***RQ: From the thematic analysis of older adults' experiences and perspectives, what are the salient factors contributing to increased vulnerability to malnutrition with advancing age?***

In Chapter 6, a thematic content analysis of older adults' experiences and perspectives was conducted to better understand factors that influence vulnerability of malnutrition. Due to the qualitative nature of this study design, we claim no generalisability of the findings. Nonetheless, the purposive sampling we employed can allow transferability of the findings to similar target groups; as we noted that some (not all) of the perspectives shared in our study had been observed in other international in-depth interviews (chapter 6). The diverse range in body mass index, nutritional status and ethnic diversity of our participants provided a platform to better understand multiple perspectives unique to older New Zealanders. Of the six themes identified, we found that a decline in physical status (low mobility and ability for to partake ADL) was the most salient factor contributing to increased vulnerability with advancing age (*theme 1*). Indeed, this finding is not surprising to note, since low physical status can prevent older adults from performing ADL necessary to maintain a healthy diet (e.g. unable to prepare food daily). However, what we found most interesting is participants indicated the influence of low physical performance goes beyond hinderance of food preparation. With participants justifying eating less as 'the

logical thing to do in the presence of low physical activity', it was clear that the vicious cycle between malnutrition and physical functioning goes beyond physiological explanation.

Participants also described eating as a chore, indicating appetite loss, low food enjoyment and lack of interest in food (*theme 2*). While appetite loss is a well-established risk factor for low food intake among older adults, our findings provide insights into how older adults perspectives can influence appetite or the desire to eat. For example, themes 4-6 show that participants preferred foods they grew up with and trust (*theme 4*); they could not eat all they desired to eat and had illnesses or conditions that forced them to avoid certain foods (*theme 5*); overall their perceptions of healthy eating influenced their dietary habits – they ate more of what they perceived to be healthy and some participants adopted restrictive eating habits. A novel outcome from our inductive reasoning was while companionship can encourage eating, carer stress might limit the benefit (*theme 3*). Participants living alone reported loneliness and indicated how they would probably eat more with others; while for those who lived with others companionship made eating pleasurable. Participants also spoke of getting help to prepare meals – which altogether encourages eating, as absence of help with preparation of food (when needed) can lead to low dietary variety and limited food choices (Locher et al. 2009; Chatindiara et al. 2019). Nonetheless, the positive effects of companionship seemed limited among participants who were the primary carer of a spouse with multiple illnesses. They reported feeling depressed and some chose to align their food choice and food intake to that of the ill spouse. Our study is one of the first to explore and report the relationship of social frailty and vulnerability to malnutrition. We found that social frailty or absence of resources essential for fulfilment of basic social needs (Bunt et al. 2017) such as presence of social participation, financial status, family ties, limitation in ADL, social support and loneliness can all influence food intake. These findings from our qualitative enquiry indicate that there is no one-size-fit-all intervention for this group; and assessments to elicit features of an intervention or prevention strategies that will be acceptable and sustainable may need to be narrowed down to individual level, or subgroups such as those with illnesses, similar social status or ethnic backgrounds.

7.3. Synthesis of study findings to inform prevention/intervention strategies to reduce malnutrition prevalence with advancing age.

RQ: What conclusion can be made as the key strategy to <u>prevent</u> malnutrition with advancing age? Thesis findings as evidence base for key factors to target.

Some of the methodological considerations (strengths and limitations) of the studies conducted in this research have been highlighted above. The main limitation is the small sample sizes which increase the chances of failing to detect associations between malnutrition and risk factors i.e. failure to identify the risk factors that are key to consider when designing intervention strategies [type 11 errors (Banerjee et al. 2009)]. However, the fact that in all the three settings all analyses were able to detect the association between malnutrition and physical frailty components is a strong indication that low physical functioning is the key risk factor for malnutrition. It is well established that low physical function is also a consequence of malnutrition or poor dietary practices, indicating the vicious cycle between the two factors (Jeejeebhoy 2012). In addition to physical frailty and its individual components, evidence from the current research shows that the prevalence of malnutrition was significantly associated with low cognition and dysphagia – both conditions can be improved by routine physical activity or reducing physical frailty (Vance et al. 2016; Payne and Morley 2018). Furthermore, from older adults' perspectives and experiences, low physical status including reduced mobility and ADL ability was found to be the most salient factor associated with increased vulnerability to malnutrition. Thus, overall, the findings from this research suggest that targeting physical function for example through improving muscle mass and strength should be the key and primary strategy to prevent decline in food intake and malnutrition. The strong relationship between nutrition and physical functioning is not surprising. However despite scientific evidence-based calls for incorporation of objective physical performance assessments in practice (Cesari et al. 2009; Cooper, Kuh, and Hardy 2010), this has not been set as a standard for health care settings.

In our quantitative results chapters (3 to 5), results were discussed as significant only when significance was seen after adjusting for covariates. These factors are low muscle and fat mass, low body weight, low physical performance, low muscle strength, low gait speed, Fried frailty phenotype model, low cognition and high dysphagia risk – indicated in **Fig 1** by superscripts in blue font ($^{£§*}$). Additionally, factors which were significant (p<0.05) or at borderline significance (p=0.05-0.06) in

an unadjusted model only i.e. bivariate analyses (black font superscripts [£§*]), namely ADL disability, number of comorbidities, number of medications and impaired dental status are also highlighted in Fig 1. In this synthesis chapter, we consider all the factors as important to consider when designing an intervention, because of the likelihood to fail to detect some associations across these studies (especially in adjusted models) due to the limited sample size. There is a high chance that larger sample sizes could have maintained significance for all the factors seen in bivariate analyses (Banerjee et al. 2009). While our results indicate primarily targeting physical function; taken together, findings from both our quantitative and qualitative research indicate that the factors associated with malnutrition (risk) or low food intake can be categorised under three dimensions of frailty (**Fig. 1**); hence thorough assessments of all the dimensions prior interventions is warranted.

NB: The Fig. 1 below is an edited version of the Fig 4 in Chapter 2, page 16 (literature review) where a detailed discussion of how several age-related changes can prevent healthy eating and consequently healthy ageing.

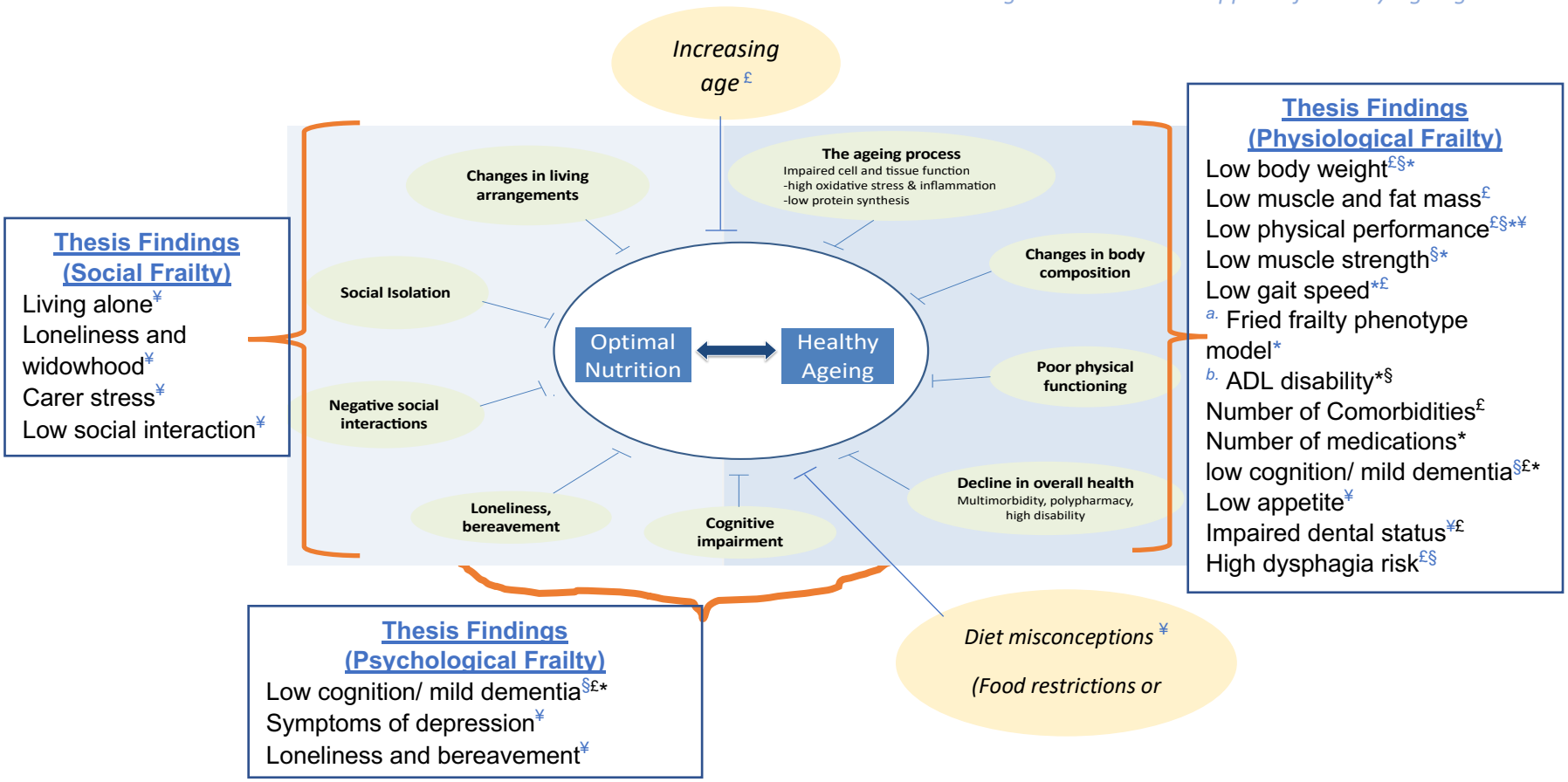

Fig. 1. Thesis findings categorised under three dimension of frailty that prevent optimal nutrition and healthy ageing.

£§*¥ – Significant (p<0.05) findings from the community£, hospital§ and RAC* quantitative studies; **OR** the factor was found salient in the qualitative analysis of older adults' experiences¥

£§* – In cases where the footnote for significance is given in black font, this indicates that results were significant (p<0.05) or at borderline significance (p=0.05-0.06)) in bivariate analyses i.e. unadjusted models only.

a. Fried frailty phenotype model: indicates presence of 3 or more of the 5 components: low gait speed, low muscle strength, low physical activity, frequent exhaustion and unintentional weight loss.

b. ADL disability: indicates inability to independently undertake Activities of Daily Living such as shopping, cooking and cleaning.

7.3.0. Planning Intervention Strategies to Prevent Malnutrition with Advancing Age.

The robust association between a decline in physical functioning across our three quantitative studies, together with the identification of low physical status as the most salient factor associated with increased vulnerability to malnutrition from the qualitative enquiry; suggests the promotion of habitual physical activity is a key intervention strategy to prevent low food intake and malnutrition with advancing age. Additional key strategies include routine and targeted screening; mandatory screening; assessment of malnutrition status; implementation of timely prevention or treatment interventions to optimise nutrition intake; and use of trained health workforce to help improve food intake and demystify dietary misconceptions.

7.3.1. Promote habitual physical activity among both independent and vulnerable older adults.

As discussed above, overall, the findings from this research suggest that targeting physical function should be the key and primary strategy to prevent malnutrition. Promoting habitual physical activity is the key to promote muscle mass, strength and function (Taylor 2013). While this recommendation may be more acceptable to independent individuals, there is greater need to ensure such encouragement is also provided to vulnerable and physically frail older adults who are more likely to consider it safer to avoid walking or exercising due to the increased risk of falls (Chatindiara et al. 2019). Given that some older adults admit that they are only comfortable to do exercises in the presence of a health professional (Chatindiara et al. 2019), it is paramount that interventions for falls prevention programs such as that initiated by the New Zealand ACC [available at: https://www.livestronger.org.nz/] are marketed well enough to ensure all older adults are aware of such services. From our qualitative study, most participants indicated a desire to be physically active although this was a challenge as almost all participants reported reduced mobility; with some dependent on a walker to be mobile and some participants indicated concerns over falls. Nonetheless, for older adults with health conditions, including those at risk of falls, non or low impact exercises, such as tai chi can help strengthen legs and improve balance and posture and reduce the risk of falls (Huston and McFarlane 2016). Older adults can start with planning an exercise routine as simple as moving hands and legs while sitting (Ministry of Health 2013b). Exercising with family or friends, or taking part in a community or home-based supervised programmes – while exercising personal preferences, are additional ways to support routine physical exercising

(Brawley, Rejeski, and King 2003; Picorelli et al. 2014). Attainment or maintenance of routine physical activity can help prevent malnutrition by: 1) promoting maintenance the physical functioning required to prepare healthy meals i.e. functional independence (Taylor 2013) 2), can promote appetite (NHS choices 2018), and 3) address the "logical reasoning" of eating less in response to low physical activity (Chatindiara et al. 2019), among other reasons.

7.3.2. Mandatory: routine and targeted screening for malnutrition (risk)

Screening is the first step to ensure proper nutritional support is given (Australian and New Zealand Society for Geriatric Medicine 2017) – and commonly used validated screening tools in New Zealand include the MNA®SF (across settings) and SCREEN 11 (community only).

Screening for all adults in the community may be non-feasible hence a targeted approach is more suitable (Laur and Keller 2017). This targeted approach can include older adults with unintentional weight loss, vulnerable or frail groups including homebound older adults, upon the first homecare visits and at primary care visits (Bales, Locher, and Saltzman 2015; Laur and Keller 2017). An Australian study demonstrated that it is both feasible and acceptable to patients to implement routine nutrition screening of older patients attending General Practice using the MNA®SF (Hamirudin et al. 2016). Furthermore, among more independent community dwelling older adults, it may be helpful to promote self-screening. The SCREEN 11 can be self-administered and has an online version which provides automatic feedback based on the individual's responses (Laur and Keller 2017). The process of self-screening using the Nutri-eSCREEN® has been initiated in NZ Canterbury DHB, although research reporting acceptability, feasibility or usefulness of this self-screening process in New Zealand is still limited. The MNA®SF has also been validated for self-screening in two studies, one of which found specificity of 75% (Donini et al. 2018), while in the other study the self-MNA®SF demonstrated sufficient [sensitivity 99% and 98% specificity] interrater reliability for use in nutrition screening among community-dwelling older adults (Huhmann et al. 2013). Both SCREEN11 and self MNA®SF could be very useful for self-screening in the community, but more studies are needed to validate this. It is also important to note that success of self-screening procedures among older adults who strongly hold the perception that they eat healthily and are not at risk may be a challenge. Such individuals may ignore the score item and be reluctant to seek or receive nutritional support (Hamirudin et al. 2016; Reimer, Keller, and Tindale 2012). Strategies to improve awareness among older adults may be needed.

In institutions, routine screening of all older adults at admission and routinely seems prudent, which is why this is already a standard practice in several countries including the USA, UK, Netherlands and some parts of Denmark (Elia, Zellipour, and Stratton 2005). The frequency of routine or repeat screening can vary depending with type of care given to older adults – can be at monthly intervals, or longer (e.g. every three months) when there is little or no clinical concern (Elia, Zellipour, and Stratton 2005). There are several ways to ensure mandatory screening is attainable. An Australian study noted that typical barriers to routine screening can be summarised into three sub-categories: organisational (time, resources, policy and procedure, and lack of training and education to upskill non-dietitians), staff (poor knowledge among some staff, staff seeing screening as a burden and absence of management support) and older adults (poor knowledge and communication, whereby older adults did not recognise malnutrition as an issue) (Craven et al. 2017). Such factors can be helpful when considering strategies to promote mandatory screening. It is important to note that the process of screening itself can be done by several health care workers as no specialised training is required (Field and Hand 2015), hence organisational support to ensure dietitians can provide brief training to other staff maybe one of the primary strategies. Nutrition screening tools such as the MNA®SF can be incorporated into both printed and electronic health records [available at: https://www.mna-elderly.com/mna_forms.html], which can enable nurses or other health care workers to conduct screening as part of other routine geriatric screening procedures. Registered dietitians do not necessarily have to perform the screening but can provide training or orientation to other health care workers, who can then refer those identified as at risk of malnutrition for nutrition assessment to them. This model of practice whereby several health workers are mandated to perform screening and refer patients [e.g. using the MNA®SF simple referral guide available at: http://www.mna-elderly.com/interventions.html] can facilitate routine and timely interventions in institutions. In Australia, it has been shown that screening followed by assessment is a successful intervention strategy (Hamirudin et al. 2016), particularly when it results to timely implementation of appropriate interventions (Hamirudin et al. 2016). New Zealand data to support this is still limited.

7.3.3. Nutritional assessment including all three dimensions of frailty.

The Fig 1 on page 9 shows that based on this thesis findings, the key areas to target when designing strategies to prevent malnutrition can be categorised into three dimensions of frailty. These dimensions – physiological, psychological and social frailty are interlinked, hence there is a high chance they will occur and work together

to increase malnutrition risk. The social frailty dimension is the least explored in research (Bessa, Ribeiro, and Coelho 2018; Bunt et al. 2017). Although there is enormous research supporting the association between social factors (e.g., socioeconomic, living arrangements and social support) and malnutrition (Wham et al. 2015; Keller et al. 2007; Donini et al. 2013; Streicher et al. 2018), research incorporating social interventions are still limited. The New Zealand senior chef program (https://www.seniorchef.co.nz/) is a Canterbury DHB initiative that has been helpful at improving cooking skills of older adults as well as promoting social facilitation of eating. Scientific research showing feasibility and efficacy of social strategies on prevention of malnutrition is needed for policy and practice to prioritise resources for such strategies (Saffel-Shrier, Johnson, and Francis 2019). Although unable to ascertain efficacy nor causality, the current research suggests that several components of psychosocial frailty including loneliness, bereavement, low social interactions, absence of social support, living alone, and carer stress (depression), can prevent optimal nutrition intake. Although living alone is a key (social) risk factor for malnutrition (Tomstad et al. 2012; Vesnaver et al. 2015; Vesnaver and Keller 2011; Wham et al. 2015), in the current research vulnerability to malnutrition risk was apparent among both participants living alone, and those who were living with a spouse or 'others'. It is therefore vital that social and nutrition intervention programs not only prioritise older adults living alone but consider the quality of relationships or social connectedness of all older adults, as a means to prevent malnutrition. Special support may be needed for older adults who are carers for their spouse or other family members. Factors such as depression and forgetfulness may worsen appetite and malnutrition status (Andreae, Strömberg, and Årestedt 2016; Moreira et al. 2016), but their impact can be minimised with social interaction (Stroebele-Benschop, Depa, and de Castro 2016). Assessment of psycho-social frailty can help inform appropriate interventions.

Unfavourable physiological changes that occur with ageing (physiological frailty) results from malfunctioning of multiple systems from molecular level to organ failure, often coupled with an overall disruption of homeostasis leading to multiple illnesses (Anisimova et al. 2018; Clegg et al. 2013; Hartl 2016). Physiological frailty can lead to poor appetite, low food intake and nutrition deficiencies (Pilgrim et al. 2015), hence should be assessed prior to intervening. While some assessments of physiological status e.g. body composition and biomarkers may be complicated and require more resources to be undertaken, some robust, quick and inexpensive physical performance measures such as gait speed and handgrip strength are available.

These physical performance measures are independent markers of physiological health and they can also predict the risk of several adverse health outcomes including falls, morbidity, hospitalisation and mortality (Cesari et al. 2009) and malnutrition or sarcopenia (Cruz-Jentoft et al. 2010). It is therefore prudent to ensure that at least one or two physical performance assessments are conducted prior to designing nutrition intervention. The importance of promoting routine physical activity has been discussed above; and an assessment of physical performance is important to ensure appropriate recommendations for exercise routines are given. The Australian and New Zealand Society for Geriatric Medicine (ANZSGM) position statement on undernutrition emphasises the importance of screening and assessment of sarcopenia to prevent the development of frailty (Australian and New Zealand Society for Geriatric Medicine 2017).

7.3.4. Implement timely prevention or treatment interventions to optimise nutrition intake.

Findings from our qualitative work provide insights on what influences eating behaviours and nutrition intake of older New Zealanders, particularly leading to low food intake – chapter 6 (Chatindiara et al. 2019). In chapter 2 of this thesis, a broad discussion of ways to optimise nutrition intake among older adults has been provided. Scientific based international literature indicates that nutrition interventions which can prevent decline in food intake and reduce malnutrition (risk) include: manipulation of diet quality and/or quantity, use of nutrition or dietary supplements, nutrition education or counselling, improving access to food or healthy meals (including use of home delivery meal services, promotion of age friendly communities, and provision of cooking classes) and finally improving social status or social facilitation of eating (Chapter 2, Table 2, page 45). Although New Zealand studies that test efficacy of these interventions are still limited, the current research provided insights on factors to consider before designing or implementation of such interventions.

From the sample of vulnerable older adults, who were experiencing unintentional weight loss and low appetite (Chatindiara et al. 2019), it was apparent that the evidence based intervention strategies such as consumption of high energy and protein diets, food fortification, and/or use of oral nutrition supplements, could be all beneficial to optimise daily intake (Mills et al. 2018; Milne et al. 2009; Nieuwenhuizen et al. 2010) – a task which can be best achieved with the use of a registered dietitian. Unintentional weight loss is a risk factor for malnutrition that can be easily identified if general practice health workers weigh older adults frequently and track weight changes. We found several participants had impaired dental status or chewing

problems and some had swallowing difficulties (dysphagia), which highlights the need for interventions including texture modifications – a task which can be best achieved with the use of an interdisciplinary team including dental services, speech pathologist and dietitians (Australian and New Zealand Society for Geriatric Medicine 2017). In support of the ANZSGM position statement on undernutrition, to optimise nutrition intake of older adults and prevent decline in nutrition intake, both pharmacological and non-pharmacological interventions are paramount. Proper management of nutrition intake requires an inter-disciplinary team including non-medical workforce such as social workers, psychologists and community service providers e.g. Meals on Wheels, as they are best experience to identify and rectify non-pharmacological risk factors (Australian and New Zealand Society for Geriatric Medicine 2017). The current thesis supports the multifactorial nature of the (underlying) causes of malnutrition with advancing age and indicates that there is no a "one-size-fits-all" way of optimising food intake with advancing age. Most important, this thesis data provided multiple viewpoints that can help investigate and prevent loss of appetite – the key factor to target towards optimising food intake.

7.3.4.1. Consider multiple ways to prevent appetite loss guided by all three dimensions of frailty.

Appetite simply means the "desire to eat" and is influenced by a myriad of social, physiological, psychological (Hays and Roberts 2006; Morley 1997; Wysokiński et al. 2015; Mathey et al. 2001; Giezenaar et al. 2016). As they are multiple factors that can promote loss of appetite at older age, it is therefore understandable why in the current research participants with decline in appetite were unable to explain what had led to their appetite loss (chapter 6). However, our findings provided several insights on possible ways to prevent loss of appetite with advancing age. Following the quantitative statistical analysis showing low physical performance as the key risk factor for malnutrition, thematic content analysis revealed that this decline in physical status contributed to a decline in the desire to eat more as eating less was more 'logical' to them. Currently in the UK older adults are recommended to try improving their appetite by exercising (NHS choices 2018), although more research is needed to ascertain this recommendation (Clegg and Godfrey 2018). However, our study adds this insight that by *investigating older adults' physical status,* researchers can proceed to assess older adults' perspectives of the relationship between their food intake and physical status and provide necessary dietary recommendations which encourages older adults to eat well.

Food enjoyment is a goal priority towards attainment of satisfaction with food-related quality of life (Dean et al. 2008), which helps improve appetite, reduce experiences of food apathy and promote regular eating patterns (Vesnaver et al. 2012); yet this can be hindered by the presence of multiple *comorbidities, difficulties chewing and swallowing* – identified as risk factors in our quantitative work and previous studies (Moreira et al. 2016). If such factors are not assessed, there is a high risk of missing the effective ways to improve appetite. *Social factors* including provision of social support, availability of companionship especially at mealtimes and improving social interaction or averting loneliness are additional ways to promote food enjoyment and older adults' appetite (chapter 6). Our qualitative research indicates that *embracing individuals' food preferences* whether they are habitual or shifting preferences is paramount to improve appetite. It must not be assumed that older adults who moved to New Zealand at younger age have adopted typical NZ dietary habits as we noted those who had moved from UK, Tonga, Samoa repeatedly cited foods they ate at younger age in those respective countries of origin (chapter 6). We found that the uniqueness of individuals preferences stretches to food preparation, hence that should also be evaluated as part of intervention designing. For example, for someone who questions hygiene of food prepared in her absence, interventions such as home delivery system will not likely improve his/her intake. For such an individual, family or community support to ensure meals are prepared at the older adult's house will be a more promising solution to improve his/her appetite. Finally, *identifying foods perceived as relevant* and including them as part of most meals might help improve appetite, as we found that older adults were more likely to consume foods they perceived as healthy or relevant – congruent to previous research (van der Zanden et al. 2014; Provencher, Polivy, and Herman 2009). As an example, one participant who reported appetite loss indicated less preference for home delivered meals because the meals did not include sufficient vegetables which she considered most relevant for her health. However, due to ADL disability she was still receiving the home delivered meals but hoping to be well enough to prepare her own meals. It is highly likely the decline in appetite for older adults like her could be explained by a lack of inclusion of foods perceived as healthy. Social services offering meals need to investigate older adults' perspectives and preferences.

7.3.5. Demystify dietary misconceptions – Use of trained health workforce

From our qualitative study, older adults were constantly observing their actions and trying to do what's right for their health, but this often led to food avoidance or

restrictions. However, literature indicates that among vulnerable older adults, liberalised diets may be more beneficial (Niedert 2005) and dietary restrictions are not efficient at preventing morbidity, low quality of life nor mortality (Darmon et al. 2010). There is a clear need to assess the appropriateness of healthy eating concepts that influence food intake with advancing age. We found there was an overwhelming sense of tiredness with several older adults describing themselves as 'lazy". The tiredness repeatedly described by participants was, at least partially, the result of a lower energy intake. However, most participants who expressed extreme tiredness did not relate their low food intake to the frequent tiredness. When asked what they considered healthy eating in relation to their current health status, participants unanimously primarily outlined "eating fruits and vegetables". Indeed, fruits and vegetables are important components of a healthy diet as they provide micronutrients required to work with macronutrients to ameliorate immune function, prevent bone loss and reduce fatigue (Marian and Sacks 2009). However, eating a wider range of foods is important for maintaining health; and consuming (more) fruits and vegetables should not be the primary dietary solution for extreme tiredness, low energy, or to prevent weight loss. It is the consumption of energy dense foods or drinks (macronutrients) that directly increases energy levels. With continuous consumption of energy dense foods, a positive energy balance can be obtained to increase weight gain (Hall et al. 2012) – an ideal outcome for several participants who were experiencing unintentional weight loss (chapters 3-6).

Misconceptions and confusion surround healthy eating, especially when an individual has existing (multiple) health conditions. From our study, the most notable misconception was that fat intake would worsen heart diseases; hence participants reported reducing consumption of meat, dairy and other high fat foods such as cheese. Presence of such misconceptions needs to be investigated and eliminated. It's non debatable that complete exclusion of any food group or nutrient especially without any health restriction is not a healthy practice. A previous study described "fat intake causing cardiovascular diseases (CVDs)" was a myth, and discussed how eliminating fat might actually worsen CVD risk (Malhotra 2013). In a randomised controlled trial, a low fat diet resulted in an unhealthy lipid pattern, and increased insulin resistance in comparison to a low carbohydrate diet (Ebbeling et al. 2012). Recent literature indicates that it is not avoiding saturated fat that matters, but rather what the fat gets replaced with (Sacks et al. 2017). Eliminating fat intake and increasing sugars or carbohydrate intake has not demonstrated beneficial effects on CVDs. The current recommendation suggests lowering (not eliminating) the intake of

saturated fats and replacing with unsaturated fats (Sacks et al. 2017). It is important to note that, among frail older adults, avoiding the consumption of energy dense foods such as standard full cream milk, meat and cheese can make it harder for them to attain the protein and overall energy intake required to prevent unintentional weight loss. Such foods are even listed on dietary guidelines for preventing malnutrition and frailty (Ministry of Health 2013a; NHS choices 2018). While the source of information for some of the participants understandings of healthy eating could not be identified, it was quite concerning to note that some of the nutritional information was gained at health centres. For example, one couple stated their health practitioners had recommended eliminating avocadoes from the diet after diabetes diagnosis. However, the intake of avocadoes can help control insulin levels and prevent development of metabolic syndrome (Devalaraja, Jain, and Yadav 2011). Overall, our findings indicate that dietary recommendations in the presence of coexisting conditions can be complicated and may be better achieved with the help of a registered dietician or nutritionist.

The beneficial service of dietitians in New Zealand has been reported about a decade ago (Chisholm, Jensen, and Field 2011), but there is still no legislative requirement for dietetic input into nutrition care of institutionalised older adults. In a report of promoters and barriers to achieving optimal nutrition in 50 New Zealand RAC homes, the presence of a dietitian was found beneficial as it led to appropriate menu auditing, education of nurses, caregivers and cooks, expert nutritional interventions and treatment; whereas lack of dietetic input led to several barriers including under recognition of nutrition risk status, no usage of validated nutrition screening tools or appropriate follow-up assessment and unnecessarily restrictive special diets were recommended (Jensen 2010; Chisholm, Jensen, and Field 2011). It is recommendable that it becomes a legislative requirement for all hospitalised, institutionalised or vulnerable community dwelling older adults are routinely assessed by a dietitian.

7.4. Implications and Recommendations for policy and practice

1. Mandatory screening for malnutrition across all settings (targeted in the community and routinely in institutions) is recommended in support of the ANZSGM position statement on undernutrition (Australian and New Zealand Society for Geriatric Medicine 2017). Routine screening should become mandatory in institutions (hospitals and RAC). The recommended times are at admission to the institution for everyone; and repeat screening can vary depending with type of care given to older adults – can be at monthly intervals, or longer (e.g. every three months) when there is little or no clinical concern (Australian and New Zealand Society for Geriatric Medicine 2017; Bales, Locher, and Saltzman 2015; Laur and Keller 2017).

2. Due to the high absolute numbers of older adults living in the community, targeted screening for malnutrition among community-dwelling older adults is recommended at primary care level. The target groups should include primarily vulnerable older adults including at discharge from the hospital, homebound and recipients of homecare services, at annual attendance to general practice and all older adults experiencing unintentional weight loss.

3. This research found that malnutrition risk is higher among adults of ≥85 years old, and that the risk increases with every yearly increase in age. To reduce prevalence of malnutrition with advancing age, screening should occur from the age of 65+ or latest 75+. Indeed, malnutrition is more likely to occur among older adults of the advanced age group, but malnutrition is a chronic condition which its manifestation in later age is most likely a result of failure to screen and identify at an earlier age.

4. Screening is only the first step to identify malnutrition and all those identified to be at risk of malnutrition need referral to a dietitian for nutrition assessment. The MNA®SF and SCREEN 11 are examples of validated screening tools which can be easily incorporated in practice to facilitate timely referral and intervention.

5. As this thesis findings identified physical frailty as a key determinant of nutrition status, and there has been calls to ensure physical performance measures are part of every geriatric assessment procedures (Cesari et al. 2009; Cooper, Kuh, and Hardy 2010); it is recommended that at least one or two physical

performance measures be incorporated in all routine geriatric assessments. These can be gait speed, hand grip strength, sit-to-stand tests or standing balance – all validated and inexpensive objective measures. The 2016 ANZSGM position statement on undernutrition emphasises the importance of screening and assessment of sarcopenia to prevent the development of frailty, and the aforementioned assessments are all components and predictors of sarcopenia.

6. It is recommended that the interventions designed to prevent malnutrition should incoporates all the three dimensions of frailty (physiological, psychological and social) i.e. both pharmacological and non-phamarcological interventions are needed. This can only be achieved if management of malnutrition is conducted by an interdesciplinary team (Australian and New Zealand Society for Geriatric Medicine 2017). The three dimensions of frailty are interelated and most likely work together to either prevent or promote both optimal nutrition intake and healthy ageing; hence an intervention including all is likely to achieve more positive outcomes.

7. In line with all the above recommendations, it is well acknowledged that there are some potential workforce and fiscal constraints to achieve timely screening, assessments and intervention. One pragmatic way of achieving such a goal is through facilitating mechanisms of communication across the health sector's multidisciplinary teams. It is recommended that there should be a clear pathway for (electronic) data documentation to ensure no department will re-assess measures that would have been already assessed in another department. Most assessments that are required to detect the risk of malnutrition e.g. loss of body weight and physical decline are already getting assessed by some clinicians — for example as part of the interRAI suite. Since the interRAI is a comprehensive assessment tool mandated by the Ministry of Health, a large number of older adults may have an interRAI assessment hence data can be made available for use. Given that the interRAI nutrition indicators have a low sensitivity compared to validated malnutrition screening tools (MNA®SF and SCREEN11), it is recommended that a short malnutrition screening tool e.g. the MNA®SF be administered alongside the interRAI; or at least to improve the sensitivity of the interRAI by changing the BMI cut off point for detecting malnutrition risk to <23kg/m^2 versus the current <20kg/m^2.

7.5. Recommendations for future studies

1. Findings from this research indicate the importance of mandatory screening and nutrition assessments to enable timely interventions. However, the cross-sectional nature of the studies cannot ascertain efficacy of this recommendation; therefore, randomised controlled trials or longitudinal studies are needed to investigate the effectiveness of mandatory screening on malnutrition (risk) prevalence.

2. Scientific based evidence supporting acceptability and usefulness of self-screening tools is still limited. Given that it may be non-feasible to screen all community dwelling older New Zealanders and a targeted approach has been recommended above; it is important for future research to evaluate acceptability and usefulness of self-screening in NZ.

3. A broader discussion of the types of intervention strategies that can be implemented to prevent malnutrition is provided in chapter 2.4 of this thesis. While these interventions can target one or more risk factors of malnutrition, there is need for more novel strategies that incorporates all three dimensions of frailty as these factors often occur together. Future research involving designing and testing feasibility and efficacy of such novel strategies particularly in a New Zealand setting is warranted.

4. Social frailty is still the least explored dimension of frailty. While our qualitative work provided insights on the relationship between malnutrition risk and social frailty, there is need for research that further investigates this relationship using both objective and subjective measures.

7.6. Conclusion

Data from this mixed methodology research provides evidence suggesting that malnutrition (risk) is a challenge across settings, indicating the importance of mandatory screening – routine among institutionalised older adults and targeted for those living in the community. The focus of this thesis has been mostly relevant to the New Zealand context as limited data had been published on malnutrition prevalence and risk factors; and qualitative data reporting older adults' perspectives on healthy eating or food intake was lacking. From the statistical analyses across settings, low physical functioning (gait speed, muscle strength and physical frailty – phenotype model) was identified as the key risk factor for malnutrition; and additional factors were dysphagia risk, low cognition and unintentional weight loss (low BMI, fat and muscle mass). Thematic content analysis of older adults' experiences and perspectives revealed that vulnerability to malnutrition increases with advancing age due to a myriad of factors that relates to low physical function, appetite loss, living arrangements or companionship, conditioned food preferences, food avoidance in relation to illnesses and perceived healthiness of foods. Addressing such factors will require an interdisciplinary team. Overall the thematic analyses indicated that low food intake can be prevented by considering multiple ways to promote appetite and this includes correcting misconceptions related to healthy eating.

Since unintentional weight loss is the main indicator of malnutrition risk, routine weighing of older adults is a quick and easy way to identify older adults who need to receive screening, assessment and/or interventions for preventing malnutrition. Based on this thesis findings, it can be concluded that to prevent malnutrition with advancing age, it is important for policy and practice interventions to target all the three dimensions of frailty (physiological, psychological and social). This will help promote both optimal nutrition intake and healthy ageing. Mandatory screening for malnutrition, followed by assessment when needed are the key strategies to promote timely intervention and reduce malnutrition prevalence. Although malnutrition (risk) is more prevalent in institutions, policies that focus on preventing malnutrition in the community are primarily needed as our data shows that majority of participants get hospitalised or institutionalised when already malnourished or at risk.

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Appendix

Appendix Literature review

Appendix #1: Licence or Permission to re-use frailty figure (Fig 5, page 32)

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Appendices Studies 1-3

Appendix #2: Ethics approval letter

Health and Disability Ethics Committees

Health and Disability Ethics Committees
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24 February 2016

Dr Jacqueline Allen
[redacted]
Auckland 1149

Dear Dr Allen

Re:	**Ethics ref:**	**14/NTA/70/AM01**
	Study title:	Multidimensional Nutritional Analysis of Waitemata DHB Elderly Population

I am pleased to advise that this amendment has been *approved* by the Northern A Health and Disability Ethics Committee. This decision was made through the HDEC Expedited Review pathway.

The main issues considered by the HDEC in giving approval were as follows.

1. This amendment involves the use of already available blood samples from pre albumin and C reactive protein as additional measures of nutritional risk.
2. The Committee noted that appropriate changes have been made to the PIS and Consent form to reflect this change.
3. The Committee requests that more care is taken in future to include tracked changes with updated documents so the committee can identify the changes that have been made.

Please don't hesitate to contact the HDEC secretariat for further information. We wish you all the best for your study.

Yours sincerely,

BJ Fergus

Dr Brian Fergus
Chairperson
Northern A Health and Disability Ethics Committee

Appendix #3: RAC Study Protocol

Study Protocol – Nutritional Risk Assessment in Residential Care Setting

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Conflict of Interests

All investigators declare no conflict of interests.

Funding

Funding is sought by grant application

Study Design

Prospective non-randomized cross-sectional observational human study

Setting

Residential Aged Care Facilities, Waitemata District

Study Aim

To determine the nutrition risk status of older adults living in the residential care setting and the major health and social factors influencing nutritional risk.

Hypothesis:

It is hypothesised that a high prevalence of nutrition risk will be observed in this study population and risk factors will be multifactorial. We expect to observe an increasing decline in nutritional status with increasing age of the participants. To be specific, a higher nutrition risk is expected to be observed within the >85years compared to the 65-84years. Furthermore, we hypothesise that positive correlations exist between several nutrition risk factors and nutrition risk status.

Specific Objectives

- To describe and document the nutrition risk status, anthropomorphic measurements, muscle mass and strength of older adults living in a residential care setting.
- Compare the nutrition risk status of the participants aged >85years with those aged 65-84 years
- Check for correlations between nutrition status and several nutrition risk factors
- Identify predictive factors associated with high nutrition risk and whether they are related to blood biomarker levels
- Measure dysphagia-specific quality of life using the EAT-10 score, and correlate oral health status with nutrition status

- Determine the prevalence of frailty and examine the association between frailty and nutrition risk status of older adults living in residential care homes

Number of Participants:

250

Proposed Timeframe:

Jan – February 2017 Ethics approval and funding confirmation,

May – July 2017 Protocol training, Participants invitations, recruitment and data collection

August 2016 – Dec 2017 Data analysis, preliminary report production and presentation

Early 2018 Manuscript preparation for publication

Rationale and Literature Review:

The New Zealand population is ageing. The older people population is currently the fastest growing population which suggests that in future older people will outnumber younger people[1]. Nutrition is a key determinant of successful ageing as food is not only critical to physiological wellbeing but also contributes to social, cultural and psychological quality of life (American Dietetic Association 2005). Clinical malnutrition is preceded by a state of nutritional risk and screening can identify older people at risk of poor nutrition or who currently have impaired nutritional status. Previous studies of older people have shown a relationship between nutrition risk and health related quality of life[2-4]. Changes in physical health with ageing are well established and higher patterns of morbidity occur in malnourished older people[5]. Frailty is a common syndrome in geriatric population. In fact, Clegg et al. (2013) stated that frailty is the most problematic expression of population ageing[6]. A 2016 review paper reported that few studies have examined the association between nutritional status and frailty in different geriatric settings. Among the studies included in that review paper, none was conducted in a residential care setting[7].

Social factors play an important role in promoting and maintenance of adequate food intake; for example, living conditions may contribute to under-eating[8]. Although in a residential care centre people may not be essentially alone, the environment and ways in which food is provided may greatly influence eating habits and consequently nutrition status. Therefore, performing nutrition risk assessment for every individual in this setting is a plausible procedure. Screening studies in New Zealand have

suggested that a third of community living older adults show high nutritional risk. Among community living adults of advanced age, more than half have been identified at high nutrition risk[9-11]. Although not much research has been done in New Zealand residential settings, international research suggests that nutrition risk is higher in residential compared to community living settings. For example, in a study conducted in 22 UK care homes, only 14% of the subjects had a normal nutritional status[12]. The New Zealand adult nutrition survey (2008) identified 0.5-2.5% of older people (71 years+) as clinically underweight[13]. Those at risk tend to have more illnesses as well as increased difficulties with physical function due to loss of skeletal muscle and muscle strength. Quality of life is compromised. Therefore, it is important to understand malnutrition risk factors and ways to reduce nutrition risk prevalence.

Validated tools have been established to screen for risk of malnutrition using questionnaires. The tools mostly combine questionnaire items with anthropomorphic measurements including body weight, standing height and calf circumference. The mini nutritional assessment (MNA)™ is the most frequently used screening tool in older adults[14]. Notably, in older adults' significant changes in body composition are often observed. For this reason, use of anthropometry alone to assess nutrition status is sometimes debatable. Bioelectrical impedance analysis (BIA) is a well-established method of assessing body fat and lean mass in larger populations especially the older population[15]. Measuring nutrition status in older adults is quite complex and all the frequently used methods have advantages and disadvantages[16]. Therefore, use of a combination of methods may be helpful in ensuring high quality data is obtained. Other common nutritional health assessments conducted in older adults include: functional 2.4 meter walk test for lower body strength and walking speed, grip strength for upper body strength, physical activity and fatigue.

In addition to determining the prevalence of nutrition risk; to prevent malnutrition, it may be helpful to also understand the possible risk factors of malnutrition. In older adults, it appears causes of malnutrition are multifactorial. We therefore plan to collect participants background data regarding socioeconomic, sociodemographic, health medications physiological and psychological factors. Validated screening tools are available to assess certain nutrition risk factors; for example, the Eating Assessment Tool (EAT-10) for assessment of dysphagia[17] and the Montreal Cognitive Assessment (MoCA) for cognitive impairment assessment[18]. Assessment of other possible risk factors is also done using the above-mentioned nutrition assessment tools.

Early understanding of malnutrition risk and prevalence in residential care setting may help develop strategies or guidelines to prevent and/or reverse malnutrition increasing the likelihood of ageing in place (older people able to stay independently living in the community). Health problems arise or worsen because of poor nutrition status or inadequate nutrition intake. Our understanding of older people's nutritional status in New Zealand is incomplete. Social setting has been demonstrated to affect nutritional status and we believe that personal living arrangements are correlated with nutritional status. Adults living independently manage their own diets and calorific intake. Once individuals translocate to residential care the question is whether their ability to be nutritionally replete is already lost and has led to the need to move, or whether other concomitant factors that mandate the change in living situation also impact nutrition. Thus, understanding nutrition risk status for adults residing in residential care centres and finding ways to promote healthy eating is a pressing public health concern.

Impact of Nutritional Status on Quality of Life and health risk

Adequate food intake is critical to physiological well-being and psychological quality of life. The impact of poor nutrition is pervasive. Low energy intake reduces further the ability to prepare food and maintain diet. Food intake, including protein amount, type and timing is essential in maintaining skeletal muscle strength and mass and thus functional status. Age related decline in muscle mass and function leads to loss of mobility, one of the primary determinants of both quality of life and the need for residential care. Immune surveillance is reduced and ability to fight infection or disease will be affected.

This population study will provide a snapshot of older people in our residential care settings and how they are faring from a nutritional standpoint. It will provide insight into differences and areas of need, as well as informing strategies for prevention of malnutrition. Identifying predictive factors for nutritional impairment will enable targeted intervention to be developed. The simple study design and cross-collaboration of several disciplines means that the study has a high likelihood of successful completion and of acceptance of results and recommendations. The researchers involved all work in older adult care and will drive change based on the study's findings.

Study Design

A prospective, non-randomized, observational, cross-sectional human cohort study

Methods and Subjects

Subjects meeting inclusion criteria and nil exclusion criteria will be invited to participate in the study. Consent will be discussed in person and written information given. Subjects will be given time to read information, ask questions and decide on whether to participate. Appropriate interpreting services will be available if needed.

Inclusion Criteria

1) Age greater than 65 years (All ethnicities other than Maori and Pacific Island), age greater than 55 years (Maori and Pacific Island ethnicity)
2) Able to complete self-assessment questionnaire
3) Willing to undergo anthropomorphic measures
4) recently Admitted to a residential care centre

Exclusion Criteria

1) Age less than 65 or 55 years (depending on ethnicity).
2) Unable to consent for participation
3) Presence of a tracheotomy tube or airway obstruction necessitating a tracheotomy tube.
4) Tumour of the larynx or pharynx (voicebox or throat)
5) Subjects with a Zenker's Diverticulum
6) Subjects with orocutaneous or pharyngocutaneous fistulae at the time of evaluation.
7) Subjects with known metabolic or nutritional malabsorption disorders.
8) Subjects with psychiatric illness affecting nutrition e.g. Anorexia nervosa.
9) Subjects under palliative care.

Study Protocol

Subjects will be invited to participate in the study by face-to-face interview (in-patients and residential residents). Interviews will take place residential care centre. Investigators will travel to the site to meet the subject.

After appropriate consent is received subjects will be enrolled into the study. A structured interview will then be performed. The interview will be done with help of a questionnaire (attached) designed using validated screening tools, including the Mini Nutritional Assessment short form (MNA- SF), for nutrition status assessment [Appendix] and the Eating Assessment Tool (EAT-10), for dysphagia assessment and the Montreal Cognitive Assessment (MoCA), for cognitive impairment assessment. Anthropomorphic measurements (Body mass index [kg/m^2], calf circumference [cm]

will also be done. Additionally, demographic and health status data will also be collected, together with dental assessment (dentate, edentulous, dental appliance). Soon after anthropometric measurements; grip strength, muscle and fat mass (BIA). and functional 2.4 meter walk test assessments shall be done. Physical activity and fatigue shall be assessed as described in previous studies[19-22]. A structured questionnaire designed through combining the validated questionnaires of the three measures will be used. Estimated time for completion of whole interview and measures is one hour. All information gathering from the subject will occur at the first visit. No further interaction is required. Information will be entered to Excel spreadsheets on personal computers accessible by password (only known by Investigators). Additional demographic information may be recovered from the patient notes by the study investigators (with consent).

Frailty Assessment: No additional measures shall be required for this assessment as they will all be captured in the previously described measures. Frailty will be classified using the Fried's phenotype criteria[19] i.e. having at least three of the following features: 1) unintentional weight loss, 2) slowed performance or walking speed 3) muscle weakness or low grip strength, 4) fatigue or poor endurance and 5) low physical activity. Having one or two of these conditions shall be classified as pre-frail[19].

Subjects identified to be at nutritional risk will be referred to the appropriate service for review and management. This will not affect study participation.

Information Collection

All information will be stored in password-protected computers accessible only by the Investigators. Only the Primary investigators will have access to the complete data set. Investigators will comply with Privacy Act tenets and requirements. Information will be reported in de-identified groups with no individual information reported.

Ethics Information

Ethical approval was gained from the Health and Disability Ethics Committee: Northern A (Application 14/NTA/70)

Adverse Events

As the primary objective of the study is to assess nutrition status at a single time point there are unlikely to be adverse events related to study participation. Possible

adverse events may be psychological in creating stress for the patient questioned about their nutritional status.

Subjects are free to withdraw from the study at any time. This will not adversely affect their ongoing care.

Study Data

Study data will be collected and analysed as a group, and no individual data will be identifiable.

The primary objective of the study is to determine the nutritional status of older adults living in the residential care setting and outline the major factors that possibly influence food and nutrition intake in this setting. The secondary objectives are listed below:

- To describe and document the nutritional status, anthropomorphic measurements, muscle mass and strength of older adults living in a residential care setting.
- Compare the nutrition risk status of the participants aged >85years with those aged 65-84years
- Investigate if any correlations exist between nutrition status and several nutrition risk factors
- Identify predictive factors associated with high nutrition risk and whether they are related to blood biomarker levels
- Measure dysphagia-specific quality of life using the EAT-10 score, and correlate oral health status with nutrition status
- Determine the prevalence of frailty and examine the association between frailty and nutritional status of older New Zealanders in residential care settings
-

Sample size and data analyses

As this residential care setting study is part of the larger study involving 2 other settings or groups (community and hospital), power calculation has been completed as follows: Estimating an effect size of 10%, that is there will be a 10% difference in average weight between best and worst groups, and to achieve 80% power with a significance level of 0.05, the number of subjects required per group is 33. However, estimating a larger standard deviation and smaller effect size with the same power and significance level suggests that 142-175 subjects would be required per group depending on SD. To detect differences between ethnic groups, we are aiming for 250 participants per group.

Descriptive statistics will be used to report group findings including inter-quartile ranges, standard deviation and relative risk. Odds ratios will be used for factors identified to be associated with worse nutrition. Correlation analysis shall be performed using Pearson correlation coefficient (r).

Impact of Research

In support of the government's 'Ageing in Place' policy (Ministry of Social Policy 2001) there is need to identify the prevalence and factors that could lead to malnutrition and intervene accordingly. If there are reliable blood markers that may enable simple screening at primary care level, then this would be valuable in predicting individuals that may need nutritional support.

This study focuses on older adults, gathering baseline data on their nutritional status which can be used to monitor changes in health status in potential future studies. Nutrition underpins much of this vulnerable age-group's health profile and ability to deal with comorbid disease. Factors contributing to nutrition are both psychosocial and physical. It is critical to understand what the current state of nutritional compromise is in our older population. Advancing knowledge in this area will inform health policy and strategy particularly at a primary intervention level to reduce long term consequences of nutritional depletion in an aging population. This study will encompass diverse ethnicities due to geographic and socioeconomic spread within Waitemata DHB and three key living situations that we believe have a major impact on nutrition in older people. Our collaboration with primary care and expert researchers in this field will enhance our ability to apply the knowledge obtained and implement effective prevention strategies and provide education to patients and caregivers. Interventions will be developed with end-users but may include meal support, in-home nutritional assessment as routine, dietary advice and social eating groups. Knowledge gained from the study can be transferred to GP's, community health nurses, dietitians and clients through written and web-based platforms.

Responsiveness to Maori

Maori will be well represented in this observational study by inclusion of catchment areas with good population representation in West Auckland. Key researchers in this study have already focused previous research on ethnic inequalities and published in this area. The study is powered to enable subgroup analysis with an aim of clarifying differentiating factors between Maori and non-Maori participants. Cultural considerations have been adopted in developing the study protocol and are approved by the Organisation's Maori research adviser.

Research Team Expertise

The study will be coordinated via WDHB Otolaryngology, Dietetics and Gerontology Services. Ethics approval is not required from HDEC (confirmation letter available) however we have full HDEC approval. Locality agreement has been obtained. Staff will provide expertise free and students are funded by Massey University.

Carol Wham, PhD is A/Professor of Nutrition and Dietetics at Massey University overseeing all Masters Students in Nutrition and Dietetics. Carol is an experienced gerontology dietitian and has published in this area specifically regarding ethnic inequities and will coordinate research, supervise students, provide analysis and deliver study goals.

Jaqueline Allen, PhD is a practicing Otolaryngologist with extensive research experience in New Zealand and the United States of America. She is grant-funded for current research and is a Senior Lecturer in the University of Auckland. She can coordinate the research, provide analysis and deliver study goals.

Marlena Kruger, PhD is the Dean, Graduate Research and Researcher Development whose research expertise will help the running of the project. She is also a Professor in Nutritional Physiology who has published in this area and have a great understanding of physiological changes that occur with ageing.

Idah Chatindiara, MSc is a PhD Human Nutrition student, whose thesis is aimed at optimising food and nutrition intake in older adults. This project is part of her PhD project. Prior to commencing her PhD, Idah worked in several human nutrition trials that aimed to promote energy balance prevent metabolic syndrome.

Teresa Stanbrook Is Clinical Lead in Dietetics and Nutrition at North Shore Hospital, WDHB. She has participated in several studies of this kind and has vast experience in nutrition risk data collection.

Stacey King and **Dushanka Hettige** are Masters Students in Nutrition and Dietetics under supervision of A/Prof Wham. They will work on data collection as masters' thesis projects. They have both completed undergraduate bachelor's degree in human nutrition

Funding

Funding will be provided by Massey University and is also sought from the Auckland Medical Research Foundation and other grant funders.

Expected Benefit and Research Impact

There may be direct benefit to the patient for study participation. They may directly benefit from being identified as having nutritional risk and being referred to appropriate services. The improvement may be mild or significant. For the society, there will be great value in understanding nutritional status and risk factors in residential care settings. This will be helpful in designing interventions that help optimise food and nutrition intake in older adults, thus preventing and/or reversing malnutrition.

There may be no benefit from participation in the study.

Presentation and publication

All published or presented data from the study will be presented in a de-identified manner, protecting patient confidentiality. Data will be presented locally and internationally at appropriate Scientific Conferences. Publication in peer-reviewed journals will be sought. Participants will be provided with data or manuscripts if requested. Personal information will only be available to the PI and co-investigator.

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23.

Appendix

Mini Nutritional Assessment short form (MNA-SF)

Eating Assessment Tool-10 (EAT-10)

Montreal Cognitive Assessment (MoCA)

Appendix #4: Across settings Study Protocol for the Quantitative study

Waitemata District Health Board
Te Wai Awhina
Making a healthy difference to the community

Allen

Elderly Nutrition Study

Study Protocol – Multidimensional Nutritional Assessment in an Elderly Urban Population

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c.a.wham@massey.ac.nz

Conflict of Interests: We declare that we have no conflict of interests, commercial involvement or financial gain from this research or in relation to any products used in this research.

Funding: Funding is sought by grant application.

Study Design:

Prospective non-randomized cross-sectional observational human study

Setting:

Tertiary Care, Waitemata District Health Board

Primary Care, Auckland Primary Health Care Organisation

Residential Aged Care Facilities, Waitemata District

Hypothesis:

1. That nutritional status and anthropomorphic measures will differ between three elderly populations – independently-living, well elderly, hospital in-patients and residential care residents
2. That blood biomarkers will be associated with level of nutritional risk as assessed by questionnaire and anthropomorphic measures.

Aim: The aim of this research is to evaluate the validity of laboratory markers prealbumin and C-reactive protein (CRP) compared to three categories of nutrition risk (nourished, at risk or malnourished) using the validated Mini Nutritional Assessment (MNA-SF) among older adults 65+ years living in the Waitemata PHO catchment.

Objectives:

i) To describe and document the nutritional status, anthropomorphic measurements, muscle mass and strength of independently living older people.

ii) Compare the nutrition risk status of the participants using the MNA SF with biomarker levels.

iii) Identify predictive factors associated with high nutrition risk and whether they are related to blood biomarker levels

iv) Measure dysphagia-specific quality of life using the EAT-10 score

Number of Participants:

750

Proposed Timeframe:

Jan 2016 – February 2016	Ethics approval and funding confirmation, protocol training
February 2016 – June 2016	Participant invitations

March 2016 – October 2016	Participant recruitment and data collection
September 2016 – January 2017	Data analysis, preliminary report production and presentation (publication), theses submission
October 2016 – April 2017	Report production and results publication and dissemination

Rationale and Literature Review:

Nutrition is a key determinant of successful ageing as food is not only critical to physiological wellbeing but also contributes to social, cultural and psychological quality of life (American Dietetic Association 2005). Clinical malnutrition is preceded by a state of nutritional risk and screening can identify older people at risk of poor nutrition or who currently have impaired nutritional status. Previous studies of older people have shown a relationship between nutrition risk and health related QOL[1-4]. Changes in nutritional status and physical health are well established; higher patterns of morbidity occur in malnourished older people[5]. Social factors play an important role in promoting the maintenance of adequate food intake. Living alone may contribute to under-eating[6].

Screening studies in New Zealand adults have suggested that a third of community living older adults show high nutritional risk[7-11]. Among community living adults of advanced age, more than half have been identified at high nutrition risk[10]. The New Zealand adult nutrition survey (2008) identified 0.5-2.5% of older people (71 years+) as clinically underweight[11]. Those at risk tend to have more illnesses as well as increased difficulties with physical function due to loss of skeletal muscle and muscle strength. Quality of life is compromised. Validated tools are available to screen for risk of malnutrition using a questionnaire. However a simple blood test may be a more effective way to

identify those at risk as screening questionnaires are time consuming and anthropometric measures sometimes difficult to collect (body mass index using weight, standing height or calf circumference). This study aims to evaluate whether prealbumin and C-reactive protein (CRP) are sensitive laboratory markers of malnutrition risk compared with the validated Mini Nutritional Assessment (MNA-SF) which identifies three categories of risk. Early understanding of malnutrition risk allows primary care interventions to be undertaken in order to prevent disease states from occurring and to reduce hospital burden. This may lead to increased ability for older adults to stay living at home rather than be moved to care facilities. Health problems arise as a result of inadequate food and nutrition intake[12]. A low prealbumin concentration is a sensitive and cost-effective method of assessing malnutrition in

patients who have a chronic disease. Prealbumin has one of the highest ratios of essential to nonessential amino acids of any protein in the body making it a distinct marker for protein synthesis. Prealbumin is regarded primarily as a signal identifying the at-risk patient, who requires assessment, monitoring and nutritional support[15]. When screening protocols that use prealbumin have been compared with a 2-stage process involving a screening questionnaire followed by an assessment by a dietitian, the prealbumin protocols identified more patients considered to be malnourished[16]. However because of its short half-life, the concentration of prealbumin falls rapidly when there is a reprioritisation of synthesis toward acute-phase proteins such as C-reactive protein (CRP) which increases in concentration within 6-12 hours post an inflammatory incident. In seriously ill patients, very low prealbumin concentrations are typical and are inversely related to CRP. Prealbumin is proposed as a laboratory marker that can identify early risk of malnutrition even when clinical signs are not evident. It is quick, simple and relatively inexpensive. It is suggested the most valuable interpretation of biochemical assessment of prealbumin concentration is in conjunction with CRP[15]. This study will evaluate whether prealbumin and C-reactive protein (CRP) are sensitive laboratory markers of malnutrition risk compared with the MNA-SF which identifies three categories of risk.

Our understanding of older people's nutritional status in New Zealand is incomplete. Social setting has been demonstrated to affect nutritional status eg. Decile living ratings associated with obesity. We believe that personal living arrangements are correlated with nutritional status. Adults living independently manage their own diets and calorific intake. Once individuals translocate to residential care the question is whether their ability to be nutritionally replete is already lost and has led to the need to move, or whether other concomitant factors that mandate the change in living situation also impact nutrition. Typically admission to hospital results from an acute insult and frequently this creates a hypermetabolic state which incurs increased nutritional requirements. Additional protein is needed to prevent protein malnutrition that is often seen on surgical wards. Hospital diets should accommodate calorific demands but often food is unappetizing and unfamiliar, feeding ability may be affected by disease, medications or instrumentation such as IV lines and cannulae, and patients do not maintain appropriate intake. Our hypothesis is that there will be significant nutritional differences between older population groups comparing healthy, independently living adults (PHO cohort) to in-patient rehabilitation ward patients to residential care residents within the Waitemata DHB catchment and that these will correlate with serum blood marker levels (prealbumin and CRP).

Impact of Nutritional Status on Quality of Life and health risk

Adequate food intake is critical to physiological well-being and psychological quality of life. The impact of poor nutrition is pervasive. Low energy reduces further the ability to prepare food and maintain diet. Food intake, including protein amount, type and timing is essential in maintaining skeletal muscle strength and mass and thus functional status. Age related decline in muscle mass and function leads to loss of mobility, one of the primary determinants of both quality of life (QOL) and the need for residential care. This further depletes energy. Immune surveillance is reduced and ability to fight infection or disease will be affected.

This population study will provide a snapshot of elderly in our community and how they are faring from a nutritional standpoint. It will provide insight into differences and areas of need, as well as informing strategies for prevention of malnutrition. Identifying predictive factors for nutritional impairment will enable targeted intervention to be developed right from a primary care level. The simple study design and cross-collaboration of several disciplines means that the study has a high likelihood of successful completion and of acceptance of results and recommendations. The researchers involved all work in the area of older adult care and will drive change as a result of the study's findings.

Study Design:

A prospective, non-randomized, observational, cross-sectional human cohort study

Methods and Subjects:

Subjects meeting inclusion criteria and nil exclusion criteria will be invited to participate in the study. Consent will be discussed in person and written information given. Subjects will be given time to read information, ask questions and decide on whether to participate. Appropriate interpreting services will be available if needed.

Inclusion Criteria:

1) Age greater than 65 yr (All ethnicities other than Maori and Pacific Island), age greater than 55 yr (Maori and Pacific Island ethnicity)
2) Able to complete self-assessment questionnaire
3) Willing to undergo anthropomorphic measures
4) Admitted to ward or residential care within no longer than five working days (for these cohorts)
5) Undergoing a blood test as ordered by GP or other physician

Exclusion Criteria:

1) Age less than 65 or 55 yrs (depending on ethnicity).
2) Unable to consent for participation
3) Presence of a tracheotomy tube or airway obstruction necessitating a tracheotomy tube.
4) Tumour of the larynx or pharynx (voicebox or throat)
5) Subjects with a Zenker Diverticulum
6) Subjects with orocutaneous or pharyngocutaneous fistulae at the time of evaluation.
7) Subjects with known metabolic or nutritional malabsorption disorders.
8) Subjects with psychiatric illness affecting nutrition eg. Anorexia nervosa.
9) Subjects under palliative care.

STUDY PROTOCOL

Subjects will be invited to participate in the study by letter of invitation (primary health care organisations) or face-to-face interview (in-patients and residential residents). Interviews will take place in the subject's residence, ward or other site deemed most convenient for the patient. Investigators will travel to the site to meet the subject.

After appropriate consent is received subjects will be enrolled into the study. An interview will then be performed which will consist of a structured interview (the Mini Nutritional Assessment [MNA])[17,18] [Appendix] and anthropomorphic measurements (Body mass index [kg/m^2], calf circumference [cm], dental assessment (dentate, edentulous, dental appliance) and completion of self assessment questionnaire (the Eating Assessment Tool, EAT-10)[19] [Appendix]. A simple screen for cognitive impairment will also be performed (Montreal Cognitive Assessment)[20]. Estimated time for completion of whole interview is 60 minutes. All information gathering from the subject will occur at first visit. Consent will be obtained to request laboratory evaluation of a previously taken blood sample from the subject, for the biomarkers prealbumin and CRP. An additional blood draw is not required. No further interaction is required. Information will be entered into Excel spreadsheets on personal computers accessible only by password known to the Investigators. Additional demographic information may be recovered from the patient notes by the study investigators (with consent).

Nutritional status will be measured using the Mini Nutritional Assessment, a validated instrument for assessment of nutritional risk. This tool has been rated as the most

effective and appropriate for assessing nutrition in the elderly[21]. Dysphagia specific quality of life will be assessed with the Eating Assessment tool (EAT-10). The EAT-10 is a validated self-administered disease specific quality of life instrument for dysphagia[20]. This questionnaire typically takes five minutes to complete.

Subjects that are detected as having nutritional risk or needing intervention will be referred to the appropriate Service for review and management. This will not affect study participation.

Information Collection

All information will be stored in password protected computers accessible only by the Investigators. Only the Primary investigators will have access to the complete data set. Investigators are aware and will comply with all Privacy Act tenets and requirements. Information will only be reported in de-identified groups with no individual information reported.

Ethics Information

This study has been entered into the HDEC system and is deemed NOT to require full HDEC review (see attached Waitemata District Health Board letter and HDEC transcript). District Health Board Ethics committee review has been performed and approved.

Adverse Events

As the primary objective of the study is to assess nutrition at a single time point there are unlikely to be adverse events related to study participation. Possible adverse events may be psychological in creating stress for the patient questioned about their nutritional status.

Subjects are free to withdraw from the study at any time. This will not adversely affect their ongoing care.

Study Data

The primary objectives of the study are to ascertain nutritional status in an elderly urban population at a single point in time and compare elderly subjects living in three different contexts. Study data will be collected and analyzed as a group, and no individual data will be identifiable.

The secondary objectives of the study are to identify factors that are predictive of poor nutrition, identify which factors are modifiable, to categorize dental status by a forced choice, three item scale (dentate, edentulous, dental appliance) and measure

dysphagia-specific quality of life (EAT-10). Identify whether serum biomarkers of prealbumin and CRP are correlated with nutritional risk categorization of with other predictors of nutritional risk.
The study will be completed at this time.

Analyses

Power calculation has been completed. Estimating an effect size of 10%, that is that there will be a 10% difference in average weight between best and worst categories, and to achieve 80% power with a significance level of 0.05, the number of subjects required per group is 33. However, estimating a larger standard deviation and smaller effect size with the same power and significance level suggests that 142-175 subjects would be required per group depending on SD.
We are interested in detecting differences between ethnic groups and considering that the proportion in the cohort will be smaller, we are aiming for 250 participants per group.
Descriptive statistics will be used to report group findings including inter-quartile ranges, standard deviation and relative risk. Odds ratios will be used for factors identified to be associated with worse nutrition. Confounding factors and comorbidity groups will be analyzed by analysis of variance. All tests will be two-sided; tests will be at level 0.05, with Bonferroni correction for multiple comparison.

Impact of Research

In support of the government's 'Ageing in Place' policy (Ministry of Social Policy 2001) there is a need to identify the prevalence and factors that could lead to malnutrition and intervene accordingly. If there are reliable blood markers that may enable simple screening at primary care level then this would be valuable in predicting individuals that may need nutritional support.

This study focuses on older adults, gathering baseline data on their nutritional status which can be used to monitor changes in health status in potential future studies. Nutrition underpins much of this vulnerable age-group's health profile and ability to deal with comorbid disease. Factors contributing to nutrition are both psychosocial and physical. It is critical to understand what the current state of nutritional compromise is in our older population. Advancing knowledge in this area will inform health policy and strategy particularly at a primary intervention level to reduce long term consequences of nutritional depletion in an aging population. This study will encompass diverse ethnicities due to geographic and socioeconomic spread within

Waitemata DHB and three key living situations that we believe have a major impact on nutrition in older people. Our collaboration with primary care and expert researchers in this field will enhance our ability to apply the knowledge obtained and implement effective prevention strategies and provide education to patients and caregivers. Interventions will be developed with end-users but may include meal support, in-home nutritional assessment as routine, dietary advice and social eating groups. Knowledge gained from the study can be transferred to GP's, community health nurses, dieticians and clients through written and web-based platforms.

Responsiveness to Maori

Maori will be well represented in this observational study by virtue of inclusion of catchment areas with good population representation in West Auckland. Key researchers in this study have already focused previous research on ethnic inequalities and published in this area. The study is powered to enable subgroup analysis with a particular aim of clarifying differentiating factors between Maori and non Maori participants. Cultural considerations have been adopted in developing the study protocol and is approved by the Organisation's Maori research adviser.

Research Team Expertise

The study will be coordinated via WDHB Otolaryngology, Dietetics and Gerontology Services. Ethics approval is not required from HDEC (confirmation letter available) however we have full HDEC approval. Locality agreement has been obtained. Staff will provide expertise free and students are funded by Massey University.

Dr Allen is a practicing Otolaryngologist with extensive research experience in New Zealand and the United States of America. She is grant-funded for current research and is an Honorary Senior Lecturer in the University of Auckland. She is able to coordinate the research, provide analysis and deliver study goals.

Dr Carol Wham is a Massey University Senior Lecturer overseeing all Masters Students in Nutrition and Dietetics. Carol is an experienced gerontology dietitian and has published in this area specifically regarding ethnic inequities and will coordinate research, supervise students, provide analysis and deliver study goals.

Dr Cheryl Johnson is a Gerontologist at WDHB and will coordinate the in-patient hospitalized elderly cohort. Dr Johnson has expertise in elderly care and nutritional disorders and will also provide analysis.

Emily Sycamore and Vicki Williams are Masters Students in Nutrition and Dietetics under supervision of Dr Wham and will complete the data collection as Masters projects. All have completed undergraduate Bachelor degrees in Human Nutrition.

Funding

Funding will be provided by Massey University and is also sought from the Auckland Medical Research Foundation and other grant funders.

Expected Benefit and Research Impact

There may be direct benefit to the patient for study participation. They may directly benefit from being identified as having nutritional risk and being referred to appropriate services. The improvement may be mild or significant. For Society as a whole there will be great value in understanding nutritional differences between groups in the cohort. In particular, whether there are factors associated with nutrition that may lead to deterioration in living circumstances and loss of independence. Detection of factors associated with risk of nutritional deterioration will allow policy decisions and intervention to be directed at those risk groups at a primary intervention level. Enhanced awareness of nutritional risk alone may benefit subjects and the community as a whole.

There may be no benefit from participation in the study.

Presentation and publication

All published or presented data from the study will be presented in a de-identified manner, protecting patient confidentiality. Data will be presented locally and internationally at appropriate Scientific Conferences. Publication in peer-reviewed journals will be sought. Participants will be provided with data or manuscripts if requested. Personal information will only be available to the PI and co-investigator.

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Appendix

Mini Nutritional Assessment (MNA)
Eating Assessment Tool-10 (EAT-10)
Montreal Cognitive Assessment (MoCA)

Appendix #5: Quantitative Participant Information Sheet

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Waitemata
District Health Board
Best Care for Everyone

Participant Information Sheet: The Enrich Study

An investigation of nutrition risk among adults recently admitted to a residential care home.

You have been invited to participate in this study, because you have recently been admitted to a residential care home. This study is looking at the nutrition status of adults over 65 years (or over 55years for Maori and Pacific) of age in the Waitemata District Health Board region.

Study Description

The aim of this study is to gain an understanding on the nutrition status and swallowing risk of older adults. We will also look at other possible risk factors of malnutrition including body weight, cognition, muscle mass and strength. This will help in identifying people at risk.

The Research Procedure

If you agree to participate in the study, the following will occur:

1. Once you have signed the consent form, you will complete a questionnaire which includes information about your nutrition, swallowing and cognitive status.
2. Your height, weight, and muscle mass will be measured. We will then measure your strength.

This study will take approximately 60 minutes, however you may withdraw at any time.

Benefits and Risks

It is possible the interviews and measures may identify a problem. If this happens, recommendations will be made for referral to the respective department where appropriate care will be obtained. Side effects may occur although this is extremely unlikely.

Participant's Rights

You do not have to accept this invitation. If you decide to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study at any time
- Ask any questions about the study at any time
- Be given a summary of the study findings when it is concluded

Choosing not to participate in this study will in no way affect your current or future care

Confidentiality

Data collected will only be used for this study. Only investigators of the study will have access to personal information, which will be held securely and treated strictly confidentially. Results of this study may be published or presented at conferences or seminars; however, no individual will be able to be identified. Non-identifiable data from this study may be used in future related studies, which have been given ethical approval from the Ethics Committee. Research data will be stored for a period of ten years (as required by New Zealand law), after which it will be destroyed.

Results:

If requested, you will be offered copies of the publications that arise from this research. However, you should be aware that a significant delay may occur between completion of data collection and completion of the final report. Alternatively, or in addition, you can choose to have the results of the study discussed with you personally by the lead investigator.

Ethics Approval

This study has been reviewed and approved by the Health and Disability Ethics Committee: Northern A, Application 14/NTA/70.

Further Information

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

- Stacey Senior
  Masters Dietetic student
  [redacted]
- Dushanka Hettige
  Masters Dietetic student
  [redacted] or
  [redacted]
- Idah Chatindiara
  PhD student, Massey University
  [redacted] or
  I.Chatindiara@massey.ac.nz
- Theresa Teresa Stanbrook
  NZRD - Professional Leader-Dietetics- Waitemata DHB
  Teresa.Stanbrook@waitematadhb.govt.nz
- Carol Wham PhD, NZ Registered Dietitian
  A/Professor of Nutrition and Dietetics, Massey University,
  c.a.wham@massey.ac.nz
- Jacqui Allen FRACS MBChB FRACS ORL HNS,
  Consultant Otolaryngologist, North Shore Hospital, Takapuna
  [redacted]

Appendix #6: Quantitative study consent form

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Waitemata District Health Board
Best Care for Everyone

Participant Consent Form: The Enrich Study

Please tick to indicate you consent to the following

I have read, or have had read to me in my first language, and I understand the Participant Information Sheet.	Yes ☐	No ☐
I have been given sufficient time to consider whether or not to participate in this study.	Yes ☐	No ☐
I have had the opportunity to use a legal representative, whanau/ family support or a friend to help me ask questions and understand the study.	Yes ☐	No ☐
I am satisfied with the answers I have been given regarding the study and I have a copy of this consent form and information sheet.	Yes ☐	No ☐
I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without this affecting my medical care.	Yes ☐	No ☐
I consent to the research staff collecting and processing my information, including information about my health.	Yes ☐	No ☐
If I decide to withdraw from the study, I agree that the information collected about me up to the point when I withdraw may continue to be processed.	Yes ☐	No ☐
I consent to my GP or current provider being informed about my participation in the study and of any significant abnormal results obtained during the study.	Yes ☐	No ☐
I agree to an approved auditor appointed by the New Zealand Health and Disability Ethic Committees, or any relevant regulatory authority or their approved representative reviewing my relevant medical records for the sole purpose of checking the accuracy of the information recorded for the study.	Yes ☐	No ☐
I understand that my participation in this study is confidential and that no material, which could identify me personally, will be used in any reports on this study.	Yes ☐	No ☐

I understand the compensation provisions in case of injury during the study.	Yes ☐	No ☐
I consent to have de-identified data collected from this study used in future related studies that have been approved by the Ethics Committee.	Yes ☐	No ☐
I know who to contact if I have any questions about the study in general.	Yes ☐	No ☐
I understand my responsibilities as a study participant.	Yes ☐	No ☐
I wish to receive a summary of the results from the study.	Yes ☐	No ☐

Declaration by participant:
I hereby consent to take part in this study.

Participant's name:

Signature: Date:

Declaration by member of research team:
I have given a verbal explanation of the research project to the participant, and have answered the participant's questions about it.
I believe that the participant understands the study and has given informed consent to participate.

Researcher's name:

Signature: Date:

Appendix #7: Quantitative study data collection questionnaire

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Waitemata District Health Board
Best Care for Everyone

The Enrich Study Residential Care Questionnaire

Interviewer **Date**

Research Assistant **Time**

1	**ID number:**				**2**	**NHI number**			
3	**Last name:**					**First Name**			
4	**D.O.B**	Day	Month	Year	**5**	**Age**	Years	Months	
6	**Gender**	(1) Male				(2) Female			
7	**Prior setting**	(1) Community				(2) hospital			

Comments:

Demographic:

8. Which of these best describes your ethnicity?

New Zealand European	Maori	Pacific	Other (please specify):
1	2	3	4

Comments: _____

_____

_____

9. What is your current marital status?

Married/partnered	Widowed	Divorced/separated	Never married
1	2	3	4

Comments: _____

_____

10. Who lives in your house/unit/apartment with you most of the time?

Living alone	Living with spouse only	Living with others
1	2	3

Comments: _____

_____

11. Do you receive any income in addition to your pension?

Pension only income	Pension plus other income
1	2

Comments: _____

_____

12. What is your highest level of education?

Primary	Secondary	Tertiary
1	2	3

Comments: _____

_____

Physical Assessment:

13. Anthropometric:

Weight (kg)			
Height (cm)		Demispan (cm)	
BMI (kg/m²)		Calf Circumference (cm)	

14. Body Composition

**** IMPORTANT – Are you fitted with a pacemaker or other internal electronic/metal medical device? Yes/No**

Lean Mass			
Fat Mass			
Fat %			
Male		**Female**	
≤ 10.75 kg/m²	> 10.75 kg/m²	≤ 6.75 kg/m²	> 6.75 kg/m²
1	2	1	2

Comments:_____

15. Maximal Grip Strength Test (MGST) – Use dominant hand

Trial 1 =	Trial 1 =		Trial 3 =
Average Dominant Hand			
Male		**Female**	
≥ 32 kg	< 32 kg	≥ 22 kg	< 22 kg
1	2	1	2

Comments:_____

_____

16. 2.4m Walk Test

Circle one: Used walking stick or frame? (1) Yes		(2) No
Trial 1 =	Trial 1 =	Trial 3 =

Fastest Time (seconds)

Speed ≤ 1m/s	[0.01 + (speed)(1.052)]		Speed > 1m/s	[0.481 + (speed)(0.581)]	
<4.6m/s	0.47-0.64m/s		0.65-0.82m/s	≥0.83m/s	
1	2		3	4	

Comments:_____

17. Physical activity

How often do you engage in activities that require a low or moderate level of energy such as gardening, cleaning the car, or going for a walk?

More than once a week	Once a week	One to three times a month	Hardly ever or never	
1	2	3	4	

Comments:_____

_____

18. Exhaustion

18a) How often in the last week did you feel that everything you did was an effort?

Rarely or none of the time (<1 day)	Some or little of the time (1 to 2 days)	Moderate amount of the time (3 to 4 days)	Most of the time 5 to 7days	
1	2	3	4	

Comments:_____

18b.) How often in the last week did you feel that you could not get going?

Rarely or none of the time (<1 day)	Some or little of the time (1 to 2 days)	Moderate amount of the time (3 to 4 days)	Most of the time 5 to 7days	
1	2	3	4	

Comments:_____

Mini Nutritional Assessment: (Nestle Nutrition Institution)

19. Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?

Severe decrease	Moderate decrease	No decrease	
0	1	2	

20. Involuntary weight loss during the last 3 months?

> 3kg	Does not know	1 - 3 kg	No weight loss	
0	1	2	3	

21. Mobility

Bed or chair bound	Able to get out of bed/chair but doesn't go out	Goes out	
0	1	2	

22. Has suffered psychological stress or acute disease in the past 3 months?

Yes	No	
0	2	

23. Neuropsychological problems

Severe dementia or depression	Mild dementia	No psychological problems	
0	1	2	

24a. Body Mass Index (BMI) $\frac{\text{weight in kg}}{\text{height in m}^2}$

BMI < 19	BMI 19 - 20	BMI 21 - 22	BMI ≥ 23	
0	1	2	3	

24b. Calf circumference (CC) in cm (answer only if unable to obtain BMI)

CC < 31 cm	CC ≥ 31 cm	
0	3	

25. MNA-SF score:

Total MNA score (max. 14 points)	**Normal (12-14)**	**At risk of malnutrition (8-11)**	**Malnourished (0-7)**

26. What is your dental status?

Dentate	Edentulous	Dental Appliance
1	2	3

Comments: _____

_____

_____

10-Item Eating Assessment Tool:

27. My swallowing problem has caused me to lose weight

0 No problem	1	2	3	4 Severe problem

28. My swallowing problem interferes with my ability to go out for meals

0 No problem	1	2	3	4 Severe problem

29. Swallowing liquids takes extra effort

0 No problem	1	2	3	4 Severe problem

30. Swallowing solids takes extra effort

0 No problem	1	2	3	4 Severe problem

31. Swallowing pills takes extra effort

0 No problem	1	2	3	4 Severe problem

32. Swallowing is painful

0 No problem	1	2	3	4 Severe problem

33. The pleasure of eating is affected by my swallowing

0 No problem	1	2	3	4 Severe problem

34. When I swallow food sticks in my throat

0 No problem	1	2	3	4 Severe problem

35. I cough when I eat

0 No problem	1	2	3	4 Severe problem

36. Swallowing is stressful

0 No problem	1	2	3	4 Severe problem

37. Total EAT-10 Score

Total EAT-10 Score (max. 40 points)	
Not at risk (< 3)	At risk of swallowing efficiently and safely (≥ 3)
1	**2**

Comments:

Health

38. Have you been told by your doctor that you have any health issues?

Yes	No
1	2

Key co-morbidities (ICD 10 code):	*Comments:*

39. Do you have any other health problems?

Yes	No
1	2

Other health problems:	*Comments:*

40. What medications, prescribed by a doctor, are you regularly taking?

	Medication:	Comment (i.e. dose, etc.)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
Total Number of Prescribed Medications		

41. What over-the-counter (OTC) medications are you regularly taking?

	Medication:	Comment (i.e. dose, etc.)

1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
	Total Number of OTC Medications	

42. What, if any, nutrition supplements e.g. Complan or vitamin and mineral supplements are you regularly taking?

	Nutrition supplement:	Comments:
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
	Total Number of Supplements	

Support Services:

43. Prior to admission, did you receive any regular subsidised support service?

Yes	No
1	2

Comments: _____

_____

_____

44. **Do you usually need help with daily tasks like shopping, cleaning, cooking?**

Yes	**No**
1	**2**

Comments: _____

_____

45. Have you had any dietetic input within the last year?

Yes	No
1	2

Comments: _____

_____

_____

Montreal Cognitive Assessment:

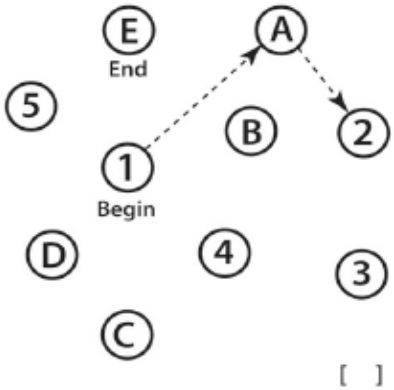
46. MoCA Score

Total MoCA Score (max. 30 points) * Add 1 point if ≤ 12y education	
Normal ≥ 26	Cognitive Impairment <26
1	2

MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME :
Education : Date of birth :
Sex : DATE :

VISUOSPATIAL / EXECUTIVE — POINTS



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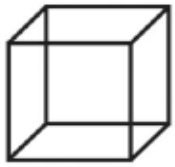


[ ] [ ]

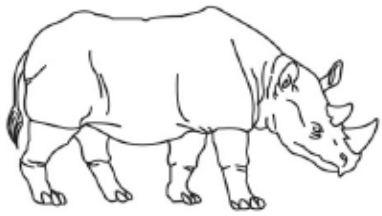
Draw CLOCK (Ten past eleven)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands

___/5

NAMING

[ ]



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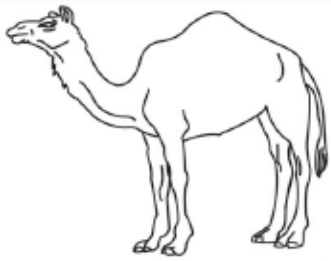

[ ]

___/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).
Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2
___/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B
___/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**
___/3

LANGUAGE Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ]
___/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words)
___/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler
___/2

DELAYED RECALL

	Has to recall words WITH NO CUE	FACE [ ]	VELVET [ ]	CHURCH [ ]	DAISY [ ]	RED [ ]	Points for UNCUED recall only
Optional	Category cue						
	Multiple choice cue						

___/5

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City
___/6

© Z.Nasreddine MD **www.mocatest.org** Normal ≥ 26 / 30

TOTAL ___/30
Add 1 point if ≤ 12 yr edu

Administered by: _____

Appendices study 4

Appendix #8: Ethics approval letter

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 23 January 2018

Dear Idah Chatindiara

Re: Ethics Notification - **SOA 17/74 - Exploring older adults' perspectives, experiences and knowledge of healthy eating: a qualitative study**

Thank you for the above application that was considered by the Massey University Human Ethics Committee: **Human Ethics Southern A Committee** at their meeting held on **Tuesday, 23 January,**

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Brian Finch
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand **T** 06 350 5573; 06 350 5575 **F** 06 355 7973
E humanethics@massey.ac.nz **W** http://humanethics.massey.ac.nz

Appendix #9: Study protocol qualitative study

Enrich Study Research Proposal

Exploring older adults' perspectives, experiences and knowledge of healthy eating: a qualitative study

Idah Chatindiara, PhD Candidate, Nicolette Sheridan, PhD, Marlena Kruger, PhD, Carol Wham, PhD

Introduction

The WHO defines nutrition as the intake of food, considered in relation to the body's dietary needs (1). Heathy eating, which is synonymous with good nutrition is attained when one consumes food as per his or her dietary needs. While individuals' dietary needs change with advancing age, healthy eating is essential for healthy ageing (2). In fact, positive associations exist between proper nutrition, health and the ageing process (3). Accordingly, the *Healthy eating healthy ageing* concept is a well-established notion whereby encouraging optimum food and nutrition intake at older age, is regarded as a helpful way to improve overall health and quality of life with aging. However, although optimum nutrition is essential for healthy ageing, eating healthy is a challenge for many older adults and this places them at nutrition risk. Several studies have established multi-factors (Fig 1.) that not only place older people at nutrition risk but are associated with malnutrition. While some of the nutrition risk factors are part of the natural aging process, most of the risk factors are modifiable (4-9).

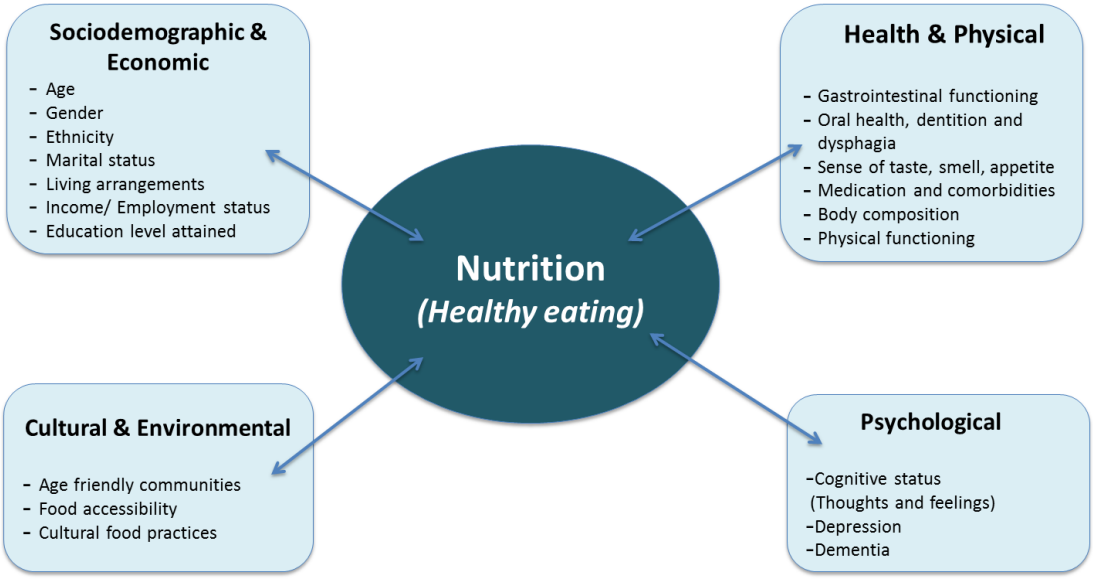

Fig.1. Multi-factors associated with nutrition risk in older age

Summarised from (4-9)

Currently the population of adults over 65 years is growing faster than younger age groups (10); hence establishing healthy aging strategies is a pressing public health concern. Because of the multifactorial nature of nutrition risk factors (Fig 1.),

designing multi-domain interventions which integrate major nutrition risk factors may contribute to optimising food and nutrition intake (healthy eating) for older adults. Given that the older people population is heterogeneous (11) conducting a qualitative inquiry can inform the design of an acceptable and appropriate intervention. In addition, a qualitative inquiry can provide baseline information that supports researchers to better understand the types of interventions that might work for this population (12). For example, a qualitative inquiry can help to elicit features of an intervention that are often perceived as burdensome, unaffordable, unacceptable, inaccessible or unsustainable (13, 14). By undertaking in depth interviews with older adults we can better understand their perspectives, experiences, and knowledge regarding healthy eating. Interviews are a useful way to identify potential risk factors that can be modified to prevent malnutrition (15). We are not aware of any qualitative studies have been conducted in New Zealand with the goal to understand malnutrition risk among older adults. A central purpose is to design an intervention that might prevent malnutrition in older adults living in their own homes.

Project overall aim

This qualitative inquiry aims to explore older adults' perspectives, experiences and knowledge of healthy eating to complement an ongoing quantitative investigation of possible interventions for malnutrition prevention among older New Zealanders (ethical approval NTA/70/AMO1).

Study objectives

In older adults:

a. To explore changes in food and nutrition intake, preferences, and eating patterns
b. To identify risk factors for poor food and nutrition intake and malnutrition
c. To understand perceptions of healthy eating
d. To explore attitudes to accessing and using nutrition information and advice
e. To identify approaches to improve food and nutrition intake

Methods

The study will conduct 16 in-depth interviews with older adults – fewer if saturation is reached earlier i.e. when no new information is obtained from the interviews (16, 17).

Sampling

Sampling will be purposive with age, gender, ethnicity and severity of illness.

The New Zealand statistics shows a difference in Maori and Pacific life expectancy (10, 18).While 65 years is the most established cut off for older adults in the Organisation for Economic Co-operation and Development (OECD) countries,

several research studies in New Zealand employ two cut off points to classify people as older adults, based on ethnicity: 55 years for Māori and 65 years for non-Māori. As nutrition risk (undernutrition) among older adults living in their own homes has been observed at a later age, the current study will recruit 75 years and over; 10years younger if Maori/Pacific, as in a previous New Zealand nutrition study (19).

Data will be collected across ethnicities - Māori, Pacific, Asian or New Zealand European; gender – men and women; and illness severity - low, medium and high (based on Predicted Readmission Risk or equivalent scores).

Recruitment and data collection protocol

Participants will be proficient in the English language and will be recruited from up to three Auckland general practices. One general practice has agreed in principle to support recruitment. This practice is contracted to the Very Low Cost Access scheme, is located in South Auckland, and serves a high proportion of Māori and Pacific patients and those living in areas of high deprivation.

The applicant will engage with one or more practice nurses at each general practice, asking them to identify potential participants, approach them and ask for permission to pass on contact details to the applicant. The applicant will also ask the nurses to place a poster in the practice waiting room, inviting people to contact the applicant directly. The applicant will phone or email potential participants to explain the study, collect sufficient information to guide recruitment by the stated selection criteria, and invite relevant people to participate. These people will be given a Participant Information Sheet and given an opportunity to ask any questions about the study and will be asked to sign the Consent Form ahead of the interview.

Interviews will be face-to-face and conducted in participants' homes or a place of their choosing, such as a room within the general practice. Before the interview begins, participants' background characteristics will be recorded together with their nutrition risk status (Mini nutritional assessment short form, MNA®SF). The MNA®SF is a 5 minutes' questionnaire therefore it will not cause significant burden to the participants' (19). Each interview is estimated to last about an hour.

A pilot interview will be conducted with one or two older adults to test the interview guide for clarity of questions, flow and timing. Adjustments to the guide may be done accordingly.

Topics covered in the interview guide:

1. Foods and drinks regularly consumed
2. Vulnerability to nutrition risk factors
3. Perceptions of healthy eating
4. Attitudes to accessing and using nutrition information and advice

5. Approaches to improve food and nutrition intake

The study will employ a qualitative descriptive approach, drawing on phenomenological and ethnographic strategies and methods (15, 18)

Transcript return

At the end of the interview participants will be offered the opportunity to review their interview transcript and contribute feedback by email or in-person. This allows participants an opportunity to confirm accuracy.

Second interview

Information collected in this study will contribute to the design of the intervention. We will invite up to six participants to a second interview. Invitation will be based on their first interview and anticipated ability to offer critique of the proposed intervention.

Transcribing, data coding, analysis and reporting

Data will be transcribed either by the applicant or by a professional transcribing agency (see confidentiality agreement). Transcripts will be the basis of coding and classification using NVivo 10 software. Coding will be done by the applicant, confirmed by one or more of the supervisors.

Study findings will be reported in a manner that ensures participant anonymity. Data will be presented locally and internationally at scientific conferences and published in peer-reviewed journals.

Confidentiality and data storage

All data will be reported in a de-identified form. Where appropriate, pseudonyms will be used. Consent forms, questionnaires or any other printed data will be stored in a locked cabinet at Massey University and will be kept for 6 years following which it will be destroyed. All data in electronic format will be encrypted and password protected so that only the named researchers and supervisors have access to it. Study findings will be reported in a manner that ensures participant anonymity.

Perceived benefits of the study

Participants will have an opportunity to share their perspectives and experiences on this topic. There may be no other direct benefits for those participating in this study. This study will help develop interventions that can be formally tested in a subsequent study.

Discomfort of participants

The researcher will ensure participants are given a Participant Information Sheet and the opportunity to ask any questions about the study. Participants will be asked to sign a Consent Form ahead of the interview. If a participant feels uncomfortable at any time they are free to withdraw from the study without penalty.

Harm to interviewee

No harm to participants is anticipated. The study will recruit only those older adults residing in their own homes and who are living independently. No invasive measures will be undertaken that could cause harm. Participants will be fully informed of their right to decline to answer any question or withdraw from the study at any time without penalty.

Conflict of interest

The applicants are all Massey university academic researchers and have no direct involvement with the potential participants. Furthermore, recruitment will be done by practice nurses in general practice, not the researchers. Neither researchers nor participants will receive payment for participating in this research. No conflict of interest has been identified.

Timelines

1. Protocol and interview guide designing — October and November 2017
2. Submit ethics application: — 22 November 2017
3. Recruitment and data collection: — January to May 2018
4. Data analysis and draft report: — March to June 2018

Responsiveness to Maori

A general practice with high enrolled numbers of Māori patients has agreed on principle to support recruitment. The focus of the qualitative inquiry is on older adults with differing severity of illness. While 'older adult' is commonly defined as 65 years or older, for Māori we will use a younger age of 55 years as Māori often experience morbidity and mortality 10 years earlier than non-Māori. One supervisor is of Māori descent (Prof Sheridan, Ngāpuhi) and will oversee the integrity of the research methods.

Research Team Expertise

Four key researchers from Massey University will participate in this research.

Idah Chatindiara, MSc, is a PhD candidate in Nutrition. This project is part of her doctoral project, which aims to develop an intervention to attain and maintain good nutrition in older adults, through encouraging healthy eating. Prior to commencing her PhD, Idah worked in the Netherlands and USA in human nutrition trials that aimed to promote energy balance and prevent metabolic syndrome in adults. In the past 1.5years, Idah has been conducting nutrition research in older New Zealanders. Within this time frame, Idah spent 6 months conducting nutrition risk assessments in older adults admitted to Waitemata DHB age related care homes.

Marlena Kruger, PhD is Professor of Nutritional Physiology and Associate Dean Higher Degree Research in the College of Health. Dr Kruger spent time in Germany on a DAAD scholarship after her PhD which was awarded in 1986; she, was appointed as post-doctoral fellow in biochemistry at the University of Texas at Austin, USA in the same year. Marlena migrated to New Zealand to take up an appointment at Massey University in April 2000 where her role was to establish bone research in the university. Marlena is internationally recognised for her research on bone health and mobility specifically in older women. Her current research focuses on nutrition and bone and joint health with an emphasis on dairy foods, lipids and polyphenols.

Carol Wham, PhD is Carol Wham, PhD is Associate Professor of Nutrition and Dietetics in the School of Sport, Exercise and Nutrition. She has led the nutrition enquiry of a large longitudinal cohort study of ageing “Life and living to Advanced Age – A Cohort Study” (LILACS NZ) since 2008 and collaborates with the Healthy Ageing Research Team at Massey University with an investigation of nutrition status and trajectories of outcomes in the Health, Work and Retirement Longitudinal Study. In partnership with the Waitemata DHB Carol has led an investigation to examine nutrition and dysphagia risk in older adults across primary care, hospital and residential care settings. This enquiry informs the current ENRICH study (Evaluating Nutrition Risk and Intervening to enCourage Healthy-eating).

Nicolette Sheridan, PhD is Professor and Director of the Centre for Nursing and Health Research at Massey University. She is a registered nurse with over 30 years’ experience in clinical practice, education and research. She has a PhD and Master’s in Public Health from the University of Auckland. She has tribal affiliations to Ngāpuhi and her research includes the health care experiences of Māori and Pacific older adults with long term conditions, tracking communication between clinicians and

people with newly-diagnosed diabetes, evaluating the implementation of community-based primary health care in NZ and Canada, and measuring health equity in NZ district health boards. Sheridan is an experienced qualitative researcher and will oversee the qualitative methodology.

Funding

Funding will be required for travel to interviews, transcribing interviews and publishing of the study results. This funding will be provided by Massey University, College of Health.

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Appendix #10: Qualitative study consent form

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Exploring older adults' perspectives, experiences and knowledge of healthy eating: A qualitative study

Consent Form

Declaration by participant:

I have read the Information Sheet and have had the details of the study explained to me. I have had time to consider whether to take part in this study. I have been given appropriate contact details to obtain further information and to discuss the study. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time. I have been given a copy of the Information sheet to keep. I hereby consent to the following:

1.	Participating in this study	Yes ☐	No ☐
2.	Storage of the information collected	Yes ☐	No ☐
3.	Usage of the information collected in future related studies that have been approved by the Ethics Committee.	Yes ☐	No ☐

……

Participant's name: **Signature** **Date**

Declaration by member of research team:

I have given a verbal explanation of the research study to the participant, and have answered the participant's questions about it. I believe that the participant understands the study and has been given informed consent to participate.

……

Researcher's name: **Signature** **Date**

Appendix #11: Qualitative Participant Information Sheet

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Exploring older adults' perspectives, experiences and knowledge of healthy eating: A qualitative study

Participant Information Sheet

Study Summary

You have been invited to participate in this study, because you are an adult over 75 years (or over 65 years for Maori and Pacific) enrolled at Greenstone Family Clinic. This study is part of a larger project aiming to develop an intervention to optimise food and nutrition intake in older age. This study will involve a face to face conversation where you will discuss your current food and nutrition intake and whether your food preferences have changed over the years. A doctoral student (Idah Chatindiara), supervised by senior academic researchers (*see page 3.*), will engage in the conversation with you.

The study procedure

A Massey University researcher will:

3. Ask you to sign a form consenting to take part in the study
4. Record your weight and height
5. Engage in a conversation about your food and nutrition intake with you. This will be a casual conversation and no further measurements will be undertaken.

The interview will be undertaken at your home, or at the general practice, as per your choice. This one off visit will take approximately 60 minutes. You may be invited for a short (20 minutes) second interview which will follow up the first conversation where a possible intervention that seeks to optimise food and nutrition intake in older age will be explained and discussed with you. We are interested in your thoughts and ideas.

Study Inclusion Criteria

To be eligible to participate in this study, one has to be:

1. Aged 75 years and over; for Māori or Pacific adults aged 65 years and over. (*Maori and Pacific older adults are eligible to participate at a younger age because of differences in life expectancy at birth*)

2. With or without long term illnesses
3. Living in own home
4. Proficient in the English language
5. Willing and able to provide written consent and authority for the release of transcripts

Benefits and Risks

You will have an opportunity to share your perspectives and experiences on food and nutrition intake. In recognition of your contribution, a koha (gift) of $30 Westfield or petrol voucher will be offered. There may be no other direct benefits for participating in this study. However, your participation in this study will help develop interventions that can be formally tested in a subsequent study.

No risks or harm is anticipated. No measures will be undertaken that could cause harm. The conversation will be informal and you are free to decline discussing any matter.

Participant's Rights

You do not have to accept this invitation. If you decide to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study at any time
- Ask any questions about the study at any time
- Be given a summary of the study findings when it is concluded

Choosing not to participate in this study will in no way affect your current or future care

Confidentiality

Only investigators of the study will have access to all the information collected during the interview. The interviews will be recorded, as the researcher may fail to capture everything you discuss during the interview. The recordings and all other collected data will be held securely and treated strictly confidential.

Results of this study may be published or presented at conferences or seminars; however, no individual will be able to be identified. Non-identifiable data from this study may be used in future related studies, which ethical approval will be applied for before those studies are undertaken. The studies will likely investigate interventions to optimise food and nutrition intake at older age, extending the current work. Research data will be stored for a period of six years, after which it will be destroyed.

Results

The findings of this study shall be summarised in a research manuscript at the end of the study. You will be offered a summary of the study findings and access to the published research manuscript, which will be delivered to you through email or post. However, you should be aware that a significant delay may occur between completion of data collection and completion of the final report.

Ethics Approval

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 17/74. If you have any concerns about the conduct of this research, please contact Dr Lesley Batten, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 356 9099 x 85094, email humanethicsoutha@massey.ac.nz

Further Information

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

- **Idah Chatindiara, MSc, PhD Candidate (Nutritional Sciences)**

College of Health, Massey University

Phone: [redacted]

Email: I.Chatindiara@massey.ac.nz

Or any of the academic research supervisors:

- **Carol Wham, PhD, A/Professor of Nutrition & Dietetics,**

College of Health, Massey University.

Email: c.a.wham@massey.ac.nz

- **Nicolette Sheridan, PhD, Professor of Nursing**

Director of the Centre for Nursing and Health Research,

College of Health, Massey University

Email: n.sheridan@massey.ac.nz

- **Marlena Kruger, PhD, Professor of Nutritional Physiology**

Associate Dean Higher Degree Research

College of Health, Massey University

Email: m.c.kruger@massey.ac.nz

Appendix #:12 Qualitative study background characteristics data collection tool

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Exploring older adults' perspectives, experiences and knowledge of healthy eating: A qualitative study

ID#.....

Participants' Characteristics and Nutrition Status

Researcher .....

Interview Date ..... Time .....

Last name **First name**

D.0.B **Sex:** ☐Male ☐Female

Ethnicity:

☐Maori ☐Pacific ☐New Zealand European ☐other ……..

Marital status:

☐Married ☐Partnered ☐divorced ☐separated ☐single (never married)

Living arrangements:

☐Living Alone ☐Living with others

Education attained:

☐Primary ☐Secondary. ☐Tertiary

Pension Income:

☐Pension only ☐Pension plus other income

Receiving social support:

☐Yes ☐No

Weight (kg) …… **Height (cm) ……** **BMI ……..**

Mini Nutritional Assessment (MNA®SF: Nestle Nutrition Institution)

1. **Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?**

0. Severe decrease	1. Moderate decrease	2. No decrease	

2. **Involuntary weight loss during the last 3 months?**

0. > 3kg	1. Does not know	2. 1 - 3 kg	3. No weight loss	

3. **Mobility**

0. Bed or chair bound	1. Able to get out of bed/chair but doesn't go out	2. Goes out	

4. Has suffered psychological stress or acute disease in the past 3 months?

0. Yes	2. No	

5. Neuropsychological problems

0. Severe dementia or depression	1. Mild dementia	2. No psychological problems	

6. a. Body Mass Index (BMI) $\frac{\text{weight in kg}}{\text{height in m}^2}$ **=.....**

0. BMI < 19	1. BMI 19 - 20	2. BMI 21 - 22	3. BMI ≥ 23	

6. b. Calf circumference (CC) in cm (answer only if unable to obtain BMI)

(0). CC < 31 cm	(3) CC ≥ 31 cm	

Total MNA-SF score:			
Nutrition status:	**Normal (12-14)**	**At risk of malnutrition (8-11)**	**Malnourished (0-7)**

Field Notes

Interview Location: .....

Environment

Key comments & quotes

Interviewee overall feelings about the way the interview went

Appendix #13: Qualitative Study Manuscript Appendix 1: Participants' Background Characteristics (per individual)

Study ID	Gender	Age (years)	BMI (kg/m^2)	Ethnicity	Marital Status	Living Alone / With Others	Education Attained	*Income source	Receiving Home Care	Malnutrition Status	Illness severity
P#001	W	94	25.6*	NZ Euro	W	Living alone	Secondary	P+	Yes	Malnourished	Severe
P#002	M	81	33. 3*	Euro	M	With Others	Tertiary	P+	Yes	At risk	Moderate
P#003	W	84	36.9*	Pacific (Tongan)	M	With Others	Tertiary	P	No	At risk	Moderate
P#004	W	74	36.7	Pacific (Samoan)	M	With Others	Secondary	P	No	At risk	Moderate
P#005	W	85	16.9*	NZ Euro/ Euro	W	With others (son only)	Secondary	P	No	Malnourished	Severe
P#006	W	76	34.8	NZ Euro	W	With spouse	Secondary	P	Yes	At risk	Severe
P#007	M	76	35.0*	NZ Euro	M	With spouse	Secondary	P	Yes	Well nourished	Mild
P#008	W	88	18.4*	NZ Euro	W	Living alone	Secondary	P	Yes	Malnourished	Moderate
P#009	W	82	25.2*	NZ Euro	W	With spouse	Secondary	P	No	At risk	Moderate
P#010	M	84	22.4*	NZ Euro	M	With spouse	Secondary	P	No	At risk	Moderate
P#011	M	74	43.3	Maori	M	With others	Secondary	P	No	At risk	Moderate
P#012	W	65	17.9*	Maori	W	With others (2 daughters interchange)	Secondary	P	No	Malnourished	Severe
P#013	W	90	19.9*	NZ Euro/ Euro	W	Living alone	Primary	P+	No	Malnourished	Severe
P#014	M	82	24.2	Maori	W	With others (2 children)	Primary	P	No	At risk	Moderate

P#015	M	83	25.5*	NZ Euro	Single, never married	Living alone (but eat with others)	Tertiary	P	Yes	At risk	Moderate
P#016	M	81	24.7	Pacific (Samoan)	M	With spouse	Secondary	P+	No	Well nourished	Nil

Gender: M-men, W-women, Income source: P-pension only, P+ Pension plus additional income. Nutritional status: Well-nourished (MNA®-SF score ≥12), At risk of malnutrition (MNA®-SF 8-11), Malnourished (MNA®-SF score 0-7); *Age break down: 65-74 (n=3), 75-79 (n=2), 80-84 (n=7) 85-89 (n=2), 90-93 (n=2). *Has been experiencing unintentional weight loss

Appendix #14: Qualitative Study Manuscript Appendix 2: Severity of illness

Study ID#	Medications	Health conditions	Personal context	Severity of illness*
P#01	**Regular** 1. Fluticasone propionate inhaler 2. Filixotide inhaler 3. Respigen inhaler 4. Losartan 25mg tab 5. Metoprolol 23.75mg CR tab 6. Aspirin 100mg tab 7. Atorvastatin 40mg tab 8. Fosamax Plus 140 mcg 9. Colecalciferol 1.25mg tab 10. Pantoprazole 40mg tab **11.** Lorazepam 1mg tab **As needed** 1. Oxycodone 5mg CR tab 2. Oxynorm 5mg/5ml 3. Paracetamol 500mg tab 4. Laxsol 50mg/8mg tab	1. Chronic lung disease 2. Hypertension 3. High cholesterol 4. Osteoporosis 5. Vitamin D deficiency 6. Gastric reflux 7. Disrupted sleep 8. Pain	93 years of age, living alone and is malnourished. In 2017 suffered a major fall; recently started using a walker. Takes oxycodone, oxynorm and paracetamol for pain, which may be frequent.	**Moderate**
P#02	**Regular** 1. Sinemet 125mg tab 2. Atorvastatin 40mg tab 3. Aspirin tab	1. Parkinson's disease 2. Cardiovascular risk 3. Osteoarthritis (spine) 4. Falls 5. Joint pain 6. Hip replacement	80 years of age and lives with his wife who has dementia. Suffers from Parkinson's disease, has difficulties with ambulation, falls often, and experiences some joint pain. He is no longer able to drive and cares for his wife, which he finds stressful.	**Severe**

P#03	**Regular** 1. Doxazosin 4mg tab 2. Indapamide 2.5mg tab 3. Diltiazem 240mg CD cap 4. Aspirin 100mg EC tab 5. Allopurinol 100mg, 300mg tab 6. Paracetamol 500mg tab 7. Cholecalciferol 1.25mg cap	1. Stroke in 2017 2. Hypertension 3. Gout 4. Arthritis	83 years of age and lives with family who helps with daily activities. Would like "home care". Does not have extra income. Managing arthritis and gout with medications.	**Moderate**
P#04	**Regular** 1. Glipizide 2. Metformin 3. Doxazosin 4. Cilazapril 5. Metoprolol 6. Amlodipine 7. Atorvastatin 8. Omeprazole 9. Aspirin	1. Diabetes 2. Hypertension 3. High cholesterol 4. Gastric reflux 5. Pacemaker	74 years of age and the primary carer of her husband. Would like "home help" because she finds it difficult to manage. Had a pacemaker inserted in 2008 and now does less physical activity.	**Moderate**
P#05	**Regular** 1. Morphine 2. M-Eslon capsules 3. Colecalciferol 1.25mg cap 4. Plendil Tablets 5. Normacol 6. Vitamin D3 7. Erythromycin 8. Sensedol	1. Pain 2. Recurrent falls 3. Hypertension 4. Gastric problems 5. Food allergies	85 years of age and lives with her son who does almost all of the housework. Is frail, underweight, has a number of food allergies and has been prescribed an oral nutrition because she is malnourished. In constant pain, she takes morphine routinely. The interview	**Severe**

	9. Vitamin B12		was conducted while she was in bed.	
P#06	**Regular** 1. Gliclazide 80mg tab 2. Protaphane 100 IU/ml 3. Metoprolol 47.5mg CR tab 4. Candesartan 32mg tab 5. Doxazosin 2mg tab 6. Allopurinol 100mg tab 7. Amitriptyline 10mg tab 8. Cetirizine 10mg tab 9. Omeprazole 20mg	1. Severe COPD 2. Diabetes 3. Hypertension 4. Gout 5. Depression 6. Allergies 7. Gastric reflux	75 years of age and lives with spouse. Does not receive extra income. To live with severe respiratory disease oxygen therapy is needed for more than 15 hours each day. Everyday activities are severely restricted.	**Severe**
P#07	**Regular** 1. Doxazosin 2. Metoprolol 3. Atorvastatin 4. Omeprazole	1. Hypertension 2. Cholesterol 3. Gastric reflux 4. Kidney stones	76 years of age and living with spouse. Does not receive extra income. No indication of anything other than mild illness.	**Mild**
P#08	**Regular** 1. Aspirin 2. Dipyridamole 3. Fish oil	1. Stroke (10 years ago) 2. Hernia 3. Weight loss	87 years of age and lives alone. Receives home help and is underweight and malnourished. Routinely takes an oral nutrition supplement. Often feels tired. Still experiences some effects from an earlier stroke but not enough to stop her living alone.	**Moderate**
	Regular 1. Metoprolol CR 23.75mg tabs	1. Heart failure	81years of age and lives with spouse. Does not receive home	**Moderate**

P#09	2. Atacand 16mg tab 3. Furosemide 40mg tab 4. Spironolactone 25mg tab 5. Dabigatran 110mg cap 6. Carbimazole 5mg tab 7. Colecalciferol 1.25mg cap 8. Omeprazole 40mg caps 9. Prednisone 1mg tab 10. Triazolam 0.125mg tab 11. Molaxole oral powder	2. Atrial fibrillation 3. Hypertension 4. Hyperthyroidism 5. Osteoporosis 6. Gastric reflux 7. Gallstones 8. Polymyalgia rheumatic	help. Manages her symptoms and conditions very well. Has frequent contact with health professionals.	
P#10	**Regular** 1. Cilazapril 2.5mg tab 2. Bendrofluazide tab 3. Clopidogrel 75mg tab 4. Atorvastatin 40mg tab 5. Cholecalciferol 1.25mg cap 6. Omeprazole 20mg cap 7. Triazolam 0.125mg tab 8. Laxsol tab	1. Stroke (2016) 2. Hypertension 3. Cholesterol 4. Osteoporosis 5. Arthritis (neck) 6. Spinal surgery 7. Gastric reflux	83 years of age and lives with wife. Does not receive home help or extra income. Recent spinal surgery. Frequently tired.	**Moderate**
P#11	**Regular** 1. Glipizide 5mg tab 2. Metformin 500mg tab 3. Candesartan 32mg tab 4. Felodipine 2.5mg ER tab 5. Metoprolol 47.5mg CR tab 6. Aspirin 100mg tab	1. Diabetes 2. Hypertension	73 years of age and lives with family who help with everyday activities. Has pain, is afraid of falling, and expressed sadness at not being able to go for walks.	**Moderate**

	7. Atorvastatin 80mg tab 8. Omeprazole 40mg cap	3. High cholesterol 4. Gastric reflux 5. Obesity 6. Pain		
P#12	**Regular** 1. Roxithromycin 300mg tab 2. Digoxin 62.5mcg tab 3. Amitriptyline 50mg tab 4. Sandomigran 500mcg tab 5. Cetirizine 10mg tab 6. Omeraprazole 20mg cap 7. Domperidone 10mg tab 8. Paracetamol 500g tab 9. Zopiclone 7.5mg tab	1. COPD 2. Chest infection 3. Atrial fibrillation 4. Migraines 5. Osteoporosis 6. Eczema, allergies 7. Gastric reflux 8. Nausea 9. Severe weight loss	65 years of age and has two daughters who live with her and help with everyday activities. Does not receive home care. Severe COPD with chest infection, severe weight loss and malnourished.	**Severe**
P#13	**Current medications** 1. Ondansetron 4mg tab 2. Coloxyl tab 3. Laxsol tab 4. Trimethoprim 300mg tab 5. Propanolol tab 6. Mirtazapine tab 7. Cholecalciferol 1.25mg cap 8. Paracetamol 500mg tab Self-prescribed supplements	1. Nausea 2. Constipation 3. Weight loss 4. Bladder infection 5. Sodium imbalance 6. Jaw tremor 7. Cramps 8. Depression 9. Osteoporosis	90 years of age and lives alone. Recently moved to a new house and is finding the shift difficult. Does not receive home help. Has extra income. Is malnourished, has a fluid restriction related to a sodium imbalance, and often experiences nausea. Recent bladder infection. 3 weeks ago.	**Severe**

	9. Esterified vitamin C100 10. Fish oils 11. Magnesium 12. Olive leaf extract			
P#14	**Regular** 1. Metoprolol 47.5mg CR tab 2. Furosemide 40mg tab 3. Quinapril 5mg tab 4. Dabigatran 110mg 5. Atorvastatin 40mg tab 6. Salbutamol 100mcg 7. Duolin inhaler 8. Seretide 250/50mcg 9. Eltroxin 50mcg tab 10. Allopurinol 300mg tab 11. Omeprazole 20mg cap 12. Laxsol 50mg/8mg tab 13. Bonvit powder	1. Heart failure 2. Atrial fibrillation 3. Hypertension 4. Cholesterol 5. Chronic lung disease 6. Hypothyroidism 7. Gout 8. Arthritis 9. Gastric reflux 10. Constipation	81 years of age and lives with his daughter who helps with everyday activities. Does not receive home help. Tries to be active but because of the chronic respiratory disease gets tired easily.	**Moderate**
P#15	1. Methotrexate 2.5mg, 10mg tab 2. Folic acid 5mg tab 3. Morphine 100mg tab 4. Gabapentin 400mg cap 5. Nortriptyline 10mg tab 6. Baclofen 10mg tab 7. Paracetamol 5mg tab 8. Cilazapril 500mcg tab 9. Vesicare 5mg tab	1. Rheumatoid Arthritis 2. Physical pain 3. Hypertension 4. Urinary urgency	83 years of age and lives alone but eat with others. Recovering from a fractured vertebrae and rheumatoid arthritis. Poor appetite; is taking an oral nutrition supplement. Is in constant pain.	**Moderate**

	10. Laxsol 50mg/8mg tab			
P#16	1. Cilazapril 500mcg tab 2. Aspirin 100mg tab 3. Simvastatin 40mg tab	1. Hypertension 2. Cholesterol	80 years of age and lives with spouse. Does not receive home help. Has extra income. Feels well.	**Nil**

***Severity of illness**

Given the complex information available for each patient, it was considered useful to attempt a summary assessment of severity of illness. There is no standard measure of severity of illness. Stein et. al suggests there are three main categories commonly measured as severity – physiological, functional and burden of disease (1). Functional severity and burden of disease, in particular, may be assessed very differently by different affected parties (e.g. patient or caregiver) (1). Severity measures are commonly available for individual diseases, whereas fewer are available to account for co-existence of multiple conditions (and the purpose of those that do address multiple conditions may be as administrative and funding tools) (2, 3). In each case the measures are limited to using the data available, which is generally enquiry from patient, review of medical records, or use of administrative data. Nevertheless, and with these caveats in mind, in the current study we offer a summary assessment of severity as an attempt at communicating clearly with the reader, where our assessment is principally weighted to current symptoms, i.e. functional severity in Stein's classification. This assessment offers the opportunity to explore data for differences between differently-categorised patients (which would support theory-building). To report each participant's severity of Illness, four categories – Nil, Mild, Moderate or Severe were used. Table 2 and the *supplementary file 1* provides all the participant details which were considered and the allocated category of illness severity, per individual.

A general practitioner (PhD), nurse/researcher (PhD), and prescribing pharmacist (PhD) consulted on the data entered into the Appendix for Table 2.

References

1. Stein RK, Perrin E, Pless IB, Gortmaker S, Perrin J, Walker D, et al. Severity of illness: concepts and measurements. The Lancet. 1987;330(8574):1506-9.
2. Horn SD. Measuring severity of illness: comparisons across institutions. American Journal of Public Health. 1983;73(1):25-31.
3. Horn SD, Horn RA, Sharkey PD. The Severity of Illness Index as a severity adjustment to diagnosis-related groups. Health Care Financing Review. 1984;1984(Suppl):33.

Appendix #15: Qualitative Study Manuscript Appendix 3: Nutritional Risk Status by Individual MNA®SF Scores

ID#	MNA®SF Q1	MNA®SF Q2	MNA®SF Q3	MNA®SF Q4	MNA®SF Q5 (*main cause of depression)*	MNA®SF Q6	Total MNA®SF score
P#001	1	0	2	0	1	3	7
P#002	2	0	2	0	1	3	8
P#003	2	1	2	2	1	3	11
	2	3	2	0	0 (*burden related to care of husband)*	3	10
P#004							
	1	0	2	2	0 (*frail, and coping with severe allergic reactions)*	0	4
P#005							
	2	3	2	0	0 (Unable to go out as desired, *on oxygen therapy 24/7 and prescribed amitriptyline)*	3	10
P#006							
P#007	2	1	2	2	2	3	12
	0	0	2	0	0 (*Living alone and lonely, currently looking for a boarder)*	0	
P#008							
	1	2	2	0	0 (*Stomach problems, fear from uncertainty of diagnosis)*	3	8
P#009							
P#010	1	0	2	2	1	2	8
P#011	1	3	2	0	1	3	10
P#012	1	2	2	0	1	0	6
	0	0	2	0	0 (*recent relocation & current illness)*	1	3
P#013							
	1	0	2	2	0 (*poor health, tiredness and an inability to do activities)*	3	8
P#014							
P#015	2	3	2	0	0 (*Living with a lot of physical pain)*	3	10
P#016	2	3	2	2	2	3	14
Total number of times the	**9**	**11** Weight loss	**0** *Mobility	**10**	**14**	**5** BMI <23	***n*=2** nourished well

MNA®SF item was altered	Decrease in food intake	Psychological stress or acute disease	#Neuropsychological problems: 0=depression; 1=mild/severe dementia	***n*=9** at risk of malnutrition ***n*=5** malnourished

*****Mobility: One weakness of the MNA®SF on mobility assessment is that it gives a n impression that this population were mobile, because indeed, all were able to get up and walk. However, almost all (n=14) discussed significant challenges at performing ADLs due to impaired mobility, with 6 depending on walking aids to move around. P#005 was not even allowed to walk outside the gate.
#Participants with severe dementia were excluded.

Appendix #16: Qualitative Study Manuscript Appendix 4: Suggested Participant Recruitment Plan Provided to Recruiting Staff

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Exploring older adults' perspectives, experiences and knowledge of healthy eating: A qualitative study

Suggested Participant Recruitment Plan Provided to Recruiting Staff

Study Inclusion Criteria

To be eligible to participate in this study, one has to be:

1. Aged 75 years and over; for Māori or Pacific adults aged 65 years and over.

The older the better!

2. With or without long term illnesses.

Ideally 12 "With" and 4 "without"? It appears we may get more information from the ill & older!

3. Living in own home
4. Proficient in the English language
5. Willing and able to provide written consent and authority for the release of transcripts

3 out of the 4 in each ethnic group will be 'unwell' (moderate to severe illness)	Male		Female		Age The older the better!
	Living Alone	Living with others	Living Alone	Living with others	
Maori	1	1	1	1	3/4 over 75 years
Pacific	1	1	1	1	3/4 over 75 years
NZ European	1	1	1	1	3/4 over 85 years
Other	1	1	1	1	3/4 over 85 years

NB: This will just be a guide to help identify the appropriate potential participants. It will be fine if there will be some slight alterations during recruitment.

Appendices Publications

Appendix #17: DR16 Forms – Statements of contribution doctorate with publications/manuscripts

DRC 16

MASSEY UNIVERSITY
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STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Idah Chatindiara
Name/title of Primary Supervisor:	Professor Marlena Kruger
Name of Research Output and full reference:	
Chatindiara Idah, Vicki Williams, Emily Sycamore, Marilize Richter, Jacqueline Allen, and Carol Wham. "Associations between nutrition risk status, body composition and physical performance among community-dwelling older adults." Australian and New Zealand journal of public health 43, no. 1 (2019): 56-62.	
In which Chapter is the Manuscript /Published work:	Chapter 3
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	75 %
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Responsible for most aspects of the manuscript including literature search, conceptualisation and design of the manuscript, data and statistical analysis, drafting the manuscript and manuscript submission	
For manuscripts intended for publication please indicate target journal:	
Candidate's Signature:	
Date:	19/11/2019
Primary Supervisor's Signature:	
Date:	21/11/2019

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DRC 16 _Chapter 3DRC 16

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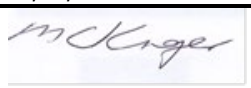
Name of candidate:	Idah Chatindiara
Name/title of Primary Supervisor:	Professor Marlena Kruger
Name of Research Output and full reference:	
Chatindiara, Idah, Jacqueline Allen, Amy Popman, Darshan Patel, Marilize Richter, Marlena Kruger, and Carol Wham. "Dysphagia risk, low muscle strength and poor cognition predict malnutrition risk in older adults at hospital admission." BMC geriatrics 18, no. 1 (2018): 78.	
In which Chapter is the Manuscript /Published work:	Chapter 4
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	75%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Responsible for most aspects of the manuscript including literature search, conceptualisation and design of the manuscript, data and statistical analysis, drafting manuscript and manuscript submission	
For manuscripts intended for publication please indicate target journal:	
Candidate's Signature:	
Date:	19/11/2019
Primary Supervisor's Signature:	
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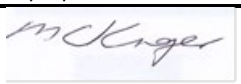
Name of candidate:	Idah Chatindiara
Name/title of Primary Supervisor:	Professor Marlena Kruger
Name of Research Output and full reference:	
Chatindiara, Idah, Jacqueline Allen, Amy Popman, Darshan Patel, Marilize Richter, Marlena Kruger, and Carol Wham. "Dysphagia risk, low muscle strength and poor cognition predict malnutrition risk in older adults at hospital admission." BMC geriatrics 18, no. 1 (2018): 78.	
In which Chapter is the Manuscript /Published work:	Chapter
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	80%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Responsible for most aspects of the manuscript including literature search, conceptualisation and design of the manuscript, data and statistical analysis, drafting manuscript and manuscript submission	
For manuscripts intended for publication please indicate target journal:	
Australian and New Zealand journal of public health	
Candidate's Signature:	
Date:	19/11/2019
Primary Supervisor's Signature:	
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Name of candidate:	Idah Chatindiara
Name/title of Primary Supervisor:	Professor Marlena Kruger
Name of Research Output and full reference:	
Chatindiara Idah, Nicolette Sheridan, Marlena Kruger, and Carol Wham. "Eating less the logical thing to do? Vulnerability to malnutrition with advancing age: A qualitative study." *Appetite* (2019): 104502.	
In which Chapter is the Manuscript /Published work:	Chapter 6
Please indicate:	
• The percentage of the manuscript/Published Work that was contributed by the candidate:	80%
and	
• Describe the contribution that the candidate has made to the Manuscript/Published Work:	
Responsible for most aspects of the manuscript including literature search, conceptualisation and design of the manuscript, data and statistical analysis, drafting manuscript and manuscript submission	
For manuscripts intended for publication please indicate target journal:	
Candidate's Signature:	
Date:	19/11/2019
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