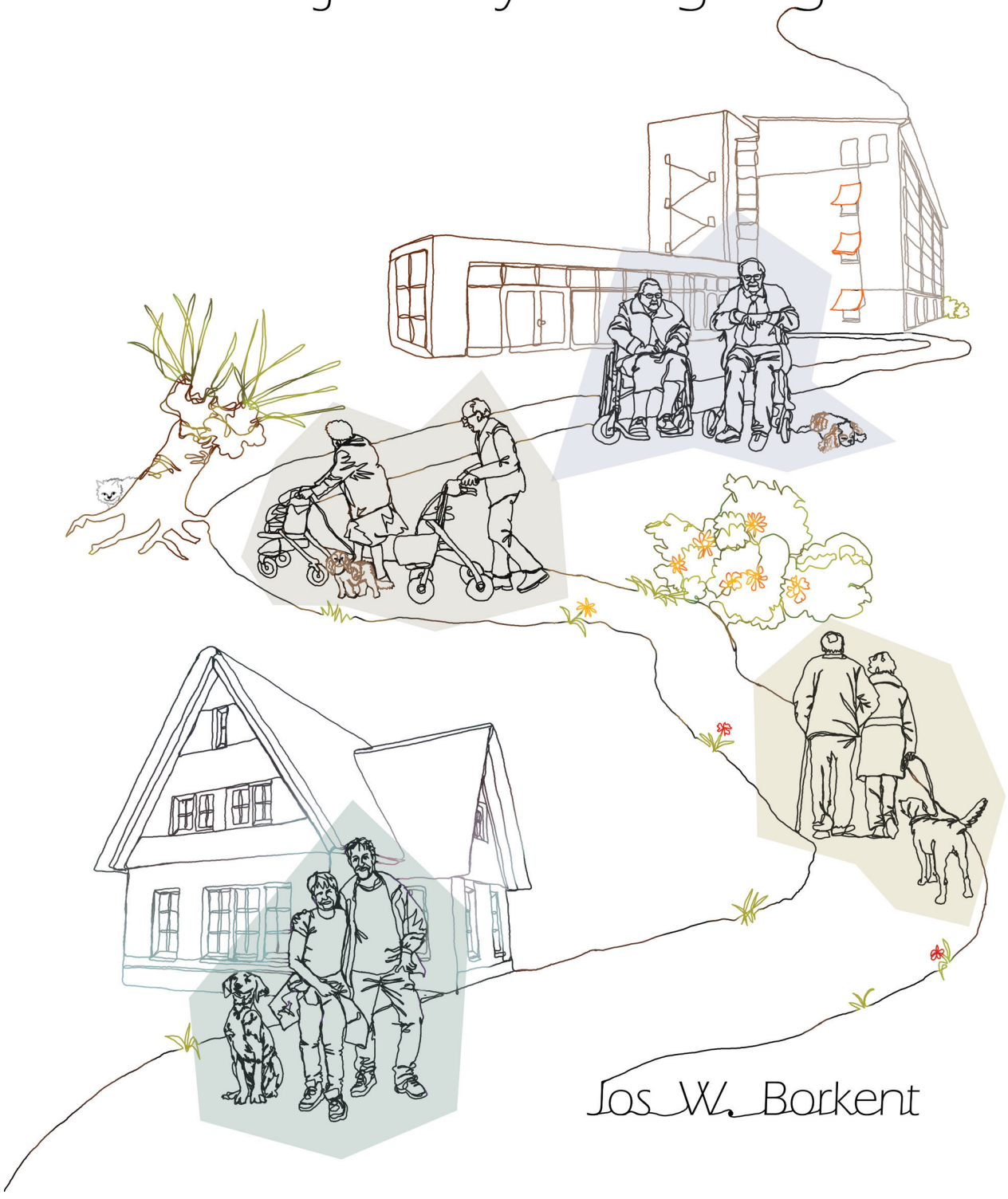
Malnutrition during the journey of ageing



Jos W. Borkent

Propositions

1. Malnutrition screening tools focus too much on anthropometric parameters and too little on nutritional intake.
(this thesis)

2. Older adults who are placed on a waiting list for a long-term care facility should already be monitored for nutritional status and offered nutrition support when appropriate.
(this thesis)

3. By violating the code of conduct for research integrity, one deserves losing academic titles.

4. It is indispensable to use at least 2% of the total project budget for knowledge dissemination aimed at the general public.

5. During a Ph.D. trajectory, you learn more about yourself than about your topic.

6. Fake news is the biggest threat to mankind, even bigger than global warming.

Propositions belonging to the thesis, entitled
Malnutrition during the journey of ageing
Jos Borkent
Wageningen, 9 November 2022

Malnutrition during the journey of ageing

Jos Borkent

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Malnutrition during the journey of ageing

Jos Borkent

Thesis

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Table of contents

CHAPTER 1

General introduction

The ageing society.

The Dutch society is ageing rapidly. In the Netherlands, life expectancy has steadily increased from 67.5 years in 1946 to 82.1 years in 2019 [1]. In 1990, about 12.8% of the Dutch population was aged >65 years, in 2021 this had risen to 19.8%. This increase was also seen in the oldest old; the number of people aged >100 year increased with ~250% [2]. This 'double process of ageing' can be explained the ageing of the so called 'baby boom' generation in combination with the increased life expectancy.

The increase in life expectancy over the last decades is not as fast as compared to the period after the second world-war [3], when better hygiene [4], vaccination [5], the discovery of antibiotics [6], and other major innovations in healthcare provided opportunities to cure diseases that previously caused death [5]. Over the last decades, the increase in life expectancy was mainly driven by better medical treatments that changed life threating diseases into chronic disorders [7]. This has led to a situation where people live longer, but often have multiple diseases and require care for a substantial time of their life [8].

Disease burden and increased care requirements accelerate with ageing [9]. During their journey of ageing, older adults move through different stages [10]. Older adults in the Netherlands, who retire at ~65 years of age, currently are mostly active and in a relatively healthy condition [11,12]. They travel for holidays, play sports, take care of their grandchildren and work as volunteers [13]. At this stage, they are vital and independent of care. As the years go on, these older adults are slowly facing the effects of the unavoidable ageing process. Accumulated damage to cell structures, the loss of muscle mass and muscle quality, the occurrence of acute or chronic diseases and the lack of recovery from disease makes them more vulnerable [14] and care dependent [10] over the years. Eventually, these problems accelerate and accumulate, making them frail [10]. This is also reflected in the high number of comorbidities (over 40% has one or more comorbidities) [15] and the large share (25.2%) of community-dwelling older adults that suffer from problems with doing activities of daily living [16]. However, these numbers are lowest in the 'young' older adults and increase with age [15]. In long-term care facilities, these numbers are even higher; nearly all residents are frail (88%), care dependent for their daily living activities (94.7%) and they suffer from multiple comorbidities (on average 3).

The combination of an ageing society and the increased number of comorbidities in older adults has changed the landscape of older-adult care in the western society. Due to increased health care costs and the wish of older adults to remain independent,

ageing-in-place has become the desired policy for older-adult care [17]. The Dutch *ageing-in-place* policy is based on the principle that older adults should remain in their own environment by enforcing their self-reliance as long as possible [10,18]. Informal and formal caregivers such as the general practitioner (GP), district nurse and social workers should support older adults to age in place. Only older adults with an indication for intensive medical care are eligible for admission to a long-term care facility [17]. This has led to decreasing admission rates to long-term care facilities, despite an increasing number of older adults [19]; in 1980 63% of all older adults aged >80 year lived in a long-term care facility [19], compared to 13% in 2017 [20]. As a consequence, most residents of long-term care facilities nowadays have a complicated health profile and suffer from multimorbidity [19]. Since these older adults are in their latest phase of life, care is mostly focused on relieve of symptoms and optimizing quality of life.

The interplay between frailty, sarcopenia and malnutrition.

Typical age-related diseases that could lead to institutionalization, loss of dependency and decrease of quality of older adults are frailty, sarcopenia and malnutrition [21–27]. These conditions are interrelated and share some underlying mechanisms, and all are related to adverse outcomes such as decline in functional status, loss of quality of live, morbidity and even mortality [28]. Despite similarities, they are too different from each other to be combined into one broad geriatric syndrome [29].

Frailty

Frailty is a relative commonly used word to express 'weakness'. The most commonly used criteria to diagnose frailty are those from Fried et al. [30] and Rockwood et al. [31] At this moment, frailty is officially not recognized as a disease (it has no ICD-11 code) [32] but it is clearly linked with adverse outcomes such as falls, hospitalization, decreased functioning and mortality [14].

In 2001, Fried et al. described frailty as a construct consisting of weakness, loss of endurance, slowness, low physical activity, and loss of weight [30]. Within this phenotypical approach, frailty is defined as a pre-disability syndrome [33]. This is in contrast to the frailty definition of Rockwood et al. that defines frailty as an accumulation of deficits [33]. Within the Rockwood frailty index, a set (up to 70 variables) of different criteria is used to assess the severity of frailty [31]. The Rockwood frailty index is, compared to the Fried criteria, a more comprehensive geriatric assessment that takes disease burden and influence of disabilities in daily living into account [33]. Other frailty indicators such as

the Tilburg [34] and Groningen [35] frailty indicator, are based on either the Fried criteria or the Rockwood frailty index.

The prevalence of frailty depends on the used definition, cut-of values, age group and living setting. Just after the age of retirement, prevalence of frailty in the community is 7.5% for males and 13% for females and these numbers increase to 32% and 44% for older adults aged ≥87 year [36]. In long-term care facilities, nearly all residents are frail (88%). As the Dutch society is ageing, the number of frail older adults is expected to rise in the upcoming years.

Sarcopenia

Another age-related disease that is frequently seen in older adults is sarcopenia. In contrast to frailty, sarcopenia has recently been appointed an ICD-11 code [37]. Sarcopenia is defined as the chronic and progressive loss of muscle strength, mass and function [38,39]. The underlying mechanisms for this decline are multifactorial but consist of muscle, neural and hormonal changes [38].

Recently, the European Working Group on Sarcopenia in Older People (EWGSOP) published a guideline to define and identify sarcopenia [39]. Based on the proposed algorithm, sarcopenia is present if muscle strength (based on grip strength or chair stand test) and muscle quality (based on DXA, BIA, MRI or CT-scan) are low. Severity grading of sarcopenia is defined by physical performance tests [39]. Dutch prevalence rates for sarcopenia in community-dwelling older adults differ widely between cohorts, varying from ~5-30%, with the highest prevalence rates in men and the oldest age groups [40–42].

Malnutrition

Based on the ESPEN Blue Book, malnutrition could be defined as followed: *"Malnutrition is a state resulting from lack of intake or uptake of nutrition that leads to altered body composition (decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease"* [43]. As this definition is broad, it includes all forms of malnutrition including kwashiorkor, cachexia, anorexia as well as micronutrient deficits. In 2017, ESPEN made a distinction between different underlying mechanisms of malnutrition: Disease-related malnutrition with inflammation, Disease related malnutrition without inflammation and malnutrition without underlying disease [44]. However, in older adults, the term malnutrition is mostly used for protein-energy malnutrition [44,45].

Malnutrition is categorized as a disease within the ICD-11 classification but, instead of malnutrition, the term undernutrition is used. Older adults are categorized as undernourished when BMI is below 18.5 kg/m^2 [37]. A proposal for an "Malnutrition in adults" diagnosis has been submitted to the WHO in is now under consideration [46].

Over time, different diagnostic criteria were proposed to identify older adults at risk of malnutrition. In 2015, ESPEN proposed a definition that used BMI, (recent) weight loss and fat free mass index (FFMI). Based on this definition, someone is malnourished as BMI is very low (<18.5 kg/m$^{2)}$), or when unintentional weight loss (>5% within one month or 10% irrespective of time) is accompanied with a low age-specific BMI (<20 kg/m^2 for adults <70 year / <22 kg/m^2 for adults >70 year) or FFMI (<15 and 17 kg/m^2 in women and men respectively) [45]. However, this definition was never globally accepted [47], because the ESPEN 2015 definition strongly depends on BMI which is not suitable for the Western society (especially the US) were a large share of the population is suffering from overweight and obesity [47,48].

The use of different criteria hampers proper diagnoses of malnourished older adults and make research results difficult to compare [48]. To improve unity and to improve treatment, the Global Leadership Initiative on Malnutrition (GLIM) proposed diagnostic criteria for diagnosing malnutrition [47] and these criteria have been globally accepted in 2019. According to these criteria the first step in diagnosing malnutrition is screening with a validated screening tool for malnutrition. When positive, further assessment is needed. Someone is regarded malnourished if (at least) one phenotypical criterion (weight loss, low BMI or low muscle mass) and one etiological criterion (decreased food intake/assimilation or disease burden/ inflammatory condition) is present. After the diagnosis, severity grading is needed to guide the intervention [47].

As the GLIM criteria are relatively new, no data is available about prevalence of malnutrition in Dutch older adults based on this set of criteria. Data from the Longitudinal Aging Study Amsterdam (LASA) from 2011-2012 indicate a three-year malnutrition incidence (as defined by a BMI <20 kg/m^2 and recent weight loss of ≥ 4 kg) of ~5% among community-dwelling older adults [49]. Based on the 2015 National Prevalence Measurement of Quality of Care (LPZ), a similar risk was seen were ~10% was suffering from very low BMI (<18.5 kg/m^2) combined with recent weight loss (>3 kg in last month or >6 kg in last six months) [50]. These numbers indicate that malnutrition is a serious problem in Dutch older adults.

As described above, frailty, sarcopenia and malnutrition are highly prevalent in Dutch older adults. They are closely related to each other and a substantial part of all older adults

suffer from combinations of these problems [51,52]. The presence of frailty, sarcopenia and malnutrition could lead to a perpetual cycle: one of the underlying mechanisms for frailty and sarcopenia is the presence of malnutrition. On the other hand, malnutrition can be a consequence of frailty and sarcopenia [53]. As neural and hormonal changes are difficult to improve, nutrition and exercise can play an important role in preventing older adults from becoming frail and sarcopenic [53].

Role of nutrition and recommendations.

Nutrition is one of the key elements of staying healthy, being able to live independently and experiencing good quality of life. A good nutritional status enables the body to (among others) maintain muscle mass, optimize the immune system, and recover from illness and injuries [54]. Consequently, a good nutritional status is associated with a reduced risk of falls [55], a better quality of life [25] and a lower risk of institutionalization [26]. Even in the oldest age groups, switching towards a healthy diet could increase life expectancy with several years [56]. Preventing older adults from becoming malnourished is therefore a key element for healthy ageing.

Both for well-nourished and malnourished older adults, an optimal protein and energy intake is required to remain fit and vital. In 2021, the Dutch Health Council advised a recommended dietary allowance (RDA) of 0.83 gram protein per kg bodyweight per day (g protein kg/bw per day) for all older adults [57]. The Health Council also states that *'[…] it is possible that higher protein intake could lead to a higher lean body mass'* but the evidence was found to be insufficient to recommend a protein intake higher than 0.83 g protein kg/bw per day. This advice contrasts with earlier international expert opinions and recommendations from other European countries (a.o. Germany, Ireland and the Nordic countries), which advice to use 1.0-1.2 g protein kg/bw per day because of the reduced ability to use available protein and a greater need of protein of older adults [58–60]. In ill older adults, these experts even advise to use 1.2-1.5 g protein kg/bw per day [61,62]. The advice of the Health Council is based on RCTs in relatively healthy populations that already had a relatively high protein intake. It therefore remains unclear whether the 0.83 g protein kg/bw per day is also sufficient in more frail and malnourished populations [63]. It is important to realize that approximately 20% off all older adults does not even reach the minimum recommendation of 0.83 g protein kg/bw per day [64].

Different stages of malnutrition during ageing.

At this moment, research towards malnutrition focusses mostly on older adults with malnutrition, indicated by low BMI and recent weight loss. As physical decline due to malnutrition is hard to overcome in older adults [26], treatment should focus on preventing older adults from entering this stage of malnutrition. Preventative measures can be taken long before obvious signs of malnutrition are present and should be tailored to someone's needs and to someone's nutritional status [65]. There may be early risk factors for malnutrition long before a person becomes malnourished. These risk factors are, for example, low appetite, problems with grocery shopping, physical risk factors such as problems with biting and chewing, and social risk factors such as loneliness [66]. These factors, in turn, can result in an early stage of malnutrition where a low(er) food intake and exclusion of different food groups are present. Eventually, these problems can result in later stage malnutrition with evident loss of muscle mass and a decline in functional status [65].

Screening tools and early identification of malnutrition

To improve the treatment of malnutrition in older adults, the MalNutrition in the ELderly knowledge hub (MaNuEL) project was started in 2016, funded by the Joint Programme Initiative Healthy Diet for a Healthy Life, initiated by the Council of Europe. This has resulted in papers on the state-of-the-art regarding the prevalence of malnutrition [67], screening tools [68], determinants that could lead to malnutrition [49,66] and non-pharmaceutical interventions to treat malnutrition [69]. Moreover, the published MaNuEL studies also showed also remaining knowledge gaps.

One of these gaps is the use of different screening tools. Screening for malnutrition is the first step to identify persons at risk of malnutrition and should be done with a validated screening tool [47]. Based on the MaNuEL paper by Power et al., published in 2018, 24 validated screening tools are available to identify older adults at risk of malnutrition [68]. Most of these tools, including the screening tools for older adults mostly used in the Netherlands SNAQ^{65+} (community) and SNAQ^{rc} (long-term care facilities), are based on late phase malnutrition symptoms such as low BMI and weight loss (table 1). They therefore identify malnourished older adults when physical decline is already present. Therewith, screening partly misses it aims: identifying persons at risk of becoming malnourished. Especially in the community, this is an important aim. A tool that focuses on early determinants of malnutrition is SCREEN II [70], a tool originally designed for early identification of malnutrition. SCREEN II consists of 16 items that assess early determi-

nants of malnutrition such as poor food intake, eating alone, problems with preparing meals and doing grocery shopping. SCREEN II provides a sum score but the separate items can also be used to identify why someone is at risk. In table 1, an overview is provided of items included in the screening tools SNAQ^{65+}, SNAQ^{rc} and SCREEN II.

Table 1, *overview of items included in SNAQ^{65+}, SNAQ^{rc} and SCREEN II*

SNAQ^{65+}	**SNAQ^{rc}**	**SCREEN II**
Weight loss	Recent weight loss	Weight change (gain or loss)
Upper arm circumference	BMI	Intention to change weight
Appetite	Eating assistance needed	Perception of body weight
Walking stairs	Decreased appetite	Skipping meals
		Avoidance of products
		Appetite
		Fruit vegetable intake
		Use of meat (replacements)
		Dairy intake
		Fluid intake
		Swallowing problems
		Biting/chewing problems
		Use of meal replacements
		Eating together
		Meal preparation
		Grocery shopping problems

Power et al. stated that SCREEN II is the tool with the greatest validity (sensitivity against dietetic assessment 84-90%, specificity 62-86%) for older adults in the community [68]. However, European/Dutch data is lacking as this tool is mostly used in Canada [71] and New Zealand [72,73]. At this moment, it is unclear which part of Dutch community-dwelling older adults is at risk of a poor nutritional status based on SCREEN II, which groups are at highest risk, and which particular risk factors are most prevalent. In addition, it is unclear how outcomes of nutritional risk based on SCREEN II differ from outcomes based on the advised Dutch malnutrition screening tool SNAQ^{65+}.

Nutritional interventions

When community-dwelling older adults are at risk of malnutrition, interventions are needed to prevent them from further nutritional decline. Previous studies towards malnutrition mainly focused on providing oral nutritional supplements (ONS) [69]. In the early stage of malnutrition, these interventions do not address the underlying problems.

When community-dwelling older adults suffer from problems such as grocery shopping and/or meal preparation, ONS will not be the most appropriate solution. Instead, the use of ready-made meals could be a solution to increase food intake [74]. At this moment we lack evidence on how a shift from self-prepared meals towards ready-made meals may affect protein and energy intake of community-dwelling older adults.

Long-term care facilities

When older adults are not able to remain independent in the community, admission to a long-term care facility is sometimes inevitable. At this moment, 115.000 older adults are living in such a facility [75]. Recent data is lacking but in 2012, 35% of Dutch community-dwelling older adults who received homecare were malnourished [76]. It is therefore expected that malnutrition prevalence is already high at admission to a long-term care facility and will further increase during stay. However, recent Dutch data on prevalence and development of malnutrition in elderly care homes is lacking. Identifying groups at risk for malnutrition at admission or during stay in a long-term care facility allows for timely interventions.

Moreover, it is yet unknown whether the dietary intake of older adults residing in long-term care facilities is appropriate to prevent deterioration of their nutritional status. The latest data on dietary intake in long-term care facilities stem from the period 2000-2003 and results indicated that protein and energy intake was low [77]. More recently, attention has been drawn to improving nutritional services in long-term care facilities. The report "Taskforce healthy eating with older adults" (Dutch: *Taskforce Gezond Eten met Ouderen*) describes 11 good practices to increase food intake in long-term care facilities [78]. However, most of these good practices are only implemented within a few long-term care facilities or are already stopped. It is therefore unclear whether food intake in Dutch residents of long-term care facilities is adequate and which groups are at an increased risk for having a low protein/energy intake. By identifying which groups are at an increased risk for a poor food intake, nutritional interventions could be tailored to these groups.

General outline of this thesis

A good nutritional status is important to optimally support healthy ageing. Both in the community and in long-term care facilities, it is important to identify people at risk of malnutrition at the earliest stage possible.

Therefore, this thesis aims to identify groups at risk of becoming malnourished during the journey of ageing; from healthy older adults in the community to frail residents in long-term care facilities (Figure 1). In this thesis, we will show prevalence rates of (early determinants of) malnutrition during this journey. In addition, we will study whether the provision of ready-made meals can be an effective intervention to improve dietary intake among community-dwelling older adults who are not able to prepare their own meals. In long-term care facilities, we will test which groups are at an increased risk for having a low protein/energy intake and which groups are at risk of being malnourished at admission or/and at risk of becoming malnourished during stay. Identifying these groups at risk will create opportunities to prevent (further) decline and helps to maintain optimal quality of life and care independency.

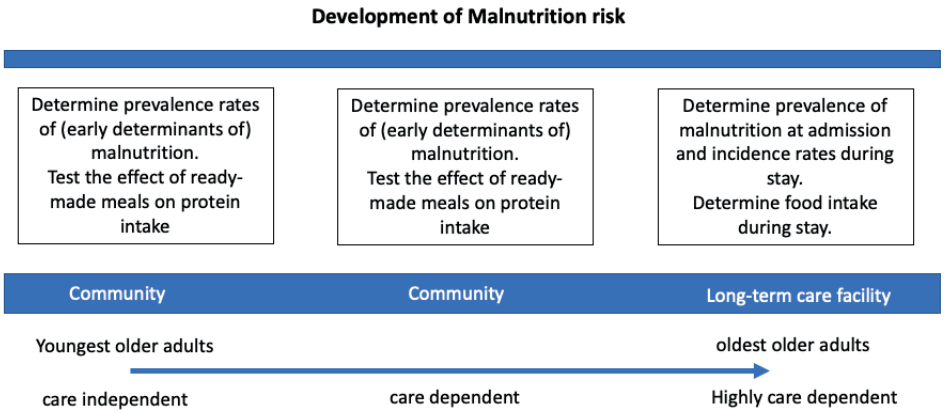

Figure 1, *Overview of different phases in the trajectory of ageing with accessory research objectives.*

Chapter 2 of this thesis provides an overview of early determinants of malnutrition based on the screening tool SCREEN II for different age categories in the Netherlands. In this study, data is used from the website www.goedgevoedouderworden.nl. In chapter 3, the data from chapter 2 are compared with data from other Western countries, particularly Canada and New Zealand, as SCREEN II is frequently use in these countries. In this chapter we compared prevalence rates and tested whether individual risk factors for a poor nutritional status differed between these countries. For this, we used data from www.goedgevoedouderworden.nl, www.nutritionscreen.ca_and the HART-study. a cohort from New Zealand. Chapter 4 describes a comparison between a screening tool for early determinants of malnutrition (SCREEN II) and late symptoms of malnutrition (SNAQ^{65+}). In chapter 5, the effect of switching from self-prepared meals towards ready-made meals on protein and energy intake are described. Data for chapter 4 and 5 is obtained from the ConsuMEER study. This RCT focused on the use of ready-made meals in community-dwelling older adults. In chapter 6, we describe prevalence and

incidence rates of malnutrition in long-term care facilities of residents with behavioural-cognitive problems. In chapter 7, the prevalence and incidence rates of malnutrition in long-term care facilities of residents with somatic problems are shown. Both chapter 6 and 7 are based on data from InterRAI. This is a large prospective register, based on patient files, which consist of ~9,000 residents of Dutch long-term care facilities. Chapter 8 will provide an overview of actual food intake compared to requirements of residents in 5 long-term care facilities in the Netherlands. Finally, chapter 9 provides the overall findings of this thesis, discussion and implications of the results.

CHAPTER 2

2

Prevalence and determinants of undernutrition in a sample of Dutch community-dwelling older adults: Results from two online screening tools.

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Abstract: To stimulate undernutrition screening among Dutch community-dwelling adults, a website was developed with general information on healthy eating for healthy ageing and self-tests. Based on cross-sectional data obtained from the self-tests, we studied nutritional risk factors (early determinants) as well as risk of undernutrition (late symptoms). SCREEN II (n = 2470) was used to asses nutritional risk factors. This tool consists of 16 items regarding nutritional intake, perception of body weight, appetite, oral health and meal preparation. An adjusted SNAQ^{65+} (n = 687) was used to assess risk of undernutrition. This four-item tool contains questions on weight loss, appetite, walking stairs and body mass index. Differences between age-groups (65–74, 75–84, ≥85) were tested by logistic regression. Overall prevalence of nutritional risk factors was 84.1%, and increased risk of undernutrition was 56.8%. Participants aged ≥85 scored worst on almost all items of the SCREEN II and the SNAQ^{65+}. In conclusion: A large proportion of older adults reported early determinants for increased nutrition risk, while a smaller, yet remarkable proportion scored positive on undernutrition risk. Internet screening may be a useful, contemporary, and easy, accessible way to reach older adults who are at nutritional risk and may thus contribute to early identification and prevention of undernutrition.

Introduction

In the Netherlands, undernutrition rates in community-dwelling older adults range from 10% to 35%, depending on level of care and age [50,76,79]. While these rates are lower compared to hospitals and nursing homes, in absolute numbers, the largest number of undernourished older adults live at home [80]. Undernutrition is associated with adverse outcomes such as impaired recovery from diseases, cognitive decline, institutionalization, and mortality [27,81,82]. Therefore, early identification of older adults at nutritional risk is necessary to be able to take preventive measures.

In the process of identifying persons at risk of undernutrition, screening tools are essential. Over the last decades, many screening tools have been developed and validated [68]. Most screening tools for undernutrition in older adults include low body mass index (BMI), loss of (muscle) mass, and/or impaired functioning as criteria [83]. However, these phenotypic, late symptoms of undernutrition indicate that a person is already at high risk or even undernourished [47]. Undernutrition should preferably be prevented in an earlier stage [65]. The preceding stages of undernutrition are characterized by the presence of early determinants such as problems with poor appetite, low food intake or difficulties with meal preparation [65]. Most screening tools only briefly addresses these early determinants.

In the Netherlands, screening for undernutrition in the community is mainly done by general practitioners (GPs), nurse practitioners, and home care nurses [84]. However, not all older adults attend GP offices regularly, not all older adults who visit a general practitioner are screened for undernutrition, and not all older adults receive home care. Therefore, a large group of older adults may be at risk for undernutrition without being identified. E-health initiatives offer new possibilities for self-screening; in the Netherlands, internet access of adults aged >65 year is 86.4%, and over half (52.5%) of older adults use internet to search for health information [85].

In 2017, the Dutch Malnutrition Steering Group, with financial help from the Dutch government, launched a website with general information on healthy eating for healthy ageing and self-tests. On this website www.goedgevoedouderworden.nl -translated as healthy eating for healthy ageing- older adults or their informal caregivers can test their nutritional risk by answering questions on early determinants of undernutrition (based on the validated screening tool 'Seniors in the Community: Risk evaluation for eating and nutrition, Version II' (SCREEN II)) [70]. They can also test their undernutrition risk by answering questions on late symptoms of undernutrition (based on the modified version of 'Short Nutritional Assessment Questionnaire for 65+' ($SNAQ^{65+}$)) [86]. After filling out

the test for early determinants (SCREEN II), participants receive personalized feedback and advice based on their answers to each question. For example, if the outcome of the test shows problems with preparing meals, advice will be shown for this problem. If someone is found at risk for undernutrition or at high nutritional risk, the advice is to visit the GP or a dietitian.

Previous studies among Dutch older adults were mostly based on undernutrition screening of late symptoms (weight loss, BMI, functionality) [50,76,79]. From previous research, we know that ageing is a risk factor for late symptoms of undernutrition [87]. Very few data on prevalence of early determinants (nutritional risk factors) of undernutrition are available [88]. Data for early determinants in relation to ageing are lacking. Therefore, we explored differences in both early determinants and late symptoms of undernutrition between age-groups of Dutch community-dwelling older adults based on the cross-sectional data obtained from internet-based self-tests.

Materials and Methods

Participants

Data were obtained from the website www.goedgevoedouderworden.nl. No recruitment was performed; data were used from attenders from the website that filled in the self-tests. All data were obtained anonymously. Only the age, gender, and zip code of the participants were stored in each self-test. Data-collection was done in the period April 2017–February 2019.

For all self-tests, the following inclusion criteria were used: Self-test had to be completed fully, and participant was aged >65 year.

Measurements

The website provides two tools for assessing undernutrition risk: SCREEN II, a tool to assess nutritional risk, and a modified version of SNAQ$^{65+,}$ a tool to assess undernutrition risk. Both tools could be filled out by the participant or by his/her informal care giver.

SCREEN II: The SCREEN II has been validated in community-dwelling older adults aged >65 year in Canada and New Zealand and can be self-administered. In these validation studies, high agreement was seen between SCREEN II and a nutritional risk assessment by a dietitian [70,89]. SCREEN II is a 16-item tool that covers nutritional risk factors such as weight change, perception of body weight, skipping meals, avoidance of products, appetite, intake of dairy/meat (replacements)/fruit and vegetables and fluids, problems

with biting and chewing, use of meal replacements, eating together, meal preparation, and problems with doing groceries. For each separate item, a score can be achieved ranging from 0–4 points, whereby a score of ≤2 points is categorized as a nutritional risk for that specific item [70]. The maximum score of the SCREEN II is 64 points. Based on Keller et al. [70], a score below 54 indicates an increased overall nutritional risk.

The modified version of SNAQ^{65+}: SNAQ^{65+} has been validated in Dutch community-dwelling older adults and was validated as a predictive tool for 15 years mortality. The tool consists of 4 questions: Mid-upper arm circumference (<25 cm), weight loss (≥4kg last six months), appetite, and walking stairs [86]. Based on a pilot study (results not published), self-assessment of mid-upper-arm circumference showed to be unreliable. Therefore, for the purpose of online self-testing, mid-upper-arm circumference was replaced by BMI, as BMI correlates highly with mid-upper arm circumference [19]. BMI was categorized according to the recently published Global Leadership Initiative on Malnutrition consensus criteria for undernutrition (GLIM criteria)with the following cut-off points for low BMI: <20 kg/m^2 for adults 65–70 years and <22 kg/m^2 for adults ≥70 years [47].

According to SNAQ^{65+}, participants were categorized at high risk for undernutrition if they scored BMI <20 or weight loss ≥4kg last six months; participants were categorized as moderate risk if they had low appetite and problems with walking stairs. On the website, participants who had lost ≥4kg over the last six months were not further questioned on appetite, problems with walking stairs or BMI, as they had already scored high-risk.

Analyses

Data were checked for normality using a QQ-plot. Descriptive statistics were performed by reporting means with standard deviation and numbers with percentages for categorical data. In order to investigate which risk factors occurred most frequently, all items of SCREEN II were reported separately stratified by age-group (65–74, 75–84, ≥85). Differences between age-groups on separate items of SCREEN II were tested using a chi-square test. Based on logistic regressions, odds ratios with 95% CI were calculated for proportions reaching <54 points. Differences in total points between age-groups were tested using linear regression. Analyses were tested for confounding by gender; however, the effect size differed <10%, so no adjustments were made.

Differences between age-groups in outcome based on the modified version of SNAQ^{65+} were tested by logistic regression. To do so, the modified version of SNAQ^{65+} was dichotomized into low vs. moderate/high risk as well into low/moderate vs. high risk. As all data were anonymous, data of the two self-tests could not be analysed at individual

participant level. All analyses were performed in SPSS 24 (IBM, Chicago VS), and a *p*-value of <0.05 was considered significant.

Results

Screen II

In total, 2470 participants completed the SCREEN II questionnaire. The mean age of all participants was 74.3 (SD:6.9) years, and 57.8% of the participants were aged 65–74 years. The majority of the participants were female (75.5%). A minor part of the questionnaires was filled in by an informal caregiver (14.7%); this was highest in the age-group ≥85 years (58.3%).

The mean score was 47.8 (SD:7.1) in participants aged 65–74 years, 45.1 (SD:8.7) in the age-group 75–84 years, and 39.2 (SD:9.0) in participants aged ≥85 years. Proportion at risk (<54 points) was 81.4% in participants aged 65–74 years, 85.5% in age-group 75–84 years, and 95.8% in age-group ≥85 years. Differences between age-groups were significant ($p < 0.05$) for mean total scores as well for proportions <54 points (Table 1).

Table 1, mean scores on SCREEN II and proportions <54 point.

Age	Total score	Mean difference
Total (n=2470)	46.1 (SD:8.3)	
Age: 65-74 (n=1428)	47.8 (SD:7.1)	Reference category
75-84 (n=802)	45.1 (SD:8.7)	−2.7 [95%CI: −3.3; −2.0]
≥85 (n=240)	39.2 (SD: 9.0)	−8.6 [95%CI: −9.6; −7.5]
	Proportion <54	Odds ratio
Total (n=2470)	2078 (84.1%)	
Age: 65-74 (n=1428)	1162 (81.4%)	Reference category
75-84 (n=802)	686 (85.5%)	1.4 [95%CI: 1.1; 1.7]
≥85 (n=240)	230 (95.8%)	5.3 [95%CI: 2.8; 10.1]

Continues data are shown as mean (difference) with standard deviation or 95%CI.
Categorical data are shown as number with percentage or odds ratio's with 95%CI.

In Table 2, nutritional risk factors based on SCREEN II are shown. Most frequently scored risk factors on SCREEN II were: Problems with perception of own weight (62.6%), a low intake of fruit and vegetables (67.5%)/meat (replacements) (55.4%)/dairy products (55.3%), limiting and avoiding products (40.6%), eating meals alone (40.7%) problems

with preparing meals (39.5%) or changes in body weight (38.7%). Less frequently scored risk factors were the use of meal replacements (9.4%), unintentional weight loss (9.8%), problems with biting and chewing (14.9%) or coughing/pain when swallowing (17.5%), doing groceries (17.4%), skipping meals (21.5%), problems with appetite (24.1%) or low fluid intake (24.9%).

Table 2, Nutritional risk factors according to the 17 questions of SCREEN II, compared between age categories.

Nutritional risk factor	65–74 years N = 1428	75–84 years N = 802	≥85 years N = 240	Total N = 2470	p-value **
Change in weight last six months					
Gained or lost ≥ 2.5kg *	509 (35.6%)	301 (37.5%)	145 (60.4%)	955 (38.7%)	**<0.001**
Remained stable	919 (64.4%)	501 (62.5%)	95 (39.6%)	1515 (61.3%)	
Unintentional weight last six months					
Yes *	101 (7.1%)	88 (11,0%)	52 (21.7%)	241 (9.8%)	**<0.001**
No	1327 (92.9%)	714 (89.0%)	188 (78.3%)	2229 (90.2%)	
Perception body weight					
More or less than it should be *	936 (65.5%)	479 (59.7%)	131 (54.6%)	1546 (62.6%)	**<0.001**
Just right	492 (34.5%)	323 (40.3%)	109 (45.4%)	924 (37.4%)	
Limitation or avoiding certain products					
Limitation and avoiding *	581 (40.7%)	303 (37.8%)	120 (50.0%)	1004 (40.6%)	**0.003**
No limitation or avoiding	847 (59.3%)	499 (62.2%)	120 (50.0%)	1466 (59.4%)	
Skipping meals					
Rarely or never	1180 (82.6%)	619 (77.2%)	139 (57.9%)	1938 (78.5%)	**<0.001**
Sometimes or more frequent *	248 (17.4%)	183 (22.8%)	101 (42.1%)	532 (21.5%)	
Appetite					
(Very) good	1202 (84.2%)	572 (71.3%)	101 (42.1%)	1875 (75.9%)	**<0.001**
Fair or poor *	226 (15.8%)	230 (28.7%)	139 (57.9%)	595 (24.1%)	
Portions of fruit or vegetables per day					
Four or more	532 (37.3%)	230 (28.7%)	40 (16.7%)	802 (32.5%)	**<0.001**
Three or less *	896 (62.7%)	572 (71.3%)	200 (83.3%)	1668 (67.5%)	
Eating meat, eggs, fish or meat substitute					
Once a day or less *	755 (52.9%)	453 (56.5%)	161 (67.1%)	1369 (55.4%)	**<0.001**
More than once a day	673 (47.1%)	349 (43.5%)	79 (32.9%)	1101 (44.6%)	
Dairy products per day					
Once a day or less *	805 (56.4%)	414 (51.6%)	148 (61.7%)	1367 (55.3%)	**0.011**
More than once a day	623 (43.6%)	388 (48.4%)	92 (38.3%)	1103 (44.7%)	
Fluid use per day					
≤ four glasses *	290 (20.3%)	227 (28.3%)	99 (41.3%)	616 (24.9%)	**<0.001**
≥ five glasses	1138 (79.7%)	575 (71.7%)	141 (58.8%)	1854 (75.1%)	
Problems with biting or chewing					
Sometimes or often *	131 (9.2%)	138 (17.2%)	98 (40.8%)	367 (14.9%)	**<0.001**
Rarely or never	1297 (90.8%)	663 (82.8%)	142 (59.2%)	2102 (85.1%)	

Table 2, Nutritional risk factors according to the 17 questions of SCREEN II, compared between age categories. (*continued*)

Nutritional risk factor	65–74 years N = 1428	75–84 years N = 802	≥85 years N = 240	Total N = 2470	p-value **
Problems with coughing, choking or pain when swallowing					**<0.001**
Sometimes or often *	207 (14.5%)	159 (19.8%)	67 (27.9%)	433 (17.5%)	
Rarely or never	1221 (85.5%)	643 (80.2%)	173 (72.1%)	2037 (82.5%)	
Eating meals together					**<0.001**
Sometimes or fewer *	457 (32.0%)	406 (50.6%)	142 (59.2%)	1005 (40.7%)	
Regularly / nearly always	971 (68.0%)	396 (49.4%)	98 (40.8%)	1465 (59.3%)	
Meal preparation					**<0.001**
Meal preparation is hard / I do not enjoy the meals that were prepared for me *	508 (35.6%)	356 (44.4%)	112 (46.7%)	976 (39.5%)	
Enjoy preparing meals / I enjoy the meals that were prepared for me	920 (64.4%)	446 (55.6%)	128 (53.3%)	1494 (60.5%)	
Use of meal replacements / supplements					**<0.001**
Sometimes or more frequent *	111 (7.8%)	83 (10.3%)	38 (15.8%)	232 (9.4%)	
Rarely or never	1317 (92.2%)	719 (89.7%)	202 (84.2%)	2238 (90.6%)	
Problems with doing groceries					**<0.001**
Rarely or never	1301 (91.1%)	604 (75.3%)	134 (55.8%)	2039 (82.6%)	
Sometimes or more often *	127 (8.9%)	198 (24.7%)	106 (44.2%)	431 (17.4%)	

Note: Data are presented as number (percentage), * Risk factors according to Keller et al. [70], ** *p*-value based on the chi square test.

Adjusted SNAQ65+

The adjusted SNAQ^{65+} was filled out by 687 participants, mean age 77.6 years (SD: 8.4), and most of them were female (75.4%). Nearly half of the questionnaires were filled out by an informal caregiver (46.3%); this was highest in the age-group ≥85 years (76.3%). In total, 390 (56.8%) participants were at high risk for undernutrition and 6.0% at moderate risk (Table 3). Within the high-risk group, 60.0% had lost over 4 kg body weight in the last six months, and 40% had a low BMI. High risk on undernutrition was highest in the age-group ≥85; this group had 3.0 [95%CI: 1.9–4.4] times higher odds of being at high risk of undernutrition compared to participants aged 65–74 years. The higher odds were also seen in the comparison of low vs. moderate/high; participants aged ≥85 had 3.8 [95%CI: 2.6–6.0] times higher odds compared to participants aged 65–74 (Table 3).

Table 3, Proportions 'Short Nutritional Assessment Questionnaire for 65+' (SNAQ) score and odds ratio's compared between age categories.

Age	Low risk	Moderate	High	Odds ratio moderate / high vs. low	Odds ratio high vs. low / moderate
Total (n = 687)	256 (37.3%)	41 (6.0%)	390 (56.8%)		
Age:					
65–74 (n=278)	139 (50%)	17 (6.1%)	122 (43.9%)	Reference category	Reference category
75–84 (n = 240)	82 (34.2%)	8 (3.3%)	150 (62.5%)	1.9 [95%CI: 1.4; 2.8]	2.1 [95%CI: 1.5; 3.0]
≥85 (n = 169)	35 (20.7%)	16 (9.5%)	118 (69.8%)	3.8 [95%CI: 2.5; 6.0]	3.0 [95%CI: 2.0; 4.4]

Data are shown as number (percentage) or as odds ratio with 95% CI.

Table 4, Risk factors of adjusted SNAQ^{65+}, compared by age-group.

Age	Weight loss >4 kg	Problems appetite	Problems walking stairs	Low (age-specific) BMI
Total (n = 687 / 460) *	234 (34.1%)	151 (33.4%)	143 (31.6%)	156 (34.4%)
65-74 (n = 278 / 211) *	67 (24.1%)	54 (25.6%)	44 (20.9%)	55 (26.1%)
75-84 (n = 240 / 155) *	90 (37.5%)	50 (33.3%)	50 (33.3%)	63 (40.6%)
≥85 (n = 169 / 93) *	77 (45.6%)	47 (51.6%)	49 (53.3%)	41 (43.6%)

Data are shown as number (percentage). * First number of participants only applies to weight loss, second number to 'problems appetite', 'problems walking stairs', and 'BMI<20 kg/m2'.

Discussion

The results of two online self-screening tests for risk of undernutrition show different prevalence rates for early determinants of undernutrition (84.1%) vs. late symptoms of undernutrition risk (56.8%) in a sample of Dutch community-dwelling older adults. These findings underline our assumption that early identification, based on nutritional risk factors, may be helpful in undertaking preventive measures. Based on the 16 individual risk items of the SCREEN II, tailored individual advice can be given. At a group level, interventions should focus on risk factors that are most common. Our results also indicate the need for self-screening among community-dwelling older adults. More than 2000 valid screening tests were filled out within two years. A large proportion of the visitors of the website www.goedgevoedouderworden.nl was at risk for undernutrition (based on the adjusted SNAQ^{65+}), and most visitors had many nutritional risk factors (based on SCREEN II). Proportions of visitors at risk for undernutrition and with nutritional risk factors increased with age; in participants aged ≥85, over half of the participants were at high risk for undernutrition, and nearly everyone (>95%) reported one or more nutritional risk factors.

The most frequently reported nutritional risk factor in the older Dutch population was perception of body weight; 62.6% judged their body weight as too high or low (without distinguishing between the two). Both overweight and underweight may lead to undernutrition. Not only underweight or overweight is a risk factor for older adults, but also attempts to lose weight may lead to loss of muscle mass if protein intake is not sufficient. Weight loss in older adults is associated with loss of muscle and bone mass [20]. Therefore, attempts to lose weight should incorporate exercise and optimal protein intake in order to prevent older adults from losing muscle and bone mass [90]. Any unintentional weight loss should lead to further nutritional and physical assessment, no matter the BMI.

Other frequently reported risk factors were a low intake of meat (replacements) or fish and low dairy intake. These products are a major source of protein in community-dwelling older adults [64,91]. An adequate protein intake is needed to maintain and restore muscle mass. Based on recent guidelines, an intake of >1.0 gram per kilogram body weight is advised for healthy older adults [74]. In addition to the higher daily recommendation, an even distribution of protein intake over the day is also important. An intake of >25 grams protein per meal could optimize synthesis of muscle mass [61]. Especially during breakfast and lunch, protein intake is known to be below this recommendation [91,92]. The low intake of meat (replacements), fish, and dairy products is therefore a risk factor for muscle loss.

A large part of the participants frequently ate their meals alone, which could have a negative impact on food intake. When eating alone, people tend to eat less [93], food is rated less tasteful [94], and meals are skipped more frequently [95]. To improve food intake, focus should not only be on meal composition but also on the setting. For community-dwelling older adults, it is important to activate their social network in order to prevent them from eating alone.

In our study, we found that nutritional risk factors as well as high risk for undernutrition were associated with age. This is in line with most other studies where higher age is associated with increased risk of undernutrition [49,96]. However, previous international studies based on SCREEN II showed no association with age or a higher risk in lower age-groups [72,73,97]. There are several reasons that could explain the differences. Previous studies tested the association for age based on a linear relationship, while in our study, age showed to have an exponential relationship. Further, especially participants above 85 years of age were at risk, and most previous studies had few participants in this age category. Last, we were not able to adjust for important confounders in our study such as marital status, education level, and physical activity levels, as these data were not

available. Based on the strength of the association, it is not likely that confounding alone could explain the difference between age-groups; however, attenuation of results for the oldest age-group is expected.

The proportions at risk for undernutrition based on SNAQ^{65+} and nutritional risk factors based on SCREEN II are higher in our study compared to previous Dutch studies. In these studies, prevalence rates for undernutrition based on SNAQ^{65+} differed between 10% and 35% [50,76,79] compared to 56.8% in our study. A similar difference is seen on nutritional risk factors based on SCREEN II; in a small, exploratory study by Haakma et al. [88], 67% was at risk compared to 84.1% in our population. This study was hampered by a low number of participants (n = 335), and only adults aged 75–85 were included. Not only Dutch studies showed lower prevalence rates on SCREEN II. Studies from Canada and New Zealand showed prevalence rates of 34–40% based on SCREEN II [72,73,97]. The higher risk on both tools in our study can be explained by the origin of our data; www.goedgevoedouderworden.nl was launched with the aim to raise attention to undernutrition and GPs and dietitians refer to the website. Visitors of the website may therefore have been less healthy or at suspected nutritional risk in comparison to a more general population. The high prevalence of undernutrition and nutritional risk factors underline the importance of a website that provides self-screening and information about (under) nutrition for community-dwelling older adults.

As data were collected anonymously, we do not know whether the collected data on the adjusted SNAQ^{65+} and SCREEN II were based on partly the same, or a different sample of participants. Nevertheless, early determinants of undernutrition (SCREEN II) seemed to be more prevalent compared to late symptoms of undernutrition (SNAQ^{65+}). It is important, and likely easier, to intervene on early determinants, because they develop into late symptoms such as loss of weight and muscle mass [65]. A website such as www.goedgevoedouderworden.nl can be a useful, contemporary tool, as it provides both self-tests as direct feedback how to improve the diet, based on nutritional risk factors.

The adjusted version of SNAQ^{65+} used BMI instead of mid-arm circumference, as arm-circumference was hard for older adults to measure. However, also the use of self-reported data for BMI could be unreliable. Previous studies showed an underestimation of weight and overestimation of height in older adults resulting in a too-low BMI [98–100]. However, underestimation of BMI is most frequently seen in overweight and obese older adults [99,101] and less frequently in participants with normal or underweight [102]. More research is needed to study the value of self-reported data of anthropometric measurements.

A recent study of O'Keeffe et al. [103] categorized determinants of undernutrition in seven domains. SCREEN II focuses mainly on food intake by addressing the oral, psychosocial, and nutritional domains, but not the medication and care, health, physical functioning, and lifestyle domain. Especially health-related problems are of interest as, next to nutrient intake, decreased absorption or an increased protein/energy need could result in undernutrition [104]. It is not known from our data how these domains would have affected outcomes on nutritional risk and undernutrition risk.

Despite the high access to internet of older adults in the Netherlands (86.4%)[85], a minor group is not able to use the internet. Lower internet use is mainly seen in higher age-groups, females, persons living alone [105], and those with lower education levels [106]. These groups could therefore be underrepresented in our study. However, most of the participants in our study were female, and the oldest age-group was relatively well represented as their informal care givers filled in the questionnaires. Even though the number of people not having access to internet declines year by year [107], and even though persons with low internet literacy tend to ask their surroundings for help [105], it must be acknowledged that e-health initiatives might not reach the most vulnerable population. Nevertheless, e-health is regarded as a novel way of reaching out to the Dutch (older) population while internet access rates are rather high.

A strong point of our study is the large study sample with a large subgroup of participants aged ≥85 years. Therefore, we had enough power to show differences in prevalence rates as well as differences in subitems of both screening tools across different age-groups.

Finally, some limitations should be considered. First, the use of self-reported data could have led to misclassification. Secondly, the adjusted SNAQ^{65+} is not a validated tool, as it replaces arm-circumference by BMI. However, the tool covers most aspects of the recently published GLIM criteria for malnutrition [47]. Thirdly, selection bias is likely, as the website www.goedgevoedouderworden.nl focuses on participants that are interested in undernutrition and healthy food for older adults. Thus, prevalence rates of undernutrition and nutritional risk factors cannot be generalized towards the Dutch population. Further, as with online (self-)screening, this method has its limitations: Participants could have filled in questionnaires more than once, resulting in biased results. Further, data filled in by an informal care giver could have been biased. Finally, no information is available on important confounders such as marital status, health status, health literacy, and physical activity.

Conclusion

In conclusion: Based on the self-tests filled in at www.goedgevoedouderworden.nl—translated as "Healthy eating for healthy ageing"—over half of the older participants were at risk of undernutrition, and four out of five reported early determinants of nutritional risk. Risks increased with increasing age. Self-testing of undernutrition may be a useful, contemporary, and easy, accessible way to reach older adults who are at nutritional risk and may thus contribute to early identification and prevention of undernutrition.

CHAPTER 3

3

Cross-country differences and similarities in undernutrition prevalence and risk as measured by SCREEN II in community-dwelling older adults.

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Abstract: Undernutrition is highly prevalent among community-dwelling older adults. Early identification of nutrition risk is important to prevent or treat undernutrition. This study describes the prevalence rates of nutrition risk in community-dwelling older adults (aged ≥ 65) using the same validated tool across different countries and aims to identify differences in nutritional risk factors. Cross-sectional data was obtained from three datasets including participants from the Netherlands (NL), Canada (CA) and New Zealand (NZ). Seniors in the Community Risk Evaluation for Eating and Nutrition II (SCREEN II) was used to assess nutritional risk factors and prevalence of risk. Differences between countries were tested with logistic and linear regression. Sensitivity analyses were conducted to test the influence of sampling strategy. A total of 13,340 participants were included, and 66.3% were found to be at high nutrition risk. After stratifying the data for method of data sampling, prevalence rates showed some differences across countries (NL: 61.5%, NZ: 68.2%, CA: 70.1%). Risk factor items that contributed to nutrition risk also differed among countries: NZ and CA participants scored higher for weight change, skipping meals, problems with meal preparation, use of meal replacements, problems with biting and chewing, low fluid intake and problems with doing groceries, as compared to participants in NL. Low intake of fruits and vegetables and meat were more prevalent in NL. In conclusion: nutrition risk is a worldwide, highly prevalent problem among community-dwelling older adults, but risk factors contributing to nutrition risk differ by country.

Introduction

The World Health Organization (WHO) estimated that the number of people aged over 65 years was approximately 524 million in 2010, comprising 8% of the world's population [1]. The WHO projected that in 2050 this number will rise towards 1.5 billion people, which will then comprise 16% of the world's population [108]. The ageing world population results in more age-related health problems, one of them being undernutrition [109]. The development of undernutrition in older adults is multifactorial and consists of physiological, social, pathological and economic factors [66,109]. Undernutrition can have several unfavourable consequences, such as loss of independence, poorer physical or mental function, reduced quality of life, increased risk of fragility fractures and mortality [83].

In order to identify persons at risk for undernutrition, various screening tools are available (such as: Short Nutritional Assessment Questionnaire 65+ ($SNAQ^{65+}$), malnutrition universal screening tool (MUST) and mini nutritional assessment (short form) (MNA-SF), which are often based on symptoms of (severe) weight loss or a low body mass index (BMI) [68]. In addition, these tools measure undernutrition when functional decline is likely to be already present. Undernutrition in community-living older people in Western societies is typically a process that starts with impaired food intake, and results in significant changes in body composition and functionality [65]. Relevant screening tools that include early determinants of undernutrition provide a more comprehensive view of risk. The identification of early risk factors contributing to an impaired food intake can give direction to promote health status and to prevent undernutrition. A screening tool that focuses on risk factors that can lead to impaired food intake and eventual undernutrition is the Seniors in the Community Risk Evaluation for Eating and Nutrition II (SCREEN II). This tool is a valid and reliable 17-item instrument that, in contrast to other screening tools, assesses upstream and early determinants that can influence food intake (e.g., difficulty with grocery shopping). Identification of these factors makes it possible to take early preventive measures, at a population or individual level, to prevent the onset of undernutrition [70].

Previous research based on SCREEN II showed different prevalence rates of nutrition risk across Western countries. The prevalence of nutrition risk in Dutch community-dwelling adults was 46%–67% [110,111], whereas in New Zealand this was 52% [72] and 34% in Canada [71]. However, different cut-off values for SCREEN II (≤53 points vs. ≤49 points), different questionnaires (short form vs. full version of SCREEN II) and different methods of data collection (online questionnaires vs. telephone calls) were used, hindering comparison of prevalence rates across studies. Next to these methodological differences,

differences in eating patterns, behaviours and risk factors between countries may also explain differences in prevalence rates. The present study was designed to compare prevalence rates based on SCREEN II between Canada, the Netherlands and New Zealand, applying the same cut-off points, and to study potential differences between risk factors contributing to undernutrition across countries.

Materials and Methods

Study Design

Cross-sectional data was used from three different datasets: a Canadian dataset including participants from six continents, a dataset from the Netherlands and one from New Zealand. All datasets contain data on participant age, gender and all seventeen items from the SCREEN II questionnaire.

Data Collection

Canadian Derived International Dataset

The Canadian dataset contains cross-sectional data from 38,361 participants worldwide (44 countries), with the majority of participants (91%) living in Canada. Data was collected in the period 2015–2018 via the website www.nutritionscreen.ca. This online self-screening survey contains the SCREEN II questionnaire. At the beginning of the questionnaire, participants were informed about the possibility that responses could be used for research anonymously. In case of the outcome high nutrition risk, the participant was advised to contact a health professional. From this dataset, only participants of Canada (n = 34,822), New Zealand (n = 673) and the Netherlands (n = 42) were included. Analyses were conducted by authors at the HAN University of Applied Sciences; the HAN University of Applied Sciences Ethical Review Committee judged that no ethical approval was necessary as long as participants were informed about the possibility that answers can be used for research anonymously.

Dutch Dataset

The Dutch data was derived in the period April 2017–February 2019 from the website www.goedgevoedouderworden.nl (translated as: "healthy eating for healthy ageing") [13] and contains cross-sectional data from 4848 participants. This website is based on the international website www.nutritionscreen.ca [12]. The Dutch version was developed by the Dutch Malnutrition Steering Group and gives advice and information about nutrition and physical activity, recipes and contains several health tests. One of these online self-tests is the questionnaire *"Hoe eet ik nu?"* (translated as: "How do I eat now")?"

based on SCREEN II. The HAN University of Applied Sciences Ethical Review Committee judged that no ethical approval was necessary as long as participants were informed about the possibility that answers can be used for research anonymously. This data is previously described by Borkent et al. [112].

New Zealand Dataset

For this study, data was used from the 2014 wave of the longitudinal cohort, The New Zealand Health, Work and Retirement Study (HART 2014 survey) (n = 3050). Participants in this study were approached via electoral rolls on which registration is mandatory in New Zealand. Inclusion criteria was age > 55 years and participants were excluded if they were institutionalized. A postal questionnaire was used to assess individual factors related to retirement, wellbeing and independence. Participants filled in the questionnaire by themselves. Nutrition risk was determined once, in 2014, using the SCREEN II questionnaire. Inclusion and exclusion criteria are described elsewhere [113]. The study was approved by the Massey University Human Ethics Committee.

Participants Current Study

All datasets were merged, resulting in data from 46,259 participants. All participants aged < 65 years or who had not completed the full questionnaire were excluded. After excluding participants from countries other than Canada, the Netherlands or New Zealand 13,340 remained for data-analyses.

Measurements

Nutrition risk and risk factors were measured with the SCREEN II questionnaire. SCREEN II is a 17-item tool that covers the following nutritional risk factors: weight change, perception of body weight, skipping meals, avoidance of products, appetite, intake of dairy/meat (replacements)/fruit and vegetables and fluids, problems with biting and chewing or coughing and swallowing, use of meal replacements, eating with others, who prepares meals (not scored), difficulties with meal preparation, and problems with doing groceries. Each response was given a score from 0 to 4, where a score ≤2 is characterized as a potential nutrition risk for the specific item [70]. The sum of the 16 scored items results in a total score of ranging from 0 to 64, with a lower score indicating a higher nutrition risk. According to Keller et al. [70] a total score ≤53 is indicative of any nutrition risk and ≤49 as high nutrition risk. Information about age, gender and country was measured in each data set and was used to characterize the samples.

Data Analysis

Continuous data was checked for normality by stem and leaf plots and QQ-plots. Descriptive statistics (means with standard deviation and number with frequencies) were

used to represent the characteristics of the participants, prevalence rates of scored items of the SCREEN II questionnaire and the total score for nutrition risk. Logistic regression analyses were applied to test associations between countries (independent variable) and nutrition risk (dependent variable), based on the cut-off values for nutrition risk (≤53) and high nutrition risk (≤49) [70]. Logistic regression analyses were also used to assess the associations between countries (independent variable) and separate items of SCREEN II (nutritional risk factors) as dependent variables. For this analysis, the score for every single SCREEN II item was dichotomized into potentially leading to nutrition risk (≤2) and not leading to risk (≥3) [70]. Lastly, a linear regression analysis was performed to assess the association between the independent variable 'country' and the total SCREEN II score as the dependent variable. The Netherlands was used as the reference category in all analyses. Previous studies showed associations between nutrition risk and age categories [71,112] and between nutrition risk and gender [71,73]. Therefore, these variables were added as potential confounders to models. Statistical analyses were performed using SPSS V24.0 (IBM, Chicago VS); because of the large sample-size, values were considered significant when $p < 0.01$.

Sensitivity Analysis

Sensitivity analyses were performed because of the differences in recruitment of participants between datasets; online sampling in Canada and the Netherlands, vs. sampling by electoral roll in New Zealand. Datasets derived from online surveys were also analysed without the New Zealand dataset.

Results

The total number of participants in the different datasets was 46,259 (Figure 1). A total of 32,843 participants were excluded, because they did not meet the inclusion criteria (age < 65, $n = 30,769$; incomplete questionnaires, $n = 1508$; countries other than Canada, the Netherlands or New Zealand $n = 642$). This resulted in a total population of 13,340 participants to be analysed.

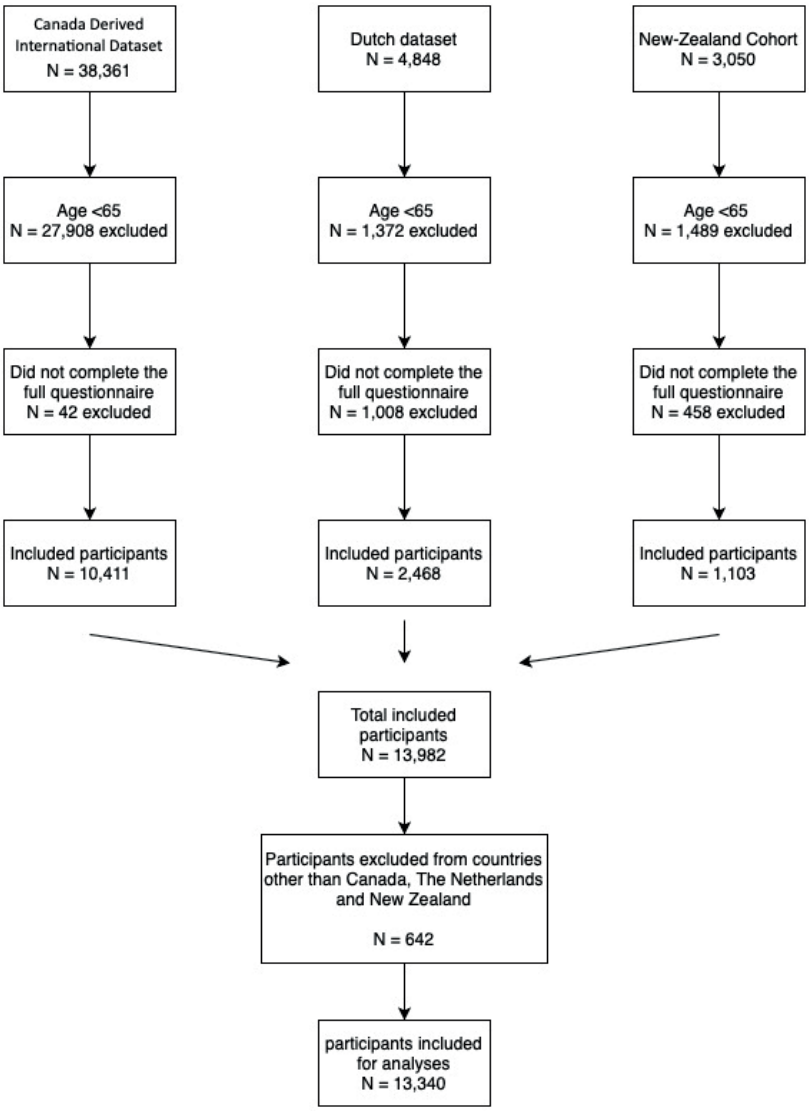

Figure 1, Flowchart of included participants for analyses showed for three datasets.

The main characteristics of the participants and the total scores of the SCREEN II questionnaire are shown in Table 1. Most participants were from Canada (*n* = 9538; 71.5%), followed by the Netherlands (*n* = 2482; 18.6%) and New Zealand (*n* = 1320; 9.9%). The majority (*n* = 9.796; 73.4%) of the included participants were woman. More than half of the participants (*n* = 8773; 65.8%) were in the younger age category of 65–74 years of age. Overall, the mean total score for SCREEN II was 44.6 (SD: 9.3) with a range from 0 to 64. The overall prevalence of any nutrition risk (total score ≤ 53) was 85.7% (*n* = 11,431) and the prevalence of high nutrition risk (total score ≤ 49) was 66.3% (*n* = 8841).

Table 1, Participant characteristics and Seniors in the Community Risk Evaluation for Eating and Nutrition II (SCREEN II) scores by country/continents.

	Total	The Netherlands	New Zealand	Canada
	N = 13,340	*N* = 2482	*N* = 1320	*N* = 9538
Gender				
Men	3544 (26.6%)	607 (24.5%)	589 (42.2%)	2368 (24.8%)
Women	9796 (73.4%)	1875 (75.5%)	807 (57.8%)	7170 (75.2%)
Age				
65–74	8773 (65.8%)	1437(57.9%)	1025 (77.7%)	6311 (66.2%)
75–84	3569 (26.8%)	805 (32.4%)	283 (21.4%)	2481 (26.0%)
≥85	998 (7.5%)	240 (9.7%)	12 (0.9%)	746 (7.8%)
SCREEN II				
≥54	1909 (14.3%)	394 (15.9%)	343 (26.0%)	1172 (12.3%)
≤53 *	11,431 (85.7%)	2088 (84.1%)	977 (74.0%)	8366 (87.7%)
OR		ref	0.54 (0.43–0.67)	1.35 (1.15–1.59)
Adjusted OR ***			0.60 (0.48–0.75)	1.39 (1.18–1.64)
SCREEN II				
≥50	4499 (33.7%)	956 (38.5%)	690 (52.3%)	2853 (29.9%)
≤49 **	8841 (66.3%)	1526 (61.5%)	630 (47.7%)	6685 (70.1%)
OR		ref	0.57 (0.48–0.68)	1.47 (1.30–1.66)
Adjusted OR ***			0.66 (0.55–0.79)	1.53 (1.36–1.73)
SCREEN II				
total score	44.6 (9.3)	46.1 (8.3)	48.7 (7.4)	43.7 (9.5)
Regression coefficient		ref	2.6 (1.9; 3.5)	−2.4 (−2.9; −1.8)
Adjusted Regression coefficient ***			1.4 (0.6; 2.2)	−2.7 (−3.2; −2.2)

Data are shown as number (percentage)/mean (standard deviation) or OR (99%CI)/Mean differences (99%CI). * indicative for nutrition risk according to Keller et al.; ** indicative for high nutrition risk according to Keller et al. *** adjusted for age and gender.

Total Score with All Included Datasets

Nutrition risk was the highest in Canada. Compared to the Netherlands (reference), the odds ratio of being at nutrition risk (total score ≤ 53) in Canada was 1.39 (99%CI: 1.18–1.64) and the odds ratio of being at high nutrition risk (total score ≤ 49) was 1.53 (99%CI: 1.36–1.73). New Zealand had the lowest prevalence with odds ratios of 0.60 (99%CI: 0.48–0.75) and 0.66 (99%CI: 0.55–0.79) respectively.

Sensitivity Analyses: Total Score with only Datasets from Online Websites

Table 2 shows the main characteristics of the participants and the total scores of the SCREEN II questionnaire when only including data derived through the Canadian and

the Dutch websites (*n* = 12,237). The majority of the participants lived in Canada (*n* = 9538, 77.9%), the Netherlands (*n* = 2.482, 20.3%), and a relatively small group that lived in New Zealand (*n* = 217, 1.8%) was obtained from the Canadian dataset. Two-thirds of the participants (*n* = 7902; 64.6%) were in the younger age category of 65–74 years of age and most of the participants (*n* = 9193; 75.1%) were woman. The mean total score for nutritional risk from New Zealand decreased by 5.7 points, compared to the data set described in Table 1. This resulted in a 1.17 (99%CI: 0.70–1.96) times higher odds of being at any nutrition risk (total score ≤ 53) and a 1.47 (99%CI: 1.00–2.18) times higher odds of being at high nutrition risk (total score ≤ 49) in New Zealand as compared to the Netherlands.

Table 2, Characteristics of the participants and total scores of SCREEN II questionnaire, compared between countries with data only from online websites.

	Total	The Netherlands	New Zealand	Canada
	N = 12,237	*N* = 2482	*N* = 217	*N* = 9538
Gender				
Men	3044 (24.9%)	607 (24.5%)	69 (31.8%)	2368 (24.8%)
Women	9193 (75.1%)	1875 (75.5%)	148 (68.2%)	7170 (75.2%)
Age				
65–74	7902 (64.6%)	1437 (57.9%)	154 (71.0%)	6311 (66.2%)
75–84	3340 (27.3%)	805 (32.4%)	54 (24.9%)	2481 (26.0%)
≥85	995 (8.1%)	240 (9.7%)	9 (4.1%)	746 (7.8%)
SCREEN II				
≥54	1598(13.1%)	394 (15.9%)	32 (14.7%)	1172 (12.3%)
≤53 *	10,639 (86.9%)	2088 (84.1%)	185 (85.3%)	8366 (87.7%)
OR		ref	1.09 (0.65; 1.82)	1.35 (1.15; 1.59)
Adjusted OR ***			1.17 (0.70; 1.96)	1.39 (1.18; 1.64)
SCREEN II				
≥50	3878 (31.7%)	956 (38.5%)	69 (31.8%)	2853 (29.9%)
≤49 **	8359 (68.3%)	1526 (61.5%)	148 (68.2%)	6685 (70.1%)
OR		ref	1.34 (0.91; 1.99)	1.47 (1.30; 1.66)
Adjusted OR ***			1.47 (1.00; 2.18)	1.54 (1.36; 1.74)
SCREEN II				
total score	44.2 (9.3)	46.1 (8.3)	43.0 (10.3)	43.7 (9.5)
Regression coefficient		ref	−3.1 (−4.8; −1.4)	−2.4 (−2.9; −1.8)
Adjusted Regression coefficient ***			−3.8 (−5.5; −2.2)	−2.7 (−3.2; −2.2)

Data are shown as number (percentage)/mean (standard deviation) or OR (99%CI)/Mean differences (99%CI). * indicative of nutrition risk according to Keller et al. ** indicative of high nutrition risk according to Keller et al. *** adjusted for age and gender.

As prevalence rates of scored nutritional risk factors changed after stratifying by the source of data collection, Table 3 presents the results of the datasets from online questionnaires only, to be able to make a true comparison of nutritional risk factors among countries. The results of the differences in risk factors between countries with all data are presented in supplementary Table A1 (Appendix A).

Table 3. Nutritional risk factors according to the SCREEN II compared between countries, with data from online websites.

	Total	The Netherlands	New Zealand	Canada
	N = 12,237	*N* = 2482	*N* = 293	*N* = 9538
Change in weight in last six months (gained or lost ≥ 2.5 kg)	6023 (49.2%)	964 (38.8%)	119 (54.8%)	4940 (51.8%)
OR		ref	1.91 (1.33–2.76)	1.59 (1.31–1.92)
adjusted OR *			2.00 (1.38–2.89)	1.73 (1.43–2.10)
Unintentional weight change last six months	1703 (13.9%)	245 (9.9%)	45 (20.7%)	1413 (14.8%)
OR		ref	2.39 (1.50–3.80)	1.48 (1.24–1.76)
adjusted OR *			2.87 (1.79–4.61)	1.62 (1.35–1.93)
Perception bodyweight (more or less than it should be)	8864 (72.4%)	1554 (62.6%)	145 (66.8%)	7165 (75.1%)
OR		ref	1.20 (0.82–1.77)	1.80 (1.59–2.04)
adjusted OR **			1.13 (0.77–1.67)	1.74 (1.54–1.97)
Skipping meals (sometimes or more frequent)	4632 (37.9%)	536 (21.6%)	64 (29.5%)	4032 (42.3%)
OR		ref	1.52 (1.01–2.27)	2.66 (2.32–3.05)
adjusted OR *			1.62 (1.08–2.42)	2.76 (2.40–3.16)
Limitation or avoiding certain products	6148 (50.2%)	1011 (40.7%)	100 (46.1%)	5037 (52.8%)
OR		ref	1.24 (0.86–1.79)	1.63 (1.45–1.83)
adjusted OR*			1.27 (0.88– 1.83)	1.63 (1.45–1.84)
Fair/poor Appetite	2595 (21.2%)	597 (24.1%)	55 (25.3%)	1943 (20.4%)
OR		ref	1.07 (0.70–1.63)	0.81 (0.70–0.93)
adjusted OR*			1.35 (0.87–2.08)	0.88 (0.76–1.02)
Low intake fruit or vegetables per day (three or less portions)	6455 (52.7%)	1674 (67.4%)	85 (39.2%)	4696 (49.2%)
OR		ref	0.31 (0.21–0.45)	0.38 (0.28–0.52)
adjusted OR *			0.32 (0.22–0.46)	0.48 (0.42–0.54)
Low intake of meat, eggs, fish or meat substitute (once a day or less)	5113 (41.8%)	1376 (55.4%)	124 (57.1%)	3613 (37.9%)
OR		ref	1.07 (0.74–1.55)	0.49 (0.44–0.55)
adjusted OR*			1.12 (0.77–1.62)	0.50 (0.45–0.56)
Low dairy intake (one portion a day or less)	7434 (60.8%)	1373 (55.3%)	142 (65.4%)	5919 (62.1%)
OR		ref	1.53 (1.04–2.24)	1.32 (1.18–1.49)
adjusted OR*			1.51 (1.03–2.22)	1.32 (1.17–1.48)

Table 3. Nutritional risk factors according to the SCREEN II compared between countries, with data from online websites. (*continued*)

	Total	The Netherlands	New Zealand	Canada
	N = 12,237	*N* = 2482	*N* = 293	*N* = 9538
Low fluid intake (≤four glasses)	4514 (36.9%)	622 (25.1%)	65 (30.0%)	3827 (40.1%)
OR		ref	1.28 (0.86–1.91)	2.00 (1.76–2.28)
adjusted OR *			1.41 (0.94–2.11)	2.16 (1.89–2.46)
Problems with coughing, choking or pain when swallowing (sometimes or often)	2245 (18.3%)	437 (17.6%)	37 (17.1%)	1771 (18.6%)
OR		ref	0.96 (0.59–1.56)	1.07 (0.92–1.24)
adjusted OR *			1.08 (0.66–1.77)	1.12 (0.96–1.31)
Problems with biting or chewing (sometimes or often)	2187 (17.9%)	369 (14.9%)	44 (20.3%)	1774 (18.6%)
OR		ref	1.46 (0.92–2.30)	1.31 (1.12–1.54)
adjusted OR *			1.78 (1.12–2.85)	1.44 (1.22–1.70)
Use of meal replacements/supplements (sometimes or more frequent)	2362 (19.3%)	236 (9.5%)	31 (14.3%)	2095 (22.0%)
OR		ref	1.59 (0.93–2.69)	2.68 (2.22–3.23)
adjusted OR *			1.78 (1.04– 3.03)	2.89 (2.39–3.49)
Eating meals with others (sometimes or fewer)	5143 (42.0%)	1014 (40.9%)	125 (57.6%)	4004 (42.0%)
OR		ref	1.97 (1.36– 2.85)	1.05 (0.93–1.18)
adjusted OR *			2.31 (1.58–3.35)	1.12 (0.99–1.26)
Meal preparation (meal preparation is hard/I do not enjoy the meals that were prepared for me)	6123 (50.0%)	984 (39.6%)	135 (62.2%)	5004 (52.5%)
OR		ref	2.51 (1.72–3.65)	1.68 (1.49–1.89)
adjusted OR *			2.94 (2.00–4.33)	1.77 (1.57–2.00)
Problems with doing groceries (sometimes or more often)	2794 (22.8%)	433 (17.4%)	61 (28.1%)	2300 (24.1%)
OR		ref	1.85 (1.22–2.79)	1.50 (1.30–1.75)
adjusted OR *			2.42 (1.58–3.71)	1.72 (1.48–2.01)

Note: data is presented as number (percentage) or OR (99%CI) * adjusted for age and gender. Bold = significantly different from reference category.

Nutritional Risk Items

Overall, the most frequently reported nutritional risk factors on the SCREEN II questionnaire were: problems with perception on bodyweight (72.4%), low intake of fruit and vegetables (52.7%)/meat, eggs, fish or meat substitute (41.8%)/dairy (60.8%), limitation and avoiding of certain foods (50.2%), problems with meal preparation (50.0%), change in bodyweight (49.2%) and eating alone (42.0%).

Significant differences were seen in most items between the Netherlands and New Zealand, except in perception of bodyweight, limitation or avoiding certain products,

intake of meat and alternatives, poor appetite, low fluid intake and problems with coughing. Significant differences between the Netherlands and Canada were seen in all nutritional risk factors, except in problems with appetite, problems with coughing and eating meals with others. Overall, nutritional risk factors were reported more frequently in New Zealand and Canada compared to the Netherlands, with the exception of the intake of fruit and vegetables, and meat and alternatives. These risk factors were more frequent in the Netherlands.

Discussion

This study showed different prevalence rates for any nutrition risk according to SCREEN II (total score ≤53) in Canada (87.7%), the Netherlands (84.1%) and New Zealand (74.0%). However, these differences were attenuated after stratifying the data by the source of the data collection: the prevalence rates of any nutrition risk (total score ≤53) for data obtained only from online-self administration was 87.7% (Canada), 84.1% (the Netherlands) and 85.3% (New Zealand). In contrast with the total score for nutrition risk, notable differences in single items of the SCREEN II questionnaire were shown. These findings are in line with our hypothesis that differences in food consumption, habits and sociocultural status between countries result in a varying prevalence of factors that contribute to nutrition risk. As a result of these differences, nutritional interventions should focus on frequently scored risk factors in specific countries, and should be tailored to specific age groups [112].

Previous studies showed different prevalence rates between countries; the prevalence rate of nutrition risk according to the SCREEN II was 46%–67% in the Netherlands [110,111], 52% in New Zealand [72] and 34% in Canada [71]. As described earlier, methodological issues may have contributed to these differences. The current study showed higher prevalence rates of nutrition risk, but only small differences between countries. The higher prevalence could be explained by the method of sampling. The majority of the participants in this study were recruited via online websites that provided information about healthy ageing. These websites are thought to be used by health care professionals to refer older adults who may be at increased risk of undernutrition. Alternatively, older adults who are concerned about their nutritional health may seek out these websites. However, this selection bias is likely to occur in each country (Canada, the Netherlands and New Zealand) and presumed to not vary by country of origin. Selection bias mainly affects prevalence rates [114] but associations are relatively immune for this type of bias [114–116]. So, despite the possibility of a non-representative study-

population, the comparison of individual nutritional risk factors provides a valuable insight in differences between three western countries.

The data used for this study is from three different continents. However, this data is likely not to be representative for other countries, especially in North America and Europe. Canada and the Netherlands are rich countries with a well-developed health care system and good social securities. It is likely that other countries in Europe and North America have other nutritional risk factors for malnutrition. No data is available for such countries, and a validation study is needed to determine if SCREEN II is applicable in less developed countries and other continents.

SCREEN II is originally designed as a nutrition screening tool [70]. Therefore, it does not address the full spectrum of psychological and physical determinants associated with undernutrition. Two questions addressing these determinants are 'eating alone' and 'inability to perform grocery shopping', but we do not have data to test how these two questions relate to psychological or physical health. A recent publication showed that SCREEN II was associated with food intake but only in a lesser extent to physical parameters, while the SNAQ^{65+} screening tool was more related to physical health [117]. The combination of the two might provide supplementary information on undernutrition risk, covering both early stage and late stage malnutrition [117].

To our knowledge, this is the first study exploring nutritional risk factors across three countries. Differences were seen in the intake of several food groups. The majority of the Dutch participants (65.9%) consumed three or less portions of fruit or vegetables per day. This risk factor was less commonly reported in New Zealand (39.2%) and Canada (49.2%); however, this difference may be explained by potatoes being considered a vegetable in the latter countries [118,119]. A low intake of meat and alternatives was frequently reported by participants from the Netherlands (55.4%) and New Zealand (57.1%), but to a lesser extent in Canada (37.9%). The higher meat intake in Canada is line with the national food consumption surveys, where the meat consumption of older adults in the Netherlands (men: 134 g per day; women: 114 g per day) [120] was lower than the meat consumption of older adults in Canada (men: 189 g per day; women: 140 g per day) [121]. In contrast, dairy consumption was higher in the Netherlands, with 44.7% using more than one serving of dairy per day, compared to New Zealand (34.6%) and Canada (37.9%). Both meat and alternatives and dairy products are a major source of protein intake in the Netherlands [120], Canada [121] and New Zealand [122]. Protein intake is associated with changes in lean body mass in community-dwelling older adults [61], and increasing the intake of dairy and meat (or alternatives) is therefore an important public health message targeting this age group.

Between-country differences were also seen in fluid intake. The prevalence rate of this risk factor was the highest in Canada (40.1%) and lowest in the Netherlands (25.1%). Although fluid intake not only consists of water intake, differences in fluid use between countries are difficult to explain. Seasonal differences could have played a role, but this is unlikely as the surveys were completed throughout the year in all of the data collections. Fluid intake decreases with age and older adults are therefore at higher risk of dehydration [123]. However, no differences in proportions in different age groups were seen in this analysis. Attention to intake of fluid can prevent dehydration [124], which is more prevalent in older adults [125].

Differences were also seen in problems with biting or chewing. This risk factor was scored more frequently in New Zealand (20.3%) and Canada (18.6%), compared to the Netherlands (14.9%). The large differences in biting and chewing problems between the countries have also been shown in a previous study [126]. Good dental care is essential for preventing biting and chewing problems [127]. However, access to dental care differs between countries and is not always guaranteed for older adults with a low income [128]. Biting and chewing problems can result in the avoidance of certain food groups, especially hard fruits, vegetables and meat [129,130]. Processing and cooking can soften fruits and vegetables if needed. Different cooking technics, such as marinating, slow cooking or the use of cooking bags, could make meat easier to chew [131].

Finally, differences were seen in problems with doing grocery shopping. This risk factor was scored more frequently in New Zealand (28.1%) and Canada (24.1%), compared to the Netherlands (17.4%). Reasons for the difference may be the distance to the nearest shops, many of those living in the Netherlands can walk or take public transport to grocery shops, whereas older people in NZ are reliant on the use of a private car, as public transport is limited, and in Canada, the winter season will affect access to grocery stores for many older adults. Possible difficulties with traveling to the supermarket and the inability to reach items, to push trolleys and carry groceries home, especially by public transport, could hinder older adults in buying some food items [132,133]. Interventions could focus on support from relatives or friends, to assist with grocery shopping or promoting delivery services and online shopping.

One of the strengths of this study is the large sample size. Pooling dataset from three different countries/continents made it possible to do meaningful analyses on overall nutrition risk and risk factors contributing to risk. Another strength is the use of different forms of sampling, and when sensitivity analyses were completed, the differences in prevalence due to sampling methods could be detected. These findings suggest that

the sampling method may be more important than countries when determining the prevalence of nutrition risk.

A major limitation in this study is the lack of background information of the participants, specifically from the online version of SCREEN II. Only gender and age, important confounders [71,112], were available and, thus, further characterization of the sample, as well as control for potential confounding was not possible. Other relevant characteristics to measure in future studies should include educational status, living status and comorbidities. Secondly, selection bias is a potential limitation. The Canadian and Dutch websites (www.nutritionscreen.ca and www.goedgevoedouderworden.nl) were widely available, and participants may have had a special interest in nutrition or may have had a specific concern, that may have resulted in a higher prevalence of nutrition risk. Internet access is high in the Netherlands, Canada and New Zealand (>75% in adults aged 65+) [85,134,135], but especially older adults with a higher social economic status and women are more likely to search for health information [136]. This likely resulted in selection bias. As stated previously, these types of selection bias are likely to be non-differential between countries and mainly affect prevalence rates but not associations. In addition, as a consequence of the use of online questionnaires, participants could have filled in the questionnaires several times, and/or provided incorrect answers, which could not be verified.

Conclusions

In conclusion, nutrition risk is a worldwide common problem among community-dwelling older adults, with the majority of older adults displaying multiple nutrition risk factors and/or increased nutritional risk. When controlling for the source of the data, the prevalence of nutrition risk appeared to be quite similar across Canada, the Netherlands and New Zealand. It is important to realize that the prevalence rates of nutrition risk may depend on the method of data collection. This study revealed significant differences between countries in nutrition risk factors, indicating that interventions should differ for each country and should focus on frequently scored risk factors in a specific region.

CHAPTER 4

What do screening tools measure? lessons learned from SCREEN II and SNAQ^{65+}

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Abstract

Background: Over the last decade, different screening tools for malnutrition have been developed. Within these tools, a distinction can be made between tools that assess nutritional risk and tools that assess protein energy malnutrition. Insights in differences in characteristics of participants at risk and in differences in prevalence rates will aid in deciding which tool(s) to use in daily practice.

Methods: Dutch community-dwelling older adults (n=200, 78.2±6.9 years), not known to have specific nutrition problems, were recruited to participate in this cross-sectional study. SNAQ^{65+} (low risk vs moderate/high risk) was used to assess risk of protein energy malnutrition and SCREEN II was used to assess nutrition risk (score <54 out of 64). Chi-square tests were used to test associations between demographic, health, physical and social factors and outcome of SNAQ^{65+} and SCREEN II.

Results: Of all participants 69.0% were at nutrition risk (SCREEN II), while 13.5% were at risk of protein energy malnutrition (SNAQ^{65+}). Agreement between the two tools was poor (kappa<0.20). Gender, BMI, living status, income, activity level and protein/energy intake were associated with SCREEN II; age, BMI, comorbidities, medication use, help at home, activity level and low basic mobility were associated with SNAQ^{65+}.

Conclusion: SCREEN II and SNAQ^{65+} measure different concepts of malnutrition and therefore identify different persons at risk. SCREEN II is more inclusive and comprises both undernutrition and overnutrition as well as different determinants that can impact on food intake, while SNAQ^{65+} is solely focused on protein-energy malnutrition.

Introduction

As the older adult population in Western Europe grows [137], health care costs to support their health and wellbeing also increase [138,139]. To reduce these increasing costs, government policies are focusing on ways to support older adults to live healthy and independently for as long as possible [140]. Because malnutrition is associated with increased morbidity and institutionalization [27], early identification of community-dwelling older adults with nutrition risk is of major interest, especially in primary care. Screening for risk may be a first step to identify older adults who are prone to become malnourished in the future [45].

Most malnutrition screening tools, often based on recent weight loss, low BMI, presence of disease and/or low appetite) [83], are designed, at least initially, for use in hospitals and aim at identifying persons with already existing malnutrition [68]. Thus, they measure mostly 'the late phase' where signs of merely protein energy malnutrition (e.g. unintentional weight loss and loss of muscle mass) are already present [65]. Fewer tools have been developed for the community setting. SNAQ^{65+} and SCREEN II are two malnutrition screening tools validated for use in community-dwelling older adults [68]. Despite both being called 'malnutrition screening tools', these tools may not be interchangeable. SCREEN II was originally designed as a nutrition risk screening tool and identifies risk factors, including determinants of food intake, that can lead to inadequate food intake and eventual malnutrition in community-dwelling older adults if no interventions are put into place. It also determines weight change (both gain and loss) and the intentionality of this change [70]. In contrast, SNAQ^{65+} identifies common indicators of protein energy malnutrition, and specifically, involuntary weight loss, low upper arm circumference, loss of appetite and inability to walk stairs, which may indicate that a person is already experiencing malnutrition [76].

Power et al, in their systematic review [68] briefly mention the different aims of malnutrition screening tools (a poor nutrition status or protein energy malnutrition), but do not discuss the potential differences in prevalence rates that are expected when using different tools, which is a factor in the decision to use a tool. Comparing prevalence rates using different tools within one population [141] and examining differences in characteristics of those identified at risk would be a first step to understanding which tool, for which purposes, may be most useful in primary care. This study aims to determine: a) risk prevalence rates according to SCREEN II and SNAQ^{65+}, b) the association between risk and participants' demographic, health, physical, functional and social factors, and c) the agreement between risk as measured by SCREEN II and SNAQ^{65+}. Based on these

results, we will consequently discuss how different screening tools can exist, and even complement each other, and how they can be deployed in primary care.

Methods

Participants

A cross-sectional convenience sample of 200 community-dwelling adults aged over 65 years, not known to be at nutrition risk or malnourished, participated. One hundred were recruited from the ConsuMEER study [111], primarily via advertisements in local newspapers, in February and March 2017. To increase external validity and statistical power for a comparison between SNAQ^{65+} and SCREEN II, another 100 participants were additionally recruited by students of the bachelor program 'Nutrition and Dietetics' from their neighbourhood; a sample size and power calculation was not performed as this study reports exploratory, secondary analyses. All participants met the following inclusion criteria: aged 65 years or over; living at home; being able to eat independently; and being able to understand, read and speak Dutch. Excluded were those following a diet limiting protein intake and/or suffering from terminal illness or cognitive impairment. Participants with cognitive impairment (MMSE <24) were only included if a partner could provide answers on all questionnaires.

Measurements

All data collection was completed at the participants' home by trained nutrition and dietetics students. Nutrition risk was measured with SCREEN II. This tool was validated among Canadian older adults (aged >55 years) and translated into Dutch with permission of the author. A translation agency performed the initial translation. A team consisting of health care professionals, welfare professionals and older adults judged the translation for language and cultural aspects and made additional changes when the Dutch translation caused confusion or was unclear. The translated version was pre-tested in a cohort of community-dwelling older adults which led to minor textual changes. SCREEN II consists of 17 items: weight change (loss or gain), intentionality of this change and perception of body weight; appetite; problems with swallowing and chewing; use of meal replacements and difficulties managing diet restrictions; skipping meals; food (fruit and vegetables; dairy; meat and alternatives) and fluid intake; eating alone; and challenges with cooking and grocery shopping [70]. Total scores range from 0 to 64 with a lower score indicating higher nutrition risk. A score < 54 for moderate risk and < 50 for high risk, according to the validation study among Canadian older adults, aged >55 – 99 years [70]. Risk of protein energy malnutrition was measured with *SNAQ^{65+}*. This screening tool is based on four items (involuntary weight loss, low upper

arm circumference, low appetite and inability to walk stairs) and categorizes participants into three groups: 'no risk of malnutrition', 'moderate risk of malnutrition' and 'severe risk of malnutrition'[86]. Participants were categorized as 'severe risk of malnutrition' if they had lost ≥4kg body weight in the last month or had an upper arm circumference of <25 cm; if participants had a poor appetite and were not able to walk stairs without resting, they were categorized as 'moderate risk of malnutrition'.

To provide a description of participants and to identify subgroups at risk, a variety of participant characteristics were also measured. Student assessors were trained on all procedures, but inter-rater reliability was not assessed due to feasibility. As measures were in participants' homes, feasibility drove decisions for measuring techniques. *Height* was measured twice, without shoes with use of a tape measure and an empty wall, with the participant standing against as erectly as possible. When measurements differed by more than 0.3 cm, an additional measurement was performed and the average of the two closest measurements was used. *Weight* was measured twice with the participant's own scale, in clothes and without shoes. If measurements differed over 0.1 kg an additional measurement was performed and the average of two measurements that were closest was used. *BMI* was calculated based on height and weight. Cut-off values were <20 for underweight, 20-27.5 for normal weight and >27.5 for overweight/obesity. The underweight cut-off was based on the recent GLIM consensus criteria [47], and the larger range for normal weight (compared to WHO criteria) was chosen as previous studies suggest that being slightly overweight is protective for mortality [142]. *Handgrip strength* was measured with a Jamar dynamometer by using the Dutch standard operating procedure (sitting on a chair without arm support, arm bent at the elbow in 90° angle); both hands where measured three times and the highest value was used [143]. Cut-off points for low hand grip strength were based on reference values of Dodds et al. [144] with the 10th percentile used to define low hand grip strength. Participants who were not able to perform handgrip measurements because of physical problems were recorded as having low handgrip strength. *Timed "Up & Go"* is a performance test that screens for balance and gait abnormalities and fall risk. If the test took more than 12 seconds, this was categorized as low basic mobility [145]. Participants who were not able to perform Timed "Up & Go" because of physical problems were categorized as having a low basic mobility. To screen for cognitive capacity, *the Mini Mental State Exam (MMSE)* was used; this 19-item tool provides a score ranging from 0-30 with a score below 24 indicating likely cognitive impairment [146]. *LAPAQ (LASA Physical Activity Questionnaire)* was used to measure activity levels of participants: this 18-item questionnaire assesses physical activity over the last two weeks and provides information in minutes per week. Categorization can be made based on low or high intensity activities [147]. Low activity level was categorized as less then 150 minutes of high intensity activity

per week [148]. *Self-reported comorbidities:* Number of comorbidities was based on self-report by using a pre-specified list. Comorbidities included: high blood pressure, lung disease (asthma, COPD, emphysema), stomach-liver-bowel disease, kidney or bladder disease, joint wear (arthritis, rheumatism), osteoporosis, back disorders, diabetes, stroke or cerebral haemorrhage/infarction, heart attack, other severe heart problems (heart failure, angina pectoris), cancer and 'other'. Comorbidities were dichotomized into <2 or ≥2 comorbidities. *Income* of participants was self-reported and based on healthcare allowance. Low income was defined as a yearly income <€28.500 for singles or <€35.000 for couples. Self-reported data was used for gender, age, education (low, middle or high education), living alone or living together and help provided at home. *Food intake* was measured using a 3-day structured food diary. The mean intake of energy (calories) and protein (grams) during these three days was used. Food intake was only measured by participants of the ConsuMEER study (n=96)[111]

Data analysis

Descriptive statistics were used to summarize participants' characteristics and results were stratified based on outcome of SCREEN II and SNAQ^{65+}. Continuous data was checked for normality by using Q-Q and boxplots. Data was reported as mean (SD) or median (Q1-Q3) for continuous data and number (%) for categorical data.

Agreement between SCREEN II (<50 and <54 points) and SNAQ^{65+} was tested by a Cohen's kappa. For this purpose, SNAQ^{65+} was dichotomized into low/moderate vs high malnutrition risk as well as low vs moderate/high malnutrition risk. Strength of agreement was judged by the following cut-off values K <0 = poor; 0-0.20 = slight, 0.21-0.40 = fair; 0.41-0.60 = moderate, 0.61-0.8= substantial and >0.80= almost perfect [149].

Differences in characteristics between participants at risk based on SCREEN II (<54 points) and SNAQ^{65+} (moderate and high risk combined) were tested by a chi-square test for categorical variables (or Fischer's exact test if expected count was <5) and unpaired t-test (or Mann Whitney U test if skewed distributed) for continuous variables. All analyses were performed using SPSS 24 (IBM, Chicago, Il) and a p-value <0.05 was considered significant.

Results

Prevalence of participants at risk based on SCREEN II and SNAQ^{65+} was 68.5% and 13.5% respectively. Of those who were at risk based on SNAQ^{65+}, 81.5% (n=22) was also at risk based on SCREEN II. Contrarily, of those identified at risk based on SCREEN II, 16.1%

(n=22) were also at risk based on SNAQ^{65+} (Table 2). SCREEN II identified females to be more frequent at risk, while differences in prevalence between genders were small in SNAQ^{65+}. Participants higher in age were more frequent at risk based on SNAQ^{65+}, but not on SCREEN II. Weight of participants at risk based on SCREEN II was significantly higher and they were more likely to be overweight compared to participants not at risk. In contrast, participants at risk based on SNAQ^{65+} had lower weights and were less likely to be overweight compared to participants not at risk. Nearly everyone (n=71, 88.8%) who lived alone was at risk based on SCREEN II, but living alone was not associated with being at risk based on SNAQ^{65+}. Participants with a low income were more frequent at risk based on both tools.

For both tools, participants at risk were less vital compared to participants not at risk. Although no direct comparisons can be made, participants at risk based on SNAQ^{65+}seemed to be even less vital compared to participants at risk based on SCREEN II: being at risk based on SNAQ^{65+} was associated with multimorbidity (88.9%), polypharmacy (55.6%), being inactive (88.9%), help at home (81.5%), having a low handgrip (median handgrip strength 20.9 KgF (16.0 – 26.6), 14.8% below p10 of Dodds et al. [144]) and a low mobility level (median timed "Up & Go": 12.1 (9.0 – 19.7)). The percentage triggering low handgrip strength and timed 'Up and Go' was relatively similar between the tools, but median HGS and TUG was lower for participants at risk on SNAQ^{65+}. On SCREEN II, participants at risk were less vital compared to the ones not at risk but only 'activity level' and timed "Up & Go" differed significantly.

In the subgroup of participants with dietary food records (n=96), protein intake overall was adequate with a mean of ≥1 gram protein per kilogram bodyweight per day (g/kg bw/day). In the at-risk groups (both SCREEN II and SNAQ^{65+}) a higher percentage of participants did not reach the limit of 1 g/kg bw/day (SCREEN II 50.7%; SNAQ^{65+} 55.0%). Importantly, protein intake was highest in the group that was *not* at risk based on SCREEN II. In this group, 63.0% consumed >1 g/kg bw/day. Being at risk was associated with a lower energy intake for both screening tools and again participants *not* at risk according to SCREEN II displayed the highest energy intakes (table 1).

There was no agreement between tools (kappa <0.20 and/or p>0.05) for both cut-off values of SCREEN II (<50 and <54) and categorization of SNAQ^{65+} (low vs moderate/high and low/moderate vs high) indicating that tools are identifying different individuals (Figure 1).

Table 1, factors associated with SCREEN II and SNAQ^{65+}

	SCREEN II		P-value^	SNAQ^{65+}		P-value^
	Not at risk (Screen II ≥54)	At risk (Screen II <54)		Not at risk	At risk (moderate and high risk combined)	
	32.0% (N=62)	69.0% (N=138)		86.5% (N=173)	13.5% (N=27)	
Gender						
Male	53.2% (33)	27.5% (38)	**<0.001**	37.0% (64)	25.9% (7)	0.264
Female	46.8% (29)	72.5% (100)		63.0% (109)	74.1% (19)	
Age (years)	78.3 (SD: 6.8)	78.1 (SD: 6.9)	0.858	77.6 (SD: 6.8)	82.9 (SD: 6.2)	**0.001**
65-74	40.3% (25)	35.5% (49)	0.723	41.0% (71)	11.1% (3)	
75-84	45.2% (28)	47.1% (65)		44.5% (77)	59.3% (16)	**0.007**
≥85	14.5% (9)	17.4% (24)		14.5% (25)	29.6% (8)	
BMI (kg/m^2)	26.1 (SD: 3.7)	28.7 (SD: 4.9)	**<0.001**	28.1 (SD:4.6)	27.0 (SD:5.8)	0.269
<20 kg/m^2	1.6% (1)	0	**<0.001**	0	3.7% (1)	**0.018**
20-27.5 kg/m^2	74.2% (46)	44.2% (61)		52.0% (90)	63.0% (17)	
>27.5 kg/m^2	24.2% (15)	55.8% (77)		48.0% (83)	33.3% (9)	
Living status						
Living together	85.5% (53)	48.6% (67)	**<0.001**	60.1% (104)	59.3% (16)	0.933
Living alone	14.5% (9)	51.4% (71)		39.9% (69)	40.7% (11)	
Income§						
Low	30.6% (19)	50.0% (69)	**0.011**	42.2% (73)	55.7% (15)	0.193
High	69.4% (43)	50.0% (69)		57.8% (100)	44.4% (12)	
Education						
Low	41.9% (26)	36.2% (50)	0.155	36.4% (63)	48.2% (13)	0.345
Middle	25.8% (16)	40.6% (56)		37.0% (64)	29.6% (8)	
High	27.4% (17)	21.0% (29)		24.3% (42)	14.8% (4)	
missing	4.4% (3)	2.9% (4)		1.7% (4)	7.4% (2)	
Comorbidities						
<2	41.9% (26)	31.9% (44)	0.168	38.7% (67)	11.1% (3)	**0.005**
≥2	58.1% (36)	68.1% (94)		61.3% (106)	88.9% (24)	

Table 1, factors associated with SCREEN II and SNAQ^{65+} (*continued*)

	SCREEN II		P-value^	SNAQ^{65+}		P-value^
	Not at risk (Screen II ≥54)	At risk (Screen II <54)		Not at risk	At risk (moderate and high risk combined)	
	32.0% (N=62)	69.0% (N=138)		86.5% (N=173)	13.5% (N=27)	
Use of medication						
<5	66.1% (41)	64.5% (89)	0.822	68.2% (118)	44.4% (12)	**0.016**
≥5	33.9% (21)	35.5% (49)		31.8% (55)	55.6% (15)	
Help at home|						
No help	58.1% (36)	43.5% (60)	0.056	52.6% (91)	18.5% (5)	**0.001**
Home care or domestic help	41.9% (26)	56.5% (78)		47.4% (82)	81.5% (22)	
MMSE (points)	29 (28 – 30)	29 (27 – 30)	0.499	29 (27 – 30)	28 (27 – 30)	0.258
<24 points	6.3% (4)	5.8% (8)		4.7% (8)	7.4% (2)	
Lapaq (minutes activity / day),		75.0 (45.2 – 113.6)	0.529	75.0 (45.0 –120.0)	76.4 (45.2 – 126.4)	0.857
Low intensity	77.5 (42.8– 134.4)	20.0 (3.9 – 46.0)	**0.001**	30.0 (11.5 - 55.2)	3.6 (0.0 – 12.0)	**<0.001**
High intensity	38.0 (19.8 – 63.4)					
		54.3% (75)	**0.002**	40.5% (70)	88.9% (24)	**<0.001**
Low activity*	30.6% (19)	3.6% (5)		2.9% (5)	7.7% (2)	
Missing	3.2% (2)					
TUG (seconds)	9.8 (8.6 – 12.4)	10.5 (8.5 – 14.1)	0.203	9.9 (8.3 – 13.3)	12.1 (9.0 – 19.7)	**0.026**
<12 sec	69.4% (43)	54.3% (75)	**0.046**	61.8% (107)	40.7% (11)	**0.038**
≥12 sec†	30.6% (19)	45.7% (63)		38.2% (66)	59.3% (16)	
Handgrip (KgF)	28.8 (23.8 – 35.0)	25.8 (19.0 – 31.0)	**0.005**	27.1 (21.5 – 34.0)	20.9 (16.0 – 26.6)	**<0.001**
<p10‡	9.7% (6)	13.0% (18)	0.498	11.6% (20)	14.8% (4)	0.628
≥p10	90.3% (56)	87.0% (120)		88.4% (153)	85.2% (23)	

Table 1, factors associated with SCREEN II and SNAQ^{65+} (*continued*)

	SCREEN II		P-value^	SNAQ^{65+}		P-value^
	Not at risk (Screen II ≥54)	At risk (Screen II <54)		Not at risk	At risk (moderate and high risk combined)	
	32.0% (N=62)	69.0% (N=138)		86.5% (N=173)	13.5% (N=27)	
Protein (G/kg bw/day)	N=27	N=69		N=76	N=20	
	1.17 (SD:0.42)	1.02 (SD:0.37)	**0.080**	1.07 (SD:0.36)	1.03 (SD:0.49)	0.741
<1.0 (G/kg bw/day)						
≥1.0 (G/kg bw/day)	37.0% (10)	50.7% (35)	0.227	44.7% (34)	55.0% (11)	0.413
	63.0% (17)	49.3% (34)		55.3% (42)	45.0% (9)	
Kcal						
	2083	1913	**0.021**	1971	1858	0.119
Missing	(1884 – 2339)	(1619 – 2113)		(1714 – 2167)	(1371 – 2125)	
	N=35	N=69		N=97	N=7	

Abbreviations: BMI (Body mass index), MMSE (Mini-mental state examination), LAPAQ (LASA Physical Activity Questionnaire), TUG (Timed "Up & Go").

**) Below 150 minutes of high intensity activities per week*

†) >12 seconds or not performed because of low mobility

‡) Below p10 of Dodds et al.[144] *or not performed because of medical conditions*

§) low income was defined as year income < €28,500 for singles or < €35,000 for couples

|) Combinations of help at home possible

^) p-value based on chi-square / Fischer's exact test for categorical data, unpaired t-test for continues data and Mann-Whitney U test for non-normal distributed data.

	SNAQ^{65+}		Kappa & p-value
	Low risk	Moderate & high risk	
SCREEN ≥54	57 (28.5%)	5 (2.5%)	
SCREEN <54	116 (58.0%)	22 (11.0%)	K=0.053 P=0.132

	SNAQ^{65+}		Kappa & p-value
	Low & Moderate risk	high risk	
SCREEN ≥54	58 (29.0%)	4 (2.0%)	
SCREEN <54	126 (62.0%)	12 (6.0%)	K=0.015 P= 0.588

	SNAQ^{65+}		Kappa & p-value
	Low risk	Moderate & high risk	
SCREEN ≥50	101 (50.5%)	9 (4.5%)	
SCREEN <50	72 (36.0%)	18 (9.0%)	K=0.126 P=0.015

	SNAQ^{65+}		Kappa & p-value
	Low & Moderate risk	high risk	
SCREEN ≥50	104 (29.0%)	6 (2.0%)	
SCREEN <50	80 (62.0%)	10 (6.0%)	K=0.061 P= 0.142

Figure 1, Agreement between SNAQ^{65+} and SCREEN II

DISCUSSION

This study showed that nutritional risk in community-dwelling older adults was high (69.0%, based on SCREEN II), while protein energy malnutrition was low (13.5%, based on SNAQ^{65+}). Herewith, this study confirms that both screening tools differ in their focus and identify different groups of participants at risk. SCREEN II was more associated with food intake, social aspects and also overweight, while SNAQ^{65+} covered more of the physical and disease related aspects of malnutrition.

Most protein energy malnutrition screening tools pay little attention to predictive factors of becoming malnourished; they are 'downstream' identifying malnutrition and not nutrition risk, which is conceptually 'upstream'. As noted previously, most of these tools were initially designed for hospital populations and are based on a comparable set of items, i.e. low BMI, recent weight loss, presence of disease and/or low appetite. These items indicate loss of critical amounts of body weight and muscle mass which are late symptoms of malnutrition. Early determinants of malnutrition like inadequate dietary intake are poorly addressed in most screening tools. As a result, these screening tools partly miss their aim, detection of malnutrition at an early stage to be able to start interventions to prevent further decline. In a community primary care setting, this is an important aim.

The findings of our study confirm that a nutrition risk tool and a malnutrition risk tool identify different populations. Participants who scored at risk on SNAQ^{65+} were older, fewer had overweight, more frequently needed help at home, they more often had co-morbidities and functional problems and more often reported polypharmacy. SNAQ^{65+} results are consistent with populations expected to be identified by GLIM diagnostic criteria for malnutrition [47], which are based on weight loss, low BMI, low muscle mass,

poor intake and inflammation. Participants who scored at risk on SCREEN II were more often female and often lived alone. Low activity was also reported, but not as high a proportion as on SNAQ^{65+} group. Being at risk according to SCREEN II was often associated with a higher BMI. Importantly, *not* being at risk according to SCREEN II was associated with higher intake of both energy and protein. SCREEN II identifies nutritional problems before depletion of body reserves becomes present and herewith offers windows of opportunities for early preventive measures. Moreover, a positive screening result on SCREEN II should be followed up by an assessment into undernutrition ánd overnutrition.

Good nutrition, and especially a high protein intake is associated with a reduced risk of malnutrition. The prevalence rates of malnutrition described in this study are in line with earlier studies in the Netherlands [76,88] and with a recent meta-analysis where 8.5% of community-dwelling older adults in Europe was at risk of malnutrition [67]. This is much lower compared to our and other studies based on SCREEN II, with prevalence rates of nutritional risk between ranging from 34 to 67% [72,88,89,97]. As the majority of older adults displays one or more nutrition risk factors, this explains the high prevalence rates of nutrition risk when using SCREEN II.

The differences between the two tools clearly illustrate that they measure different concepts. Based on the items included in the tool, SCREEN II pays attention to poor nutritional habits and living circumstances which may ultimately lead to malnutrition / undernutrition. After positive screening with SCREEN II results, older adults should be further assessed to determine if they are potentially over- or undernourished. In contrast, SNAQ^{65+} (and many other malnutrition screening tools) focuses on loss body weight, function and muscle mass, and thus protein energy malnutrition. A positive SNAQ^{65+} result should also result in assessment, to determine the cause and severity of protein-energy malnutrition.

The GLIM group advises use of a validated screening tool as a first step towards a diagnosis of malnutrition; only patients identified at malnutrition risk should be further diagnosed for malnutrition [47]. The group does not give specific suggestions for tools to use. Our study implies that the initial step in GLIM may be highly influential for the second step. The GLIM criteria will be further refined within the next few years and, with the focus of GLIM being on protein energy malnutrition, we advise the GLIM group to suggest a set of malnutrition screening tools that fits within this focus. A distinction between malnutrition tools could therefore be useful. We suggest to divide screening tools in three groups: protein energy malnutrition, nutrition status and appetite tools. Based on the items of the 22 validated tools for older adults [68], the following tools

seems to focus on protein energy malnutrition: MST, MUST, MNA-SF/FF, African NST, SNAQ^{65+}, Ayrshire NST, Rapid Screen, CNS, GNRI, NRAT, MRST, CNST, MEONF-II and SNS-T. Four tools should rather be considered nutrition status screening tools, which primarily focus on identifying nutrition risk (factors): ENS, DETERMINE, NUFFE and SCREEN (II). Finally, CNAQ and SNAQ-US merely focus on impaired appetite. We recommend further research and discussion towards this classification as our suggestion is now only based on items of the tools.

In daily practice, SCREEN II and SNAQ^{65+} may be used as complementary tools to reveal different aspects of nutritional status. We advise to carefully consider what the purpose of screening is, and to select the optimal screening tool accordingly. For example, in primary care offices, tools like SCREEN II that focus on early determinants of malnutrition may be most useful for preventing malnutrition. Feasibility of the tool is also an important consideration. SCREEN II can be completed by the senior themselves, while SNAQ^{65+} requires a trained assessor to complete anthropometric measures.

Some considerations should be made regarding our data. Firstly, our dataset was relatively small and underpowered for more complex analyses. Secondly, the lack of a criterion for malnutrition hampers the comparison of tools. A validation against the recent GLIM-criteria could give valuable insights in the validity of both tools, although one must realize that GLIM is a set of diagnostic criteria, rather than a gold standard (criterion). Unfortunately, we lacked all details to perform a validation study to GLIM, but, based on previous arguments, we strongly suspect that the correlation between SNAQ^{65+} and GLIM will be higher than that between SCREEN II and GLIM. Finally, no statistical tests are available to compare associations of SNAQ^{65+} with SCREEN II in order to see if associations differ significantly between both tools. Despite these limitations, this study is the first one to compare different screening tools in the community setting. Our study highlights the importance of making a clear difference between screening tools for nutrition risk and for 'late phase' malnutrition. Depending on the goal of screening, one could use either one of the tools, or even use both of them as both seem to give valuable and complementary information.

In conclusion: SCREEN II and SNAQ^{65+} measure different concepts on a continuum between nutrition risk and malnutrition risk; SCREEN II is more inclusive and includes both items for both undernutrition and overnutrition risk as well as different determinants that can impact on food intake, while SNAQ^{65+} is solely focused on protein-energy malnutrition/undernutrition. A screening tool should be selected according to the goal of its use and tools may even be used complementary to identify possible risk factors that can be intervened on, as well as to determine the extent of depletion of body reserves.

CHAPTER 5

5

The ConsuMEER study: A randomized trial towards the effectiveness of protein-rich ready-made meals and protein-rich dairy products in increasing protein intake of community-dwelling older adults after switching from self-prepared meals towards ready-made meals.

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Abstract: Undernutrition risk of older community-dwelling adults increases when they are no longer able to shop or cook themselves. Home-delivered products could then possibly prevent them from becoming undernourished. This single-blind randomized trial tested the effectiveness of home-delivered protein-rich ready-made meals and dairy products in reaching the recommended intake of 1.2 grams of protein per kg bodyweight/day (g-P/kg-bw/day) and ≥25 grams of protein per meal. Community-dwelling older adults (n=98, mean age: 80.4 SD:6.8) switched from self-prepared to home-delivered hot meals and dairy products for 28 days. The intervention group received ready-made meals and dairy products high in protein; the control group received products lower in protein. Dietary intake was measured at baseline, after two weeks (T1), and four weeks (T2). Multilevel analyses (providing one combined outcome for T1 and T2) and logistic regressions were performed. Average baseline protein intake was 1.09 g-P/kg-bw/day (SE:0.05) in the intervention group and 0.99 (SE:0.05) in the control group. During the trial, protein intake of the intervention group was 1.12 (SE:0.05) g-P/kg-bw/day compared to 0.87 (SE:0.03) in the control group (between group differences $p<0.05$). More participants of the intervention group reached the threshold of ≥25 grams protein at dinner compared to the control group (Intervention T1:84.8%, T2:88.4% vs. control T1:42.9%, T2:40.5%, $p<0.05$), but not at breakfast and lunch. Our findings suggest that switching from self-prepared meals to ready-made meals carries the risk of a decreasing protein intake, unless extra attention is given to protein-rich choices.

Background

The risk of undernutrition among community-dwelling older adults in developed countries is shown to be as high as 24%, with an even higher risk and prevalence among frail older adults [150]. Protein-energy wasting is the main cause of undernutrition among older adults [151–153] and is induced by a reduced energy and protein intake [153].

The average protein intake of community-dwelling healthy older adults in the Netherlands is 0.9 g protein per kg bodyweight per day (g P/kg bw/day) [154]. Although this is above the recommended daily intake of 0.8 g P/kg bw/day, approximately 20% of all older adults do not reach this level [64]. Moreover, international groups of experts argue that the current recommendations do not fulfil the needs of older adults; an intake of 1.0-1.2 g P/kg bw/day is recommended for healthy older adults and in case of illness 1.2-1.5 g P/kg bw/day or even higher is advised [61,155]. Furthermore, not only the total intake per day, but also the distribution of protein intake is said to be important: an intake of at least 25-30 grams of protein per meal is thought to be optimal in stimulating muscle protein synthesis [61,156].

There are different reasons why community-dwelling older adults do not meet the recommended protein intake. Well known factors affecting nutritional intake are physical, psychological, social and/or medical problems [109,157]. Impaired mobility, for example, affects older adults' possibilities to do groceries and prepare meals [133]. This could lead to a situation where community-dwelling older adults will have to rely on home-delivered ready-made meals [74].

The impact of switching from self-made meals to ready-made meals in terms of protein intake is unclear. Most previous research on the topic of ready-made meals and protein intake is cross-sectional and therefore does not provide evidence about causality of switching from self-made meals to ready-made meals [158]. Intervention studies on this topic are scarce and not generalizable as most studies were performed in the US, involving economically disadvantaged populations, where ready-made meals were provided as a part of a welfare program [159].

Sharkey and colleagues found that a large group of older adults who are regular customers of meal-delivery services suffer from multiple health limitations [160]. Herewith, a recommended intake of over 1.2 g P/kg bw/day would be optimal for this vulnerable population [61]. Previous Dutch intervention studies in older-adults provided evidence that ready-made meals and desserts, enriched with extra protein, could increase protein intake towards 1.2 g P/kg bw/day [161,162]. However, these studies cannot be general-

ized to a community setting as one study was performed in a rehabilitation setting [162] and the enriched products of both studies are mostly not commercially available.

While a low intake or a low protein content of ready-made meals could be a risk for a (too) low protein intake, meals high in protein could contribute to optimizing the protein intake especially when combined with a dessert rich in protein [64]. Therefore, the aim of this study is to test the effectiveness of commercially available protein-rich ready-made meals and protein-rich dairy products compared to standard ready-made meals and dairy products lower in protein in reaching the protein goal of 1.2 g P/kg bw/day for older adults.

Methods

Study design and participants

This study was performed as a single blind, randomized trial with a parallel design. The aim of the study was to test the effectiveness of home-delivered protein-rich ready-made meals and dairy products in reaching the protein goals for older adults, compared to standard ready-made meals and dairy products lower in protein.

Participants were recruited via the database of a meal delivery service (www.maaltijd-service.nl) and via advertisements in local newspapers in February and March 2017. All participants had to meet the following inclusion criteria: aged 65 years or over; living at home; being able to eat independently; having a microwave to heat meals; being able to understand, read and speak Dutch. Exclusion criteria were: following a diet with protein restriction or a vegetarian diet; allergies or intolerances prohibiting the use of dairy products; only using texture modified foods or a liquid diet; diagnosed with renal insufficiency; suffering from a terminal illness, Mini Mental State Examination (MMSE) score < 24 (exception: within couples, one participant with a score below 24 was allowed if the partner scored at least 24 points and helped with the food diary).

Randomization and blinding

A randomization scheme was generated by using the website www.randomization.com. Stratified randomization was performed by group (male, female or couple) and in permuted blocks of 8 for male and female and 4 for couples. Participants were allocated by a 1:1 ratio to the intervention or control group. A researcher who was not aware of the allocation sequence performed the inclusion of participants.

Participants and investigators were not informed about the allocation of participants. However, the commercially available products were provided in their normal packages with mandatory nutrition labelling information. Therefore, based on the used products, researchers could identify the allocation of participants. In order to optimize blinding, participants were neither informed that protein was the main nutrient of interest, nor were they informed which products the other group received. The researcher who performed the analyses was not blinded to the group allocation of participants, but the database was re-blinded before running the analyses.

Treatment

Participants in the intervention group could choose from 32 home-delivered ready-made protein-rich hot meals and protein-rich dairy products (table 1**)**. The protein-rich meals contained at least 20 energy percent of protein and on average 30.5 (SD: 5.8) grams of protein. Participants in the control group could choose between 30 home-delivered standard (not classifying as protein-rich) ready-made hot meals and drinks (low-protein desserts or fruit juices, table 1). The protein content of these standard meals was on average 21.3 (SD: 4.2) grams per meal. During 4 weeks (28 consecutive days), participants received ad libitum drinks and dairy products (free choice). As a typical Dutch meal pattern is based on two bread meals and one hot meal, participants received 1 hot meal a day. All products provided were free of charge (total value of approximately 250 euro for the whole intervention period), chosen by participants themselves and delivered at home once a week. There was no possibility to order extra products between regular deliveries if participants ran out of products. Participants were asked to use one ready-made meal a day but the use of the other products was at their own choice. Besides

Table 1, *Provided (dairy) products and ready-made meals during the ConsuMEER study.*

	Intervention group			**Control group**	
Products	Portion size	Grams protein per portion		Portion size	Grams protein per portion
(Semi-skimmed) milk	150 ml	5.4	Juice (3 flavours)	200 ml	0,6
Buttermilk	150 ml	5.4	Custard. (3 flavours)	150 ml	4.2
Drinking yoghurt					
Greek style (3 flavours)	150 ml	6.3	Butter	5 g	0.1
Protein-rich (2 flavours)	150 ml	7.8			
(Semi) skimmed yoghurt	150 ml	7.1			
Greek yoghurt (3	150 ml	11.6			
flavours)	30 g	5.1			
Cheese spreads	30 g	7.6			
Cheese (48+)	150 ml	6.0			
Oatmeal porridge					
Ready-made meals Protein-rich meals	500-550 g	30.5* (SD: 5.8)	standard meals	500-550 g	21.3* (SD: 4.5)

*) average protein content

the products provided in the trial, they were free to use any additional products they wanted. All products were commercially available and were provided by Sligro Food Group (Veghel, the Netherlands) and Friesland-Campina (Amersfoort, the Netherlands).

Measurements

Eleven trained students of the BSc programs "Nutrition and Dietetics", "Food innovation" and "Food technology" performed all measurements. Measurements were performed at three time points: baseline, T1 (two weeks after start of the intervention) and T2 (four weeks after start of the intervention). Students visited the participants at their homes in duos. During the trial, each participant was measured by the same set of students.

Baseline measurements were performed to obtain a participants' general health status. These measurements were only conducted at the start of the trial and included:

MMSE: A validated questionnaire containing 19 items to assess cognitive performance [163]. A score below 24 (maximum score 30 points) indicates cognitive impairment [146].

SCREEN II*:* A validated questionnaire based on 17 items to identify the risk for impaired nutritional status in community-living older adults. This questionnaire focuses on food habits that are associated with an impaired nutritional status. A score below 50 points (maximum score 64 points) indicates a high risk for impaired nutritional status [70].

SNAQ^{65+}A validated tool containing 4 items (involuntary weight loss, upper arm circumference, appetite and ability to walk stairs) to assess the risk of undernutrition in community-dwelling older adults. Persons are categorized into three groups: No risk of undernutrition, moderate risk of undernutrition and severe risk of undernutrition [86].

LAPAQ: A validated tool containing 18 items to assess physical activity of older people in the last two weeks. LAPAQ provides information about physical activity in minutes per week. Activities can be categorized in low intensity (walking and low-intensity house-holding activities) and high intensity (bicycling, sports and high intensity house-holding activities) [147]. Low activity was categorized as <150 minutes of high intensity activities per week [148].

Timed "Up & Go": A validated tool to identify gait speed and mobility level in older people [164]. A time below 12 seconds is recognized as normal [145]. Participants that were not able to perform timed "Up & Go" because of low mobility were categorized as >12 seconds.

Handgrip strength: Handgrip was measured by a Jamar dynamometer and expressed in kg. The Jamar dynamometer is proven to be an accurate measurement tool for handgrip strength [165]. Sex-specific reference values of Dodds et al. [144] were used for cut-off points; maximum handgrip strength (of both hands) below the 10th percentile (p10) was considered as low handgrip strength. Unperformed measurements because of medical conditions were categorized as low handgrip strength.

Weight: Participants' bodyweight was measured twice at baseline, in clothes and without shoes, by using the scale of the participants. If the two measurements differed >0.1 kg, a third measurement was performed. The average of two measurements that were nearest was used.

Height: Participants height was measured twice at baseline, without shoes. If measurements differed >0.3 cm, a third measurement was performed. The average of two measurements that were nearest was used.

Comorbidities: Number of comorbidities was assessed by using a pre-specified list and was based on self-report. Comorbidities were categorized as: high blood pressure, lung disease (asthma, COPD, emphysema), stomach-liver-bowel disease, kidney or bladder disease, joint wear (arthrosis, rheumatism), osteoporosis, back disorders, diabetes, stroke or cerebral haemorrhage/infarction, heart attack, other severe heart problems (heart failure, angina pectoris), cancer and 'other'.

Dietary assessment

Participants were requested to fill-out 3-day structured food diaries (gold standard for measuring food intake) [166] at three time points: baseline, T1 and T2. Food diaries were delivered before the start of the study and participants were instructed how to fill out the diaries. Additional information on filling out the diaries, including examples (e.g. weighing foods, describing fat content of dairy) were provided in the first pages of the diaries. Diaries were pre-structured by three meal moments and three in-between moments. Food diaries were filled out by the participants themselves, three days before each measurement. Trained students of 'Nutrition and dietetics' checked the food diaries for completeness in collaboration with the participants during the home visits. Brands and types of products and quantity (grams, volumes, sizes of cups/glasses etc.) were asked if not registered by the participants.

The food diaries were digitized in Evry (Evry, Alphen aan de Rijn, the Netherlands). This program is frequently used by dietitians in the Netherlands, to calculate food intake. Calculations within Evry are based on the Dutch food composition table 2013 [167].

Macronutrient (g) and total energy intake (kcal) of participants were calculated and reported as daily averages as well as protein intake per meal moment (3 main meals and 3 in-between meals).

Liking meals and compliance

A 5-point scale was used to asses liking of meals, ranging from 1 (dislike a lot) to 5 (like a lot). Compliance of eating ready-made meals was based on recorded intake in the three-day food diary.

Ethics

The study was conducted according to the principles of the Declaration of Helsinki. The ethics committee of Radboud University Nijmegen Medical Centre evaluated the study and it was judged not to fall within the remit of the Medical Research Involving Human Subjects Act (WMO). All patients provided written informed consent before the start of trial. Participants were allowed to retract from the study at any time point. If possible, reasons for retraction were asked.

Data analysis

Sample size calculation

Primary outcome of this study was: achieving a total protein intake of at least 1.2 g P/kg bw/day. Secondary outcomes were: daily protein intake (g), protein intake at breakfast, lunch and dinner (g) and achieving an intake of ≥25 g protein at every meal moment.

A sample size calculation was performed based on results of a previous study [154], in which the average protein intake in community-dwelling older adults was shown to be 0.9 (SD:0.3) g /kg bodyweight. As an intake of 1.2 g P/kg bw/day (SD:0.3) is thought to be optimal [61,155,168], an increase of 0.3 g P/kg bw/day would be relevant. Based on a power of 90% and an alpha of 5%, a sample size of 21 participants was needed per group to detect this increase in protein intake. However, to compensate for loss to follow-up and to allow for analyses other than the primary outcome, a sample size of 50 participants per group was chosen.

Intention-to-treat analysis based on available cases was used for all data, meaning that all participants were analysed according to their group allocation. When participants withdrew from the study, unperformed measurements were recorded as missing data.

Confounding

Despite randomization, potential confounders could possibly not be equally distributed over both groups. However, if confounders influence the protein intake of the participants, this effect is likely to be already present at the baseline measurement. Therefore, adjusting for protein intake at baseline measurement will correct for potential confounding. Furthermore, adjusting for protein intake at baseline will correct for regression to the mean. Therefore, *'protein intake at baseline'* was added as a covariate in all analyses.

Analyses

Outcomes of continuous data were checked for normality using QQ-plots and box plots. Baseline characteristics were reported as mean (sd) or median (Q1-Q3) for continuous data and frequency (%) for categorical data. Linear mixed models was used to test for differences in continuous outcomes (protein intake in grams and g P/kg bw/day) between the intervention and control group. A three-level structure was used to correct for clustering within the two measurements (T1 and T2) and within participants because of the clustered data of the 3-day food diary. Therefore, a random intercept was created at measurement and participant level. Allocated group and *'protein intake at baseline'* were used as fixed-effects term. Protein intake at baseline was added to the model at T1 and T2 as fixed-effects term because of differences in protein intake at baseline between intervention and control group.

Within-group differences during the trial for protein intake in grams and g P/kg bw/day were tested by a multilevel analysis. Analyses were performed separately for intervention and control group with a random intercept at participants' level and "time point" as fixed-effects term.

Logistic regression was used to test for differences in the dichotomous outcomes of reaching the threshold of 1.2 g P/kg bw/day and ≥25 grams per meal moment. For each time point the average daily protein intake of each participant was calculated by aggregating the data of the 3-day food diaries and divided by the participant's bodyweight. Thereafter, this variable was dichotomized in < / ≥ 1.2 g P/kg bw/day. The same procedure was performed for the ≥25 grams protein per meal moment; for each time point the average protein intake per meal moment was calculated and thereafter this variable was dichotomized into < / ≥ 25 g protein per meal.

The average meal acceptance during the trial was calculated per week and reported for the intervention and control group separately. Differences between intervention and control group were tested with an unpaired t-test.

All statistical analyses were performed using Statistical Product and Service Solutions (SPSS) software 24 (IBM, Chicago, Il) and a p-value <0.05 was considered significant.

Results

One hundred participants were recruited to participate in the trial (figure 1). Two participants already used ready-made meals before the trial, both allocated to the control group. After the baseline measurement two participants were found to have a low MMSE score and were therefore excluded. Of the remaining 98 participants, 49 were allocated to the intervention group and 49 to the control group. During the trial, 12 participants (4 in the intervention and 8 in the control group) were lost to follow up due to various reasons (reasons are shown in figure 1).

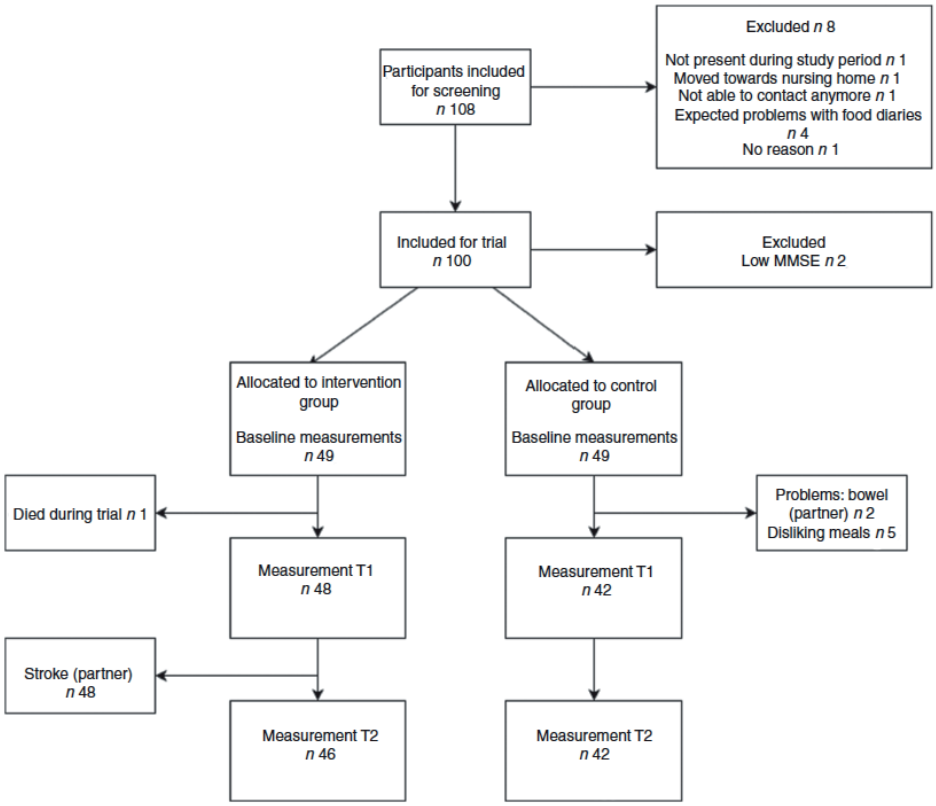

Figure 1, *Flowchart of enrolment and dropout of participants during the ConsuMEER study.*

Baseline data

Participants characteristics are shown in table 2; 60 (61%) were female, mean age was 80.4 (SD:6.8) years and mean BMI was 27.9 (SD:5.0) kg/m2. Seven participants were categorized with a low MMSE score (<24 points), but were included as their partners had a MMSE ≥24. Based on SCREEN II, 45 participants had a risk of an impaired nutritional status (<50 points). In addition, 20 participants were at moderate or severe risk of undernutrition according to SNAQ 65+, but none of them used oral nutritional supplements. As can be read from table 2, more than 50% of participants had a low activity level (by LAPAQ), almost 50% had a prolonged Timed up & go > 12 seconds, and more than 15% had a low grip strength. Most participants had one or more comorbidities (91.8%), had received middle (40.8%) or high (30.6%) education, had a higher income (54.1%) and received home care or domestic help (66.3%).

Table 2, *Baseline characteristics of participants included in the ConsuMEER study.*

	Control (n=49)	Intervention (n=49)	Total (n=98)
Gender			
Male	20 (40.8%)	18 (36.7%)	38 (38.8%)
Female	29 (59.2%)	31 (63.3%)	60 (61.2%)
Age (years)	80.6 (SD:6.7)	80.2 (SD:7.0)	80.4 (SD:6.8)
BMI (kg/m2)	27.9 (SD:4.5)	27.9 (SD:5.4)	27.9 (SD:5.0)
Marital status			
Single	24 (49.0%)	24 (49.0%)	48 (49.0%)
Couple	25 (51.0%)	25 (51.0%)	50 (51.0%)
MMSE (points)	29 (27 – 30)	28 (26 – 30)	29 (26 -30)
<24	1 (2.0%)	6 (12.2%)	7 (7.1%)
Screen II (points)	50.1 (SD:6.4)	49.0 (SD:7.0)	49.6 (SD:6.7)
<50	23 (46.9%)	22 (44.9%)	45 (45.9%)
SNAQ 65+			
No risk of undernutrition	39 (79.6%)	39 (79.6%)	78 (79.6%)
Moderate risk undernutrition	7 (14.3%)	3 (6.1%)	10 (10.2%)
Severe risk undernutrition	3 (5.9%)	7 (14.3%)	10 (10.2%)
Lapaq (minutes activity / day)			
Low intensity	65.0 (45.0 – 120.0)	76.1 (38.9 – 120.0)	75.0 (40.0 – 120.0)
High intensity	15.0 (2.1– 33.9)	21.4 (4.3 – 42.9)	16.8 (2.1 – 42.9)
Low activity*	33 (67.3%)	26 (53.1%)	59 (60.2%)
Timed "up and go" (seconds)	10.3 (8.9 – 13.6)	10.1 (8.5 – 13.9)	10.3 (8.7 – 13.7)
>12 seconds†	22 (44.9%)	17 (34.7%)	39 (39.8%)
Not performed	5 (10.2%)	3 (6.1%)	8 (8.2%)
Handgrip strength (kg)	24.0 (20.8 – 31.5)	28.5 (20.0 – 34.9)	26.5 (20.1 – 32.1)
Low handgrip‡	8 (16.3%)	7(14.3%)	15 (15.3%)
Not performed	3 (6.1%)	3 (6.1%)	6 (6.1%)
Comorbidities (amount)	3 (1 – 4)	3 (1 – 4)	3 (1 – 4)
No comorbidities	3 (5.9%)	6 (12.2%)	9 (8.2%)

Table 2, *Baseline characteristics of participants included in the ConsuMEER study.* (*continued*)

	Control (n=49)	Intervention (n=49)	Total (n=98)
Education			
Low	7 (14.3%)	16 (32.7%)	23 (23.5%)
Middle	25 (51.0%)	15 (30.6%)	40 (40.8%)
High	16 (32.7%)	14 (28.6%)	30 (30.6%)
Missing n=	1 (2.0%)	4 (8.2%)	5 (5.1%)
Income§			
Low	17 (34.7%)	28 (57.1%)	45 (45.9%)
High	32 (65.3%)	21 (42.9%)	53 (54.1%)
Help at home|			
Home care or Domestic help	31 (63.3%)	34 (69.4%)	65 (66.3%)
No help	18 (36.7%)	15 (30.6%)	33 (33.7%)

Continuous data are presented as mean (SD) or median (Q1-Q3), categorical data as frequency (%)
**) Below 150 minutes of high intensity activities per week*
†*) >12 seconds or not performed because of low mobility*
‡*) Below 10th percentile (p10) of Dodds et al.* [144] *or not performed because of medical conditions*
§*) low income was defined as year income < €28,500 for singles or < €35,000 for couples*
|*) Combinations of help at home possible*

Baseline nutritional intake

As shown in table 3, protein intake at breakfast and lunch were comparable between both groups and neither group reached the threshold of 25 grams of protein. At dinner, for both groups average intake reached the threshold of 25 grams of protein. At this meal moment, the intake of the intervention was 38.7 (SE: 2.5) and in the control group 33.7 (SE:2.2). Daily protein intake in g P/kg bw/day was 1.09 (SE: 0.05) in the intervention group and 0.99 (SE: 0.05) in the control group.

Table 3, *Protein intakes per meal moment and differences (in grams) between intervention and control group.*

	Control	Intervention	Between group difference*	Between group difference adjusted for baseline protein intake *
	Gr (SE)	Gr (SE)	Gr (95%CI)	Gr (95%CI)
Breakfast protein intake				
Baseline (n=49/49)	14.1 (0.9)	13.4 (1.0)	-0.7 (-3.2, 1.7)	
During trial (t1 n=42/48) (t2 n=42/46)	14.8 (0.8)	15.4 (0.7)	0.6 (-1.5, 2.6)	1.4 (-0.3, 3.1)
Lunch protein intake				
Baseline (n=49/49)	15.9 (1.2)	18.2 (1.1)	2.3 (-1.0, 5.5)	
During trial (t1 n=42/48) (t2 n=42/46)	15.3 (1.0)	18.4 (1.0)	3.2 (0.5, 5.9)	2.0 (0.0, 4.0)
Dinner protein intake				
Baseline (n=49/49)	33.7 (2.2)	38.7 (2.5)	5.1 (-1.1, 11.3)	
During trial (t1 n=42/48) (t2 n=42/46)	24.5 (0.9)	34.8 (0.9)	10.3 (7.8, 12.9)	9.6 (7.1, 12.1)
Daily total protein intake				
Baseline (n=49/49)	73.9 (3.3)	80.4 (4.1)	6.5 (-3.0, 16.0)	
g P/kg bw/day	0.99 (0.05)	1.09 (0.05)	0.10 (-0.04, 0.23)	
During trial (t1 n=42/48) (t2 n=42/46)	64.4 (2.0)	79.8 (1.9)	15.4 (10.0, 20.8)	13.6 (9.0, 18.3)
g P/kg bw/day	0.87 (0.03)	1.12 (0.05)	0.24 (0.15, 0.33)	0.23 (0.14, 0.31)
Daily total kcal intake				
Baseline (n=49/49)	1871 (76)	2037 (78)	165 (-51, 183)	
During trial (t1 n=42/48) (t2 n=42/46)	1865 (47)	1795 (45)	-71 (-199, 58)	

Data are presented as mean (SE) or mean difference (95%CI).
**) Based on multilevel analysis.*

Intervention effects

Effect of the ready-made meals and dairy on protein intake

The total protein intake of participants in the intervention groups was higher than that of the control group (mean difference: 13.6 g [95%CI: 90, 18.3]. Despite a 0.23 [95%CI: 0.14, 0.31] g P/kg bw/day higher protein intake in the intervention group, neither the intervention nor the control group reached the average daily protein goal of 1.2 g P/kg bw/day. At breakfast and lunch, differences in protein intake between groups remained small (<2 grams protein difference) but were significant at lunch (mean difference 2.0 g, [95% CI: 0.0, 4.0]) (table 3). Also, a significant higher intake of protein (g) was seen at dinner for the intervention group compared to the control group (mean difference: 9.6 g [95%CI: 7.1, 12.1]).

In the control group, protein intake decreased compared to baseline, both at dinner and total protein per day ($p<0.05$). In the intervention group, a higher intake compared to baseline was seen at breakfast at both time points, while intake at dinner decreased at T1 but this was not seen at T2. No differences ($p>0.05$) were seen in daily protein intake in the intervention group compared to baseline. Also, for all meal moments no differences ($p>0.05$) were seen between T1 and T2 for either intervention or control group.

Reaching threshold of 1.2 g P/kg bw/day or 25 grams per meal moment

In table 4, the percentages/proportions of participants reaching 1.2 g P/kg bw/day and/or ≥25 grams of protein per meal are shown. More participants reached an intake of 1.2 g P/kg bw/day in the intervention group compared to the control group (T1 OR: 4.85 [95%CI: 1.59, 14.80]; T2 OR: 3.56 [95%CI: 1.15, 11.14]). Despite the higher odds for the intervention group, only one third of all participants reached the threshold of 1.2 g P/kg bw/day in this group (T1: 34.8%, T2: 32.6%).

The higher intake of protein in the intervention group was also reflected in proportions of participants reaching the threshold of 25 grams of protein per meal moment. At breakfast and lunch, no significant differences were seen between intervention and control group. At dinner, participants of the intervention group were more likely to reach an intake of 25 grams protein compared to the control group (T1 OR: 8.24 [95%CI: 2.73, 24.83], T2 OR: 11.99 (95%CI: 3.70, 38.83).

Table 4, *Percentages and odds-ratios for reaching 25 grams protein per meal moment or 1,2 g P/kg bw/day.*

	Control Number (%)	**Intervention** Number (%)	**Effect size*** OR (95%CI)	**Effect size adjusted for baseline protein intake *** OR (95%CI)
Daily 1.2 g P/kg bw/ day	13 (26.5%)	15 (31.9%)	1.42 (0.60, 3.45)	
Baseline (n=49/49)	4 (9.5%)	16 (34.8%)	5.20 (1.73, 15.69)	4.85 (1.59, 14.80)
T1 (n=42/48)	5 (11.9%)	14 (32.6%)	3.57 (1.15, 11,07)	3.56 (1.15, 11.04)
T2 (n=42/46)				
Breakfast ≥25 g P/ meal	1 (2%)	4 (8.5%)	n.a	n.a
Baseline (n=49/49)	2 (4.8%)	4 (8.7%)	n.a	n.a
T1 (n=42/48)	1 (2.4%)	4 (9.3%)	n.a	n.a
T2 (n=42/46)				
Lunch ≥25 g P/ meal				
Baseline (n=49/49)	6 (12.2%)	7 (14.9%)	1.25 (0.39, 4.05)	
T1 (n=42/48)	5 (11.9%)	11 (23.9%)	2.33 (0.73, 7.37)	2.99 (0.70, 12.86)
T2 (n=42/46)	6 (14.3%)	9 (20.9%)	1.59 (0.51, 4.94)	1.41 (0.43, 4.63)
Dinner ≥25 g P/ meal				
Baseline (n=49/49)	34 (69.4%)	42 (89.4%)	3.71 (1.22, 11.22)	
T1 (n=42/48)	18 (42.9%)	39 (84.8%)	7.43 (2.70, 20.40)	8.24 (2.73, 24.83)
T2 (n=42/46)	17 (40.5%)	38 (88.4%)	11.18 (3.66, 34.17)	11.99 (3.70, 38.83)

n.a= Not applicable due to a low incidence.
**) Based on logistic regression.*

Protein intake derived from dairy products and ready-made meals

Post-hoc analyses towards protein intake from dairy products and ready-made meals are shown in table 5. The use of ready-made meals resulted in an average daily intake of 25.8 (SE: 0.5) grams of protein in the intervention group compared to 18.5 (SE: 0.5) grams in the control the group; this difference was significant [difference 6.9 grams, 95%CI: 5.5, 8.3]. Daily protein intake from dairy products was significantly higher in the intervention group compared to the control group at every meal moment. The largest difference was observed at dinner where the intervention group consumed 3.9 [95%CI: 2.3, 5.6] grams of protein (derived from dairy products) more than the control group. The total daily difference of protein derived from dairy products between control and intervention group was 9.6 [95%CI: 6.2, 13.1] grams.

Table 5, *Protein intake from dairy products and ready-made meals in grams during the ConsuMEER study.*

	Control Gr (SE)	**Intervention** Gr (SE)	**Between group difference*** Gr (95%CI)	**Between group difference adjusted for baseline protein intake *** Gr (95%CI)
Ready-made meals				
During trial (t1 n=42/48) (t2 n=42/46)	18.5 (0.5)	25.8 (0.5)	7.2 (5.8, 8,7)	6.9 (5.5, 8.3)
Breakfast dairy				
Baseline (n=49/49)	4.3 (0.5)	4.4 (0.5)	0.1 (-1.4, 1.5)	
During trial (t1 n=42/48) (t2 n=42/46)	4.7 (0.6)	6.6 (0.6)	1.9 (0.3, 3.6)	2.2 (0.6, 3.8)
Lunch dairy				
Baseline (n=49/49)	5.2 (0.6)	6.9 (0.6)	1.7 (-0.1, 3.5)	
During trial (t1 n=42/48) (t2 n=42/46)	4.7 (0.6)	7.7 (0.6)	3.0 (1.3, 4.8)	2.5 (0.9, 4.1)
Dinner dairy				
Baseline (n=49/49)	3.4 (0.5)	4.9 (0.5)	1.5 (0.0, 3.0)	
During trial (t1 n=42/48) (t2 n=42/46)	3.5 (0.6)	7.7 (0.6)	4.2 (2.6, 5.8)	3.9 (2.3, 5.6)
Daily total dairy				
Baseline (n=49/49)	16.0 (1.2)	19.5 (1.3)	3.5 (-0.1, 7.0)	
During trial (t1 n=42/48) (t2 n=42/46)	15.8 (1.3)	26.1 (1.3)	10.3 (6.7, 13.9)	9.6 (6.2, 13.1)

Data are presented as mean (SE) or mean difference (95%CI).
**) Based on multilevel analysis.*

Liking and compliance

Overall acceptance of meals was 3.6 (SD:0.5) in the control group and 3.6 (SD:0.6) in the intervention group based on a 5-point scale (mean difference: 0.0 [95%CI: -0.2, 0.3])

Based on the three-day food diaries, participants in the intervention group used ready-made meals on 88.9% of the registered days at T1 and on 79.7% at T2. In the control group these numbers were 92.1% at T1 and 84.1% at T2.

Discussion

The aim of this study was to test the effectiveness of commercially available protein-rich ready-made meals and protein-rich dairy products in increasing protein intake, after switching from self-prepared meals towards home-delivered ready-made meals. In contrast to expectations, results show that switching from self-prepared meals towards standard ready-made meals turned out to be a risk for a decreasing protein intake;

this effect was not seen in participants who used protein-rich ready-made meals and protein-rich dairy products. Both ready-made meals and dairy products contributed to this higher intake of the intervention group. Although participants receiving products high in protein consumed more protein than participants receiving products with lower protein content, their total protein intake did not increase compared to their pre-study protein intake and did not reach the goal of 1.2 g P/kg bw/day. Moreover, not all participants of the intervention group reached the recommended intake of >25 gram protein at dinner.

The characteristics of the participants included in the present ConsuMEER study showed only minor differences compared to the Dutch LASA cohort [76] and participants of the Dutch National Food Consumption Survey Older Adults (DNFCSOA) [64]. Overall age of the participants in the ConsuMEER study (80.4 ±6.7) was slightly higher when compared to the DNFCSOA (Mean age: male 76.6 (SD unknown), female 78.4 (SD unknown)) and LASA cohort (77.3 ±6.7). BMI of participants in the ConsuMEER study was relatively high (male: 27.1 (SD:4.1); female 28.4 (SD:5.4)) and comparable to the BMI reported in the DNFCSOA (27.1, SD: unknown) and BMI of female participants of the LASA cohort (27.9 ±4.8). However, the BMI was higher compared to that of male participants of the LASA cohort (25.9 ±3.4). In the ConsuMEER study, 21% of all participants were at moderate or severe risk of undernutrition according to SNAQ^{65+}, in LASA, this percentage was 18.3% and in the DNFCSOA, this was 13,1%. Protein intake of the participants of the ConsuMEER study at baseline was comparable with the protein intake of the DNFCSOA where on average 1.01 (SD: unknown) g P/kg bw/day was consumed. Thus, despite some minor differences in participants' characteristics with previous performed studies, the participants of the ConsuMEER study seem to be a good reflection of older adults in the Netherlands.

The ConsuMEER study is one of the first trials investigating the protein intake of community-dwelling older adults when changing from self-prepared meals towards commercially available home-delivered, ready-made meals. The protein intake in the control group decreased, while the protein intake in the intervention group remained stable. In addition, our results suggest that protein-rich ready-made meals and protein-rich dairy are effective in reaching the threshold of ≥25 grams protein at dinner but not at breakfast and lunch. Because of the low intake at breakfast and lunch, the threshold of 1.2 g P/kg bw/day was not reached for most participants. These results are in line with the results of a recent study by Denissen et al. [169] where ready-made meals containing as much as 40 grams of protein per meal were not sufficient in reaching 1.2 g P/kg bw/day either. Our results are not in line with earlier studies from the United States though. These studies showed that standard ready-made meals were associated with higher

protein intake [170]. However, most of these studies were performed in participants receiving ready-made meals because of the *"Older Americans Act" (OAA)*. People who are dependent of meals of the OAA are generally poor and therefore they may not have had enough money to buy relatively expensive products like meat and dairy products [159]. In those studies, the provided ready-made meals may therefore not have replaced self-prepared meals but may have been used instead of skipping a meal. This could explain the higher protein intake after switching towards ready-made meals in these studies.

The observed decrease in protein intake at dinner of the control group after switching from self-cooked meals to regular ready-made meals was not seen in a comparable study of Ziylan et al. [161]. In this study, protein intake of the control group at dinner remained unchanged. This could be explained by the higher protein content of the standard meals in the control group of the Ziylan et al. study compared to the ConsuMEER study (average protein content Ziylan et al. 27.9 (SD:3.4) vs. 21.3 (SD:4.5) in our study). Both the results of Ziylan et al. [161] and the results of the present study indicate that a good choice of protein-rich ready-made meals and dairy products is necessary to prevent older adults from a decreasing protein intake after switching from self-prepared meals towards ready-made meals. This is of great interest because in the upcoming years, a larger group of older adults will have to rely on ready-made meals due to the ageing society and the government's policy of living at home as long as possible. Protein-rich ready-made meals and protein-rich dairy products could help to maintain a healthy nutritional status in older adults. Switching towards ready-made meals also has a downside. Meal preparation is important as it could provide joy to older adults [171] and makes them feel independent [172]. It is also important they keep cooking themselves to stay active, as a loss in daily activities cannot always be reversed [173,174] and daily activities have a beneficial effect on cognitive functioning [175]. Therefore, older adults should try to keep preparing their own meals as long as possible.

During the trial a (borderline) significant difference in protein intake derived from dairy products between control and intervention group was seen at breakfast and lunch. However, this difference was relatively small (<3 grams) and therefore protein intake in the intervention group still did not reach the threshold of ≥ 25 grams of protein per meal moment. These results are in contrast to the study by van Til et al. [162] where intake during breakfast and lunch was over 25 grams. However, in this trial both protein-enriched dairy products (8 gram protein per 100 ml; products not commercially available) and protein-enriched bread were used. Regular dairy products may be insufficient in increasing intake towards the recommended levels because of the large gap between regular intake at breakfast and lunch and the recommendation of eating ≥25 grams of protein. Because an intervention based on protein-enriched bread alone was also not

sufficient in reaching the threshold of ≥25 grams of protein per bread meal [161], future interventions should focus on all food products within a meal.

One of the reasons for the low increase in protein intake at breakfast and lunch could be unawareness about the importance of protein among older adults. Before and during the trial, no information was given about protein being the target nutrient of the study or about healthy eating in general. Older adults are interested in eating healthy to stay healthy but on average their knowledge is low [176,177]. Healthy eating is mainly described as eating a varied diet and eating a sufficient amount of fruit and vegetables [176]. The importance of eating enough protein and the distribution of protein intake is generally unknown in older adults [177,178]. Because of the free choice in using the provided dairy products and the supposed lack of knowledge about the advantages of consuming these products, it is plausible that some participants did not use the provided products at all. Providing protein-rich dairy products combined with dietary advice about the importance of protein, is thought to make an intervention based on protein-rich dairy products more successful.

Some limitations need to be discussed to place the results of this study in perspective. First, the duration of the intervention was relatively short (28 days). Therefore, no information is available on whether the protein intake will be maintained over a longer time period. It is possible that eating ready-made meals for a longer period could result in less appreciation for these meals, which could result in a lower intake. However, in the recent study of Denissen et al. [169], where ready-made meals were used for a period of 3 months, overall appreciation of the meals remained high, also over a longer period of time. Another limitation is the use of one supplier for the ready-made meals; different brands of ready-made meals will differ in sensory aspects and macronutrient composition. Finally, the effect of the intervention on physical parameters was not measured. However, no changes were expected considering the intervention lasted only 4 weeks [179]. It can be argued that 1.2 gP/kg-bw/day may be a too high goal for community-dwelling older adults. Based on expert opinion, a protein intake of 1.0-1.2 g P/kg bw/day for healthy older adults and 1.2-1.5 g P/kg bw/day for older adults with acute or chronic illness, and even up to 2.0 g P/kg bw/day when severe illness is present is advised [61]. Based on a median of 3 comorbidities in our study population, we considered our participants not fully healthy; therefore, we decided that a cut-off of 1.2 g P/kg bw/day would be appropriate. Finally, a true control group is missing as both groups received an intervention. as both groups received an intervention, an option to overcome this issue could have been the use of a cross-over design in which group 1 starts with the intervention, followed by a control period, and group 2 starts with a control period, and then the intervention

One of the strengths of this study is the high rate of follow up (drop-out rate only 12%). This could indicate that the intervention was easy to implement in daily life of participants and was well tolerated. This is of great importance because switching towards ready-made meals is likely to be a lasting change for older adults who are no longer capable to cook their own meals. Another strength of the study is that it is similar to daily practice; the products that were used are commercially available, well known and fit in the daily lifestyle of Dutch older adults. Previous studies showed that older adults preferred the use of products they are familiar with in order to increase protein intake [177,180]. Also, no information about healthy eating was given and participants were free to make their own choices. Therefore, the results of the control group give valuable information how protein intake can decrease when older adults change from self-prepared to ready-made meals without information about healthy eating.

Because of the relatively high protein intake at dinner and the importance of distribution of protein intake over meals, future interventions should focus on protein intake at breakfast and lunch. At these meal moments, the highest increase in protein intake could be achieved. Regular dairy products have the right nutritional composition to increase protein intake, are low in price, are easily accessible and are common in Dutch eating habits. Further qualitative research is needed on how older adults can be motivated to increase their protein intake at breakfast and lunch, as they are known to struggle to change their regular eating habits [181,182].

Conclusion

Switching from a regular diet to ready-made meals carries the risk of a decreasing protein intake if meals are not selected for high protein content. Protein-rich ready-made meals and protein-rich dairy products could prevent older adults from a decrease in protein intake but the combination of products provided in this trial was not effective in increasing protein intake towards 1.2 g P/kg bw/day. More research is needed whether additional advice about protein intake could make an intervention based on regular protein-rich products more effective.

CHAPTER 6

6

Behavioural and cognitive problems as determinants of malnutrition in long-term care facilities, a cross-sectional and prospective study.

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Abstract:

Objectives: To investigate the cross-sectional and prospective associations between behaviour and cognitive problems and malnutrition in long-term care facilities (LTCF).

Design: Cross-sectional and prospective routine care cohort study.

Setting: 6874 Residents in Dutch LTCFs (period 2005-2020)

Participants: Data were obtained from the InterRAI-LTCF instrument. Cross-sectional analyses on prevalence of malnutrition at admission included 3722 residents. Prospective analyses studied incident malnutrition during stay (total follow-up time 7104 years) and included data of 1826 residents with first measurement on admission (*'newly-admitted')* and n=3152 with first measurement on average ~1 year after admission (*'existing')*.

Measurements: InterRAI scales for communication problems (CS), aggressive behaviour (ABS), social engagement (RISE), depressive symptoms (DRS), cognitive performance (CPS) and the total number of behaviour and cognitive problems were investigated as independent variables and malnutrition (ESPEN 2015 definition) as dependent variable in regression analyses. Results were stratified for gender and group '*newly-admitted' vs. 'existing'*.

Results: On admission, 9.5% of residents was malnourished. In men, low social engagement was associated with prevalence of malnutrition. In women, all behaviour and cognitive problems except depression were associated with malnutrition in the unadjusted analyses, but this attenuated in the full model taking all problems into account. The incidence of malnutrition during stay amounted to 8.9%. No significant associations of behaviour and cognitive problems with malnutrition incidence were seen in '*newly-admitted'* male residents while in *'existing'* male residents all determinants were significantly associated. In *'newly-admitted'* female residents CS, ABS and CPS, and in *'existing'* female residents CS, RISE, ABS and CPS were significantly associated with incident malnutrition. All associations slightly attenuated after adjustment. Malnutrition incidence increased with increasing number of combined behaviour and cognitive problems.

Conclusion: Residents with behaviour and cognitive problems are at an increased risk of being malnourished at admission, or becoming malnourished during stay in a LTCF, especially residents with multiple behaviour and cognitive problems.

Background

The European population of 65 years and older is expected to increase from 19% nowadays, towards 28.5% in 2050 [183]. Many European countries encourage 'ageing-in-place', whereby most older adults remain living in their own home and community with or without (informal) care [184]. Ageing-in-place enables older adults to remain as autonomic, independent and (socially) active as possible [185,186]. Based on this policy, older adults only move to residential care facilities when their level of dependency is high and home-care is no longer sufficient [187]. Older adults with severe behaviour and cognitive problems become affected in their (instrumental) activities of daily living (ADL) [188,189], and this puts a high burden on formal and informal care at home [190]. When people with advanced behaviour and cognitive problems become fully care-dependent, they are more likely to become institutionalized [190–192].

While still living at home, the ability to perform grocery shopping and prepare meals is one of the first functions that is lost in older adults with cognitive decline, herewith increasing the risk of impaired food intake [188]. Previous cross-sectional studies have shown a clear association between cognitive impairment and the presence of malnutrition, both in the community and during stay in a long-term care facility (LTCF) [103,193–196]. However, studies describing incident malnutrition during stay in a LTCF in residents suffering from behaviour and cognitive problems are lacking.

We hypothesize that residents with behaviour and cognitive problems are at increased risk to be already malnourished at admission to a LTCF, or to become malnourished during stay. Therefore, the aim is of this study is to describe the cross-sectional and long-term associations between behaviour and cognitive problems at admission, malnutrition prevalence at admission and incident malnutrition during stay in a LTCF in a large population.

Methods

Data source

Data were obtained from InterRAI; a non-profit international multidisciplinary collaboration that aims to improve quality of life of older adults through systematic, accurate and standardized data collection of residents' physical and psychosocial functioning [197]. A specific assessment form was developed for each healthcare setting [198]. The RAI Long-Term Care Facilities (LTCF) assessment form is a minimum data set (MDS) which includes nineteen sections, including residents' nutritional, cognitive and psychosocial

status. The assessment form is administered by trained nurses in interaction with the residents, their family members and other health professionals [198]. Several studies have shown high validity and reliability of the assessment form [199–201].

Two groups were derived from residents admitted to a LTCF: the '*newly admitted*' and the '*existing*' residents. The newly admitted group had their first assessment taken place within one month after admission to a LTCF ('admission assessment'); thereafter residents were monitored typically with quarterly or semi-annual follow-up assessments.

When a LTCF started using InterRAI, no 'admission assessment' was performed for the residents who were already living in that facility ('*existing*' residents). A 'delayed first assessment' was then noted as first measurement.

Dutch InterRAI subjects (aged ≥ 65 years) living in LTCF between 2005 and 2020 were included in this study. In total, 4190 residents with an 'admission assessment' were available, median time to first assessment was 16 days [IQR: 7-30] after admission. These residents represent *'newly-admitted'* residents.

In contrast, the '*existing*' residents are defined by having had their first measure after their initial admission. In total 5592 residents with a 'delayed first assessment' were available and this assessment took place with a median time of 345 [IQR: 117 -914] days in male and 546 [IQR: 165-1363] days in female residents after their initial admission. Thus, the defining difference between the groups is the time elapsed between their admission and their first assessment, which was shorter in the newly admitted group and longer in the '*existing*' residents' group.

Inclusion criteria cross-sectional analyses

For the cross-sectional analyses, only data of 'admission assessments' were used (n=4190). Residents were included if data regarding malnutrition status were available. Exclusion criterion was presence of end-stage disease, i.e. terminally ill residents with a life expectancy <6 months as indicated by the treating physician, to exclude residents with incurable malnutrition. After exclusion, 3722 residents were available for analyses.

Inclusion criteria prospective analyses

For the prospective analyses, first assessment data of '*newly-admitted*' residents as well as first assessment data of '*existing*' residents and all subsequent follow-up measurements were used. Residents were included when they were not malnourished at their first available measurement and had one or more follow-up measurements where nutrition status was measured. Exclusion criterion was presence of end-stage disease at first

or last measurement. After exclusion, 4978 residents were available for analyses. Figure 1 provides an overview of the in- and exclusion process

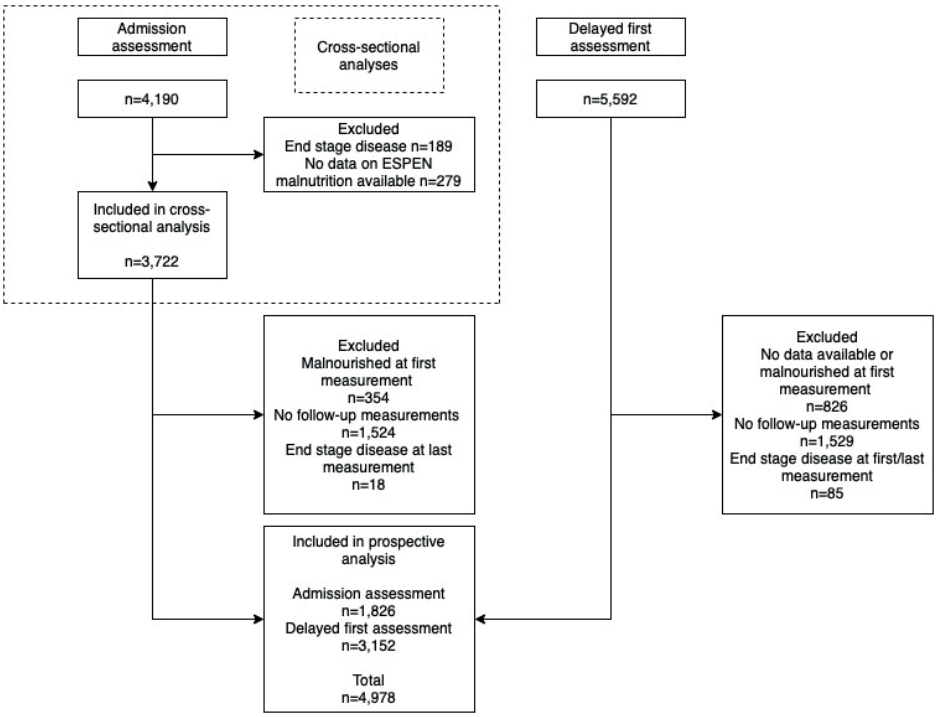

Figure 1, *flowchart of included participants in cross-sectional and prospective analyses.*

Measurements

We used the following InterRAI scales for behaviour and cognitive problems as independent variables: Communication Scale (SC), Cognitive Performance Scale (CPS), Depression Rating Scale (DRS), Revised Index of Social Engagement (RISE), Aggressive Behaviour Scale (ABS) and total number of behavioural-cognitive problems. Malnutrition based on the ESPEN 2015 criteria was used as dependent variable.

Communication Scale (CS)

The CS is a standardized questionnaire that assesses the communication performance of subjects living in a LTCF. It consists of two communication items (understanding others, making oneself self-understood). The scale provides a score ranging from 0 (good communication performance) till 8 (poorest communication performance)[202]. No validated cut-off values are available for CS but previous research showed that a cut-off value of ≥3 will identify the 10% most severe cases with communication problems [203].

The CS was dichotomized into good communication performance (CS ≤2) or moderate to severe impairment (CS ≥3).

Cognitive Performance Scale (CPS)

The CPS is a standardized and validated questionnaire containing five items (decision making, memory, disordered thinking, change in mental status, change in decision making) to assess cognitive performance of subjects living in a LTCF [204,205]. It provides a total score ranging from 0 (cognitive performance intact) till 6 (very severe cognitive impairment) [205]. The CPS has been validated against the MMSE, whereby a CPS score of 2 equals a MMSE score of 19 [205]. Therefore, the CPS scale was dichotomized into ≤2 and ≥3.

Depression Rating Scale (DRS)

The DRS is a standardized and validated screening questionnaire to screen for depressive symptoms in subjects living in a LTCF [206,207]. It includes seven depressive mood and behavioural indicators (negative statements, anger, unrealistic fears, health complaints, anxious complaints, sad expressions, crying). All indicators have possible scores of 0 (indicator not present during the past 30 days), 1 (indicator present 1 till 5 times a week) or 2 (indicator present 6 or 7 days a week), resulting in a total maximum score of 14. A total score ≥ 3 indicates a resident is at risk for depression [207]. Therefore, this item was dichotomized in low (≤2) or high depression risk (≥3).

Revised Index of Social Engagement (RISE)

The RISE is a standardized and validated measure of social engagement of subjects living in a LTCF [208]. It includes six dichotomous indicators of social engagement (initiating social interaction, accepting social interaction, activity participation, accepting invitations and facility involvement). The scale provides a score ranging from 0 (poor social engagement) till 6 (high social engagement) [208]. Based on the original validation paper of RISE, a cut-off of ≤2 reflects a division between low- and high functioning people [209]. Therefore, the RISE was dichotomized into low social engagement (RISE score ≤2) and high social engagement (RISE score ≥3). The high social engagement group (RISE score ≥3) was chosen as reference group in our analysis.

Aggressive behaviour scale (ABS)

The ABS is a validated four-item scale based on the following items: verbal abuse, physical abuse, socially inappropriate behaviour and resisting care [210]. These items are coded as: not present (0), present in last three days (1), happened once or twice in three days (2) or daily (3). Based on the four items, scores range from 0-12, and higher scores

indicate aggressive behaviour. The ABS was dichotomized into no aggressive behaviour (ABS=0) or aggressive behaviour present (ABS ≥1) [210].

Total number of behaviour and cognitive problems

Based on the dichotomized scores of the scales mentioned above, a sum score of CS, CPS, DRS, RISE, ABS was created, which indicated on how many of the behavioural-cognitive scales problems were identified (range 0-5).

Malnutrition

The primary end point of this study was malnutrition based on the ESPEN 2015 criteria; Body Mass Index (BMI) < 18.5 kg/m^2, or weight loss (5% during last month or 10% in six months), in combination with a reduced age-specific BMI (< 20 kg/m^2 < 70 years or < 22 kg/m^2 ≥ 70 years) [45].

Covariables

Data on age, gender, living status before admission (together vs. alone) and number of underlying diseases were obtained from the RAI-LTCF Assessment Form.

Ethical considerations

InterRAI assessments are performed for clinical purposes as part of routine care. Data is de-identified and thereafter transferred to the InterRAI database at the Amsterdam University Medical Centres – Location VUmc. Residents are informed (by their practice nurse, through newsletters, posters and website) in general terms that their data can be used for research purposes. Residents can object against use of their data and an opt-out procedure is available therefore. The Ethical committee of VUmc approved the use of data for research in this way.

Statistical analysis

All statistical analyses were performed in SPSS version 25 (IBM Corp., Armonk, New York, USA). Descriptive statistics were stratified by nutritional status and gender. Normality was checked by QQ-plots and stem-and-leaf plots. Means with standard deviations were used to describe continuous variables and numbers and percentages for categorical data. Logistic regression analyses were used to study the associations between CPS, CS, DRS, RISE, ABS and total number of behaviour and cognitive problems (independent variables), and malnutrition (dependent variable). Kaplan-Meier curves and Cox Proportional Hazard regression analyses were performed with malnutrition as event and CPS, CS, DRS, RISE, ABS, and total number of behaviour and cognitive problems as independent variables. Time to event was defined as days between first available assessment and the first follow-up assessment where malnutrition occurred. If someone was

categorized as malnourished, all further follow-up measurements were removed. Residents who stayed well-nourished during their total follow-up period were censored and event time ended at their latest available measurement. Kaplan-Meier curves provided a graphical evaluation of the proportional hazard assumption. As these assumptions were met, Cox Proportional Hazard regression analyses were performed.

Stratification for gender was based on the significance of interaction terms (behaviour-cognitive problem * gender). In the cross-sectional analyses this interaction term was significant ($p<0.10$) [211] for RISE, CPS and total number of behaviour-cognitive problems. In the prospective analyses, interaction terms for DRS and total number of behaviour-cognitive problems were statistically significant.

Thereafter, we tested whether there was effect modification by type of first assessment in the prospective analyses (behaviour-cognitive problem * type of first assessment). Significant interaction terms ($p<0.10$) [211] were seen for male gender (CS, DRS, ABS, CPS and total number of behaviour-cognitive problems). Based on this number of significant interaction terms and the large differences in effect sizes between men/women and newly-admitted/existing residents, we decided to present four different strata (for illustration, see appendix 1 for additional Kaplan-Meier curves on CS).

As previous studies showed that malnutrition is related to very old age (≤ 90 years vs. ≥ 91 years) [212], number of comorbidities (≤1 vs. ≥2) [67,117] and living status before admission (alone vs. together) [49], all regression analyses were adjusted for these variables (model 1). As most behavioural-cognitive problems are associated with each other, a full model was created which included in addition all five determinants (CS, DRS, RISE, ABS and CPS) (full model).

Results

Cross-sectional analysis

Table 1 shows the characteristics of the 3722 included residents at LTCF admission. Most residents were women (67.6%), lived alone before admission (64.3%), were aged <90 years (81.9%) and their BMI was within the normal range (mean 24.7 kg/m2, SD 4.6). Prevalence rates of behavioural-cognitive problems ranged from 22.4% for aggressive behaviour (ABS) to 27.8% for depression risk (DRS).

In total, 88 male residents (7.3%) and 266 (10.6%) female residents were malnourished at admission. In women, prevalence rates of malnutrition ranged from 12.5-13.5% for each

of the behaviour and cognitive problems. In male residents, malnutrition was lowest (6.5%) in residents with cognitive problems and highest (10.4%) in residents with low social engagement (table 2).

Bivariate analyses showed that CS, DRS, RISE and CPS were significantly associated with an increased odds of being malnourished in female residents. Adjustments for age, number of comorbidities and living status before admission had only minor influence (see appendix 2). In the full model associations attenuated, but a trend for higher prevalence of malnutrition in residents with behaviour and cognitive problems remained. In men, only RISE was significantly associated with malnutrition. In women, a clear trend (p-value <0.001) was seen between having multiple behavioural-cognitive problems and prevalence of malnutrition. In male residents, this trend was not seen but power was low in this group.

Table 1, *Characteristics of included participants at admission to LTCF, stratified by gender and nutritional status.*

	Male N=1207 (32.4%)		Female N=2515 (67.6%)		Total N=3722
	Malnourished N=88 (7.3%)	Well-nourished N=1119 (92.7%)	Malnourished N=266 (10.6%)	Well-nourished N=2249 (89.4%)	
Age (years)	82.8 (SD:6.8)	81.8 (SD:7.2)	84.3 (SD:7.0)	83.7 (SD:6.9)	83.1 (SD:7.1)
≤ 89 years	75 (85.2%)	963 (86.1%)	197 (74.1%)	1815 (80.7%)	3050 (81.9%)
≥ 90 years	13 (14.8%)	156 (13.9%)	69 (25.9%)	434 (19.3%)	672 (18.1%)
BMI	18.5 (SD:2.1)	25.5 (SD:3.9)	18.1 (SD:1.9)	25.3 (SD:4.1)	24.7 (SD:4.6)
Living status before admission					
Alone	49 (55.7%)	523 (46.7%)	187 (70.3%)	1636 (72.7%)	2395 (64.3%)
Together	39 (44.3%)	590 (52.7%)	78 (29.3%)	602 (26.8%)	1309 (35.2%)
Missing	0	6 (0.5%)	1 (0.4%)	11 (0.5%)	18 (0.5%)
Number of underlying diseases					
≤ 1	33 (37.5%)	396 (35.4%)	107 (40.2%)	862 (38.3%)	1398 (37.6%)
≥ 2	55 (62.5%)	723 (64.6%)	159 (59.8%)	1387 (61.7%)	2324 (62.4%)
CS					
≤ 2	62 (70.5%)	783 (70.0%)	187 (70.3%)	1736 (77.2%)	2768 (74.4%)
≥ 3	26 (29.5%)	336 (30.0%)	79 (29.7%)	511 (22.7%)	952 (25.6%)
Missing	0	0	0	2 (0.1%)	2 (0.1%)
DRS					
≤ 2	61 (69.3%)	842 (75.2%)	170 (63.9%)	1601 (71.2%)	2674 (71.8%)
≥ 3	27 (30.7%)	273 (24.4%)	93 (35.0%)	641 (28.5%)	1034 (27.8%)
Missing	0	4 (0.4%)	3 (1.1%)	7 (0.3%)	14 (0.4%)

Table 1, *Characteristics of included participants at admission to LTCF, stratified by gender and nutritional status.* (*continued*)

	Male N=1207 (32.4%)		Female N=2515 (67.6%)		Total N=3722
	Malnourished N=88 (7.3%)	Well-nourished N=1119 (92.7%)	Malnourished N=266 (10.6%)	Well-nourished N=2249 (89.4%)	
RISE					
	34 (38.6%)	292 (26.1%)	77 (28.9%)	503 (22.4%)	906 (24.3%)
≤ 2	53 (60.2%)	821 (73.4%)	188 (70.7%)	1736 (77.2%)	2798 (75.2%)
≥ 3	1 (1.1%)	6 (0.5%)	1 (0.4%)	10 (0.4%)	18 (0.5%)
Missing					
ABS					
0	63 (71.6%)	818 (73.1%)	202 (75.9%)	1801 (80.1%)	2884 (77.5%)
≥ 1	25 (28.4%)	300 (26.8%)	64 (24.1%)	444 (19.7%)	833 (22.4%)
Missing	0	1 (0.1%)	0	4 (0.2%)	5 (0.1%)
CPS					
≤ 2	64 (72.7%)	772 (69.0%)	184 (69.2%)	1701 (75.6%)	2721 (73.1%)
≥ 3	24 (27.3%)	340 (30.4%)	80 (30.1%)	530 (23.6%)	974 (26.2%)
Missing	0	7 (0.6%)	2 (0.8%)	18 (0.8%)	27 (0.7%)
Number of behavioural-cognitive problems					
0	26 (29.5%)	425 (38.0%)	91 (34.2%)	997 (44.3%)	1539 (41.3%)
1	28 (31.8%)	259 (23.1%)	61 (22.9%)	526 (23.4%)	874 (23.5%)
2	8 (9.1%)	177 (15.8%)	51 (19.2%)	321 (14.3%)	557 (15.0%)
3	16 (18.2%)	135 (12.1%)	32 (12.0%)	215 (9.6%)	398 (10.7%)
4	6 (6.8%)	92 (8.2%)	21 (7.9%)	124 (5.5%)	243 (6.5%)
5	4 (4.5%)	31 (2.8%)	10 (3.8%)	64 (2.8%)	109 (2.9%)
Missing	0	0	0	2 (<0.1%)	2 (<0.1%)

Data is shown as mean (Standard deviation) or as number (percentage)

Abbreviations: BMI (body mass index), CS (communication scale), DRS (depressive rating scale), RISE (revised index of social engagement), ABS (aggressive behaviour scale), CPS (cognitive performance scale).

Table 2, *Odds Ratio's for CPS, CS, DRS, RISE, ABS and total number of behavioural-cognitive problems in relation to malnutrition, stratified by gender.*

	Male N=1297 (32.4%)			Female N=2515 (67.6%)		
	Malnutrition prevalence	Bivariate analyses	Full model*	Malnutrition prevalence	Bivariate analyses	Full model*
CS						
≤ 2	7.3%	Ref.	Ref.	10.2%	Ref.	Ref.
≥ 3	7.2%	0.98 (0.61-1.57)	1.08 (0.57-2.05)	13.4%	1.44 (1.08-1.90)	1.21 (0.83-1.75)
DRS						
≤ 2	6.8%	Ref.	Ref.	9.6%	Ref.	Ref.
≥ 3	9.0%	1.37 (0.85-2.19)	1.35 (0.80-2.29)	12.7%	1.37 (1.04-1.79)	1.22 (0.90-1.66)
RISE						
≥ 3	6.1%	Ref.	Ref.	9.8%	Ref.	Ref.
≤ 2	10.4%	1.80 (1.15-2.83)	1.80 (1.13-2.86)	13.5%	1.41 (1.07-1.88)	1.33 (0.99-1.78)
ABS						
0	7.2%	Ref.	Ref.	10.1%	Ref.	Ref.
≥ 1	7.6%	1.08 (0.67-1.75)	0.96 (0.55-1.67)	12.5%	1.29 (0.95-1.73)	1.04 (0.73-1.48)
CPS						
≤ 2	7.7%	Ref. †	Ref.	9.7%	Ref. †	Ref.
≥ 3	6.5%	0.85 (0.52-1.39)	0.77 (0.40-1.48)	13.5%	1.40 (1.06-1.85)	1.06 (0.73-1.54)
Number of behavioural-cognitive problems						
0	26 (5.8%)	Ref. †	Ref.	91 (8.4%)	Ref. †	Ref.
1	28 (9.8%)	1.76 (1.01-3.07)	1.79 (1.02-3.12)	61 (10.4%)	1.27 (0.90-1.78)	1.24 (0.88-1.75)
2	8 (4.3%)	0.74 (0.33-1.66)	0.77 (0.34-1.73)	51 (13.7%)	1.74 (1.21-2.51)	1.72 (1.19-2.49)
3	16 (10.6%)	1.96 (1.02-3.76)	2.11 (1.09-4.08)	32 (13.0%)	1.60 (1.03-2.46)	1.58 (1.02-2.45)
4	6 (6.1%)	1.06 (0.43-2.65)	1.13 (0.44-2.83)	21 (14.5%)	1.88 (1.13-3.13)	1.82 (1.08-3.05)
5	4 (11.4%)	2.24 (0.73-6.86)	2.37 (0.77-7.30)	10 (13.5%)	1.71 (0.85-3.43)	1.68 (0.83-3.41)
P-value test for trend		0.291	0.188		0.001	0.001

Data is shown as percentage or odds ratios with 95% confidence interval.

Abbreviations: CS (communication scale), DRS (depressive rating scale), RISE (revised index of social engagement), ABS (aggressive behaviour scale), CPS (cognitive performance scale) N.A. (Not applicable).

* For behavioural-cognitive scales, model consist of: CS, DRS, RISE, ABS, CPS, age category (≤ 89 years vs. ≥ 90 years), number of comorbidities (≤1 vs. ≥2) and living status before admission (alone vs. together). For total number of behavioural-cognitive problems, model consist of total number of behavioural-cognitive problems, age category (≤ 89 years vs. ≥ 90 years), number of comorbidities (≤1 vs. ≥2) and living status before admission (alone vs. together).

† significant interaction term ($p<0.10$) between behavioural-cognitive problem and gender

Prospective analysis

As depicted in table 3, data of 4978 residents were available for the prospective analysis, 1,826 with an 'admission assessment' ('*newly-admitted*' residents) and 3,152 with a 'delayed first assessment' as reference assessment ('*existing*' residents). Most residents were women (71.3%), aged <90 years (78.5%), had ≥2 diseases (61.6%), and a mean BMI of 25.7 kg/m^2. Nearly 1 out of 3 residents had depressive symptoms based on DRS (31.0%), other behavioural-cognitive problems ranged between 25.5-28.0%.

Total follow-up of all participants was 7104 residents' years with a median individual follow up of 357 days. During this period, 17217 follow-up measurements were performed (including last assessment). Incident malnutrition occurred in 106 (7.4%) male residents and 337 (9.5%) female residents. Incident malnutrition per follow-up year was lowest in '*existing*' male residents (0.052 per follow-up year) and highest in '*newly-admitted*' female residents (0.071 per follow-up year).

As shown in table 4, none of the behaviour and cognitive problems was significantly associated with incident malnutrition in '*newly-admitted*' male residents (n=599). In contrast, in *'existing'* male residents (n=831), all behavioural-cognitive problems were associated with incident malnutrition in the bivariate analyses. Like in the cross-sectional analysis, adjustments for age, number of comorbidities and living status before admission had little influence (appendix 2). In the full model a clear trend was seen for an increased risk of becoming malnourished for all behaviour and cognitive problems, although only for DRS this was statistically significant (HR:1.72 [95%CI: 1.00-2.96]).

In women, small differences were seen between *'newly-admitted'* (n=1227) and *'existing'* residents (n=2321) (Table 4). In the bivariate analysis, all behavioural-cognitive problems (except DRS in both groups and RISE in *'newly-admitted'* female residents) were significantly associated with incident malnutrition. In the full model, only communication problems remained independently associated with becoming malnourished in *'newly-admitted'* female residents (CS HR:2.32 [95%CI: 1.40-3.86]). No clear trend was seen for the other behaviour and cognitive problems.

Having more behaviour and cognitive problems was related to a higher risk of becoming malnourished. In *'newly-admitted'* male residents this was not observed, but in *'existing'* male residents as well in both female groups this was observed (p-value test for trend <0.001). Especially in 'existing' male residents high HRs were observed, with HR's ranging from 6.03-9.88 for 4-5 behaviour and cognitive problems. In female residents, we found an increased risk of malnutrition in residents with 1-3 behavioural-cognitive problems (HR's ranging from 1.05-1.66), and this was even stronger for residents with 4-5 problems (HR's ranging from 2.71-3.55) (Table 4).

Table 3, *Characteristics included participants for prospective analysis stratified by gender, assessment type and their nutritional status.*

	'Admission assessments' in *'newly-admitted'* residents' N=1826				'Delayed first assessments' in *'existing'* residents N=3152				
	Male N=599 (41.9)		Female N=1227 (28.8)		Male N=831 (58.1)		Female N=2321 (71.2)		Total N=4,978
	Became Malnourished N=41 (6.8)	Stayed well-nourished N=558 (93.2)	Became Malnourished N=103 (8.3)	Stayed well-nourished N=1124 (91.7)	Became Malnourished N=65 (7.8)	Stayed well-nourished N=766 (92.2)	Became Malnourished N=234 (10.1)	Stayed well-nourished N=2087 (89.9)	
Age (years)	84.3 (6.5)	81.7 (6.6)	83.5 (6.5)	83.7 (6.8)	82.2 (7.0)	82.5 (7.5)	86.5 (6.7)	84.8 (6.8)	83.9 (7.0)
≤ 89 years	31 (75.6)	500 (89.6)	83 (80.6)	909 (80.9)	56 (86.2)	636 (83.0)	149 (63.7)	1542 (73.9)	3906 (78.5)
≥ 90 years	10 (24.4)	58 (10.4)	20 (19.4)	215 (19.1)	9 (13.8)	130 (17.0)	85 (36.3)	545 (26.1)	1072 (21.5)
BMI (kg/m^2)	23.0 (2.4)	25.8 (3.9)	21.8 (2.1)	25.7 (4.5)	22.8 (2.6)	25.8 (3.8)	22.3 (2.5)	26.3 (4.6)	25.7 (4.4)
Living status before admission									
Alone	18 (43.9)	278 (49.8)	74 (71.8)	802 (71.4)	36 (55.4)	375 (49.0)	170 (72.6)	1451 (69.5)	3204 (64.4)
Together	23 (56.1)	278 (49.8)	28 (27.2)	316 (28.1)	28 (43.1)	385 (50.3)	62 (26.5)	605 (29.0)	1725 (34.7)
Missing	0	2 (0.4)	1 (1.0)	6 (0.5)	1 (1.5)	6 (0.8)	2 (0.9)	31 (1.5)	49 (1.0)
Diseases									
≤ 1	16 (39.0)	208 (37.7)	36 (35.0)	436 (38.8)	25 (38.5)	292 (38.1)	93 (39.7)	805 (38.6)	1911 (38.4)
≥ 2	25 (61.0)	350 (62.7)	67 (65.0)	688 (61.2)	40 (61.5)	474 (61.9)	141 (60.3)	1282 (61.4)	3067 (61.6)
CS									
≤ 2	31 (75.6)	403 (72.2)	62 (60.2)	873 (77.7)	34 (52.3)	537 (70.1)	158 (67.5)	1544 (74.0)	3642(73.2)
≥ 3	10 (24.4)	155 (27.8)	41 (39.8)	250 (22.2)	31 (47.7)	227 (29.6)	76 (32.5)	543 (26.0)	1333 (26.8)
Missing	0	0	0	1 (0.1)	0	2 (0.3)	0	0	3 (0.1)
DRS									
≤ 2	32 (78.0)	427 (76.5)	72 (69.9)	804 (71.5)	34 (52.3)	539 (70.4)	154 (65.8)	1357 (65.0)	3419 (68.7)
≥ 3	9 (22.0)	127 (22.8)	30 (29.1)	318 (28.3)	31 (47.7)	225 (29.4)	80 (34.2)	725 (34.7)	1545 (31.0)
Missing	0	4 (0.7)	1 (1.0)	2 (0.2)	0	2 (0.3)	0	5 (0.2)	14 (0.3)
RISE									
	12 (29.3)	132 (23.7)	24 (23.3)	241 (21.4)	30 (46.2)	230 (30.0)	71 (30.3)	527 (25.3)	1267 (25.5)
≤ 2	29 (70.7)	422 (75.6)	79 (76.7)	879 (78.2)	35 (53.8)	534 (69.7)	163 (69.7)	1554 (74.5)	3695 (74.2)
≥ 3	0	4 (0.7)	0	4 (0.4)	0	2 (0.3)	0	6 (0.3)	16 (0.3)
Missing									

Table 3, *Characteristics included participants for prospective analysis stratified by gender, assessment type and their nutritional status.* (*continued*)

	'Admission assessments' in *'newly-admitted'* residents' N=1826				'Delayed first assessments' in *'existing'* residents N=3152				
	Male N=599 (41.9)		Female N=1227 (28.8)		Male N=831 (58.1)		Female N=2321 (71.2)		Total N=4,978
ABS									
0	32 (78.0)	400 (71.7)	73 (70.9)	884 (78.6)	30 (46.2)	504 (65.8)	169 (72.2)	1566 (75.0)	3658 (73.5)
≥ 1	9 (22.0)	158 (28.3)	30 (29.1)	238 (21.2)	35 (53.8)	260 (33.9)	65 (27.8)	521 (25.0)	1316 (26.4)
Missing	0	0	0	2 (0.2)	0	2 (0.3)	0	0	4 (0.1)
CPS									
≤ 2	26 (63.4)	388 (69.5)	68 (66.0)	848 (75.4)	36 (55.4)	537 (70.1)	158 (67.5)	1498 (71.8)	3559 (71.5)
≥ 3	15 (36.6)	166 (29.7)	34 (33.0)	268 (23.8)	29 (44.6)	225 (29.4)	76 (32.5)	580 (27.8)	1393 (28.0)
Missing	0	4 (0.7)	1 (1.0)	8 (0.7)	0	4 (0.5)	0	9 (0.4)	26 (0.5)
Number of behavioural-cognitive problems									
0	15 (36.6)	224 (40.1)	36 (35.0)	494 (44.0)	11 (16.9)	257 (33.6)	77 (32.9)	790 (37.9)	1904 (38.2)
1	8 (19.5)	127 (22.8)	25 (24.3)	259 (23.0)	11 (16.9)	179 (23.4)	59 (25.2)	481 (23.0)	1149 (23.1)
2	10 (24.4)	80 (14.3)	13 (12.6)	168 (14.9)	11 (16.9)	129 (16.8)	37 (15.8)	332 (15.9)	780 (15.7)
3	5 (12.2)	68 (12.2)	13 (12.6)	117 (10.4)	11 (16.9)	102 (13.3)	22 (9.4)	257 (12.3)	595 (12.0)
4	3 (7.3)	48 (8.6)	11 (10.7)	56 (5.0)	15 (23.1)	61 (8.0)	26 (11.1)	155 (7.4)	375 (7.5)
5	0	11 (2.0)	5 (4.9)	29 (2.6)	6 (9.2)	36 (4.7)	13 (5.6)	72 (3.4)	172 (3.5)
Missing	0	0	0	1 (0.1)	0	2 (0.3)	0	0	3 (0.1)

All characteristics are number with percentage except age (years) and BMI (kg/m^2) which are presented as mean with standard deviation. Abbreviations: BMI (body mass index), CS (communication scale) DRS (depressive rating scale), RISE (revised index of social engagement), ABS (aggressive behaviour scale), CPS (cognitive performance scale)

Table 4, *Hazard ratio's for CPS, CS, DRS, RISE, ABS and total number of behavioural-cognitive problems in relation to malnutrition, stratified by gender and assessment type.*

	'Admission assessments' in *'newly-admitted'* residents		'Delayed first assessments' in *'existing'* residents	
	Bivariate analyses	Full model*	Bivariate analyses	Full model*
CS ref ≤ 2				
Male ≥ 3	1.02 (0.50-2.10)**†,**δ	0.69 (0.28-1.70)	2.94 (1.79-4.84)δ	1.67 (0.86-3.26)
Female ≥ 3	2.46 (1.65-3.67)**†**	2.32 (1.40-3.86)	1.83 (1.39-2.41)	1.44 (0.97-2.14)
DRS ref ≤ 2				
Male ≥ 3	1.14 (0.54-2.41)δ	1.05 (0.48-2.30)	2.55 (1.56-4.18)**†,**δ	1.72 (1.00-2.96)
Female ≥ 3	1.15 (0.75-1.76)	0.76 (0.46-1.24)	1.11 (0.85-1.46)**†**	0.94 (0.70-1.26)
RISE ref ≥ 3				
Male ≤ 2	1.27 (0.65-2.50)	1.39 (0.70-2.76)	1.92 (1.18-3.12)	1.40 (0.84-2.33)
Female ≤ 2	1.26 (0.80-2.00)	1.02 (0.62-1.67)	1.49 (1.12-1.96)	1.27 (0.95-1.70)
ABS ref = 0				
Male ≥ 1	0.80 (0.38-1.70)δ**,†**	0.67 (0.30-1.51)	2.60 (1.59-4.24)δ**,†**	1.54 (0.86-2.74)
Female ≥ 1	1.61 (1.05-2.47)**†**	1.29 (0.80-2.08)	1.39 (1.04-1.85)**†**	1.14 (0.82-1.58)
CPS ref ≤ 2				
Male ≥ 3	1.47 (0.77-2.79)	2.17 (0.95-4.97)	2.75 (1.67-4.52)	1.42 (0.72-2.80)
Female ≥ 3	1.78 (1.17-2.68)	1.06 (0.63-1.78)	1.74 (1.32-2.29)	1.33 (0.90-1.98)
Number of behavioural-cognitive problems Male				
0	Ref.**†,**δ	Ref.	Ref.**†,**δ	Ref.
1	0.81 (0.34-1.92)	0.81 (0.34-1.93)	1.76 (0.76-4.07)	1.78 (0.77-4.12)
2	1.64 (0.73-3.66)	1.67 (0.74-3.80)	2.36 (1.02-5.45)	2.48 (1.06-5.77)
3	1.71 (0.61-4.82)	1.70 (0.60-4.84)	3.42 (1.47-7.93)	3.42 (1.46-8.01)
4	1.08 (0.31-3.76)	1.05 (0.30-3.71)	8.80 (3.99-19.45)	9.88 (4.40-22.21)
5	N.A.	N.A.	5.94 (2.18-16.21)	6.03 (2.18-16.72)
P-value test for trend	0.564	0.548	<0.001	<0.001
Number of behavioural-cognitive problems Female				
0	Ref.**†**	Ref.	Ref.**†**	Ref.
1	1.36 (0.82-2.28)	1.33 (0.80-2.23)	1.46 (1.04-2.05)	1.42 (1.01-1.99)
2	1.11 (0.59-2.10)	1.05 (0.55-2.00)	1.42 (0.96-2.10)	1.49 (1.00-2.22)
3	1.71(0.90-3.23)	1.66 (0.87-3.17)	1.25 (0.77-2.03)	1.29 (0.79-2.10)
4	3.54 (1.79-7.00)	3.55 (1.79-7.05)	2.58 (1.65-4.03)	2.71 (1.70-4.32)
5	2.97 (1.16-7.58)	2.78 (1.07-7.24)	2.79(1.55-5.04)	3.06 (1.67-5.61)
P-value test for trend	0.001	0.001	<0.001	<0.001

Data is shown as Hazard ratios with 95% confidence interval.

Abbreviations: CS (communication scale) DRS (depressive rating scale), RISE (revised index of social engagement), ABS (aggressive behaviour scale), CPS (cognitive performance scale), N.A. (Not applicable).

* For behavioural-cognitive scales, model consist of: CS, DRS, RISE, ABS, CPS, age category (≤ 89 years vs. ≥ 90 years), number of comorbidities (≤1 vs. ≥2) and living status before admission (alone vs. together). For total number of behavioural-cognitive problems, model consist of total number of behavioural-cognitive problems, age category (≤ 89 years vs. ≥ 90 years), number of comorbidities (≤1 vs. ≥2) and living status before admission (alone vs. together).

† significant interaction term (p<0.10) between behavioural-cognitive problem and gender

δ significant interaction term (p<0.10) between behavioural-cognitive problem and type of first assessment

Discussion

Our results show that approximately 9.5% of all LTCF residents with behaviour and cognitive problems are malnourished at admission and another 8.8% become malnourished during stay. The more behaviour and cognitive problems, the higher the risk of developing malnutrition.

Our data indicate that behaviour and cognitive problems are related with incident malnutrition in both men and women. For male residents in the cross-sectional and in the prospective analyses of '*newly-admitted*' residents, no clear relation with malnutrition was seen for most behaviour-cognitive problems. However, among '*existing*' residents, a clear relation between behaviour-cognitive problems and malnutrition was observed, indicating that the manifestation is later in men. In female residents, such a difference between '*newly-admitted*' and '*existing*' residents was not seen and their risk was more stable over time.

As was seen in the cross-sectional analyses, male residents are entering LTCFs in a better nutritional state compared to women. We hypothesize that this could be explained by the home situation before admission; women traditionally prepare meals, and take care of their husbands with behavioural-cognitive problems. The other way around is usually more problematic, as older men generally lack cooking skills [213]. Male residents were more frequently living with a partner or children and might therefore have been better taken care of before admission to LTCF, and this may explain the lower malnutrition rates at admission. This effect seemed to decrease over time and malnutrition developed in male *'existing'* residents as well. We thus suggest to take preventative measures in the first year after admission to LTCF.

Our statistical models showed attenuating associations when all behaviour and cognitive problems were included. The attenuation of all effect-sizes within a model can only be explained by the presence of multiple behavioural-cognitive problems within one person. Indeed, most residents with behaviour and cognitive problems had more than one problem, which reflects reality; the more problems, the higher the risk to be become malnourished. This may explain the observed loss of significance after including all problems in the model. Interventions to prevent malnutrition should therefore especially focus on residents with multiple behaviour and cognitive problems.

The prevalence of malnutrition at admission in our sample was 9.5% which was lower compared to a recent meta-analysis[67] where 17.5% was malnourished. However, in the meta-analysis most studies assessed malnutrition during stay, which also includes

long-stay residents. In addition, different definitions of malnutrition were used: the review was based on screening tool outcomes, while we used the ESPEN 2015 definition, which strongly relies on BMI. As BMI is relatively high in older adults, the ESPEN 2015 definition is thought to underestimate the prevalence of malnutrition [214]. For incidence rates, the underestimation might be even stronger. During stay, residents with overweight/obesity are not likely to lose weight to the extent that they fall below the cut-off points from the ESPEN 2015 definition. Therefore, we suggest to implement the recently published GLIM criteria [47] in the InterRAI minimum dataset form in the future as these criteria rely less on BMI [214].

We decided not to adjust our analyses for BMI at first measurement. Within the ESPEN definition, a high BMI is protective for developing malnutrition in the future as one can only be categorized as malnourished by having a low age-specific BMI combined with recent weight loss, or by having a very low BMI (<18.5 kg/m^2). In accordance with this definition, weight loss alone will not trigger these cut-off values in older adults with a high BMI. By adjusting for BMI at baseline, a potential real protective effect of BMI would have been removed, and lead to over-adjustment.

To the best of our knowledge, this is the first study in a residential-care setting on the prospective associations between behavioural-cognitive problems and malnutrition. Two previous prospective studies in the community and sheltered-house setting reported significant associations between poor cognition and malnutrition [215,216]. In contrast, one study showed no such association but in this study a relatively high cut-off value for cognitive problems was used (MMSE<24) [217]. Previous research on the association between depression and malnutrition showed contrasting results as a significant association was seen in Schilp et al. [217], but not in Mamhidir et al. [216]. Neither study adjusted for other behavioural-cognitive problems, while we have shown that the combination of problems increases the risk.

For most behaviour and cognitive problems, a stronger relation with malnutrition was seen in the prospective analysis compared to the cross-sectional analysis. This probably is because behavioural-cognitive problems are progressive over time [218–220], and this is thought to directly affect the risk of malnutrition i.e. the worse the condition of the resident, the higher the malnutrition risk. At admission, most residents still have mild or moderate cognitive problems [221] and consequences regarding malnutrition can easily be addressed by regular care [222]. However, during stay, residents are known to further lose cognitive functions and to become more care dependent [223]. Severe cognitive decline or dementia can even result in swallowing and chewing problems, and refusal to eat and drink [224]. These problems require extensive individualized care.

For daily care, we suggest to routinely check whether standard nutritional care is still sufficient in the light of someone's cognitive decline or if more individualized care is needed.

Strengths and weaknesses

Strong points of our study were the large number of residents and large total follow-up years.

The mean follow-up period per person of approximately one year may be relatively short for a prospective study on malnutrition, but is in accordance with the average length of stay in a LTCF. We excluded residents with end-stage disease, i.e. terminally ill residents with a life expectancy <6 months, at their first or last measurement to exclude residents with incurable malnutrition. In general, treatment of malnutrition in nursing homes, either curative or palliative, should be guided by the stage of life of residents and their personal wishes to be treated [225].

A weakness of our data may be the relative long interval between measurements. Unobserved changes in nutritional status may have taken place between two measurements. On the other hand, nutritional status of most persons is relatively stable. Furthermore, we used dichotomized outcomes for all behaviour-cognitive problems as this better reflects the clinical situation. Note that for ABS four categories are described in the validation paper (0, 1-2, 3-5, ≥6) but we did not have enough power in the 3-5 and ≥6 category, hence we decided to dichotomize it in ABS problems present no/yes (ABS=0 vs. ABS ≥1) [210]. Lastly, we used cognitive status at first available measurement as independent variable. Residents without behaviour and cognitive problems at first assessment could have developed these problems during their stay. This could have led to an underestimation of the effect sizes.

Conclusion

Residents in LTCF with behaviour and cognitive problems are at an increased risk of being malnourished at admission and to become malnourished during stay, and more specifically during long-term stay. Male residents with behaviour and cognitive problems are in better nutritional condition at admission and seem to develop malnutrition in a later stage compared to female residents. This emphasizes the need of early identification and treatment of malnutrition in residents with behavioural-cognitive problems.

CHAPTER 7

Diseases, health-related problems and the incidence of malnutrition in long-term care facilities.

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Not submitted yet

Abstract:

Background & Aims: Disease and malnutrition are known to co-occur in residents of long-term care facilities (LTCF). Prospective data on the association between diseases and the incidence of malnutrition are so far lacking. We assessed which diseases and health-related problems are associated with malnutrition at admission and during stay and how different definitions of malnutrition affect these associations.

Methods: Data of Dutch LTCF residents were obtained from the InterRAI-LTCF instrument (period 2005-2020). We analysed the association of presence of diseases (diabetes, cancer, pressure ulcers, neurological, musculoskeletal, psychiatric, cardiac- infectious- and pulmonary diseases) and health-related problems (aspiration, fever, peripheral oedema, aphasia, pain, supervised/assisted eating, balance-, psychiatric-, GI tract-, sleep-, dental- and locomotion problems) with malnutrition at admission (n=3713) as well as with the incidence of malnutrition during stay (n=3836, median follow-up ~1 year). Malnutrition was defined by three separate (sets of) variables: recent weight loss (WL), low age-specific BMI (BMI) and ESPEN 2015 definition (ESPEN). Associations were adjusted for gender, age, living status before admission, and admission year.

Results: Prevalence of malnutrition at admission ranged from 8.8% (WL) to 27.4% (BMI); during stay incident malnutrition ranged from 8.9% (ESPEN) to 13.8% (WL). At admission, most diseases (except cardiometabolic diseases) and health-related problems were associated with higher prevalence of malnutrition based on either criterion, but strongest with WL. This was also seen in the prospective analysis, but relationships were less strong compared to cross-sectional analysis.

Conclusion: A considerable number of diseases and health- related problems are associated with an increased prevalence of malnutrition at admission, as well as with incident malnutrition during stay in LTCFs. Low BMI is a good indicator of malnutrition at admission. The strongest relations between diseases and health-related problems were with WL. Therefore, we advise to use both BMI and WL at admission, and to closely monitor weight (changes) during stay.

Introduction

With the ageing population in Europe, the share of people aged >65yrs will increase to 30% in 2055 [226]. This process will lead to an increased number of frail, older adults who are highly care dependent [227]. The Dutch government policy aims to allow older adults to live at home for as long as possible. However, when care requirements become too high and care can no longer be provided at home, admission to a long-term care facility (LTCF) may be inevitable [190]. As a consequence, residents in LTCFs often suffer from multiple medical conditions such as dementia, neurological diseases, diabetes and cardiovascular diseases[228].

The high disease burden of residents in LTCFs increases their risk of becoming malnourished. Disease activity in older adults can reduce their ability to consume or digest food [61,229–231], while inflammation can increase protein and energy needs. Worldwide, about 17.5-28.7% of all residents in LTCFs is reported to be malnourished [67,232]. Malnutrition, in turn, can increase the risk of developing diseases, thus creating a perpetual circle [151].

As admission to a LTCF marks the latest phase in life, residential care should focus on function preservation and optimizing quality of life. A good nutritional status can contribute to this as malnutrition is associated with function loss and impaired quality of life [25,233,234]. To provide optimal nutritional care directly after admission and during stay, it is important to know which diseases are related to being or becoming malnourished. Previous studies have shown that several diseases (a.o. dementia, depression, cancer, pressure ulcers and COPD) and health-related problems (dysphagia, eating and chewing problems) are associated with malnutrition in LTCF residents [196,235]. However, most studies conducted so far used cross-sectional data, collected at a none-specified time-point during stay, providing no evidence about time of onset (before or after admission) of malnutrition. It is therefore unclear whether residents with diseases and health-related problems were already malnourished at admission, or became during stay.

In addition, previous studies used different criteria to assess malnutrition (recent weight loss, low BMI or the combination of both (ESPEN 2015 criteria [45])) which could have affected the results. For example, residents with cardiometabolic diseases, which are related to a high BMI, are not likely to trigger the cut-off value for low BMI despite recent weight loss. On the other hand, in slowly developing and chronic diseases like chronic pulmonary disease and neurological problems, weight loss may also occur slowly and therefore the criteria for malnutrition based on >5% of >10% reduction in body weight

over 1 or 6 months, respectively, will not be met. In addition, the reported prevalence rates are expected to represent an underestimation of malnutrition in LTCFs. At the same time, it remains unclear how different criteria to define malnutrition affect prevalence rates and which definitions can be used best to identify participants at risk of malnutrition at admission and during stay.

In this study we assessed the prevalence of diseases and health-related problems in LTCF residents at admission and during stay, and investigated heir relation to recent weight loss, low BMI or a combination of both.

Methods

Data source

For this research we used cross-sectional as well as prospective data obtained from the Dutch InterRAI database for Long-Term Care Facilities (InterRAI LTCF). These data have been previously described by our group [236].

InterRAI LTCF is an instrument for healthcare providers to systematically obtain information of about health conditions of LTCF residents. InterRAI LTCF is a so-called minimum dataset (MDS), firstly implemented in the Netherlands in 2005, covering up to ~50 facilities in 2020. Trained nurses use a standardized assessment form to assess resident's health status. The assessment form also contains questions regarding nutritional status (weight loss and BMI) and presence of diseases.

Each new resident is screened on average within a month after admission (admission assessment). Thereafter, follow-up assessments (same assessment form) are performed every 3-6 months. When a new LTCF first starts to use InterRAI, all existing residents are screened, despite not being recently admitted. This measurement can be seen as a 'delayed first assessment' in InterRAI.

Dutch InterRAI subjects (aged ≥ 65 years) living in LTCF between 2005 and 2020 were included in this study. Two groups were derived: the '*newly-admitted*' (those with an admission assessment) and the '*existing*' residents (those with a 'delayed first assessment'). So, the difference between these two groups is the time elapsed between their admission and first assessment, which was shorter in the *'newly-admitted'* group and longer in the '*existing*' residents' group.

In total, 4190 residents with an 'admission assessment' were available, median time to first assessment was 16 days [IQR: 7-30] after admission. In total 5592 residents with a 'delayed first assessment' were available and this assessment took place with a median time of 345 [IQR: 117 -914] days in male and 546 [IQR: 165-1363] days in female residents after their initial admission.

Inclusion criteria

Data of admission assessments ('*newly-admitted*' residents) were used to provide an overview of characteristics of the residents at admission and to perform cross-sectional analyses. Inclusion criteria were age ≥ 65 years and data on BMI and weight loss available. Exclusion criterion was presence of end-stage disease, i.e. terminally ill residents with a life expectancy <6 months as indicated by the treating physician, to exclude residents with incurable malnutrition. Total number of included residents for cross-sectional analysis was 3713.

Prospective analyses were performed for residents (both *'newly-admitted'* and '*existing*') with more than one measurement available. In addition to the inclusion criteria described above, participants were excluded when being malnourished at first available measurement (defined as having low age-specific BMI <20 kg/m^2 for residents <70 years, or <22 kg/m^2 for residents ≥70, or having recent weight loss (5% body mass in the last 30 days or 10% in the last 180 days)), or having end stage disease at first or/and last available measurement. Total number of included residents for prospective analysis was 3836. Numbers and reasons for exclusion are shown in figure 1.

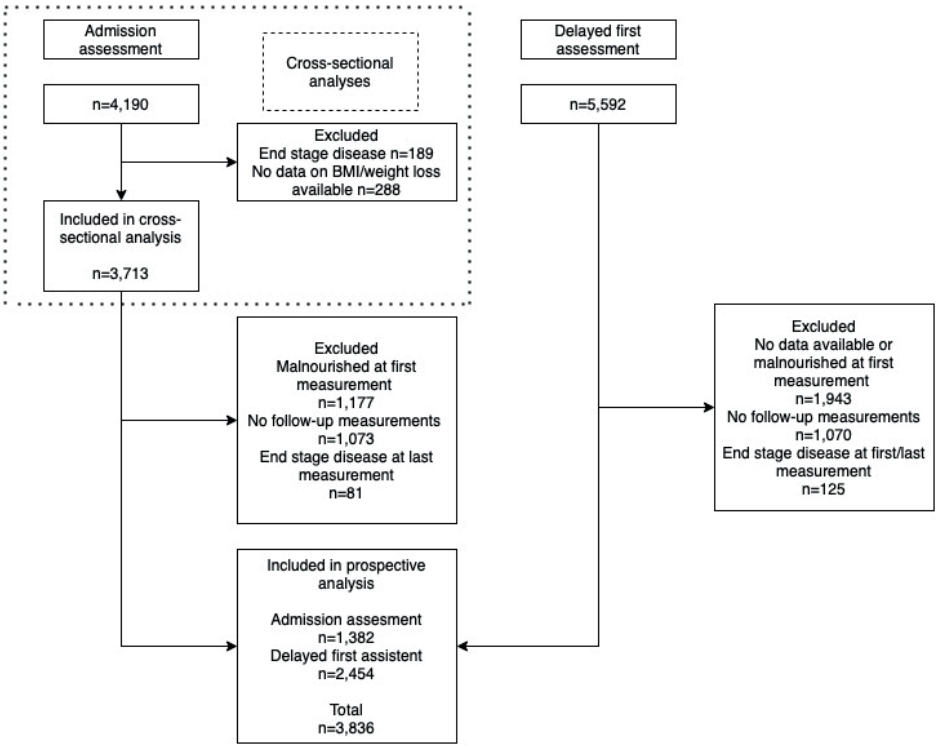


Figure 1, *flow diagram of in- and exclusion of residents for cross-sectional and prospective analysis*

Measurements

Diseases

Within InterRAI, only physician-documented diagnoses are registered by checkboxes on the assessment form [237]. The following disease groups are used (with sub diagnoses in parentheses): neurological diseases (Alzheimer's disease, other type of dementia, hemiplegia, paraplegia, quadriplegia, multiple sclerosis, Parkinson's disease, stroke/CVA), musculoskeletal diseases (hip or other fracture), cardiac diseases (coronary heart disease, congestive heart failure**)**, psychiatric disorders (anxiety, bipolar disorder, depression, schizophrenia), infectious diseases (pneumonia, urinary tract infection), diabetes, cancer, chronic pulmonary disease, and pressure ulcers.

Health-related problems

Checkboxes are used in InterRAI to indicate the following health-related problems (with sub diagnoses in parentheses): balance problems (falls last month, difficulties self-standing, difficulties turning around, dizziness, unsteady gait), psychiatric problems (abnormal thought process, delusions, hallucinations), GI tract problems (acid reflux,

constipation, diarrhoea, vomiting), sleep problems (difficulty falling/staying asleep, too much sleep), dental problems (broken teeth, mouth pain, dry mouth, chewing problems, gum inflammation), aphasia, pain, locomotion (independent/with walking devise/wheelchair/bedbound), eating help (independent (set-up help only)/supervised), aspiration, fever, peripheral oedema.

Malnutrition

Three different (sets of) criteria for malnutrition were used: recent weight loss, low age-specific BMI and the ESPEN 2015 definition for malnutrition[45]. Recent weight loss (WL) was defined as a loss of 5% body mass in the last 30 days or 10% in the last 180 days. For low age-specific BMI (BMI) a cut-off value of <20 kg/m^2 was used for residents younger than 70 years and <22 kg/m^2 was used for residents 70 years or older[45,47]. The ESPEN 2015 criteria (ESPEN) consist of having either low age specific BMI ánd weight loss, or having very low BMI (<18.5 kg/m^2).

Statistical analyses

All analyses were performed using SPSS 25. Descriptive statistics (mean with SD, or number with percentage) were used to describe characteristics of residents. Continuous data was checked for normality by using QQ-plots and stem-and-leaf plots.

Logistic regression models were used for all cross-sectional analyses. In these analyses on '*newly-admitted*' residents, diseases and health-related problems, dichotomized in having 0 or ≥ 1 disease within one disease group, were used as independent variables and three criteria for malnutrition (WL, BMI or ESPEN) as separate dependent variables. Gender, age, age, year of admission (2005-2009, 2010-2014, 2015-2020) and living status before admission were added as covariates in the multiple logistic regression models as these factors are known to be related with malnutrition [67].

For the prospective analyses, the time to event (being malnourished) was defined in days as measured from the first available assessment till the first follow-up measurement when a resident was categorized as being malnourished. If a resident was categorized malnourished, all further follow-up measurements were ignored. If a resident was not malnourished in any follow-up measurement, the resident was censored at his latest measurement.

Results were visualized by Kaplan-Meier curves to check for the proportional hazard assumption. Thereafter, Cox proportional hazard regression analyses were performed with diseases and health-related problems as independent variables and the three criteria for malnutrition (WL, BMI and ESPEN) as separate dependent variables, adjusting for

gender, age, year of admission (2006-2009, 2010-2014, 2015-2020) and living status before admission.

Post-hoc analysis, were performed to test the association between total number of diseases/health-related problems (total numbers were based on previously described categories) and malnutrition.

Effect-modification

A previous study on this data performed by our group showed effect modification by gender and type of first assessment ('admission assessment' vs. 'delayed first assessment') [236]. Therefore, effect modification was tested based on interaction terms between diseases/health-related problems and gender, and type of first assessment. As none of these terms were significant ($p<0.05$), results were not stratified.

Results

Cross-sectional analyses at admission

As shown in table 1, most residents were female (67.6%), with mean age 83.1 year (SD:7.1), had a normal BMI (mean 24.7 kg/m^2, SD:4.6) and were living alone before admission (64.3%). Most frequently reported diseases and health-related problems were balance problems (70.6%) and neurological diseases (65.4%). On average, residents had 4.6 (SD:2.3) diseases.

Prevalence of malnutrition varied from 8.8% (recent weight loss) to 27.5% (low age-specific BMI). Based on the ESPEN definition, 9.5% of all residents were malnourished. As shown in figure 1, within the population that was malnourished based on the ESPEN definition, most (69.5%) had a very low BMI (<18.5 kg/m^2). In total, 31.7% were malnourished based on any definition.

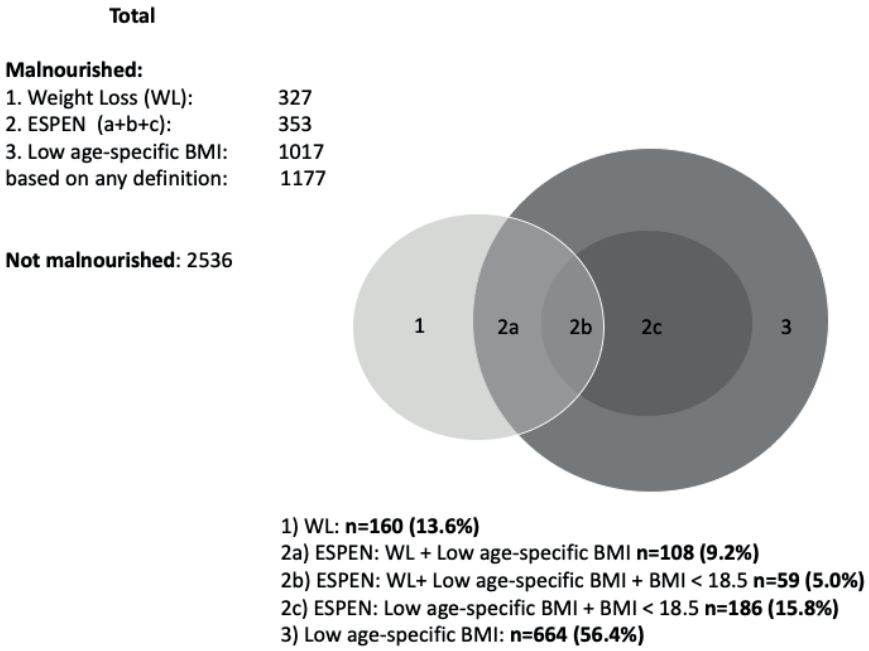


Figure 2, *malnourished residents stratified per definition of malnutrition*

At admission, nearly all diseases and health-related problems were associated with higher prevalence of malnutrition defined by WL (Table 2). The strongest associations were found for being bedbound (OR: 4.80 [95%CI: 2.90-7.96]), having pressure ulcers (OR: 2.33 [95%CI: 1.68-3.22]) or having fever (OR:2.22 [95%CI: 1.02-4.83]).

When malnutrition was defined by either low BMI or ESPEN, results were differently. Cardiac diseases, diabetes, peripheral oedema and walking with a walking devise were associated with a lower prevalence of malnutrition.

Diseases and health-related problems that were strongest related to being malnourished based on ESPEN were being bedbound (OR:2.10 [95%CI: 1.26-3.48]), pressure ulcers (OR:1.81 [95%CI: 1.30-2.53]) and supervised eating (OR: 1.63 [95%CI: 1.28-2.07]). For all associations, comparable results were seen for low BMI and ESPEN but odds ratios were smaller for low BMI.

Post-hoc analysis showed that an increased number of diseases/health-related problems was associated with higher prevalence of malnutrition based on WL (OR: 1.21 [95%CI: 1.15-1.27]). This was also seen for ESPEN, although to a lesser extent (1.06 [95%CI: 1.01-1.16]), but not for low BMI.

Table 1, Characteristics of included participants for cross-sectional analyses at admission to a LTCF ('newly-admitted' residents), stratified by weight loss, low BMI and ESPEN criteria for malnutrition.

	Weight loss		Low BMI		ESPEN		Total
	Weight loss not present	Weight loss Present	Normal/ high BMI	Low BMI	Well-nourished	Malnourished	
N (%)	3386 (91.2)	327 (8.8)	2696 (72.6)	1017 (27.4)	3360 (90.5)	353 (9.5)	N=3713
Gender							
Men	1087 (32.1)	119 (36.4)	946 (35.1)	260 (25.6)	1119 (32.3)	87 (24.6)	1206 (32.5)
Women	2299 (67.9)	208 (63.6)	1750 (64.9)	757 (74.4)	2241 (66.8)	266 (75.4)	2507 (67.5)
Age (years) (mean, SD)	83.1 (SD:7.1)	83.5 (SD:7.0)	82.8 (SD:7.1)	84.1 (SD:6.8)	83.1 (SD:7.1)	83.9 (SD:7.0)	83.1 (SD:7.0)
< 90 years							
≥ 90 years	2777 (82.0) 609 (18.0)	266 (81.3) 61 (18.7)	2256 (83.7) 440 (16.3)	787 (77.4) 230 (22.6)	2772 (82.5) 588 (17.5)	271 (76.8) 82 (23.2)	3043 (82.0) 670 (18.0)
BMI (mean, SD)	24.9 (SD:4.5)	22.4 (SD:4.7)	26.6 (SD:3.9)	19.7 (SD:1.7)	25.4 (SD:4.3)	18.1 (SD:1.8)	24.7 (SD:4.6)
Living status before admission							
Alone	2181 (64.4)	209 (63.9)	1703 (63.2)	687 (67.6)	2155 (64.1)	235 (66.6)	2390 (64.7)
Together	1191 (35.2)	115 (35.2)	980 (36.4)	326 (32.1)	1189 (35.4)	117 (33.1)	1306 (35.3)
Admission year							
2005-2009	977 (28.9)	109 (33.3)	764 (28.3)	322 (31.7)	969 (28.8)	117 (33.1)	1086 (29.2)
2010-2014	812 (24.0)	88 (26.9)	675 (25.0)	225 (22.1)	809 (24.1)	91 (25.8)	900 (24.2)
2015-2020	1597 (47.2)	130 (39.8)	1257 (46.6)	470 (46.2)	1582 (47.1)	145 (41.1)	1727 (46.5)
Diseases							
Neurological diseases	2226 (65.7)	203 (62.1)	1767 (65.5)	662 (65.1)	2213 (65.9)	216 (61.2)	2429 (65.4)
Musculoskeletal diseases	242 (7.1)	26 (8.0)	189 (7.0)	938 (92.2)	239 (7.1)	29 (8.2)	268 (7.2)
Cardiac diseases	878 (25.9)	99 (30.3)	725 (26.9)	252 (24.8)	900 (26.8)	77 (21.8)	977 (26.3)
Psychiatric disorders	626 (18.5)	63 (19.3)	480 (17.8)	209 (20.6)	609 (18.1)	80 (22.7)	689 (18.6)
Infectious diseases	450 (13.3)	72 (22.0)	367 (13.6)	155 (15.2)	469 (14.0)	53 (15.0)	522 (14.1)
Diabetes	658 (19.4)	73 (22.3)	607 (22.5)	124 (12.2)	693 (20.6)	38 (10.8)	731 (19.7)
Cancer	285 (8.4)	51 (15.6)	238 (8.8)	98 (9.6)	297 (8.8)	39 (11.0)	336 (9.0)
Chronic pulmonary disease	362 (10.7)	42 (12.8)	290 (10.8)	114 (11.2)	354 (10.5)	50 (14.2)	404 (10.9)
Pressure ulcers	256 (7.6)	53 (16.2)	205 (7.6)	104 (10.2)	262 (7.8)	47 (13.3)	309 (8.3)
Health-related problems							
Balance problems	2360 (69.7)	261 (79.8)	1893 (70.2)	728 (71.6)	2358 (70.2)	263 (74.5)	2621 (70.6)
Psychiatric problems	678 (20.0)	70 (21.4)	518 (19.2)	230 (22.6)	661 (19.7)	87 (24.6)	748 (20.1)
GI tract problems	885 (26.1)	122 (37.3)	709 (26.3)	298 (29.3)	892 (26.5)	115 (32.6)	1007 (27.1)
Sleep problems	1057 (31.2)	127 (38.8)	844 (31.3)	340 (33.4)	1065 (31.7)	119 (33.7)	1184 (31.9)
Dental problems	649 (19.2)	92 (28.1)	519 (19.3)	222 (21.8)	650 (19.3)	91 (25.8)	741 (20.0)
Aspiration	146 (4.3)	25 (7.6)	115 (4.3)	56 (5.5)	142 (4.2)	29 (8.2)	171 (4.6)
Fever	37 (1.1)	8 (2.4)	31 (1.1)	14 (1.4)	40 (1.2)	5 (1.4)	45 (1.2)

Table 1, Characteristics of included participants for cross-sectional analyses at admission to a LTCF ('newly-admitted' residents), stratified by weight loss, low BMI and ESPEN criteria for malnutrition. (*continued*)

	Weight loss		Low BMI		ESPEN		Total
	Weight loss not present	Weight loss Present	Normal/ high BMI	Low BMI	Well-nourished	Malnourished	
Peripheral oedema	628 (18.5)	63 (19.3)	550 (20.4)	141 (13.9)	645 (19.2)	46 (13.0)	691 (18.6)
Aphasia	351 (10.4)	39 (11.9)	290 (10.8)	100 (9.8)	356 (10.6)	34 (9.6)	390 (10.5)
Pain	1269 (37.5)	156 (47.7)	1047 (38.8)	378 (37.2)	1291 (38.4)	134 (38.0)	1425 (38.4)
Locomotion							
Independently	630 (18.6)	47 (14.4)	466 (17.3)	211 (20.7)	610 (18.2)	67 (19.0)	677 (18.2)
With walking devise	1844 (54.5)	153 (46.8)	1487 (55.2)	510 (50.1)	1833 (54.6)	164 (46.5)	1997 (53.8)
Wheelchair							
Bedbound	805 (23.8)	93 (28.4)	656 (24.3)	242 (23.8)	803 (23.9)	95 (26.9)	898(24.2)
	97 (2.9)	33 (10.1)	80 (3.0)	50 (4.9)	103 (3.1)	27 (7.6)	130 (3.5)
Supervised/ assisted eating	749 (22.1)	113 (34.6)	583 (21.6)	279 (27.4)	749 (22.3)	113 (32.0)	862 (23.2)
Number of diseases	4.4 (SD:2.3)	5.4 (SD:2.5)	4.4 (SD: 2.3)	4.5 (SD:2.3)	4.4 (SD: 2.3)	4.7 (SD: 2.4)	4.6 (SD:2.3)

All characteristics are number with percentage except age (years), BMI (kg/m^2) and number of diseases which are presented as mean with standard deviation.

Weight loss: a loss of 5% body mass in the last 30 days or 10% in the last 180 days. **Low BMI**: <20 kg/m2 for residents younger then 70 years and <22 kg/m2 for residents 70 years or older. **ESPEN**: Very low BMI (<18.5 kg/m^2) or weight loss combined with low age-specific BMI as described hereabove.

Table 2, *Crude and adjusted odds ratio's for diseases/health-related problems and malnutrition, based on weight loss, low BMI and ESPEN criteria for malnutrition on admission to LTCF ('newly-admitted' residents).*

	Weight loss		Low BMI		ESPEN	
	OR	Adjusted OR*	OR	Adjusted OR*	OR	Adjusted OR*
Diseases						
Neurological diseases	0.85 [0.67-1.08]	0.89 [0.70-1.14]	0.98 [0.85-1.14]	1.03 [0.88-1.21]	0.82 [0.65-1.02]	0.89 [0.70-1.12]
Musculoskeletal diseases	1.12 [0.74-1.71]	1.04 [0.67-1.61]	1.11 [0.85-1.46]	1.04 [0.78-1.38]	1.17 [0.78-1.74]	1.03 [0.68-1.56]
Cardiac diseases	1.24 [0.97-1.59]	1.23 [0.96-1.58]	0.89 [0.75-1.05]	0.88 [0.75-1.04]	0.76 [0.58-0.98]	0.76 [0.58-0.99]
Psychiatric disorders	1.06 [0.79-1.41]	1.08 [0.81-1.45]	1.19 [0.99-1.43]	1.17 [0.97-1.40]	1.32 [1.01-1.72]	1.29 [0.99-1.69]
Infectious diseases	1.84 [1.39-2.43]	1.82 [1.37-2.42]	1.13 [0.92-1.39]	1.10 [0.90-1.36]	1.08 [0.80-1.48]	1.04 [0.76-1.42]
Diabetes	1.19 [0.91-1.57]	1.19 [0.90-1.57]	0.48 [0.39-0.59]	0.50 [0.41-0.62]	0.46 [0.33-.066]	0.49 [0.35-0.69]
Cancer	2.01 [1.45-2.77]	1.99 [1.44-2.75]	1.10 [0.86-1.41]	1.14 [0.88-1.46]	1.27 [0.89-1.81]	1.32 [0.92-1.88]
Chronic pulmonary disease	1.23 [0.87-1.73]	1.19 [0.84-1.69]	1.04 [0.83-1.31]	1.10 [0.88-1.39]	1.40 [1.02-1.93]	1.47 [1.07-2.03]
Pressure ulcers	2.36 [1.71-3.25]	2.33 [1.68-3.22]	1.37 [1.07-1.76]	1.36 [1.06-1.75]	1.81 [1.30-2.52]	1.81 [1.30-2.53]
Health-related problems						
Balance problems	1.72 [1.30-2.27]	1.77 [1.33-2.34]	1.07 [0.91-1.25]	1.05 [0.89-1.23]	1.24 [0.97-1.60]	1.23 [0.96-1.59]
Psychiatric problems	1.09 [0.83-1.44]	1.12 [0.85-1.48]	1.22 [1.02-1.45]	1.26 [1.05-1.51]	1.33 [1.03-1.72]	1.40 [1.08-1.81]
GI tract problems	1.68 [1.33-2.13]	1.70 [1.33-2.15]	1.15 [0.98-1.35]	1.14 [0.97-1.34]	1.33 [1.05-1.68]	1.32 [1.04-1.68]
Sleep problems	1.40 [1.10-1.76]	1.46 [1.15-1.86]	1.10 [0.94-1.28]	1.13 [0.97-1.32]	1.08 [0.86-1.37]	1.15 [0.91-1.46]
Dental problems	1.65 [1.28-2.13]	1.73 [1.33-2.24]	1.17 [0.98-1.40]	1.17 [0.97-1.40]	1.44 [1.12-1.85]	1.52 [1.17-1.96]
Aspiration	1.83 [1.18-2.85]	2.14 [1.36-3.36]	1.31 [0.95-1.82]	1.40 [1.00-1.96]	2.00 [1.32-3.02]	2.39 [1.56-3.67]
Fever	2.27 [1.05-4.91]	2.22 [1.02-4.83]	1.20 [0.63-2.26]	1.36 [0.72-2.58]	1.19 [0.47-3.03]	1.34 [0.52-3.43]
Peripheral oedema	1.05 [0.79-1.40]	1.11 [0.83-1.48]	0.64 [0.52-0.78]	0.59 [0.48-0.72]	0.64 [0.47-0.89]	0.62 [0.45-0.85]
Aphasia	1.17 [0.82-1.66]	1.19 [0.84-1.71]	0.91 [0.72-1.16]	0.97 [0.76-1.24]	0.90 [0.62-1.30]	0.96 [0.66-1.39]
Pain	1.52 [1.21-1.91]	1.62 [1.28-2.04]	0.93 [0.80-1.08]	0.91 [0.78-1.05]	0.98 [0.78-1.22]	0.97 [0.77-1.22]

Table 2, *Crude and adjusted odds ratio's for diseases/health-related problems and malnutrition, based on weight loss, low BMI and ESPEN criteria for malnutrition on admission to LTCF ('newly-admitted' residents).* (*continued*)

	Weight loss		Low BMI		ESPEN	
	OR	Adjusted OR*	OR	Adjusted OR*	OR	Adjusted OR*
Locomotion						
Independently	ref.	ref.	ref.	Ref.	ref.	Ref.
With walking devise	1.11 [0.79-1.56]	1.09 [0.77-1.54]	0.76 [0.63-0.92]	0.65 [0.53-0.79]	0.82 [0.61-1.10]	0.71 [0.52-0.97]
Wheelchair	1.55 [1.07-2.23]	1.45 [1.00-2.11]	0.81 [0.65-1.01]	0.72 [0.58-0.91]	1.08 [0.78-1.50]	0.95 [0.68-1.33]
Bedbound	4.56 [2.78-7.47]	4.80 [2.90-7.96]	1.37 [0.93-2.03]	1.16 [0.78-1.73]	2.39 [1.46-3.91]	2.10 [1.26-3.48]
Supervised/assisted eating	1.86 [1.46-2.37]	1.87 [1.46-2.39]	1.36 [1.15-1.60]	1.39 [1.17-1.64]	1.63 [1.29-2.07]	1.63 [1.28-2.07]
Number of diseasesδ	1.19 [1.14-1.25]	1.21 [1.15-1.27]	1.01 [0.98-1.04]	1.02 [0.98-1.05]	1.05 [1.01-1.10]	1.06 [1.01-1.11]

Data is shown as odds ratios with 95% confidence interval.
Weight loss: a loss of 5% body mass in the last 30 days or 10% in the last 180 days. **Low BMI**: <20 kg/m2 for residents younger then 70 years and <22 kg/m2 for residents 70 years or older. **ESPEN**: Very low BMI (<18.5 kg/m^2) or weight loss combined with low age-specific BMI as described hereabove.
* adjusted for age category (≤ 89 years vs. ≥ 90 years), gender, living status before admission (alone vs. together), year of admission (2005-2009, 2010-2014, 2015-2020).
δ used as continues variable with 0 diseases as reference category.

Prospective analyses

In total, 3836 unique residents had one or more follow-up measurements (Table 3). Total residents' follow-up time ranged from 5522 (low BMI) to 5772 years (ESPEN) with an individual median follow up time of ~1 year. The majority of the prospective cohort was female (69.8%), aged <90 years (80.0%) and had a relative high BMI (mean 27.0 kg/m^2, SD:3.9) as residents with a low age-specific BMI were excluded in these analyses. Most frequently described diseases/health-related problems were balance problems (66.7%) and neurological diseases (63.1%). On average, prevalence of diseases was comparable to the cross-sectional cohort. Incidence proportions of becoming malnourished during stay was 13.8% for WL, 11.3% for low BMI and 8.9% for the ESPEN criteria.

The effect sizes of the associations between diseases and/health-related problems and three criteria for malnutrition were relatively comparable (Table 4). Neurological diseases, infectious diseases, balance problems, psychiatric problems, GI tract problems, sleep problems, dental problems, aphasia and supervised/assisted eating were all associated with (a trend towards) higher incidence of malnutrition, regardless the malnutrition criterion used. In contrast to the cross-sectional analysis, diabetes showed only a minor lower

risk for developing malnutrition based on BMI (HR: 0.73 [95%CI: 0.56-0.93]) and ESPEN (HR: 0.88 [95%CI: 0.63-1.24], and this was not seen for WL (HR: 1.10 [95%CI: 0.90-1.35].

Post-hoc analysis showed that incidence of malnutrition increased with a higher number of diseases (HR's ranging from 1.07-1.13).

Table 3, *Characteristics of included participants for prospective analysis stratified by weight loss, low BMI and ESPEN criteria for malnutrition.*

	Weight loss Total follow-up: 5599 years median follow up: 366 days		Low BMI Total follow-up: 5522 years median follow up: 360 days		ESPEN Total follow-up: 5772 years median follow up: 372 days		Total
	Did not lose weight	Lost weight	Normal/ high BMI	Low BMI	Stayed Well-nourished	Became malnourished	
N (%)	3307 (86.2)	529 (13.8)	3401 (86.7)	435 (11.3)	3626 (91.1)	210 (8.9)	3836
Gender							
Men	997 (30.1)	195 (30.6)	1044 (30.7)	115 (26.4)	1101 (30.4)	58 (27.6)	1159 (30.2)
Women	2310 (69.9)	514 (69.4)	2357 (69.3)	320 (73.6)	2525 (69.6)	152 (72.4)	2677 (69.8)
Age (years) Mean (SD)	83.6 (SD:7.0)	83.9 (SD:6.8)	83.5 (SD:7.0)	84.5 (SD:6.9)	83.6 (SD:7.0)	85.0 (SD:6.6)	83.6 (SD:7.0)
					2913 (80.3)	154 (73.3)	
< 90 years	2634 (79.6)	560 (81.9)	2741 (80.6)	326 (74.9)	713 (19.7)	56 (26.7)	3067 (80.0)
≥ 90 years	673 (20.4)	149 (18.1)	660 (19.4)	109 (25.1)			769 (20.0)
BMI Mean (SD)	27.1 (SD:4.0)	26.7 (SD:3.6)	27.4 (SD:4.0)	24.0 (SD:1.9)	27.2 (SD:4.0)	24.3 (SD:1.7)	27.0 (SD:3.9)
Living status before admission							
Alone	2145 (64.9)	349 (66.0)	2205 (64.8)	289 (66.4)	2354 (64.9)	140 (66.7)	2494 (65.0)
Together	1151 (34.8)	180 (34.0)	1185 (34.8)	146 (33.6)	1261 (34.8)	70 (33.3)	1331 (34.7)
missing	11 (0.3)	0	11 (0.3)	0	11 (0.3)	0	11 (0.3)
Admission year							
2005-2009	1606 (48.6)	362 (68.4)	1669 (49.1)	299 (68.7)	1808 (49.9)	160 (76.2)	1968 (51.3)
2010-2014	792 (23.9)	96 (18.1)	814 (23.9)	74 (17.0)	858 (23.7)	30 (14.3)	888 (23.1)
2015-2020	909 (27.5)	71 (13.4)	918 (27.0)	62 (14.3)	960 (26.5)	20 (9.5)	980 (25.5)
Diseases							
Neurological diseases	2063 (62.4)	356 (67.3)	2128 (62.6)	291 (66.9)	2273 (62.7)	146 (69.5)	2419 (63.1)
Musculoskeletal diseases	168 (5.1)	18 (3.4)	170 (5.0)	16 (3.7)	182 (5.0)	4 (1.9)	186 (4.8)
Cardiac diseases	980 (29.6)	147 (27.8)	1013 (29.8)	114 (26.2)	1069 (29.5)	58 (27.6)	1127 (29.4)
Psychiatric disorders	780 (23.6)	129 (24.4)	811 (23.8)	98 (22.5)	867 (23.9)	42 (20.0)	909 (23.7)
Infectious diseases	365 (11.0)	73 (13.8)	381 (11.2)	57 (13.1)	407 (11.2)	41 (19.5)	438 (11.4)
Diabetes	716 (21.7)	127 (24.0)	769 (22.6)	74 (17.0)	802 (22.1)	41 (19.5)	843 (22.0)
Cancer	234 (7.1)	40 (7.6)	241 (7.1)	33 (7.6)	258 (7.1)	16 (7.6)	274 (7.1)

Table 3, *Characteristics of included participants for prospective analysis stratified by weight loss, low BMI and ESPEN criteria for malnutrition.* (*continued*)

	Weight loss Total follow-up: 5599 years median follow up: 366 days		Low BMI Total follow-up: 5522 years median follow up: 360 days		ESPEN Total follow-up: 5772 years median follow up: 372 days		Total
	Did not lose weight	Lost weight	Normal/ high BMI	Low BMI	Stayed Well-nourished	Became malnourished	
Chronic pulmonary disease	413 (12.5)	51 (9.6)	419 (12.3)	45 (10.3)	449 (12.4)	15 (7.1)	464 (12.1)
Pressure ulcers	203 (6.1)	17 (3.2)	196 (5.8)	24 (5.5)	210 (5.8)	10 (4.8)	220 (5.7)
Health-related problems							
Balance problems	2190 (66.2)	369 (69.8)	2268 (66.7)	291 (66.9)	2410 (66.5)	149 (71.0)	2559 (66.7)
Psychiatric problems	743 (22.5)	151 (28.5)	769 (22.6)	125 (28.7)	827 (22.8)	67 (31.9)	894 (23.3)
GI tract problems	1004 (30.4)	192 (36.3)	1041 (30.6)	155 (35.6)	1115 (30.8)	81 (38.6)	1196 (31.2)
Sleep problems	1027 (31.1)	210 (39.7)	1084 (31.9)	153 (35.2)	1153 (31.8)	84 (40.0)	1237 (32.2)
Dental problems	610 (18.4)	96 (18.1)	622 (18.3)	84 (19.3)	662 (18.3)	44 (21.0)	706 (18.4)
Aspiration	92 (2.8)	14 (2.6)	92 (2.7)	14 (3.2)	98 (2.7)	8 (3.8)	106 (2.8)
Fever	30 (0.9)	11 (2.1)	33 (1.0)	8 (1.8)	37 (1.0)	4 (1.9)	41 (1.1)
Peripheral oedema	748 (22.6)	140 (26.5)	794 (23.3)	94 (21.6)	838 (23.1)	50 (23.8)	888 (23.1)
Aphasia	353 (10.7)	67 (12.7)	371 (10.9)	49 (11.3)	392 (10.8)	28 (13.3)	420 (10.9)
Pain	1224 (37.0)	189 (35.7)	1253 (36.8)	160 (36.8)	1336 (36.8)	77 (36.7)	1413 (36.8)
Locomotion							
Independently	689 (20.8)	123 (23.4)	698 (20.5)	115 (26.4)	757 (20.9)	56 (26.7)	813 (21.2)
With walking devise	1847 (55.9)	304 (57.5)	1918 (56.4)	233 (53.6)	2038 (56.2)	113 (53.8)	2151 (56.1)
Wheelchair	703 (21.4)	98 (18.5)	720 (21.2)	81 (18.6)	762 (21.0)	39 (18.6)	801 (20.9)
Bedbound	64 (1.9)	2 (0.4)	61 (1.8)	5 (1.1)	65 (1.8)	1 (0.5)	66 (1.7)
Supervised/assisted eating	657 (19.9)	142 (26.8)	677 (19.9)	122 (28.0)	995 (21.9)	139 (31.4)	799 (20.8)
Number of diseases	4.4 (SD: 2.4)	4.8 (SD: 2.5)	4.5 (SD:2.4)	4.6 (SD:2.5)	4.4 (SD: 2.4)	4.9 (SD: 2.6)	4.5 (SD: 2.4)

All characteristics are number with percentage except age (years), BMI (kg/m2) and number of diseases which are presented as mean with standard deviation.

Weight loss: a loss of 5% body mass in the last 30 days or 10% in the last 180 days. **Low BMI**: <20 kg/m2 for residents younger then 70 years and <22 kg/m2 for residents 70 years or older. **ESPEN**: Very low BMI (<18.5 kg/m2) or weight loss combined with low age-specific BMI as described hereabove.

Table 4, Crude and adjusted* hazard ratio's (HR) for diseases /health-related problems and malnutrition based on, weight-loss, low BMI and ESPEN criteria for malnutrition.

	Weight loss		Low BMI		ESPEN	
	HR	Adjusted HR*	HR	Adjusted HR*	HR	Adjusted HR*
Diseases						
Neurological diseases	1.50 [1.24-1.80]	1.55 (1.29-1.87)	1.43 [1.17-1.75]	1.55 [1.27-1.91]	1.68 [1.25-2.26]	1.89 (1.40-2.54)
Musculoskeletal diseases	0.86 [0.54-1.37]	0.86 (0.54-1.37)	0.98 [0.59-1.61]	0.98 [0.59-1.61]	0.49 [0.18-1.32]	0.47 (0.18-1.28)
Cardiac diseases	1.04 [0.86-1.26]	1.06 (0.88-1.28)	0.95 [0.77-1.18]	0.96 [0.77-1.19]	1.04 [0.77-1.41]	1.04 (0.77-1.41)
Psychiatric disorders	1.06 [0.87-1.29]	1.06 (0.87-1.30)	0.94 [0.75-1.18]	0.94 [0.75-1.17]	0.80 [0.57-1.13]	0.81 (0.58-1.14)
Infectious diseases	1.34 [1.04-1.71]	1.30 (1.05-1.61)	1.27 [0.96-1.68]	1.23 [0.93-1.63]	1.46 [1.00-2.14]	1.41 (0.96-2.07)
Diabetes	1.09 [0.89-1.33]	1.10 (0.90-1.35)	0.69 [0.53-0.88]	0.72 [0.56-0.92]	0.83 [0.59-1.17]	0.88 (0.63-1.24)
Cancer	1.15 [0.84-1.59]	1.13 (0.82-1.56)	1.17 [0.82-1.66]	1.12 [0.79-1.60]	1.18 [0.71-1.97]	1.11 (0.67-1.86)
Chronic pulmonary disease	0.76 [0.56-1.01]	0.75 (0.56-1.00)	0.85 [0.62-1.15]	0.85 [0.63-1.16]	0.56 [0.33-0.94]	0.55 (0.33-0.94)
Pressure ulcers	0.69 [0.43-1.12]	0.68 (0.42-1.11)	1.19 [0.79-1.79]	1.15 [0.76-1.74]	1.05 [0.55-1.97]	1.03 (0.55-1.95)
Health-related problems						
Balance problems	1.41 (1.17-1.69)	1.43 (1.19-1.73)	1.16 [0.95-1.42]	1.14 [0.93-1.40]	1.47 [1.09-1.99]	1.49 (1.11-2.02)
Psychiatric problems	1.64 [1.35-1.98]	1.63 (1.35-1.97)	1.56 [1.27-1.93]	1.54 [1.25-1.90]	1.88 [1.41-2.52]	1.87 (1.40-2.51)
GI tract problems	1.36 [1.14-1.63]	1.35 (1.13-1.62)	1.29 [1.06-1.58]	1.24 [1.02-1.51]	1.49 [1.13-1.97]	1.42 (1.07-1.88)
Sleep problems	1.53 [1.29-1.83]	1.53 (1.29-1.83)	1.20 [0.99-1.47]	1.20 [0.98-1.46]	1.52 [1.15-2.00]	1.53 (1.16-2.02)
Dental problems	1.15 (0.92-1.44)	1.14 (0.91-1.42)	1.23 (0.97-1.56)	1.20 (0.94-1.52)	1.38 (0.99-1.92)	1.35 (0.96-1.88)
Aspiration	1.09 [0.64-1.85]	1.13 (0.66-1.93)	1.38 [0.81-2.35]	1.45 [0.85-2.48]	1.78 [0.88-3.62]	2.02 (0.99-4.13)
Fever	2.28 [1.25-4.14]	2.15 (1.18-3.92)	1.84 [0.92-3.71]	1.80 [0.90-3.64]	2.01 [0.75-5.41]	1.94 (0.72-5.23)
Peripheral oedema	1.18 [0.98-1.44]	1.18 (0.97-1.43)	0.90 [0.71-1.13]	0.87 [0.69-1.10]	1.04 [0.76-1.43]	1.01 (0.73-1.39)
Aphasia	1.31 [1.02-1.70]	1.31 (1.01-1.70)	1.11 [0.83-1.50]	1.16 [0.86-1.57]	1.39 [0.93-2.07]	1.50 (1.00-2.25)
Pain	1.08 (0.90-1.29)	1.10 (0.92-1.31)	1.09 (0.90-1.32)	1.09 (0.89-1.33)	1.11 (0.84-1.47)	1.13 (0.85-1.51)

Table 4, Crude and adjusted* hazard ratio's (HR) for diseases /health-related problems and malnutrition based on, weight-loss, low BMI and ESPEN criteria for malnutrition. (*continued*)

	Weight loss		Low BMI		ESPEN	
	HR	Adjusted HR*	HR	Adjusted HR*	HR	Adjusted HR*
Locomotion						
Independently	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
With walking devise	0.99	1.01	0.81	0.74	0.81	0.74
	(0.81-1.22)	(0.81-1.25)	(0.65-1.01)	(0.58-0.93)	(0.59-1.12)	(0.53-1.03)
Wheelchair	1.06	1.06	0.92	0.85	0.95	0.88
	(0.82-1.39)	(0.81-1.39)	(0.69-1.22)	(0.63-1.13)	(0.63-1.43)	(0.58-1.33)
Bedbound	0.45	0.45	1.09	1.03	0.52	0.53
	(0.11-1.80)	(0.11-1.84)	(0.44-2.67)	(0.42-2.54)	(0.07-3.79)	(0.07-3.84)
Supervised/assisted eating	1.99	1.96	1.98	1.91	2.45	2.37
	(1.64-2.42)	(1.61-2.39)	(1.60-2.44)	(1.55-2.37)	(1.82-3.29)	(1.76-3.19)
Number of diseasesδ	1.12	1.13	1.07	1.07	1.13	1.13
	[1.09-1.16]	[1.09-1.17]	[1.03-1.12]	[1.03-1.11]	[1.07-1.19]	[1.07-1.19]

Data is shown as Hazard ratios with 95% confidence interval.

Weight loss: a loss of 5% body mass in the last 30 days or 10% in the last 180 days. **Low BMI**: <20 kg/m2 for residents younger then 70 years and <22 kg/m2 for residents 70 years or older. **ESPEN**: Very low BMI (<18.5 kg/m^2) or weight loss combined with low age-specific BMI as described hereabove.

*adjusted for age category (≤ 89 years vs. ≥ 90 years), gender, living status before admission (alone vs. together), year of admission (2005-2009, 2010-2014, 2015-2020) .

δ used as continues variable with 0 diseases as reference category.

Discussion

Residents of long-term care facilities are known to suffer from multiple diseases and health-related problems. In addition, malnutrition is a frequently reported phenomenon. This manuscript indicates that a considerable number of diseases and health-related problems are associated with an increased prevalence as well as incidence of malnutrition in LTCFs. Herewith, this manuscript is one of the first to describe the associations between diseases and incident malnutrition within LTCFs.

The characteristics of our study population are relative comparable to other Dutch cohorts that are population representative. On average in the Netherlands, 70% of residents in LTCFs is female which is equal to our sample. Residents in our sample were relatively younger (83.1 years) compared to the average Dutch resident as in 2019 (85.0 years) [238]. Compared to another Dutch representative cohort, our residents had a comparable BMI (24.8 vs. 24.7 kg/m^2) but the number of diseases was higher in our population (4.5 vs 3.0), which is probably explained by the fact that we also included health-related problems. In general, our population seems to reflect the average population in Dutch LTCFs.

At admission, 850 residents (22.9%) had a low age-specific BMI without recent weight loss (figure 1). This indicates that older adults have already suffered from an inadequate nutritional status for a longer period. Few specific diseases were related to a low age-specific BMI at admission, indicating that this is a general problem in older adults, regardless of disease status. Screening for early determinants of malnutrition in the community setting and adequate treatment should prevent older adults from entering residential care in a poor nutritional condition [65,117].

We showed that the prevalence and (to a lesser extent) incidence of malnutrition are influenced by the used definition; at admission low age-specific BMI (27.5%) was almost three times higher as weight loss (8.8%). During stay, weight loss (13.8%) was seen more often compared than low age-specific BMI (11.3%) and malnutrition according to ESPEN (8.9%). Associations between diseases/health-related problems and malnutrition also differed used criteria; WL was stronger related to diseases than low BMI/ESPEN (except diabetes and cardiac diseases at admission). The use of BMI for diagnosing malnutrition is often debated because of the generally high BMI in the Western societies [214]. Our results provide evidence to keep using BMI as an indicator of a poor nutritional status over a longer period. However, to assess incident malnutrition during stay in LTCFs, it is advised to use weight loss as this better reflects acute nutritional problems.

Based on the effect sizes of the associations, relatively small differences were seen between the use of BMI alone and the ESPEN criteria for malnutrition. Figure 1 visibly shows that the ESPEN 2015 definition is completely within the spectrum of low age-specific BMI. This dependency on BMI in the ESPEN definition leads to an underestimation of acute nutritional problems. This is clearly illustrated by the large differences in incident malnutrition during stay; 8.9% based on ESPEN vs. 13.8% based on WL. Although WL may indicate an acute problem, dropping below the cut-off points for BMI occurs less frequently, especially in participants with a higher baseline BMI. For example, a resident with a BMI of 27 kg/m^2 and an average length (1.70 meter) should loose ~14.5 kg bodyweight before dropping below the cut-off point of 22 kg/m^2, which is unlikely to happen keeping in mind the relative short stay in a LTCF. Therefore, involuntary WL should always be a trigger to start malnutrition interventions in LTCF residents.

As also shown in previous research [196], diabetes and cardiac diseases were associated with lower prevalence of malnutrition at admission based on ESPEN and BMI. This can be explained by the high BMIs that usually characterize these diseases. In contrast, diabetes was associated with in increased odds on WL which was also found in another study (OR:1.21 [95%CI: 1.19-1.23])[239]. However, in both studies it is unclear whether WL was involuntary or a part of the treatment for diabetes. Our study shows that malnutrition,

and especially WL can also occur in LTCF residents with cardiometabolic diseases, despite a high BMI, and should be monitored and intervened on at regular intervals.

As expected, one of the strongest predictors for developing malnutrition was the need of supervised/assisted eating. Dependency from staff or informal caregivers place residents at risk for a low intake. Assisting residents with eating their meals is time consuming [240] and shortness of staff, a common problem in residential-care facilities, may result in inadequate mealtime assistance [241]. Previously performed trials have shown that increased mealtime assistance resulted in higher intakes [240,242,243]. However, time spent on mealtime assistant in these trials was about 40 minutes per meal moment, which is far more than in a usual situation. Implementation of these programs would therefore require additional staff and funding. The use of trained volunteers and family members could relieve the pressure on staff [244].

Pressure ulcers, infectious diseases and pain were associated with WL at admission, but to a lesser extent during stay. Treatment of these problems could have decreased the risk of further nutritional decline during stay. In general, the prospective analysis may also have underestimated the malnutrition risk because of misclassification; we only used baseline disease status to study associations with malnutrition, and ignored new diseases that may have occurred during admission. We expect that residents who developed new diseases or health-related problems during stay, were at increased risk of becoming malnourished as well.

In our analyses we separately looked at disease groups and at health-related problems. In general, health-related problems (especially psychiatric-, balance- and sleep problems) were stronger associated with all three criteria for malnutrition than diseases. We assume that not all diseases were accompanied by acute health problems, especially if residents already suffered from them for dozens of years, Therefore, screening for health-related problems seems to have additional value, next to (long-)diagnosed diseases, when studying the association with malnutrition.

Our study is one of the first prospective studies that is performed in the LTCF setting. We are aware of a previous study by Torbahn et al.[235] based on NutritionDay data in nursing-home residents (N=11,923, follow-up period 6 months) that also tested the association between diseases and malnutrition (BMI< 20 kg/m^2 and/or recent weight loss (>10% within 6 months)). In this study, comparable effect sizes were seen for immobility (bedbound OR: 1.28 [99.5%CI:1.00-1.68]), and musculoskeletal diseases (OR: 1.09 [99.5%CI:0.91-1.31]) but smaller for neurological diseases (OR: 1.10 [99.5%CI:0.87-1.38]). The difference in effect-size for neurological diseases could be explained by the differ-

ence in follow-up time (6 months vs. ~1 year in our study) as most neurological diseases have a progressive development[245]. Both our as well as the Torbahn et al. study [235] underline that diseases increase the risk for developing malnutrition during stay in a LTCF.

Limitations and strengths

Health-related problems and diseases were analysed in categories as larger numbers were needed to investigate single diseases. However, it is not expected that effect sizes will differ strongly between separate diseases in one category as they are likely to share the same underlying mechanism for their relationship with malnutrition.

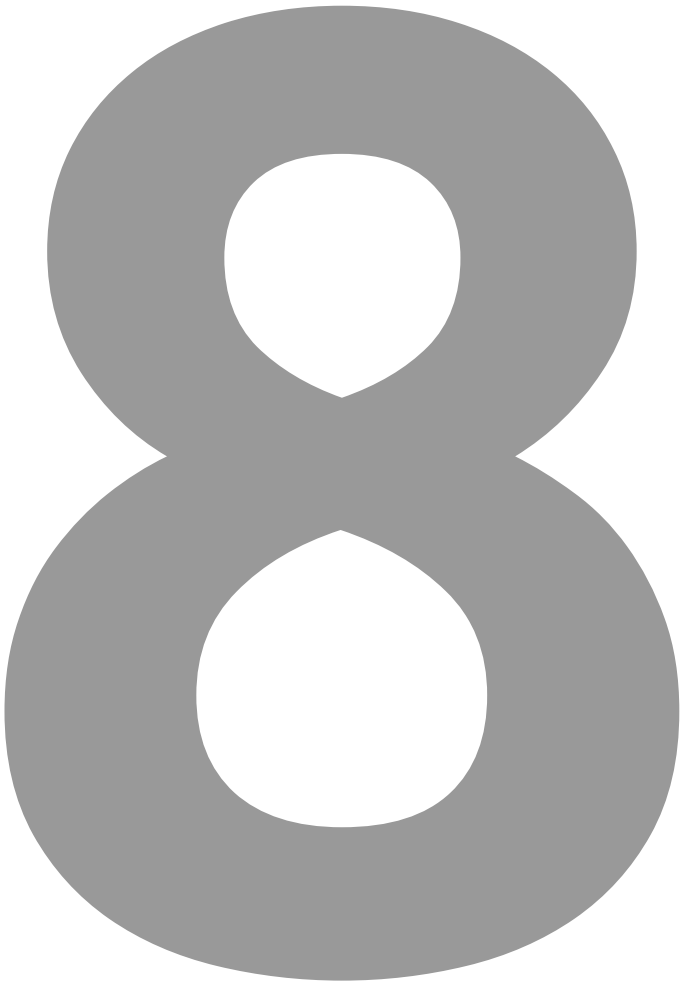
As outcome of our analysis, we used the ESPEN definition for malnutrition. Recently the GLIM criteria for malnutrition have been launched [47], and it is advocated to use GLIM in future malnutrition studies, to create homogeneity in criteria across studies. At this moment, the InterRAI MDS does not provide the necessary items to define malnutrition based on the GLIM criteria; this additionally requires data on reduced muscle mass, reduced food intake or assimilation, and inflammation or disease burden, which are notoriously difficult data to collect in a nursing home population. The use of the ESPEN definition likely underestimated the prevalence and incidence of GLIM-malnutrition in our sample as recent studies showed higher rates of malnutrition based on the GLIM criteria compared to the ESPEN 2015 definition [214,246]. In a recent observational study, we found a malnutrition prevalence rate of 21% in a sample of 176 nursing home residents, based on body weight loss, BMI and registered food intake over 3 days [247], which is indeed higher than ESPEN.

Strong points of our study are the large sample size and prospective design with long follow-up time. In addition, only physician-documented diagnoses are used in InterRAI making our data more reliable compared to self-reported health status. By reporting associations for both weight loss, low BMI and the ESPEN 2015 criteria, we provide a valuable insight how diseases affected different criteria for malnutrition and the other way around, how different criteria for malnutrition affect prevalence rates. Finally, we identified risk factors for developing malnutrition that were not previously described. Our results can contribute to refining malnutrition screening tools, as most risk factors we described are not incorporated in screening tools now days.

Conclusion

Most diseases (cardiometabolic diseases excluded) and health-related problems were associated with being malnourished at admission but also with incidence rates during stay in LTCFs. Moreover, the strength of the associations between diseases or health-related problems and malnutrition are dependent on the set of criteria to define malnutrition. At admission, the use of low age-specific BMI to assess malnutrition status is recommended as this reflects the nutritional status over a longer period. During stay, the use of recent weight loss is advised as this better reflects acute nutritional problems.

CHAPTER 8



Low protein and energy intake in Dutch nursing homes residents.

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Not submitted yet

Abstract:

Rationale: An optimal diet contributes to reducing malnutrition prevalence, increasing quality of life, and reducing morbidity in the nursing home population. For this population recommended intakes are ≥1.0 g protein/kg body weight per day (P/kg bw/d) and ≥27 energy (En) kcal/kg bw/d. Few studies have reported on the adequacy of protein and energy intake of nursing home residents, and on factors associated with poor intake.

Methods: Data were collected from 189 residents (aged ≥65 yr, mean age 85.0 yr) of 5 different Dutch nursing homes. Dietary intake was assessed by three-days observations. Linear mixed models were used to examine cross-sectional associations of En/kg bw/d and P/kg bw/d as dependent variables with determinants including gender, age, BMI, weight, nursing home facility, type of ward, dysphagia, difficulty chewing, verbal communication problems, weight loss, needing feeding assistance, reported decreased food intake, mobility level, appetite, number of diseases/medication and neuropsychological problems. Results were stratified by a protein/energy-enriched diet (P/En+).

Results: The protein intake of the residents was 0.75 (SD:0.25) g/kg bw/d, with 78.9% of all residents having an intake below the recommended 1.0 g/kg bw/d. Mean energy intake was 19.9 (SD:6.1) kcal/kg bw/d, with 83.1% having an intake below recommendation. Intakes of P and En were higher in the P/En+ group compared to regular diet: 0.88 (SD:0.27) vs. 0.69 (Sd:0.22) g/kg bw/d), and 23.5 (SD:6.1) vs. 18.2 (SD:5.4) kcal/kg/bw/d. The oldest age groups (>85 years), chair-bound residents, women, and residents having difficulties with chewing, dysphagia, a reported decreased food intake, or a decreased appetite were at a higher risk of a low P/En intake.

Conclusion: Nearly all nursing home residents were at increased risk of not meeting the minimum P/En requirements. Intakes should on average be increased with ≥ 18g P and ≥ 570 kcal to reach the minimum intake targets. Although using a P/En+ diet was associated with higher intakes, even these residents had intakes below the requirements.

Background

In the period 2002-2020 life expectancy at birth in the EU increased from 77.6 to 80.4 years, resulting in 21% of Europeans being 65 years and older in 2020 [248,249]. This number is expected to double by 2050 and even triple by 2100 [137]. Because of age-related decline in functioning, the majority of older adults will become (partly) care-dependent towards the end of their life. Most European countries, therefore, implement a policy aimed at facilitating older adults to stay in their own environment as long as possible, if necessary with assisting home care. This 'ageing-in-place' policy, aimed at reducing the burden on nursing homes, is cost-effective and is, moreover, what most older adults wish [250]. However, 'ageing-in-place' is not always feasible due to progressive disease, declining general health, risk of falling, social isolation, and medication management [250]. When care requirements become too high and home care is not sufficient anymore, older adults will eventually be admitted to a nursing home. Thus, in general, older adults only enter nursing homes when they are suffering already from (multiple) severe health conditions [251].

To prevent a further decline in quality of life during stay in a nursing home, an optimal nutritional status is warranted. However, the nutritional status of newly admitted residents is often poor, as already one out of three newly-admitted residents has a low age-specific BMI (<20 kg/m^2 in residents <70 years or <22 kg/m^2 in residents ≥70 years) [251]. In addition, approximately 10% of all residents will become malnourished during their stay [236]. These high numbers can be explained by the presence of risk factors for malnutrition, such as multimorbidity, decreased appetite, poor oral health, cognitive decline, and the inability to eat alone without help [252]. An optimal food intake, consisting of enough protein and energy, is needed to optimize the nutritional status and reduce the risk of malnutrition and accessory complications such as reduced quality of life and increased risk of comorbidities in residents of nursing homes [25,253].

For healthy older adults, a protein intake of 0.83 g/kg body weight (bw) per day is advised [254,255]. However, this traditional recommendation is still under discussion; older people are thought to need higher amounts of protein for optimal preservation of lean body mass, body functions, and health [74]. According to the latest ESPEN guidelines, a daily amount of 1.0-1.2 gram protein per kg/bw is suggested for healthy older adults [74], and expert groups advise even up to 1.2-1.5 gram protein per kg/bw for frail older adults [61]. Until proven otherwise, the current suggested intake of 1.0 g/kg bw/day should be ensured for all older adults to maintain and regain muscle mass and function [74].

To prevent protein from being used as an energy source, an adequate energy intake is also required [256,257]. Energy requirements differ between persons, but on average, 30 kcal/kg bw/day is advised for older adults [74]. Low activity can decrease energy needs, but based on indirect calorimetry 27 kcal/kg bw/day is the lower limit [74,258]. In contrast, requirements for older adults with underweight are as high as 32-38 kcal/kg bw/day [74,258].

It may be clear that a high-quality diet with satisfactory energy and protein intake is important for preserving an adequate nutritional status in older adults [74,259]. However, data regarding food intake in nursing-home residents is scarce. Most previously published articles on this topic use proxy measures for food intake, such as decreased appetite or the percentage of last served portion that was eaten, providing no true estimate of consumed protein and energy intake [260,261]. It is therefore unclear how much energy/protein is consumed by nursing home residents and which (sub-)groups are not reaching the recommendations. Data regarding this topic can help to identify groups that are at increased risk to be(come) malnourished and develop targeted preventive/curative measures for malnutrition. This study therefore, aims to assess the protein- and energy intake of Dutch nursing home residents and to examine which groups are at increased risk of not meeting the protein- and energy requirements.

Methods

Cross-sectional data were obtained from residents of five Dutch nursing homes from different parts of the Netherlands in two periods (January-March 2020 and September-October 2021). Acquisition of participating nursing homes was done, among others, via network meetings, dietitians' conferences and via a provider of electronic patient files used in nursing homes (InterRAI)

Residents were included when they were living in a nursing home, gave informed consent, either by themselves or by their proxy, and were aged ≥ 65 years. Residents were excluded when they were bedbound (and consumed food in their own rooms which hindered discrete observing); received end-of-life care or used parenteral nutrition.

Measurements

Baseline measurements were performed to obtain a picture of the general health status of the residents and were used to identify groups at risk for poor food intake. All measurements were done by trained students of the bachelor's program 'Nutrition and Dietetics' and master's program 'Nutrition and Health'.

Malnutrition risk

The Short Nutritional Assessment Questionnaire for Residential Care (SNAQ^{RC}) was used to identify residents at risk of malnutrition. This validated malnutrition screening tool for nursing-home residents is based on four items: unintentional weight loss (>3kg in the last month or >6kg in the last 6 months), needing feeding assistance, having a decreased appetite, and low BMI (<20 kg/m^2 or 20-22 kg/m^2) [262]. Residents were graded 'at moderate risk of malnutrition' when they scored positively on one of the following items: needing feeding assistance, having a decreased appetite, or having a relatively low BMI (20-22 kg/m^2). When residents displayed two or more of those items or had unintentional weight loss (as defined above) or a very low BMI (< 20 kg/m^2), they were graded 'at severe risk of malnutrition.

Anthropometry

Due to COVID-19 restrictions, the body weight and height of the residents were mainly taken from medical records. When record data regarding weight and/or height was missing, residents were weighted in clothes, but without shoes, on nursing home scales. Based on weight and height, BMI was classified in: underweight (< 22 kg/m^2); normal weight (22-27 kg/m^2); and overweight (> 27 kg/m^2)[263].

Co-morbidities and multimorbidity

The nature and number of co-morbidities were assessed alongside a pre-specified list: diabetes mellitus, heart attack, stroke or cerebral haemorrhage/infarction, other serious heart problems (heart failure, angina pectoris), cancer, hypertension, lung disease (chronic obstructive pulmonary disease, asthma, emphysema), stomach-liver-bowel disease, kidney or bladder disease, osteoporosis, back disorders, joint damage (arthrosis, rheumatism), and 'other'.

Multimorbidity was defined as the presence of three or more diseases [264].

Other variables

In addition, the following characteristics were obtained from the medical files or provided by a first responsible nurse: demographics (gender, age), protein/energy-enriched diet (P/E+ diet vs. standard diet), polypharmacy (≥ 5 medication), dysphagia, decreased food intake (severely decreased, moderately decreased, not decreased), chewing difficulties, verbal communication problems (ability to express verbally or non-verbally), type of ward (somatic, psychogeriatric, rehabilitation), mobility level (goes out, able to get out of bed/chair, chair bound), neuropsychological problems (severe dementia, mild dementia, no dementia).

Dietary assessment

Three-day structured food records, three main meals, and in-between moments were used to calculate protein and energy intake. Since food registration can be a burden for residents and is depending on memory, direct observations were used. Direct observation is considered a gold standard because it is practical, independent of a resident's memory, and can provide objective information on the actual intake of residents [265].

The researchers observed the residents throughout the day and reported the amounts consumed by the residents. Residents were informed on forehand that they could be observed but not when. Observers were overviewing the residents from a short distance. Beforehand, the standard dinnerware was measured, and the different sizes of a portion, package, or item of tableware were measured to improve estimations of the consumed food/drinks.

Food records were conducted on randomly selected days, preferably including one weekend day to account for possible changes in eating habits during the weekend. For the calculation of nutritional intake, the nutritional calculation program Compl-eat (linked to the Dutch Food Composition Table 2021/7.0 [167]) was used.

Protein and energy intake

Protein and energy intakes were generated from Compl-eat. Data was presented in total protein intake in gram per day (g/day), gram protein/kg bw per day (g/kg bw/day), total energy intake in kcal per day (kcal/day), and energy intake in kcal/bw per day (kcal/kg bw/day.

As the protein recommendations are expressed in g/kg bw/day, actual body weight can over- and underestimate protein needs [266]. In overweight residents, low-fat-free mass (FFM) can lead to an overestimation of protein needs. In contrast, in underweight residents, a relatively high FFM can lead to an underestimation of protein needs [266]. For this reason, adjustments in body weight were made to optimally estimate protein needs. For residents with underweight the adjusted protein intake in g/kg bw/day was based on body weight derived from age-specific cut-off points of BMI, 20 kg/m2 for age <70 years and 22 kg/m^2 for age ≥70 years. For overweight residents adjusted body weight was derived from BMI 27.5 kg/m^2 [267].

Ethics

The ethics committee of the HAN University of Applied Sciences evaluated the study (ECO 182.03/20), and it was judged not to fall within the remit of the Medical Research Involving Human Subjects Act (WMO).

Analyses

Statistical analyses were performed using SPSS 28.0. The normality of continuous data was assessed using QQ-plots and box plots. Background characteristics of the population were described by means with standard deviations and frequencies with percentages for categorical data.

Linear mixed models were applied to study associations of total gram protein, adj. g protein/kg bw/day, total kcal and kcal/kg bw/day with the independent variables

As the data are clustered both within residents of the same ward and within persons, because of the three-days food record repeats, random intercepts were used based on comparison of the -2 log-likelihood of the models with and without random intercepts. For protein intake random intercepts were included for ward and resident level. For energy intake a random intercept at resident level was applied.

As having a protein/energy-enriched diet (P/E+ diet) was likely a strong predictor for energy and protein intake, with the P/E+ diet being in the causal path between several independent variables and protein/energy intake, adjusting for diet group is inappropriate, Therefore, all results were stratified by P/E+ diet. To assess difference in regression coefficients between the standard diet group and P/E+ diet, interaction terms were made (determinant of interest * P/E+ diet (yes/no)). A p-value of 0.1 was considered significant [211].

Furthermore and where appropriate, the analyses were adjusted for gender, age, and mobility, well-known factors associated with protein-energy intake [64,268–270].

Results

As shown in Table 1, 189 residents were included in the study, of which 62 (32.8%) were provided a P/E+ diet. Most of the residents were female (70.4%), mean age was 85.0 yr (SD 7.4), and the majority lived in a psychogeriatric ward (72.5%). Mean BMI was 26.0 kg/m^2 (SD 5.0), and 17.5% had a low age-specific BMI. Malnutrition risk as based on $SNAQ^{RC}$ was high, with 52.9% being at moderate or severe risk. A large part (40.7%) suffered more than three diseases and 72.5 of the residents used more than five types of medication per day. Most of the residents (80.4%) had mild/moderate dementia, as indicated by their caregivers/first responsible nurse.

Table 1, *The characteristics of participants included from five different nursing homes.*

	Protein/energy-enriched diet (N=62)	Standard diet (N=127)	Total (N=189)
Gender			
Male	17 (27.4%)	39 (30.7%)	56 (29.6%)
Female	45 (72.6%)	88 (69.3%)	133 (70.4%)
Age (years)	84.2 ± 8.0	85.4 ± 7.1	85.0 ± 7.4
Body mass index (kg/m2)	23.7 ±4.5	27.2 ±4.9	26.0 ± 5.0
Missing	1	12	13
BMI < 22	21 (33.9%)	12 (9.4%)	33 (17.5%)
BMI ≥22 – 27	29 (46.8%)	50 (39.4%)	79 (41.8%)
BMI ≥ 27	11 (17.7%)	53 (41.7%)	64 (33.9%)
Weight (kg)			
<60	22 (35.5%)	8 (6.3%)	30 (15.9%)
60-80	33 (53.2%)	77 (60.6%)	110 (58.2%)
>80	7 (11.3%)	42 (33.1%)	49 (25.9%)
Nursing home			
1	43 (69.4%)	46 (36.2%)	89 (47.1%)
2	2 (3.2%)	23 (18.1%)	25 (13.2)
3	11 (17.7%)	21 (16.5%)	32 (16.9%)
4	2 (3.2%)	17 (13.4%)	19 (10.1%)
5	4 (6.5%)	20 (15.7%)	24 (12.7%)
Ward			
Psychogeriatric	44 (71.0%)	93 (73.2%)	137 (72.5%)
Somatic	7 (11.3%)	27 (21.3%)	34 (18.0%)
Rehabilitation	11 (17.8%)	7 (5.5%)	18 (9.5%)
Having dysphagia	26 (41.9%)	23 (18.1%)	49 (25.9%)
Having difficulty chewing	19 (30.6%)	8 (6.3%)	27 (14.3%)
Polypharmacy			
Missing	0	1	1
≥5 medications	50 (80.6%)	87 (68.5%)	137 (72.5%)
Multimorbidity			
≥3 diseases	27 (43.5%)	50 (39.4%)	77 (40.7%)
Verbal communication problems	23 (37.1%)	23 (18.1%)	46 (24.3%)
Weight loss (based on SNAQ^{rc})			
No weight loss	42 (67.7%)	118 (92.9%)	160 (84.7%)
1-3kg last 3 months	10 (16.1%)	4 (3.1%)	14 (7.4%)
> 3 kg last 3 months	10 (16.1%)	5 (3.9%)	15 (7.9%)
Having decreased appetite	18 (29.0%)	25 (19.7%)	43 (22.8%)
Feeding assistance needed	27 (43.5%)	25 (19.7%)	52 (27.5%)
Decrease in food intake			
No decrease	37 (59.7%)	94 (74.0%)	131 (69.3%)
Moderate decrease	14 (22.6%)	29 (22.8%)	43 (22.8%)
Severe decrease	11 (17.7%)	4 (3.1%)	15 (7.9%)
Mobility			
Goes out	4 (6.5%)	23 (18.1%)	27 (14.3%)
Able to get out of bed	26 (41.9%)	70 (55.1%)	96 (50.8%)
Chair bound	32 (51.6%)	34 (26.8%)	66 (34.9%)

Table 1, *The characteristics of participants included from five different nursing homes.* (*continued*)

	Protein/energy-enriched diet (N=62)	Standard diet (N=127)	Total (N=189)
Neuropsychological problems			
No dementia	11 (17.7%)	26 (20.5%)	37 (19.6%)
Mild dementia	15 (24.2%)	31 (24.4%)	46 (24.3%)
Severe dementia	36 (58.1%)	70 (55.1%)	106 (56.1%)
SNAQ^{RC}			
No risk of malnutrition	17 (27.4%)	72 (56.7%)	89 (47.1%)
Moderate risk of malnutrition	16 (25.8%)	38 (29.9%)	54 (28.6%)
Severe risk of malnutrition	29 (46.8%)	17 (13.4%)	46 (24.3%)
Protein intake			
Total protein intake g-per day	62.1 ± 20.3	52.4 ± 15.9	55.6 ± 18.0
Protein intake g/kg bw adjusted	0.88 ± 0.27	0.69 ± 0.22	0.75 ± 0.25
≥ 0,83 g/kg bw	44 (70.9%)	38 (29.9%)	82 (43.4%)
≥ 1,0 g/kg bw	24 (38.7%)	16 (12.6%)	40 (21.2%)
≥ 1,2 g/kg bw	11 (17.7%)	5 (3.9%)	22 (11.6%)
Energy intake			
Total energy intake kcal-per day	1509 ± 387	1373 ± 361	1417.6 ± 374.1
Energy intake kcal/kg bw/day	23.5 ± 6.1	18.2 ± 5.4	19.9 ± 6.1
≥ 27 kcal/kg bw/day	15 (24.2%)	17 (13.4%)	32 (16.9%)

Note: data is shown as mean (SD) or number (percentage)

Protein intake

The mean protein intake per day was 55.6 g/day (SD:18.0), or 0.75 g/kg bw/day (SD:0.25). For people with a P/E+ diet, this was higher with 0.88 g/kg bw/day (SD 0.27), compared to 0.69 g/kg bw/day (SD 0.22) in the standard diet group (see Figure 1).

More than half of the residents (56.6%) did not reach the lowest recommendation of 0.83 gP/kg bw/day, and an even higher proportion (78.9%) did not reach the recommended 1.0 gP/kg bw/day, let alone the higher recommendation of 1.2 g/kg bw/day (91.5%) (Table 1, Figure 1). The proportions reaching the 1.0 g/kg bw/day was higher in the P/E+ group (38.7%) compared to the standard diet group (12.6%).

Energy intake

The total mean energy intake in kcal per day was 1418 kcal/day (SD:374), or 19.9 kcal/kg bw/day (SD:6.1). For residents with a P/E+ diet the intake was 23.5 kcal/kg bw/day (SD:6.5), compared to 18.2 kcal/kg bw/day (SD:5.4) for residents without such diet (Figure 1). Despite being a low proportion, more residents reached the minimum recommendation of 27 kcal/kg bw/day in the P/E+ group (24.2%) compared to the standard diet group (13.4%) (Table 1, Figure 1).

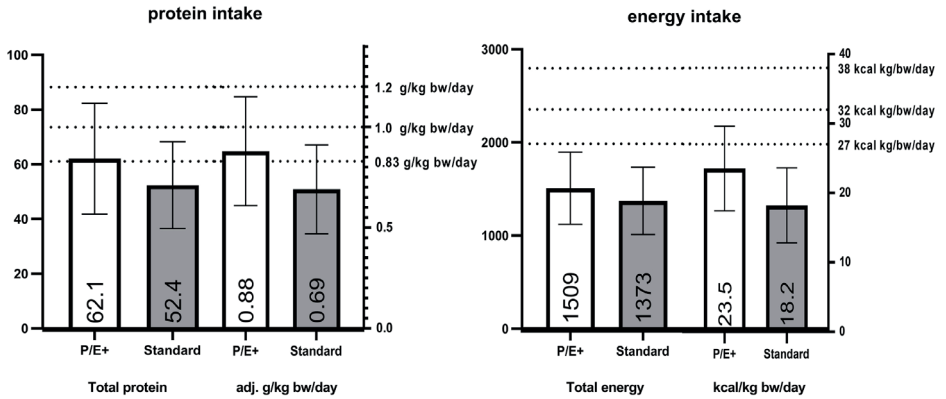

Figure 1, Overview of protein/energy intake and recommendations
Note: bars represent average intake with standard deviation.
recommendation lines for total protein/energy are based on average population weight (73.6 kg)

Groups at risk of a low protein intake

No differences in total protein intake were seen between residents within the different categories of BMI (Table 2). As a consequence, lower protein intake per kg/bw/day was observed in the higher BMI categories. Factors related to a low total protein intake were mostly also related to protein intake in adj. g/kg bw/day.

The characteristics most strongly related to a low total protein intake were, in order of effect size or regression coefficient, having difficulties chewing, mobility problems, weight loss of >3kg in the last 3 months, decreased appetite, female gender and older age.

The parameters strongest related to low protein intake based on adj. g/kg bw/day were higher body weight, difficulty chewing, mobility problems, decreased food intake and/or decreased appetite. Low BMI (<22 kg/m^2) was associated with higher protein intake.

Small, non-significant associations, for either protein outcome measure, were found for the other determinants investigated.

Protein/energy-enriched diet group

The effect sizes that were observed in the P/E+ diet group were relatively similar to those in the standard diet group. Only effect sizes for gender, age, having a decreased appetite, difficulty chewing and recent weight loss differed between both groups (interaction term $p<0.10$).

The strongest characteristics related to low total gram protein were higher age, need for feeding assistance female gender and to a lesser extent difficulty chewing and

dysphagia. Factors related to a higher intake were type of ward (psychogeriatric and rehabilitation vs. somatic) and having multimorbidity.

The strongest characteristics related to low protein intake based on adj. g/kg bw/day were female gender, residents with difficulty chewing, dysphagia, higher weights and higher age. Low BMI (<22 kg/m^2) was associated with higher intake.

Table 2, Regression coefficients for protein intake derived from linear mixed models for residents with standard and protein/energy-enriched diet

	Standard diet (n=127)		Protein/energy-enriched diet (n=62)	
	Total grams protein per day	Adjusted grams protein/ kg bw/day	Total grams protein per day	Adjusted gram protein/ kg bw/day
Gender				
Female	-6.8 (-11.3;-2.2)*	-0.04 (-0.11; 0.03)	-14.9 (-22.9; -6.8)*	-0.11 (-0.26; 0.04)
Age (years)				
65-75	Ref.	Ref.	Ref.	Ref.
75-85	-3.1 (-10.9; 4.6)*	-0.00 (-0.12; 0.12)*	-13.8 (-24.7; -3.0)*	-0.20 (-0.40; 0.00)*
>85	-6.5 (-14.1; 1.2)	-0.07 (-0.19; 0.05)	-12.5 (-22.9; -2.0)	-0.16 (-0.36; 0.04)
BMI (kg/m2)				
<22	2.7 (-5.2; 10.6)	0.18 (0.06; 0.30)	-3.7 (-11.6; 4.1)	0.18 (0.04; 0.32)
22-27	Ref.	Ref.	Ref.	Ref.
>27	2.7 (-2.4; 7.8)	-0.01 (-0.09; 0.06)	3.5 (-6.1; 13.1)	-0.01 (-0.18; 0.16)
Weight (kg)				
<60	Ref.	Ref.	Ref.	Ref.
60-80	0.3 (-8.6; 9.3)	-0.19 (-0.33; -0.06)	5.3 (-2.1; 12.7)	-0.16(-0.29; -0.03)
>80	1.8 (-7.5; 11.2)	-0.27 (-0.41; -0.13)	7.7 (-4.0; 19.4)	-0.26 (-0.47; -0.05)
Nursing home				
1	7.6 (-1.8; 16.9)	0.13 (-0.00; 0.26)	4.9 (-10.7; 20.6)	0.04 (-0.24; 0.32)
2	7.5 (-3.4; 18.3)	0.17 (0.02; 0.32)	13.8 (-18.5; 45.9)	0.25 (-0.33; 0.83)
3	3.0 (-9.1; 15.1)	0.07 (-0.09; 0.24)	-5.1 (-24.7; 14.4)	0.00 (-0.33; 0.33)
4	5.8 (-7.5; 19.1)	0.11 (-0.07; 0.29)	3.8 (-24.2; 30.5)	0.44 (-0.03; 0.91)
5	Ref.	Ref.	Ref.	Ref.
Ward				
Somatic	Ref.	Ref.	Ref.	Ref.
Psychogeriatric	-0.2 (-5.7; 5.3)	-0.05 (-0.14; 0.03)	10.2 (1.0; 19.4)	0.13 (-0.08; 0.34)
Rehabilitation	4.3 (-6.0; 14.6)	0.02 (-0.14; 0.18)	11.5 (0.7; 22.2)	0.03 (-0.15; 0.21)
Having dysphagia	-2.3 (-7.9; 3.3)	-0.01 (-0.10; 0.08)	-5.1 (-11.9; 1.8)	-0.11 (-0.24; 0.03)
Having difficulty chewing	-14.9 (-23.8; -6.1)*	-0.19 (-0.33; 0.04)	-7.0 (-15.2; 1.2)*	-0.20 (-0.35; -0.04)
Polypharmacy				
≥ 5 medicines	0.9 (-4.4; 6.2)	0.04 (-0.04; 0.12)	2.6 (-6.6; 11.8)	-0.06 (-0.23; 0.12)
Multimorbidity				
≥ 3 diseases	-0.1 (4.7; 4.4)	0.00 (-0.07; 0.07)	6.2 (0.8; 13.2)	0.01 (-0.13; 0.15)
Verbal communication problems	-3.7 (-9.4; 2.0)	-0.04 (-0.13; 0.05)	-4.9(-12.9; 3.0)	0.03 (-0.12; 0.18)

Table 2, Regression coefficients for protein intake derived from linear mixed models for residents with standard and protein/energy-enriched diet (*continued*)

	Standard diet (n=127)		Protein/energy-enriched diet (n=62)	
	Total grams protein per day	Adjusted grams protein/ kg bw/day	Total grams protein per day	Adjusted gram protein/ kg bw/day
Weight loss				
No weight loss	Ref.	Ref.	Ref.	Ref.
1-3kg last 3 months	-2.5 (-15.9; 10.9)	0.03 (-0.18; 0.23)	-4.0 (-14.1; 6.1)	0.04 (-0.15; 0.24)
> 3 kg last 3 months	-9.5 (-20.0; 1.1)*	-0.07 (-0.24; 0.10)	2.8 (-6.5; 12.1)*	0.07 (-0.11; 0.25)
Having decreased appetite				
	-7.0 (-12.2; -1.9)	-0.10 (-0.18; -0.02)*	0.6 (-7.4; 8.5)	0.07 (-0.09; 0.22)*
Feeding assistance needed				
	-4.0 (-9.7; 1.8)	-0.05 (-0.14; 0.04)	-8.2 (-16.1; -0.2)	-0.06 (-0.22; 0.10)
Decrease in food intake				
No decrease	Ref.	Ref.	Ref.	Ref.
Moderate decrease	-7.9 (-12.8; -3.0)	-0.10 (-0.18; -0.02)*	-1.9 (-10.8; 7.0)	0.05 (-0.11; 0.22)*
Severe decrease	-3.8 (-15.4; 7.7)	-0.06 (-0.25; 0.13)	-4.3 (-14.3; 5.7)	-0.04 (-0.23; 0.16)
Mobility				
Goes out	Ref.	Ref.	Ref.	Ref.
Able to get out of bed	-10.1 (-16.0; -4.2)	-0.11 (-0.20; -0.02)	-7.1 (-21.5; 7.2)	-0.13 (-0.40; 0.14)
Chair bound	-10.4 (-16.9; -4.0)	-0.16 (-0.26; -0.06)	2.1 (-12.3; 16.6)	0.03 (-0.24; 0.30)
Neuropsychological				
No problems	Ref.	Ref.	Ref.	Ref.
Mild dementia	-1.6 (-8.6; 5.4)	0.05 (-0.06; 0.16)	-0.0 (-12.1; 12.1)	0.04 (-0.18; 0.27)
Severe dementia	-0.4 (-7.7; 6.9)	0.06 (-0.05; 0.17)	-5.9 (-17.7; 5.9)	-0.00 (-0.23; 0.22)

Note: Data are shown as mean difference (95%CI), adjustments (when appropriate) were made for age category (65-75, 75 85, > 85), gender, and mobility (goes out, able to get out of bed/chair, chair bound).
* significant difference ($p<0.1$) in regression coefficient between standard and P/E+ diet

Groups at risk of a low energy intake

Comparable to for protein intake, total energy intake was only weakly related to weight/ BMI class: residents within the higher BMI categories and, to a lesser extent, higher weight categories, had a relatively lower kcal intake per kg/bw day.

Characteristics related to a low total energy intake were mostly also related to energy intake expressed in kcal/kg bw/day (Table 3).

Energy intake in standard diet group

The characteristics strongest related to total low kcal/day were female gender, having difficulties chewing, weight loss of >3kg in the last 3 months, a decreased food intake, and low mobility levels. Residents with multimorbidity consumed more energy.

The characteristics strongest related to decreased kcal/kg bw/day were female gender, higher body weight/BMI groups, living on a psychogeriatric or rehabilitation ward, difficulties chewing, poor mobility levels and having a decreased food intake. Higher intakes were seen in those with neuropsychological problems and those with polypharmacy and/or multimorbidity.

Energy intake with a protein/energy-enriched diet

Based on interaction terms, effect sizes differed significantly ($p<0.1$) between the standard diet vs. P/E+ diet for age group, decreased food intake, recent weight loss and type of ward.

The strongest associations with lower total calories per day were female gender, receiving feeding assistance, being older and to a lesser extent dysphagia and/or difficulty with chewing. Type of ward (psychogeriatric and rehabilitation compared to somatic) was associated with higher kcal intake.

The characteristics strongest related to low kcal/kg bw/day were higher weight/BMI and age, difficulty chewing and/or dysphagia. Having a low BMI (<22 kg/m^2) was associated with higher kcal/kg bw/day.

Small, non-significant associations, for either energy outcome measure, were found for the other determinants investigated.

Table 3, Regression coefficients for energy intake derived from linear mixed models for residents with standard and protein/energy-enriched diet

	Standard diet (n=127)		Protein/energy-enriched diet (n=62)	
	Total kcal per day	kcal/kg bw/day	Total kcal per day	kcal/kg bw/day
Gender				
Female	-204 (-330; -79)	-1.9 (-4.0; 0.1)	-296 (-481; -111)	-1.6 (-5.3; 2.1; 5.3)
Age (years)				
65-75	Ref.	Ref.	Ref.	Ref.
75-85	-25 (-237; 187)	1.2 (-2.3; 4.6)*	-212 (-463; 40)	-2.9 (-8.0; 2.1)*
>85	-115 (-321; 91)	-0.2 (-3.6; 3.1)	-188 (-433; 57)	-2.6 (-7.5; 2.3)
BMI (kg/m2)				
<22	-58.9 (-270; 152)	2.9 (-0.4; 6.1)	-68 (-253; 117)	5.1 (1.9; 8.3)
22-27	Ref.	Ref.	Ref.	Ref.
>27	56 (-77; 188)	-2.8 (-4.9; -0.8)	58 (-168; 284)	-3.3 (-7.2; 0.7)
Weight (kg)				
<60	Ref.	Ref.	Ref.	Ref.
60-80	126 (-121; 372)	-4.1 (-7.6; -0.6)	115 (-57; 288)	-4.7 (-7.7; -1.6)
>80	90 (-167; 348)	-8.9 (-12.6;-5.3)	164 (-112; 439)	-9.8 (-14.6; -4.9)
Nursing home				
A	77 (-112; 267)	1.8 (-3.1; 4.6)	-46 (-399; 308)	-1.8 (-8.6; 5.1)
B	11 (-195; 217)	3.1 (-1.9; 7.1)	197(-544; 938)	4.3 (-10.1; 18.6)
C	84 (-129; 297)	3.1 (-1.8; 8.4)	-143 (-523; 237)	0.1 (-7.3; 7.4)
D	39 (-180; 257)	1.4 (-4.6; 6.6)	-81 (-672; 509)	8.3 (-3.1; 19.8)
E	Ref.	Ref.	Ref.	Ref.
Ward				
Somatic	Ref.	Ref.	Ref.	Ref.
Psychogeriatric	-64 (-206; 78)*	-2.9 (-5.2; -0.7)	217 (-32; 465)*	1.4 (-3.8; 6.7)
Rehabilitation	-85 (-350; 180)	-2.2 (-6.4; 2.0)	193 (-21; 407)	-0.8 (-5.3; 3.7)
Having dysphagia	-11 (-168; 147)	0.8 (-1.8; 3.3)	-144 (-309; 21)	-3.3 (-6.6; 0.0)
Having difficulty chewing	-340 (-595; -85)	-3.7 (-7.9; 0.6)	-129 (-325; 68)	-4.1 (-8.0; -0.2)
Polypharmacy				
≥ 5 medicines	47 (-84; 177)	1.5 (-0.6; 3.6)	105 (-108; 317)	1.2 (-5.5; 3.1)
Multimorbidity				
≥ 3 diseases	107 (-11; 226)	1.6 (-0.3; 3.5)	78 (-94; 248)	-0.8 (-4.3; 2.7)
Verbal communication problems present	-133 (-286; 20)	-1.2 (-3.7; 1.3)	-123 (-304; 57)	1.4 (-2.3; 5.1)
Weight loss				
No weight loss	Ref.	Ref.	Ref.	Ref.
1-3kg last 3 months	-7 (-336; 322)	2.6 (-2.9; 8.0)	-61 (-296; 175)	1.3 (-3.5; 6.0)
> 3 kg last 3 months	-315 (-611; -12)*	-1.8 (-6.7; 3.1)	103 (-123; 328)*	1.5 (-3.1; 6.1)
Having a decreased appetite	-165 (-308; -21)	-1.7 (-4.1; 0.7)	18 (-174; 209)	1.1 (-2.7; 5.0)
Feeding assistance needed	-55 (-206; 95)	-0.7 (-3.1; 1.8)	-219 (-402; -36)	-1.7 (-5.6; 2.2)
Decrease of food intake				
No decrease	Ref.	Ref.	Ref.	Ref.
Moderate decrease	-225 (-360; -90)*	-2.4 (-4.7; -0.1)*	-10 (-214; 194)*	1.4 (-2.5; 5.1)*
Severe decrease	-122 (-445; 200)	-0.4 (-5.8; 5.0)	-131 (-370; 107)	-1.9 (-6.3; 2.6)

Table 3, Regression coefficients for energy intake derived from linear mixed models for residents with standard and protein/energy-enriched diet (*continued*)

	Standard diet (n=127)		Protein/energy-enriched diet (n=62)	
	Total kcal per day	kcal/kg bw/day	Total kcal per day	kcal/kg bw/day
Mobility				
Goes out	Ref.	Ref.	Ref.	Ref.
Able to get out bed	-147 (-303; 9)	-1.5 (-4.0; 1.1)	-15 (-350; 319)	-0.7 (-7.4; 6.1)
Bed or chair bound	-220 (-394; -47)	-3.5 (-6.3; -0.7)	-16 (-350; 317)	-1.3 (-8.0; 5.4)
Neuropsychological				
No problems	Ref.	Ref.	Ref.	Ref.
Mild dementia	-106 (-277; 65)	0.9 (-1.8; 3.7)	-11 (-263; 242)	1.6 (-3.7; 6.8)
Severe dementia	18.6 (-136; 173)	2.8 (0.3; 5.2)	-151 (-370; 67)	0.8 (-3.7; 5.3)

Note: Data are shown as mean difference (95%CI), adjustments (when appropriate) were made for age category (65-75, 75 85, > 85), gender, and mobility (goes out, able to get out of bed/chair, chair bound).
* significant difference ($p<0.1$) in regression coefficient between standard and P/E+ diet

Discussion

This study shows that residents of Dutch nursing-homes do not consume enough protein and energy. Female residents, older aged, those having difficulties chewing or dysphagia, those reported to have a decreased food intake or decreased appetite, or those who were bedor chair-bound had the highest prevalence of a poor intake. Importantly, this does not imply that other groups were not at risk. Basically, the whole study population consumed insufficient protein and energy and was at risk of not meeting the requirements. The P/E+ diet group consumed more protein/energy compared to the standard diet group. Nevertheless, over 60% of the P/E+ group did not meet the requirements.

Residents included in our study were comparable to residents included in the Dutch National Prevalence Measurements of Care Problems 2018 (LPZ), a representative cohort of Dutch nursing-home residents. The overall age of the residents in our study, 85.0 (SD:7.4) years, was slightly higher than in LPZ in which the residents were 83.2 (SD: 9.5) years old [271] and BMI (26.0 (SD:5.0) kg/m^2) was comparable with LPZ (25.1 (SD:6.3) kg/m^2). Prevalence of malnutrition risk (based on SNAQ^{RC}) was also comparable to LPZ (both 24% at high risk) [272]. Thus, our study population appears to be a good reflection of older adults in nursing homes in the Netherlands despite some minor differences compared to the characteristics of residents within the LPZ cohort.

In general, a P/E+ diet seemed to be beneficial for protein/energy intake which is in line with previous studies [273]. Residents with a P/E+ diet had a higher protein and

energy intake compared to residents in the standard diet group. In the latter group, weight loss of >3 kg and having a decreased appetite was associated with a decreased protein/energy intake while in the P/E+ diet group this was not seen. Because of the cross-sectional design, no causality can be obtained, but a P/E+ diet might already have been introduced for residents with involuntary weight loss and/or an impaired appetite which could have increased protein/energy intake.

The protein intake of the residents in our study was relatively low: over half of the participants did not meet the lower recommendation of 0.83 g protein/kg bw/day and an even smaller proportion (21.2%) met the suggested recommendation of 1.0 g protein/kg bw/day let alone the recommended intake of 1.2-1.5 for frail older adults [61]. Herewith, and regardless of the recommendation used, protein intake was (far) too low for most residents. In general, an additional ~5, ~20 or ~35 gram protein would be needed to reach respectively the 0.83, 1.0 and 1.2 g/kg bw/day, meaning that protein intake should increase with ~25-50%. Even those with a P/E+ diet consumed too little energy/protein. This suggests that nearly all residents might benefit from a P/E+ diet. It may thus be even more efficient and desirable to incorporate more energy and protein in the standard nutrition policy instead of providing a P/E+ diet to those diagnosed with a low energy/protein intake.

Oral nutritional supplements (ONS) are commonly prescribed to increase protein/energy intake in older adults in nursing homes [274]. In previously performed trials with ONS in the hospital and community setting, an average increase of 22 gram protein and 314 kcal was seen [275]. In nursing homes, such an amount would increase the average protein intake to ~1.0 g/kg bw/day at the population level, but it does not rule out ongoing deficiencies at the individual level. So, residents with a known low intake should still be monitored whether they consume enough protein as it is expected that for those with an already low intake, it is difficult to consume the prescribed ONS. It is also unclear if the 22 gram protein increase can be extrapolated to a nursing-home setting as appetite is lower compared to older adults living in the community [276]. Furthermore, it is unknown if effects of ONS will last a long time as the compliance usually declines over time and the different flavours/textures of ONS do not fulfil the older adults' needs and wishes [277,278]. Next to this, the decision on ONS for nursing home residents with dementia is a complex and ethical process [279]. Possibilities to increase the protein intake should take all nutritional solutions into account, whereby ONS is only one of them and a second choice [279].

Another intervention to increase protein intake is to replace low-protein foods with alternative protein-enriched foods. In a simulation study by Verwijs et al.[280] in com-

munity-dwelling older adults, the percentage that reached the 1.0 gram of protein kg/bw/day increased from 41.1% to 91.4% when products low in protein were substituted with protein-rich alternatives. However, these results were based on simulation data in the community and it remains unclear how effective this would be in practice. A replacement strategy without increasing the total volume of the meals might be insufficient to increase protein/energy intake as portions are small and appetite is generally low in nursing home residents. In addition, older adults prefer to only use products they have known their whole life [281,282], so replacement of products might in some case not be accepted. Enrichment of usual products could then be a solution.

Besides changes in products or providing additional products, increasing food intake could also be achieved by changing the food provision. Providing more small meals and in-between snacks can increase intake [157]. As appetite is limited in older adults [276], foods should be distributed over the whole day. An additional evening snack before bedtime, for example, might increase intake without affecting the appetite of the next meal moment. Also care should be given to meal presentation. Increasing ambiance and better presentation of meals has been shown to increase appetite and lead to higher intakes [283]. Finally, staff must be made more aware of the risk of malnutrition. Increasing their knowledge on malnutrition and healthy eating could increase intake of residents [283].

Food not only provides nutrients but it gives residents structure, joy and gives them opportunities to socialize [284,285]. When striving to increase protein and energy intake in residents, these aspects should be taken into consideration as they provide quality of life. As residents are in their latest phase of life, this is the most important factor to focus on. When changing nutritional policies to improve intake, choices should not only be guided by the nutrient composition but also by the impact of quality of life [225]. At the individual level, residents and family should be consulted whether additional food enrichments are desirable in case of deficits, especially towards the end of life [225].

Based on our data, no relation was seen between total protein intake and body weight/BMI. This results in a relatively high protein intake, expressed by gP/kg bw/day, in residents with a low BMI/weight. This does not directly imply better compliance with the guidelines as protein recommendations are higher for those with underweight/malnutrition [61,74]. Caregivers should be aware that protein intake per kg/bw could be misleading in residents with a low weight. The use of an adjusted bodyweight for residents with a low BMI is recommended [267] but ideally, their protein requirement should be based on body composition (e.g., FFM) rather than body weight [286].

Besides a low protein intake, our study population also did not reach the energy recommendations. The average energy intake was 1418 kcal and over 80% did not meet the recommendation of 27 kcal/kg bw/day let alone the 32-38 kcal/kg bw/day advised in older adults with malnutrition [74]. Considering that 52.9% of our respondents was at risk of malnutrition, the average intake of 19.9 kcal/kg bw/day is therefore too low. However, the use of standard equations for kcal based on kg bodyweight is very restricted and may not be accurate. A recent study from Belgium in nursing home residents (n=25) based on indirect calorimetry showed that average requirements were ~1575 kcal [287]. This requirement is more in line, but still higher than the average intake of our study population.

A low protein/energy intake could eventually lead to an increased risk of developing or aggravating malnutrition. We did not perform follow-up measurements, and were thus unable to assess this relation. Factors that were related to low protein intake in our study such as mobility problems, difficulty chewing and use of feeding assistance, were previously shown to be risk factors for developing malnutrition in nursing home residents [251]. In contrast, neuropsychological problems, which are widely accepted as a risk factor for developing malnutrition [66], were not associated with lower intakes in our study. A previous study by our group showed that especially residents with multiple cognitive problems are at increased risk of developing malnutrition [236]. As we had only limited data on neuropsychological problems, we were not able to test the relation of multiple cognitive problems on protein and energy intake.

Limitations

Due to COVID-19 restrictions, weight was often obtained from medical records which could be biased. However, previous studies have shown that medical records are in general a reliable source for weight measurements [288,289]. When measuring food intake, it is well known that most assessment techniques lead to an underestimation of intake which results in higher prevalence rates of residents at risk of low protein/energy intake. However, the use of observations minimizes this effect as this is regarded as the standard for criterion validity of food intake [290,291]. Finally, not all included nursing homes had all three type of wards. A rehabilitation ward was only present in one nursing home and somatic care in two nursing homes. So, power was low for these associations resulting in large confidence intervals. Associations derived for type of ward should therefore be interpreted with caution.

Conclusion

Almost all older adults in our study population consumed insufficient protein and energy. Having a P/E+ diet was associated with a higher protein-energy intake in older adults. Nevertheless, also the majority of residents who consumed a P/E+ diet had an intake below requirements. Because of the low intakes, we recommend to prescribe a protein/energy-enriched diet to all nursing home residents; this diet should be even more enriched compared to the current P/E+ diets to optimize the protein and energy intake. Given the small appetite of nursing home residents, using small servings of energy-rich and protein-rich foods to enrich meals might be useful. Future studies are needed to identify which strategies work best to increase protein and energy intake.

CHAPTER 9

9

General discussion

Overview of malnutrition during the journey of ageing

The aim of this thesis was to identify groups at risk of becoming malnourished during the journey of ageing; from healthy older adults in the community to frail residents in long-term care facilities. We also assessed the impact of switching from self-prepared meals towards ready-made meals in terms of protein and energy intake. Finally, we investigated protein and energy intake of residents in long-term care facilities. Table 1 provides a summary of the main results from our studies.

Chapters 2 and 3 provide an overview of malnutrition according to early determinants in community-dwelling older adults, based on questionnaires filled out on the internet. Early determinants are risk factors that eventually could lead to malnutrition and comprise, among others, poor food intake, problems with doing grocery shopping and/or cooking and eating alone. Both in the Dutch and international cohort, prevalence of malnutrition was over 85% and increased with age (up to ~95% in those aged ≥85 year). The prevalence of malnutrition according to early determinants was relatively comparable between countries, but individual risk factors differed between countries. For instance, low dairy intake and problems doing grocery shopping were more often seen in New Zealand and Canada compared to The Netherlands.

In chapter 4, we assessed prevalence rates of malnutrition in the community based on two different screening tools, one based on early determinants of malnutrition (SCREEN II), and the other one aimed at identifying late phase malnutrition ($SNAQ^{65+}$). In older adults aged <75 year, early determinants of malnutrition were present but late phase malnutrition (where loss of muscle mass and decline of functional status is present) was relatively scarce. Both malnutrition based on early determinants and late phase malnutrition increased with age. Early determinants of malnutrition were more related to social factors while late phase malnutrition was more associated with physical factors.

In the ConsuMEER study, chapter 5, we showed that switching from self-prepared meals towards ready-made meals carries the risk of a decreasing protein intake in community-dwelling older adults. The combination of protein-rich meals and dairy was effective in preventing this decline.

Chapters 6, 7 and 8 describe protein/energy intake and malnutrition risk in residents of long-term care facilities. In chapter 6 we showed that higher numbers of behavioural-cognitive problems were related to being malnourished at admission and becoming malnourished during stay. In chapter 7 we provided evidence that the prevalence and incidence of malnutrition and the groups at risk of being/becoming malnourished dif-

Table 1, overview of main findings of this thesis

	Community	Long-term care facility
Early determinants of malnutrition	High prevalence ~70% (Chapter 4) Risk factors for early determinants of malnutrition differed between age groups (Chapter 2) and countries (Chapter 3). Factors associated with higher prevalence rates: age groups (Chapter 2), females, older adults living alone, low income groups, low activity levels, lower protein/energy intake (Chapter 4).	
Late phase malnutrition	Prevalence ~15% (Chapter 4) Factors associated with higher prevalence rates: age, low BMI, high number of comorbidities/ medication, receiving help at home, low activity and/or mobility level (Chapter 4).	Prevalence rates at admission depend on used criteria: Weight loss: 8.8% Low age-specific BMI: 27.4% ESPEN 2015: 9.5% (Chapter 7) Factors associated with higher *prevalence* rates at admission based on weight loss: Cardiac diseases, infections, cancer, pressure ulcers, balance problems, GI-tract problems, sleep problems, dental problems, aspiration, fever, pain, low mobility, supervised eating, total number of diseases (Chapter 7). Factors associated with higher *prevalence* rates at admission based on low age-specific BMI/ ESPEN 2015 criteria: psychiatric problems, GI-tract problems, dental problems, aspiration, supervised eating, total number of diseases (Chapter 7), total number of behavioural-cognitive problems (Chapter 6). Factors associated with lower prevalence rates: Diabetes, cardiac diseases, peripheral oedema (Chapter 7). Factors associated with higher *incidence* rates of malnutrition during stay based on weight loss: Neurological diseases, infectious diseases, balance problems, psychiatric problems, GI-tract problems, sleep problems, fever, aphasia, supervised eating, total number of diseases (Chapter 7) Factors associated with higher *incidence* rates of malnutrition during stay based on low age-specific BMI/ ESPEN 2015 criteria: Neurological diseases, psychiatric diseases, GI-tract problems, sleep problems, supervised eating, total number of diseases (Chapter 7), total number of behavioural-cognitive problems (Chapter 6)

Table 1, overview of main findings of this thesis (*continued*)

	Community	Long-term care facility
Nutritional intake	Switching from self-prepared meals to ready-made meals increases the risk of a decreasing protein intake (Chapter 5)	Protein and energy intake are low in long-term care facilities. Nearly all residents had an intake below the 1.0 gram protein and/or the 27 kcal per kg bodyweight per day (Chapter 8). Residents with a protein/energy-enriched diet consume more protein/energy, but still intake is too low (Chapter 8). Low protein intake was seen in: higher age groups, females, those with communication problems, difficulty chewing, dysphagia (Chapter 8). Low energy intake was seen in residents with: difficulty chewing, dysphagia, needing feeding assistant, recent weight loss, moderate/decreased food intake, low mobility levels, females, higher age groups (Chapter 8)

fered depending on the used criteria (weight loss, low age-specific BMI or a combination of both (ESPEN 2015 criteria)). Finally, chapter 8 provides an overview of protein/energy intake of residents in long-term care facilities. We showed that both protein and energy intake were far below recommendations in nearly all residents.

Methodological considerations

SCREEN II and SNAQ65+

In chapters 2 and 3, we used data obtained from the websites www.goedgevoedouderworden.nl and www.nutritionscreen.ca. The aim of both websites is to provide reliable information and practical solutions for prevention and treatment of malnutrition in the community. Visitors of these websites are thought to be (highly) interested in nutrition and/or to be at an increased risk of malnutrition, which likely resulted in a sample being not representative for the general population\. This is indeed reflected in the higher prevalence rates of malnutrition risk of the Dutch online cohort used in chapters 2 and 3 (84.1% at risk based on SCREEN II, 62.8% at risk based on SNAQ^{65+}), compared to the more population- representative cohort of chapter 4 (69.0% at risk based on SCREEN II and 13.5% based on SNAQ^{65+}). Data of chapter 4 is more in line with previous studies [70,73,76,88]. We think that prevalence rates described in chapter 4 better represent the true prevalence of older adults at risk of malnutrition. While the prevalence rates reported in chapter 2 and 3 are not fully generalizable to the general population, the associations derived from these data are still valid, as it is not very likely that selective participation of persons with specific malnutrition risk factors in the online cohorts would have occurred [114].

Another weakness of the online cohort studies is the absence of data on potential confounding factors, such as education level, comorbidities, and mobility levels. Since these websites were originally not designed for data collection for scientific purposes, it was not allowed to ask additional and personal parameters. Residual confounding is therefore present. However, based on large effect sizes found (OR for age group ≥85 compared to 65-75 years: 5.3 [95%CI: 2.8-10.1]), it is unlikely that this would be fully explained by additional confounding.

In chapters 2-5, we used the version of SCREEN II that was developed for the website www.goedgevoedouderworden.nl. This version of SCREEN II was based on a translated version of the original English version, but no back-translation was performed as a check. However, the use of back-translation as a mandatory part of the cross-cultural adaptation of questionnaires is being argued [292]. In our case, the translated ques-

tions were tested with a panel consisting of healthcare providers and older adults and were adopted to the Dutch food habits. Based on their experiences, the questions were changed or adapted where necessary. For instance, traditional Dutch products like buttermilk were added, and household measurements were added to make it easier for older adults to fill out the questionnaire.

For all chapters reporting data on SCREEN II, we used the cut-off values of <50 and/or <54, based on the original Canadian validation study of Keller et al. [70]. These values were confirmed in a recent validation study in Bosnia [293]. However, the results of a validation study by Wham et al.[89] carried out in New Zealand, suggest cut-off values of <49 and <54. Whether the cut-off values we used were appropriate for the Dutch population can be debated. However, as previous studies all pointed towards the same cut-off values, it is expected that, despite the lack of a validation study, the cut-off values we used are also applicable to the Dutch situation.

For the comparison between SNAQ^{65+} and SCREEN II, we used the ConsuMEER database and expanded this with an additional 100 participants to increase power. However, power was still relatively low. For example the group that was at risk for malnutrition based on SNAQ^{65+} consisted of 27 subjects (13.5%). Our analyses in chapter 5 were therefore not adjusted for confounders as higher numbers are recommended to perform multiple regression analysis [211]. Especially adjusting for age would have been recommended as most determinants and exposure are strongly correlated with age.

ConsuMEER study

In the ConsuMEER study we described the effect of switching from self-prepared meals to ready-made meals (chapter 5). During the inclusion process for the RCT, we were unaware of the protein intake of participants. After inclusion, protein intake of the participants turned out to be higher than the average Dutch protein intake (~1.05 g/kg BW/day compared to ~0.90 g/kg BW/day in the general population [154]). During the trial, protein intake decreased in the control group towards 0.87 g/kg BW/day, which is close to the protein intake of the general Dutch population. Our trial had not enough power to perform subgroup analysis to test whether participants low in protein intake at baseline also decreased their protein intake during the trial. Therefore, it is unclear if the decrease in protein intake after switching towards ready-made meals would have been comparable if participants had a protein intake of about 0.90 g/kg BW/day before switching to ready-made meals.

In the trial we provided participants not only with ready-made meals but also with dairy products, that are rich in protein. Post-hoc analysis showed promising results of protein intake from dairy, i.e. an increase of ~7 gram protein per day compared to baseline. As we used a combined intervention, including ready-made meals and dairy products, we must be careful when interpreting the results. Although not formally studied, several participants told us that they disliked the ready-made meals, that these meals did not lead to satiety, and that they ate smaller portions of ready-made meals compared to normal self-prepared meals. This could have triggered participants to eat/drink more dairy products, resulting in an increased protein intake from dairy and a decrease in protein intake from the ready-made meals. Dairy products are a promising category of protein-rich food as they are protein dense. Trials only focusing on dairy should provide answers how effective these products are in increasing protein intake.

InterRAI data

In chapters 6 & 7 we studied the prevalence and incidence of malnutrition in long-term care facilities with data obtained from InterRAI. One of the advantages of working with InterRAI is that it requires a full assessment to provide outcomes for the clinical assessment protocols (CAPs), so no questions are skipped and missing values are prevented. Missing data was therefore scarce despite the large number of residents included in our study.

For the prospective analyses with the InterRAI data, we performed Cox proportional hazards regression analysis and used characteristics from the first available measurement as the starting point and related this to malnutrition incidence. However, admission to a long-term care facility marks the latest phase of life. It is therefore expected that health conditions will decline fast. So, malnutrition may also have arisen due to an acute disease during stay, which we were unable to show from our data. However, this problem will both be present in residents with or without a specific determinant. Therefore, the effect is likely to be non-differential and will have had little influence on the effect sizes [211].

Since 2019, the GLIM criteria are being used for diagnosis of malnutrition. These criteria consist of 3 phenotypical criteria (weight loss, low BMI and reduced muscle mass) and 2 etiological criteria (reduced food intake and inflammation/disease burden). As reduced muscle mass, food intake and to a lesser extent inflammation/disease burden are not available in InterRAI, GLIM malnutrition could not be constructed based on available data. We therefore used the ESPEN 2015 definition for malnutrition. Within the ESPEN definition, the combination of recent weight loss combined with low age-specific BMI

leads to the diagnosis of malnutrition. We could have chosen to specify malnutrition either based on the presence of low age-specific BMI or recent weight loss. This is more in line with GLIM, but as etiological criteria were lacking, the underlying construct of GLIM could not be made. This would have resulted in an invalid categorization and an overestimation of prevalence rates.

In chapter 6, we used the ESPEN 2015 definition to investigate the association of behaviour and cognitive problems with malnutrition. Later, in chapter 7, we observed that prevalence rates and associations between health-related problems and diseases were largely influenced by the definition of malnutrition used. In general, most diseases were more strongly related to weight loss than to malnutrition defined by ESPEN 2015. Almost all residents with behavioural-cognitive problems have a long disease history, which may suggest that low BMI might be a good indicator of malnutrition. Post-hoc analyses showed that the definition of malnutrition influenced associations only in a marginal way: for example, associations between total number of cognitive problems and malnutrition differed depending on the used definition for malnutrition between 1.19-1.24).

Recommended Dietary Allowance and Average requirement

Recently, new evidence became available that higher protein requirements are needed to maintain muscle mass in older adults. Expert groups advise 1.0 g/kg bw/day for general older adults, increasing up to 1.5 g/kg bw/day for malnourished older adults [61,62]. However, based on the latest advice (2019) of the Dutch health counsel, the average requirement (AR, corresponding with requirements of 50% of the population) remains 0.66 gram protein per kilogram bodyweight per day with a corresponding recommended daily allowance (RDA) of 0.83 gram protein per kilogram bodyweight per day. The RDA is the minimal amount that is needed to cover the average needs of 97.5% of a population, but not necessarily the optimal amount that should be consumed [294]. The AR and RDA are mainly based on nitrogen balance studies, in mostly young healthy adults [295]. In these studies, although not statistically significant, a clinically relevant difference of 30% higher nitrogen requirements for older adults (>55 years) compared to young adults (≤55 years) were found. Lack of statistical significance when comparing these groups might, however, be due to lack of statistical power. Moreover, older adults suffering from disease might profit from a positive nitrogen balance instead of a neutral balance and should, therefore, consume even more than the RDA. Therefore, in

my opinion, it is justified to use the 1.0 g/P kg/bw/day as the recommended intake for individuals.

In chapter 8, we showed that ~60% of residents of long-term care facilities did not consume the required 0.83 g/P kg/bw/day and ~80% did not consume 1.0 g/P kg/bw/day. Assessing which part of a population consumes too little protein is a population approach rather than a personal approach. In that case it is generally advised to use the AR instead of the RDA [296]. However, as there is no AR for older adults with a poor health status, we used the RDA of the general population. We are aware that this could have led to an overestimation of people at risk of low protein intake. On the other hand, experts indicate that the RDA for healthy older adults is likely too low for residents with a poor health status, which will compensate for this overestimation. More nitrogen balance studies are needed in older adults suffering from a poor health status in order to determine the average requirements and RDA.

Malnutrition in the community

Identifying older adults at risk of malnutrition in the community

As advised in the recent GLIM (Global Leadership Initiative in Malnutrition) guidelines [47], screening for malnutrition with a validated screening tool is the first step in identifying malnutrition. However, no recommendations are made regarding the tool to be used. The large differences in prevalence rates, low agreement between tools (chapter 4) and the different underlying constructs of SCREEN II and SNAQ^{65+}, opens a discussion about the term 'malnutrition screening tools'. In general, malnutrition in older adults is used to refer to protein-energy malnutrition, also called undernutrition [47], but some screening tools have a wider scope and also focus on risk factors for malnutrition or appetite. It is therefore of great importance to know with what specific aim a malnutrition screening tool was originally designed, and which risk group was aimed to be identified. We suggest a categorization into tools aiming at 1. identifying risk factors, 2. identifying undernutrition (depletion of fat mass and fat free mass) and 3. poor appetite. This suggestion for categorization is based on the underlying constructs and requires further validation.

The discrepancy between screening tools, as shown in chapter 4, can have serious implications for identification and treatment of older adults at nutrition risk. In the two-step approach of GLIM, screening tools play an important role as the first step towards further diagnosis and assessment. Both SCREEN II and SNAQ^{65+} are positioned as validated screening tools for malnutrition in older adults [68] but they clearly identify different

groups, focussing on different phases of the continuum of malnutrition. Until now, there is no consensus which screening tool is best used as a first step in GLIM. The phenotypical criteria in GLIM, low muscle mass/BMI and weight loss, are typical symptoms of late phase malnutrition. As SNAQ^{65+} is focussing on these problems, this tool resembles GLIM and may be a logical choice as a first step in the GLIM approach. In contrast, SCREEN II is advised over SNAQ^{65+} when aiming to identify risk factors for malnutrition. Both screening tools could be combined as they strengthen each other by focussing on different aspects of malnutrition. We do not yet know how the choice for one or the other screening tool influences GLIM prevalence rates. This requires further studies.

Interventions for early phase malnutrition in the community

For older adults who are no longer capable of preparing their own meals, the use of ready-made meals is advised[74]. In chapter 5 we showed that protein intake can remain stable after switching from self-prepared meals towards ready-made meals, when meals rich in protein, combined with dairy were chosen. However, before advising to switch from self-prepared meals towards ready-made meals, the underlying reason for such a switch should be assessed. Problems with doing grocery shopping or low interest in preparing meals due to loneliness, should not be solved by just providing ready-made meals. Meal preparation is important for older adults [171], keeps them active and prevents them from functional decline ('use it, or lose it') [297]. Volunteers could help older adults with grocery shopping and meal preparation to increase older-adults' self-efficacy [298]. Industry can also play a role here: it is desirable that providers of ready-made meals also include nutrient-dense, single portion, nutritious meal boxes in their assortment, so that older-adults can choose between self-preparation or ready-made. Also, supermarkets should sell meal boxes with ingredients for just one person. When the use of ready-made meals is unavoidable, guidance is needed in this process, while we have shown that poor meal choices could lead to a too low protein intake. As most providers of ready-made meals for older adults use a telephone order system, employers should be trained to inform older adults about nutrient compositions of the meals.

Early determinants of malnutrition include problems with grocery shopping, cooking, loneliness, and problems with biting and chewing. Therefore, interventions should be guided by the underlying problems. In the ESPEN guidelines 'clinical nutrition and hydration in geriatrics' by Volkert et al.[74] several practical solutions are provided. These range from providing ready-made meals to eating/cooking together and grocery shopping aid. Despite these interventions seeming reasonable, this guideline provides very little evidence for these suggestions. In our own literature search (not published), we have not identified any evidence to support these interventions either. It is therefore

unclear how how effective these advices are in increasing energy/protein intake. In addition, little research has been done on how to incorporate these advices in daily practice.

Interventions for late phase malnutrition in the community

Despite preventive measures, the occurrence of late phase malnutrition, where functional decline is present, is sometimes inevitable. A trained dietitian is an expert in providing individualized nutrition advice and is the person who can identify both early determinants of malnutrition as well as symptoms of late phase malnutrition. When early determinants of malnutrition are present, it is advised to first address these issues in order to optimize food intake. Currently, the role of identifying early determinants of malnutrition and on effectiveness of intervening on them is only described briefly in the dietetic guidelines regarding malnutrition and no advise is given how to treat these problems [299], which further elucidates the knowledge gap as described above.

When energy-protein requirements cannot be met with regular nutrition, for example because of disease, other solutions need to be considered. One of the first steps is to optimize product choice by choosing energy/protein dense products [74]. A simulation study by Verwijs et al. showed that optimization of food choice or the use of energy/protein-enriched products could increase protein intake towards recommended levels [280], but research towards the effectiveness of increasing energy/protein density in the malnourished community-dwelling older adults is scarce [161]. When appetite is low and requirements are high, the use of oral nutritional support in the form of supplements is advised [74]. Oral nutrition support (ONS) can be a good strategy to overcome a relatively short period when eating is difficult. But, in the long term, compliance with oral nutrition support prescription is often poor and, therefore, the expected effect of this intervention is low on the long term [300].

As increasing protein/energy intake is difficult when late phase malnutrition is present, it cannot be emphasized enough that earlier interventions are needed in order to slow down nutritional decline and prevent older adults from entering late stage malnutrition. In the community, the used of SCREEN II is recommended as complementary screening tool to assess early determinants of malnutrition, next to the current use of SNAQ^{65+} which identifies late phase malnutrition.

Malnutrition in long-term care facilities

Malnutrition screening before admission

In chapter 7, it was shown that 27.5% of residents of long-term care facilities had a low age-specific BMI at admission to a long-term care facility. As a decline in BMI is a process that arises over a longer time period, these residents must have been suffering from an inadequate food intake for a longer time. This is in line with the large group of community-dwelling older adults that already displays early determinants of malnutrition (chapters 2-4). Another reason for a low age-specific BMI could be the high prevalence of cognitive problems in (newly admitted) residents of long-term care facilities [271]. Doing grocery shopping and preparing food are among the first skills that are lost in older adults suffering from cognitive decline[188], which could lead to an inadequate intake. Also forgetting to eat or how to eat can result in a low food intake in older adults suffering from cognitive problems[301]. Community-dwelling older adults, especially those suffering from progressive cognitive problems, should therefore be monitored frequently to identify a possible poor food intake or involuntary weight loss. This could be done for instance by a spouse, informal caregivers or a home-care provider. The use of SCREEN II is recommended here, as it covers aspects regarding meal preparation and can be used to track changes over time [302].

Identifying malnutrition during stay

As previously stated, different screening tools are available to assess malnutrition risk, but only SNAQ^{RC} was specifically designed for the long-term care setting [68]. Other screening tools such as MNA-sf were validated for use in this setting only after their initial development [141]. Still, the MNA-sf is the malnutrition screening tool most frequently used in the long-term care setting [67]. The MNA-sf is a sensitive, but not very specific tool, and will therefore classsify large groups at risk incorrectly [68]. A recent study (not included in this thesis), based on the data described in chapter 8, showed that 64.2% of the residents were at moderate/high risk of malnutrition based on MNA-sf compared to 54.0% based on SNAQ^{RC} [247]. As both tools identified all residents who were malnourished based on the GLIM criteria, MNA-sf over-identified residents as malnourished. This is unpractical; large groups identified 'at risk' will lead to a high workload as an in-depth assessment is needed after positive screening [47]. It is therefore advised to use SNAQ^{RC} in the long-term care setting.

Although low age-specific BMI was the most frequently occurring parameter of malnutrition at admission to a long-term care facility [251], it is not very useful for detecting a decline in nutritional status during stay. Length of stay in long-term care facilities is usually short, so residents with higher BMI's are unlikely to reach the cut-off values for

low-age specific BMI despite of weight loss. The ESPEN 2015 definition strongly relies on BMI and this definition is therefore also not preferred to use to assess changes in nutritional status. Post-hoc analyses of the data used in chapter 6 and 7 showed that only a fraction (0.5%) of residents with a BMI >30 kg/m^2 at admission was classified as malnourished during stay based on the ESPEN definition. Weight loss, in contrast to BMI, is a parameter relatively sensitive to changes. Thus, weight loss should be used as most important parameter of deterioration in nutrition status of residents during stay in a long-term care facility.

Structured recordings of malnutrition parameters are needed to obtain a clear overview of development of malnutrition risk during stay. The InterRAI minimum data set (MDS) (chapter 6 and 7) is structured, but has relatively few nutritional parameters. For example, only 2 phenotypical criteria of GLIM are present in the MDS (weight loss and BMI), while muscle mass and both etiological criteria (food intake and to a lesser extend inflammation) are not measured in this MDS. A minimum dataset specialised for nutrition parameters could structure reporting, can provide an overview of development over time and could increase comparability for research purpose [303]. Updating the MDS is another option, but as the MDS is defined by the US government this will be time-consuming. For the time being, we suggest to develop a new algorithm within the existing MDS, with diseases as a proxy for inflammation. Unfortunately, estimates of body composition are not feasible in the daily routines of long-term care.

In chapters 6 and 7, it was shown that most diseases, health-related problems and behavioural-cognitive problems were associated with an increased risk of developing malnutrition during stay. Although no direct comparisons were performed, we assume, based on the derived effect sizes, that behavioural- cognitive problems were more strongly related to malnutrition than diseases and/or health-related problems. This can be related to the accumulation of problems in persons with behavioural-cognitive problems; decreased cognitive functioning is associated with increased numbers of comorbidities [304]. We thus expect that residents with cognitive problems, the majority of residents [271], have cognitive as well as somatic problems. This assumption is confirmed by the correlation between total number of behavioural-cognitive problems and number of health-related problems/diseases ($r=0.447$, $p<0.001$).

Food intake in long-term care facilities

In chapter 8 we showed that most residents in our study population did not reach the recommendations for protein and energy intake. We aimed to identify groups at increased risk of not reaching the recommendations. It turned out that nearly all residents

had a poor intake. Therefore, interventions should not focus on specific subgroups of residents but on the food policy of nursing homes in general.

In our study on food intake in long-term care residents, we were not able to distinguish between plant and animal-based protein intake. Current recommendations are based on consumption of high-quality protein such as animal-based protein. Plant based proteins (which are lower in protein quality) are mainly derived from bread, noodles, rice and meat replacements. In general, older adults in nursing home eat relatively little bread, and warm meals in nursing homes are generally based on potatoes or rice, legumes and meat. It is therefore assumed that the largest part of the consumed proteins is animal-based, with a high protein quality, which was also seen in previous research [154].

As the general recommendation of eating more protein could have negative influences on sustainability, it is ideally advised to increase protein intake by adding plant-based proteins [305]. However, it is unclear whether switching towards a more plant-based diet is feasible in residents of long-term care facilities. Issues such as acceptability, higher satiety (because of additional fibers), lower anabolic response, and challenges regarding combining of products in order to increase protein quality [306–308] make it unlikely that in the near future residents will be eating mostly plant based. Apart from this, the willingness to replace meat with plant based products is currently low in older adults [309]. A first step to work more sustainable in long-term care facilities is to reduce waste, which is particularly high in long-term care facilities [310], use local produced food and choose protein sources with a lower carbon print like poultry [305].

Implications for public health

Prevention of malnutrition in the community

As a large part of community-dwelling older adults is at risk of malnutrition, interventions are needed. However, prevention of malnutrition depends on the phase of malnutrition. Although younger and more vital older adults may show first signs of malnutrition, relatively few are suffering from late phase malnutrition. For these relatively healthy groups, preventive individual counselling from a dietitian is likely not cost-effective. General nutritional education could raise awareness about malnutrition in this group. Preventive measures should therefore be performed on different levels: general population, subgroups at increased risk and on individual level [311].

General population: increasing knowledge and awareness

In general, it is desirable to reach older adults in an earlier stage of malnutrition. Malnutrition could lead to high healthcare costs [312] (even higher than the costs associated with obesity [313]), but in '*the national prevention agreement*', regarding nutrition only prevention of obesity and lifestyle-related diseases is addressed [314]. Just recently in March 2022, the partner network malnutrition in older adults (Dutch: *'partnernetwerk ondervoeding ouderen'*) was founded to increase knowledge and awareness about malnutrition among healthcare professionals, policymakers and older adults themselves [315]. Increasing awareness by actively informing older adults is important as the actual policy relies on passive information provision; at this moment older adults should actively search for information about a problem they are likely to be not aware of [281]. A public information campaign on healthy food and requirements during ageing could improve awareness on this topic. This is needed as most older adults have little knowledge about healthy eating and protein recommendations [316]. Another option is a more individual approach by performing a general screening on early determinants performed by a GP assistant (for instance during the flu shot campaign) and then referring them to the website of goedgevoedouderworden.nl.

General population; online prevention

The Dutch website www.goedgevoedouderworden.nl or the Canadian www.nutritionscreen.ca are good examples of general nutrition education to inform older adults about optimizing their nutritional habits and risks of possible malnutrition. These websites are thought to attract visitors at (already) higher nutritional risk which is reflected in the higher proportions of malnutrition risk than in community-dwelling older adults in general (chapters 3, 4 and 5). This underlines the importance of these websites. But more is needed. The number of older adults with internet access steadily increases every year[106]. Yet, it is expected that large groups will not be reached with the message of malnutrition through this kind of website as 'unknown is unloved': if unaware, why would they visit these websites? Based on the data described in chapter 2, a large group of older adults or their caregivers who visited the website already had symptoms of late phase malnutrition. It is pretentious to think that earlier visits to the website could have prevented them from becoming malnourished. After all, having the right knowledge/information determines only a part of the effectiveness to make a change [317], and sometimes malnutrition is inevitable due to disease. However, the provision of knowledge is the first step of making older adults aware of the risk of malnutrition.

Recently, the website www.nutritionscreen.ca was terminated because of diminishing visitor rates (which is not yet seen in the Dutch website). In order to maintain or improve visitor rates, general governmental websites and leaflets about healthy eating (in the

Netherlands: www.voedingscentrum.nl) should place direct links to this specific website more clearly visible. This has actually been agreed upon within the previously mentioned *partnernetwerk Ondervoeding*. The 30 parties involved will put links to www.goedgevoedouderworden.nl on their respective websites. Another option could be deployed by international initiatives to obtain online data on prevalence data on malnutrition. Chapter 3 showed that malnutrition is a global problem, which justifies an international approach. As individual risk factors differed between countries, policy to address this should be adapted to local needs. By using a standard template for a website, countries could add country-specific general advices on actions to be taken when displaying one or more risk factors of malnutrition.

Subgroups at risk; cooperation with local partners

Specific attention needs to be given to subgroups that are difficult to reach, such as older adults with a low social economic status, a small social network, or a minority background, which are often especially at increased risk [318]. To address these groups, group education in the community could be organized. The Dutch Malnutrition Centre of Expertise has developed a group education about healthy nutrition to be used by trained dietitians. However, this is a general education, not specifically aimed at people with low health literacy, or people with a minority background. Local key figures, (religious) organizations and home-care providers know their people and could help to reach isolated older adults and inform them about available educational sessions [318]. Another option is to cooperate with these organisations and to provide educational sessions in collaboration. This could lower the burden as older adults are already familiar with these organisations. However, at this moment, no framework is available how such collaborations should be started, who will pay for it and who will take care of these projects for continuation. Local government could play a role herein by bringing together stakeholders and providing funding.

Also, the Dutch *'Volksuniversiteit'* (literal translation: university of the people) may be a partner to offer education. This institute offers a wide range of courses open for everyone, regardless of background. A course about healthy nutrition when ageing fits well with the aim of this institute to support people to participate and live in society. By making one general course outline, dietitians throughout the whole country could provide these courses via their local '*Volksuniversiteit*' establishments. As the *'Volksuniversiteit'* also provides Dutch language courses for immigrants, they are well visited by minorities. Because these universities work very locally, older adults could also meet new peers in their neighbourhood, which could reduce loneliness.

Subgroups at risk; interdisciplinary collaboration

Determinants of early malnutrition find their origin in different social and health areas. Therefore, different experts need to be involved in the prevention and treatment of these problems. Social and practical problems such as loneliness or problems with grocery shopping and meal preparation are the domain of social workers. They can help to expand older people's social networks and increase their independency. As social workers are well aware of regulations and programs of local governments, they can also support older adults in applying for care[319]. In case of biting and chewing problems, a dentist/dental hygienist or speech language therapist could help to solve underlying problems. However, both social workers, dentists/dental hygienist and speech therapist have a low level of knowledge about malnutrition and are mostly unaware of this problem. Therefore, education is needed on how these specialists could help older adults [320,321]. The use of a nutrition passport could improve communication between different disciplines. In this passport, treatment goals of caregiver and receiver can be appointed and progress of nutritional status can be noted [322]. Therewith, different caregivers have a better overview of which specialists are involved and how nutrition status changed over time.

More cooperation between various disciplines is needed but, in practice, different disciplines are often not working closely together [322]. Network groups should therefore be initiated to get to know each other and discuss how each discipline can be involved in the treatment and prevention of early determinants of malnutrition. As malnutrition is a problem that is mainly in the domain of nutrition, dietitians should take the lead in organizing these network groups. In these groups, the target population (community-dwelling older adults) should also be invited as they know best which problems they are facing. Other stakeholders such as local government and GPs should also be included as they have a broader overview of the healthcare system and health status of older adults [323].

Another group of older adults that needs attention is those who use homecare. As was shown in chapter 5, about 20% of all older adults who received homecare were at (high) risk of malnutrition. This is in line with previous research where 35% of all older adults who received homecare were at high risk of being malnourished [76]. These high prevalence rates underline the importance of frequent screening for malnutrition in this group. Based on the social support act, homecare will only be provided when screening indicates that homecare is necessary. This screening will assess needs and problems to identify what kind of homecare is needed and could be an opportunity to also assess malnutrition risk. At this moment, there is no policy regarding screening for malnutrition by homecare providers, so it is likely not performed. As malnutrition risk could change

over time, additional malnutrition screening by the homecare provider could identify new cases of malnutrition.

Subgroups at risk; the role of the local government

Local governments should play a more important role in the prevention and treatment of early determinants of malnutrition. Based on the social support act (Dutch: *Wet maatschappelijke ondersteuning* (*WMO*)), the local government should actively support older adults in remaining healthy and independent in the community [324]. This also includes help with frequently occurring early determinants of malnutrition such as grocery shopping, meal preparation, and loneliness [325]. Based on the high prevalence of these problems, as described in chapters 2 to 4, local governments should more actively inform community-dwelling older adults on how they could receive support. At this moment, applying for aid based on the social support act is difficult and time-consuming, which hinders older adults in need to explore this route [326]. The application process needs to be simplified and made more visible. The local government could increase the awareness of available services by yearly providing all retired older adults with an information leaflet with practical solutions and available support options in their region, including directions on how to request help.

Increasing awareness of early determinants of malnutrition and identifying persons at risk could also provide benefits in later phases of malnutrition. When ageing, the numbers of those who are at risk of late phase malnutrition will increase [76]. As immediate action is required in case of late phase malnutrition, it is of importance that these older adults are already familiar with the health care system and available regulations by the local government.

Individual prevention; the role of the dietitian.

For some groups, preventive individual counselling is advised. Based on the result in chapter 4, nearly all older adults who are living alone and/or aged >85 years are at increased nutritional risk. These risk groups are relatively easy to identify through governmental registers of personal details. Preventive counselling to assess nutritional risk with a dietitian should be encouraged for all people >85 years and older adults living alone. As the basic Dutch health insurance covers up to 3 hours of dietetic consultation, preventive counselling will not come along with additional costs for most older adults (except own risk cost). The high prevalence of nutritional risk in this group justifies an individual preventive approach. As the oldest age group and those who are living alone often also suffer from other problems, such as loneliness and a poor social network [327], dietitians should also involve social workers and district nurses to collaboratively address these problems. The other way around, when social workers or district nurses

visit older people living alone, they can use SCREEN II to identify food-related problems and advise those at risk to consult a dietitian.

Prevention of malnutrition in long-term care facilities

As was shown in chapters 6 to 8, malnutrition and a too low food intake are common problems in residents of long-term care facilities. In contrast to the community, residents nearly fully rely on care providers for their food provision. Preventive measures for malnutrition rely therefore mostly on the shoulders of healthcare providers.

Malnutrition before transmission to a long-term care facility.

In the period before admission, frequent screening could help to identify malnourished older adults at an early stage. As was mentioned earlier, a large part of community-dwelling older adults is suffering from malnutrition. Screening before admission could help to identify this group in an early stage. As most older adults require home care before admission to a long-term care facility [328], district nurses could be involved in this screening process. In addition, in the Netherlands, admission to a long-term care facility always requires an indication based on the long-term care act (Dutch: *Wet Langdurige Zorg* (*WLZ*) [329]. In this indication process, screening for malnutrition could identify malnourished older adults before entering a long-term care facility and interventions could be started immediately.

As most residents are on a waiting list before entering a long-term care facility, this period likely marks a time frame with high care needs, including higher chances of developing malnutrition. Preventive measures can already be taken during this period. To relieve the pressure of meal preparation and to decrease the threshold of entering a long-term care facility eventually, people on a waiting list can already be welcomed to join meal moments in a long-term care facility. When someone is placed on the waiting list, a consultation with a dietitian can identify their needs in order to improve/stabilize their nutritional status. It is preferred that this is done by a dietitian of the long-term care facility as this will be the responsible caregiver during stay. When this is not possible, a dietitian in the community could be consulted. In this situation, good communication between dietitians and caregivers in the long-term care facility is needed to ensure the transmission of information. The earlier mentioned nutrition passport could play a role herein.

Screening for malnutrition in long-term care facilities.

Based on the frequently used SNAQ protocols, screening for malnutrition is advised at admission to a LTCF. Screening for malnutrition used to be mandatory at admission [330] but this has changed and is no longer included in the quality indicators for long-term

care facilities in the Netherlands [331]. These quality indicators now focus on the food preferences of residents and do not contain questions regarding nutritional status. Screening for malnutrition should be made mandatory again as many newly admitted residents are at high risk.

At this moment, screening for malnutrition is often not performed, neither at admission, nor during stay, or no treatment is initialized after positive screening [50,332]. This could be explained by the relatively low level of knowledge and awareness of nurses working in long-term care facilities about the symptoms and treatment of malnutrition [333]. Sometimes protocols for screening and treatment of malnourished residents are also unstructured [332]. Improving knowledge about malnutrition in nurses is needed, but malnutrition is often not addressed in the current curricula of nursing education [334]. As changing curricula is a long process, immediate solutions are needed. Providing in-company training could increase the knowledge of malnutrition in a selected group of nurses. Increasing awareness about malnutrition should be the main effort as nurses play an important role in identifying persons at risk and initiating further action when residents are at increased risk.

Policy of food provision in long-term care facilities

As was shown in chapter 8, nutrient intake (protein as well as energy) was low and inadequate in most residents of LTCF. In contrast to other risk factors such as underlying diseases, a decreased food intake is something that can be optimized. Physicians, nurses, and dietitians tend to prescribe oral nutritional supplements as one of the first options [335,336]. The use of oral nutrition support is, in the short term, effective in increasing energy/protein intake [337] but fits not well in experienced-oriented care, is expensive [338] and does not increase life expectancy [275]. Different views on oral nutrition support between doctors, family members of residents, and dietitians make decision-making hard [279]. As family members play an important role in these decisions, but often lack knowledge on food and malnutrition, they have to be informed about the expected positive and negative sides of oral nutrition support. Oral nutrition support should only be provided when realistic goals, such as additional nutritional support during periods of acute illness, can be achieved [225]. The expectations of the caregiver or family member who request this intervention must therefore be explored. Especially in cognitively impaired residents, the prescription of oral nutrition support should not be taken lightly and consumption of these products should not be pushed when signs of disliking are present. As most residents of long-term care facilities are in their latest phase of life, quality of life should always prevail over food intake [225].

Regular prescription of oral nutritional supplements to residents without acute diseases is undesirable, because of the above-mentioned reasons. Regular food should always be the first choice in increasing energy/protein intake, and oral nutritional supplements should only be provided to overcome periods of severe disease when normal food intake is not possible anymore. Products that are protein-dense (such as dairy products) are good options to increase protein intake. As most older adults drink high quantities of nutrient-empty products such as coffee and tea (approximately 1.5 litres per day) [339], switching to dairy products is expected to increase protein intake [280]. Switching from empty towards nutrient-dense products will likely result in lower intakes of other products (i.e. compensation) [340] because of the reduced appetite in older adults, but this still may be a promising strategy to increase food intake. Further research is needed on how the replacement of products low in protein/kcal by nutrient-dense alternatives could increase intake.

In contrast to the community, improving nutrition intake in residents of long-term care facilities will not lead to a longer life expectancy [337]. However, a poor intake is associated with comorbidities such as infections, pressure sores and fractures due to falls [341–343], which impact on quality of life. In addition, meals provide structure, joy, and opportunities to socialize with other residents [344–346]. Higher satisfaction with meals is associated with higher food intake [344], a better quality of life and higher overall satisfaction ratings of the long-term care facility [347]. Meals and food are considered to be among the most important things for residents [348] and optimization of quality of life should therefore always be the main purpose for nutritional policy in long-term care facilities.

Despite the important role of nutrition in long-term care facilities, food budgets are very limited, making it difficult to provide healthy and tasty meals [349–351]. Not only more budget is needed, but also a better use of available funds could help. At this moment, meal preparation is mainly done by care staff with limited cooking skills and not by chefs. The use of care staff for meal preparation instead of using chefs is also undesirable as there is a shortage of skilled care workers. In addition, in the Netherlands, wages for care staff are higher compared to wages of chefs [352,353]. It is therefore advised to recruit more specialists for meal preparation to relieve pressure on care staff and to improve the meal experience [78]. Another benefit of using chefs is that they are trained on hygiene. In long-term care facilities, in contrast to catering facilities in the commercial sector, most employees responsible for food provision are not trained in hygiene protocols (HACCP). It is therefore advised to use chefs for meal preparations and make them responsible for the food policy in long-term care facilities. When chefs are

not available, nursing staff should be trained in food preparation and making healthy choices.

Our research population of chapter 8 included only native Dutch residents. Currently, also the first generation of Turkish, Moroccan, and Surinam immigrants are reaching the age of admission to a long-term care facility. Approximately 10% of all residents have a minority background now, but in the upcoming years, an increasing part of all residents will have a different ethnical background [354]. These groups often have different eating patterns and may consume different products than Dutch residents without a migration background. Herewith long-term care facilities should now start to focus on providing a more diverse food pattern. Individual portions can be ordered by the food suppliers when only a few residents have a different ethnical background.

Recommendations for future research

Screening tools

Based on the GLIM criteria, a positive screening is the first step in identifying malnutrition. In chapter 4, we described the low agreement between SNAQ^{65+} and SCREEN II which could have serious implications for identifying persons at risk. At this moment, it is unclear which screening tool is best to identify malnourished persons. Especially the criteria of low muscle mass and poor food intake are difficult to assess by using questionnaires [247]. Hence, despite the large number of available screening tools[68], it is unclear whether they are sensitive and specific enough. By performing a validation study and using all separate items of the 26 validated screening tools [68], which have a large number of overlapping items, a more sensitive tool could potentially made based on new combinations of items. Our group intends to start a Delphi study to redefine the construct of malnutrition, with a clear distinction between early and late phase malnutrition. Once the constructs have been defined, choices can be made for the most appropriate screening tool(s) for each construct of malnutrition.

Chapters 7 and 8 revealed risk factors for developing malnutrition during stay in a long-term care facility, such as the presence of multiple behavioural-cognitive problems and diseases/health-related problems. Most of these risk factors have never been incorporated into malnutrition screening tools. In addition, screening tools are mainly based on cross-sectional data providing no risk assessment for future malnutrition. Screening tools based on prospective data may therefore be better in identifying residents at risk of becoming malnourished during their stay. Based on the results of chapters 7 and 8, a new prospective prediction model could be developed.

Descriptive studies

In the MaNuEL consortium, meta-analyses and regression analyses were performed to study differences in prevalence rates of malnutrition between different countries and settings. However, in these study, only unadjusted analyses were conducted which hinders comparisons between countries and settings. For example, the prevalence rate of malnutrition was highest in Switzerland (37.7%) but in that country, only data from the hospital setting was available, where in other countries also data from the community was included. To overcome this problem, InterRAI data can be used. InterRAI data is available for different settings (community, long-term care and hospital) and is used in 13 different countries. As all variables are measured in the same way, a true comparison of prevalence and incidence rates between countries and settings could be made.

Regarding malnutrition in older adults, focus is mainly given to protein/energy malnutrition. Less attention is being paid to micronutrient deficiencies in older adults. The most recent assessment of the micronutrient status of Dutch residents in long-term care facilities dates from 2006 [77]. New research on this topic is therefore needed as guidelines on vitamins and minerals have changed over time [254]. Research should especially focus on vitamin B6 and vitamin D, both associated with functional outcomes and muscle strength [355,356]. Already half of the Dutch community-dwelling older adults consumes less than the requirements [357], which suggests that supplementation of these micronutrients is warranted in long-term care facilities. In addition, as a switch towards plant-based products is desirable for sustainability, research should also focus on how this will affect micronutrient intake.

Intervention studies

Most previous research on malnutrition was focused on providing oral nutritional support, which is a curative intervention rather than a preventive intervention. Now it is time to perform more preventive-orientated interventions that focus on early determinants of malnutrition. The practical suggestions that are given in the ESPEN guidelines 'clinical nutrition and hydration in geriatrics' by Volkert et al. [74] were never studied on effectiveness and should therefore be tested in practice by performing RCTs. When performing RCTs, it is important to assess relevant outcome measurements. The recent advice by the MaNuEL consortium on this topic is a first step in harmonizing nutritional research [358]. Relevant outcome measures such as energy/protein intake, physical functioning, quality of life and body composition, should be used to assess the effectiveness of nutritional interventions [358,359]. Previously performed trails often lacked these measurements. For instance, a large body of evidence is available about cooking workshops for older adults but the effects on changes in food intake (energy or protein intake) are rarely

described [360]. Before designing new interventions, existing initiatives and interventions should first be described with proper outcome measurements.

In the ConsuMEER study, we focused on the provision of ready-made meals for community-dwelling older adults. Ready-made meals are a relatively well-described topic in older adults, hence new research should focus on other types of interventions. A large part of older adults is suffering from problems regarding loneliness and problems with grocery shopping, but currently, very limited interventions are described that focus on these problems. In 2016, a pilot study was performed in the UK where volunteers helped older adults with grocery shopping, meal preparation and eventually eat the prepared meal together [298]. Based on the promising results of this pilot study, an additional study including more participants is recommended.

When designing new studies, already existing initiatives should not be forgotten. Advised interventions such as eating together are already taking place; local initiatives in churches and community centres already exist [78], but are rarely described in the literature. These initiatives are often taking place for a longer period and they know the pitfalls and success factors. These initiatives are worth describing or could be incorporated into new interventional studies to make them more effective.

In chapter 9, we showed that both energy and protein intake was low in nursing-home residents. /relatively large increases in intake would be needed to improve nutrient intake towards the recommended levels, interventions should be multifactorial. Nursing home interventions should consist of increasing knowledge of staff, both on malnutrition but also the protein content of products, helping them to make better choices when ordering products, and improving their food preparation skills. On the product side, residents should be supplied within-between snacks and nutrient-dense products. Outcome measures in evaluation studies should not only be described in terms of protein-energy intake but also impact on quality of life, being the most important aspect of food in nursing home residents.

Conclusion

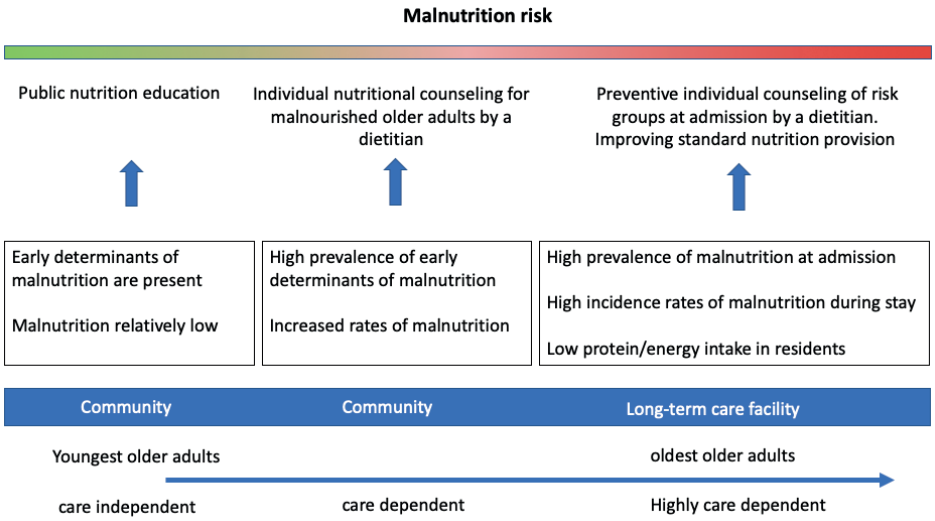

Figure 1, *Malnutrition and policy to address this problem during the journey of ageing.*

In this thesis we studied malnutrition during the journey of ageing; from healthy older adults in the community to frail residents in long-term care facilities. In the previous chapters, we aimed to assess malnutrition prevalence, to identify groups at risk, and to provide possible treatment solutions. Figure 1 provides an overview of malnutrition risk and possible solutions during the journey of ageing.

Many community-dwelling older adults already display early determinants of malnutrition. Even the youngest older adults may suffer from multiple risk factors, and these numbers increase with ageing. Eventually nearly everyone aged >85 years is at nutritional risk. Early determinants of malnutrition are often associated with social factors such as living alone, low income level, and also with poor mobility levels. Late phase malnutrition is uncommon in the youngest older adults, but increases with ageing and is associated with physical decline.

To prevent older adults from becoming malnourished, preventive measures should be taken. These measures should be guided by the stage of malnutrition. General education is needed to increase awareness about malnutrition in older adults, (informal) caregivers and family members. To treat and prevent (early determinants of) malnutrition, interdisciplinary working and collaboration is required because it is a multifactorial problem. Preventive and curative measures should address underlying problems instead of just aiming to increase food intake by for instance, providing ready-made meals or ONS.

In long-term care facilities, prevalence of malnutrition is even higher compared to the community: Over one-third of all residents is suffering from malnutrition, depending on the used criteria (weight loss, low age-specific BMI or both combined). Multiple behavioural-cognitive problems and most diseases/health-related problems are associated with increased risk of being malnourished at admission or becoming malnourished during stay.

One of the reasons for the high prevalence of malnutrition could be the low protein and energy intake of residents in long-term care facilities; most residents do not reach the requirements. As a too low intake is more rule than exception, food policy in LTCF should change: protein-rich food should become the standard, instead of providing additional products when a resident is diagnosed with a poor intake.

References

[1] Berkeley University of California, Max Planck Institute for Demographic Research. Human Mortality Database, Life expectancy at birth 2021. https://www.mortality.org/cgi-bin/hmd/country.php?cntr=NLD&level=1 (accessed October 22, 2021).

[2] CBS. Hoeveel ouderen zijn er in Nederland? 2021. https://www.cbs.nl/nl-nl/visualisaties/dashboard-bevolking/leeftijd/ouderen (accessed February 14, 2022).

[3] Rau R, Soroko E, Jasilionis D, Vaupel JW. Continued reductions in mortality at advanced ages. Popul Dev Rev 2008;34:747–68. doi:10.1111/j.1728-4457.2008.00249.x.

[4] Greene VW. Personal hygiene and life expectancy improvements since 1850: Historic and epidemiologic associations. Am J Infect Control 2001;29:203–6. doi:10.1067/mic.2001.115686.

[5] Olshansky SJ, Rudberg MA, Carnes BA, Cassel CK, Brody JA. Trading Off Longer Life for Worsening Health. J Aging Health 1991;3:194–216. doi:10.1177/089826439100300205.

[6] Adedejij W. The treasure called antibiotics. Ann Ibadan Postgrad Med 2016;14:56–61.

[7] Leon DA. Trends in European life expectancy: a salutary view. Int J Epidemiol 2011;40:271–7. doi:10.1093/ije/dyr061.

[8] Kingston A, Wohland P, Wittenberg R, Robinson L, Brayne C, Matthews FE, et al. Is late-life dependency increasing or not? A comparison of the Cognitive Function and Ageing Studies (CFAS). Lancet 2017;390:1676–84. doi:10.1016/S0140-6736(17)31575-1.

[9] Atella V, Piano Mortari A, Kopinska J, Belotti F, Lapi F, Cricelli C, et al. Trends in age-related disease burden and healthcare utilization. Aging Cell 2019;18:e12861. doi:10.1111/acel.12861.

[10] Ministeria van volksgezondheid welzijn en sport. Dialoognota ouder worden: 2020-2040. Den Haag: 2021.

[11] Barnett I, Van Sluijs EMF, Ogilvie D. Physical activity and transitioning to retirement: A systematic review. Am J Prev Med 2012;43:329–36. doi:10.1016/j.amepre.2012.05.026.

[12] Eibich P. Understanding the effect of retirement on health: Mechanisms and heterogeneity. J Health Econ 2015;43:1–12. doi:10.1016/j.jhealeco.2015.05.001.

[13] Komp K, van Tilburg T, van Groenou MB. Age, Retirement, and Health as Factors in Volunteering in Later Life. Nonprofit Volunt Sect Q 2012;41:280–99. doi:10.1177/0899764011402697.

[14] Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. Lancet 2013;381:752–62. doi:10.1016/S0140-6736(12)62167-9.

[15] Mangen MJJ, Bolkenbaas M, Huijts SM, van Werkhoven CH, Bonten MJM, de Wit GA. Quality of life in community-dwelling Dutch elderly measured by EQ-5D-3L. Health Qual Life Outcomes 2017;15. doi:10.1186/s12955-016-0577-5.

[16] Gobbens RJ. Associations of ADL and IADL disability with physical and mental dimensions of quality of life in people aged 75 years and older. PeerJ 2018;2018. doi:10.7717/peerj.5425.

[17] van Rijn M. Hervorming langdurige zorg: naar een waardevolle toekomst. 2012.

[18] Walker A. Why the UK Needs a Social Policy on Ageing. J Soc Policy 2018;47:253–73. doi:10.1017/S0047279417000320.

[19] Den draak M, Marangos A, Plaisier I, de Klerk M. Wel thuis? Literatuurstudie naar factoren die zelfstandig wonen van mensen met beperkingen beïnvloeden. Den Haag: 2016.

[20] CBS. Laatste levensjaren tachtigplussers n.d. https://www.cbs.nl/nl-nl/longread/statistische-trends/2020/laatste-levensjaren-tachtigplussers?onepage=true (accessed February 18, 2022).

[21] Robinson TN, Wallace JI, Wu DS, Wiktor A, Pointer LF, Pfister SM, et al. Accumulated frailty characteristics predict postoperative discharge institutionalization in the geriatric patient. J Am Coll Surg 2011;213. doi:10.1016/j.jamcollsurg.2011.01.056.

[22] Kojima G, Iliffe S, Jivraj S, Walters K. Association between frailty and quality of life among community-dwelling older people: A systematic review and meta-analysis. J Epidemiol Community Health 2016;70. doi:10.1136/jech-2015-206717.

[23] Rizzoli R, Reginster JY, Arnal JF, Bautmans I, Beaudart C, Bischoff-Ferrari H, et al. Quality of life in sarcopenia and frailty. Calcif Tissue Int 2013;93. doi:10.1007/s00223-013-9758-y.

[24] Pacifico J, Reijnierse EM, Lim WK, Maier AB. The Association between Sarcopenia as a Comorbid Disease and Incidence of Institutionalisation and Mortality in Geriatric Rehabilitation Inpatients: REStORing health of acutely unwell adulTs (RESORT). Gerontology 2021. doi:10.1159/000517461.

[25] Rasheed S, Woods RT. Malnutrition and quality of life in older people: A systematic review and meta-analysis. Ageing Res Rev 2013;12:561–6. doi:10.1016/j.arr.2012.11.003.

[26] Marshall S, Bauer J, Isenring E. The consequences of malnutrition following discharge from rehabilitation to the community: A systematic review of current evidence in older adults. J Hum Nutr Diet 2014;27:133–41. doi:10.1111/jhn.12167.

[27] Payette H, Coulombe C, Boutier V, Gray-Donald K. Nutrition risk factors for institutionalization in a free-living functionally dependent elderly population. J Clin Epidemiol 2000;53:579–87. doi:10.1016/S0895-4356(99)00186-9.

[28] Jeejeebhoy KN. Malnutrition, fatigue, frailty, vulnerability, sarcopenia and cachexia: Overlap of clinical features. Curr Opin Clin Nutr Metab Care 2012;15. doi:10.1097/MCO.0b013e328352694f.

[29] Severin R, Berner PM, Miller KL, Mey J. The Crossroads of Aging: An Intersection of Malnutrition, Frailty, and Sarcopenia. Top Geriatr Rehabil 2019;35. doi:10.1097/TGR.0000000000000218.

[30] Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al. Frailty in Older Adults: Evidence for a Phenotype. J Gerontol Med Sci Am 2001;56:146–56. doi:10.1093/gerona/56.3.M146.

[31] Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173. doi:10.1503/cmaj.050051.

[32] Muscedere J. Editorial: The Need to Implement Frailty in the International Classification of Disease (ICD). J Frailty Aging 2020;9. doi:10.14283/jfa.2020.2.

[33] Cesari M, Gambassi G, Van Kan GA, Vellas B. The frailty phenotype and the frailty index: Different instruments for different purposes. Age Ageing 2014;43. doi:10.1093/ageing/aft160.

[34] Gobbens RJJ, Van Assen MALM, Luijkx KG, Schols JMGA. The predictive validity of the tilburg frailty indicator: Disability, health care utilization, and quality of life in a population at risk. Gerontologist 2012;52. doi:10.1093/geront/gnr135.

[35] Schuurmans H, Steverink N, Lindenberg S, Frieswijk N, Slaets JPJ. Old or frail: What tells us more? Journals Gerontol - Ser A Biol Sci Med Sci 2004;59. doi:10.1093/gerona/59.9.m962.

[36] van Assen MALM, Pallast E, Fakiri F El, Gobbens RJJ. Measuring frailty in Dutch community-dwelling older people: Reference values of the Tilburg Frailty Indicator (TFI). Arch Gerontol Geriatr 2016;67. doi:10.1016/j.archger.2016.07.005.

[37] WHO. ICD-11 for Mortality and Morbidity Statistics (ICD-11 MMS) n.d. https://icd.who.int/browse11/l-m/en.

[38] Cruz-Jentoft AJ, Landi F. Sarcopenia. Clin Med J R Coll Physicians London 2014;14. doi:10.7861/clinmedicine.14-2-183.

[39] Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: Revised European consensus on definition and diagnosis. Age Ageing 2019;48. doi:10.1093/ageing/afy169.

[40] Trajanoska K, Schoufour JD, Darweesh SKL, Benz E, Medina-Gomez C, Alferink LJM, et al. Sarcopenia and Its Clinical Correlates in the General Population: The Rotterdam Study. J Bone Miner Res 2018;33. doi:10.1002/jbmr.3416.

[41] Schaap LA, Van Schoor NM, Lips P, Visser M. Associations of sarcopenia definitions, and their components, with the incidence of recurrent falling and fractures: The longitudinal aging study Amsterdam. Journals Gerontol - Ser A Biol Sci Med Sci 2018;73. doi:10.1093/gerona/glx245.

[42] Dorhout BG, Overdevest E, Tieland M, Nicolaou M, Weijs PJM, Snijder MB, et al. Sarcopenia and its relation to protein intake across older ethnic populations in the Netherlands: the HELIUS study. Ethn Heal 2020. doi:10.1080/13557858.2020.1814207.

[43] Sobotka L. Basics in Clinical Nutrition. Prague, Czech Republic: Galén; 2019.

[44] Cederholm T, Barazzoni R, Austin P, Ballmer P, Biolo G, Bischoff SC, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. Clin Nutr 2017;36. doi:10.1016/j.clnu.2016.09.004.

[45] Cederholm T, Bosaeus I, Barazzoni R, Bauer J, Van Gossum A, Klek S, et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clin Nutr 2015;34:335–40. doi:10.1016/j.clnu.2015.03.001.

[46] WHO. Proposals n.d. https://icd.who.int/dev11/Help/Get/proposal_main/en (accessed February 23, 2022).

[47] Cederholm T, Jensen GL, Correia MITD, Gonzalez MC, Fukushima R, Higashiguchi T, et al. GLIM criteria for the diagnosis of malnutrition – A consensus report from the global clinical nutrition community. Clin Nutr 2019;38:1–9. doi:10.1016/j.clnu.2018.08.002.

[48] Cederholm T, Jensen GL. To create a consensus on malnutrition diagnostic criteria. J Parenter Enter Nutr 2017;41. doi:10.1177/0148607116686293.

[49] Streicher M, van Zwienen-Pot J, Bardon L, Nagel G, Teh R, Meisinger C, et al. Determinants of Incident Malnutrition in Community-Dwelling Older Adults: A MaNuEL Multicohort Meta-Analysis. J Am Geriatr Soc 2018;66:2335–43. doi:10.1111/jgs.15553.

[50] Halfens RJ., Meesterberends E, Neyens JC., Rondas AAL., Rijcken S, Wolters S, et al. Landelijke Prevalentiemeting Zorgproblemen Rapportage resultaten 2015. Maastricht: 2016.

[51] Faxén-Irving G, Luiking Y, Grönstedt H, Franzén E, Seiger, Vikström S, et al. Do Malnutrition, Sarcopenia and Frailty Overlap in Nursing-Home Residents? J Frailty Aging 2021;10. doi:10.14283/jfa.2020.45.

[52] Ligthart-Melis GC, Luiking YC, Kakourou A, Cederholm T, Maier AB, de van der Schueren MAE. Frailty, Sarcopenia, and Malnutrition Frequently (Co-)occur in Hospitalized Older Adults: A Systematic Review and Meta-analysis. J Am Med Dir Assoc 2020;21. doi:10.1016/j.jamda.2020.03.006.

[53] Cruz-Jentoft AJ, Kiesswetter E, Drey M, Sieber CC. Nutrition, frailty, and sarcopenia. Aging Clin Exp Res 2017;29. doi:10.1007/s40520-016-0709-0.

[54] Saunders J, Smith T. Malnutrition: Causes and consequences. Clin Med J R Coll Physicians London 2010;10:624–7. doi:10.7861/clinmedicine.10-6-624.

[55] Trevisan C, Crippa A, Ek S, Welmer AK, Sergi G, Maggi S, et al. Nutritional Status, Body Mass Index, and the Risk of Falls in Community-Dwelling Older Adults: A Systematic Review and Meta-Analysis. J Am Med Dir Assoc 2019;20:569–82. doi:10.1016/j.jamda.2018.10.027.

[56] Fadnes L, Økland J, Øystein A, Johansson K. Estimating impact of food choices on life expectancy: A modeling study. Plos Med 2022;19:e1003889.

[57] Netherlands H council of the. Evaluation of dietary reference values for protein. Den Haag: 2021.

[58] Food Safety Authoriy of Ireland. Scientific recommendations for food-based dietary guidelines for older adults in Ireland. 2021.

[59] Fogelholm M. New Nordic Nutrition Recommendations are here. Food Nutr Res 2013;57. doi:10.3402/fnr.v57i0.22903.

[60] Richter M, Baerlocher K, Bauer JM, Elmadfa I, Heseker H, Leschik-Bonnet E, et al. Revised Reference Values for the Intake of Protein. Ann Nutr Metab 2019;74. doi:10.1159/000499374.

[61] Bauer J, Biolo G, Cederholm T, Cesari M, Cruz-Jentoft AJ, Morley JE, et al. Evidence-based recommendations for optimal dietary protein intake in older people: A position paper from the prot-age study group. J Am Med Dir Assoc 2013;14:542–59. doi:10.1016/j.jamda.2013.05.021.

[62] Deutz NEP, Bauer JM, Barazzoni R, Biolo G, Boirie Y, Bosy-Westphal A, et al. Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. Clin Nutr 2014;33:929–36. doi:10.1016/j.clnu.2014.04.007.

[63] van der Meij B, Grootswagers P, de Groot L, de van der Schueren M. Experts reageren op rapport 'Voedingsnormen voor eiwitten' voor ouderen. Ned Tijdschr Voor Diet 2021;76.

[64] Ocke M, Buurma-Rethans E, De Boer E, Wilson-Van Den Hooven C, Etemad-Ghameshlou Z, Drijvers J. The diet of community-dwelling older adults. Results from the dutch national food consumption survey-2010-2012. Ann Nutr Metab 2015;67:351–2.

[65] Keller HH. Promoting food intake in older adults living in the community: a review. Appl Physiol Nutr Metab 2007;32:991–1000. doi:10.1139/H07-067.

[66] Volkert D, Kiesswetter E, Cederholm T, Donini LM, Eglseer D, Norman K, et al. Development of a Model on Determinants of Malnutrition in Aged Persons: A MaNuEL Project. Gerontol Geriatr Med 2019;5:1–8. doi:10.1177/2333721419858438.

[67] Leij-Halfwerk S, Verwijs MH, van Houdt S, Borkent JW, Guaitoli PR, Pelgrim T, et al. Prevalence of protein-energy malnutrition risk in European older adults in community, residential and hospital settings, according to 22 malnutrition screening tools validated for use in adults ≥65 years: A systematic review and meta-analysis. Maturitas 2019. doi:10.1016/j.maturitas.2019.05.006.

[68] Power L, Mullaly D, Gibney E, Clarke M, Visser M, Dorothee V, et al. A review of the validity of malnutrition screening tools used in older adults in community and healthcare settings – A MaNuEL study. Clin Nutr 2018;24:1–13.

[69] Correa-Pérez A, Abraha I, Cherubini A, Collinson A, Dardevet D, Hebestreit A, et al. Efficacy of non-pharmacological interventions to treat malnutrition in older persons: A systematic review and meta-analysis. Ageing Res Rev 2019;49:27–48.

[70] Keller HH, Goy R, Kane S-L. Validity and reliability of SCREEN II (Seniors in the Community: Risk evaluation for eating and nutrition, Version II). Eur J Clin Nutr 2005;59:1149–57. doi:10.1038/sj.ejcn.1602225.

[71] Ramage-Morin PL, Garriguet D. Nutritional risk among older Canadians. Heal Reports 2013;24:3–13. doi:10.1109/ICB.2012.6199750.

[72] Wham CA, Teh ROY, Robinson M, Kerse NM. What is associated with nutrition risk in very old age? J Nutr Heal Aging 2011;15:247–51. doi:10.1007/s12603-010-0304-6.

[73] Wham CA, Teh R, Moyes S, Dyall L, Kepa M, Hayman K, et al. Health and Social Factors Associated with Nutrition Risk: Results from Life and Living in Advanced Age: A Cohort Study in New Zealand (LiLACS NZ). J Nutr Health Aging 2015;19:637–45. doi:10.1007/s12603-015-0514-z.

[74] Volkert D, Beck AM, Cederholm T, Cruz-Jentoft A, Goisser S, Hooper L, et al. ESPEN guideline on clinical nutrition and hydration in geriatrics. Clin Nutr 2018. doi:10.1016/j.clnu.2018.05.024.

[75] CBS. Aantal bewoners van verzorgings- en verpleeghuizen 2019 n.d. https://www.cbs.nl/nl-nl/maatwerk/2020/13/aantal-bewoners-van-verzorgings-en-verpleeghuizen-2019.

[76] Schilp J, Kruizenga HM, Wijnhoven HAH, Leistra E, Evers AM, van Binsbergen JJ, et al. High prevalence of undernutrition in Dutch community-dwelling older individuals. Nutrition 2012;28:1151–6. doi:10.1016/j.nut.2012.02.016.

[77] Manders M, de Groot CPGM, Blauw YH, Dhonukshe-Rutten RAM, van Hoeckel-Prüst L, Bindels JG, et al. Effect of a nutrient-enriched drink on dietary intake and nutritional status in institutionalised elderly. Eur J Clin Nutr 2009;63. doi:10.1038/ejcn.2009.28.

[78] ten Kate L, Peppelenbos H. Eindrapport Taskforce Gezond Eten met Ouderen. 2018.
[79] Van Der Pols-Vijlbrief R, Wijnhoven HAH, Molenaar H, Visser M. Factors associated with (risk of) undernutrition in community-dwelling older adults receiving home care: A cross-sectional study in the Netherlands. Public Health Nutr 2016;19:2278–89. doi:10.1017/S1368980016000288.
[80] Duin C., Stoeldraijer L, van Roon D, Harmsen C. Huishoudensprognose 2015–2060: jongeren en ouderen langer thuis. Den Haag: 2016.
[81] Lim SL, Ong KCB, Chan YH, Loke WC, Ferguson M, Daniels L. Malnutrition and its impact on cost of hospitalization, length of stay, readmission and 3-year mortality. Clin Nutr 2012;31:345–50. doi:10.1016/j.clnu.2011.11.001.
[82] Chapman IMP. Nutritional Disorders in the Elderly. Med Clin North Am 2006;90:887–907. doi:10.1016/j.mcna.2006.05.010.
[83] Phillips MB, Foley AL, Barnard R, Isenring EA, Miller MD. Nutritional screening in community-dwelling older adults: A systematic literature review. Asia Pac J Clin Nutr 2010;19:440–9.
[84] Ziylan C, Haveman-Nies A, van Dongen EJI, Kremer S, de Groot LCPGM. Dutch nutrition and care professionals' experiences with undernutrition awareness, monitoring, and treatment among community-dwelling older adults: a qualitative study. BMC Nutr 2015;1:38. doi:10.1186/s40795-015-0034-6.
[85] CBS. Internet; toegang, gebruik en faciliteiten 2018. https://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=83429ned&D1=0-69&D2=3-19&D3=0&D4=a&VW=T (accessed May 22, 2020).
[86] Wijnhoven HAH, Schilp J, van Bokhorst-de van der Schueren MAE, de Vet HCW, Kruizenga HM, Deeg DJH, et al. Development and validation of criteria for determining undernutrition in community-dwelling older men and women: The Short Nutritional Assessment Questionnaire 65 +. Clin Nutr 2012;31:351–8. doi:10.1016/j.clnu.2011.10.013.
[87] van der Pols-Vijlbrief R, Wijnhoven HAH, Schaap LA, Terwee CB, Visser M. Determinants of protein-energy malnutrition in community-dwelling older adults: A systematic review of observational studies. Ageing Res Rev 2014;18:112–31. doi:10.1016/j.arr.2014.09.001.
[88] Haakma T., Wham CA. High prevalence of nutrition risk among community living older people in woerden, the Netherlands. J Aging Res Clin Pract 2015;4:230–4.
[89] Wham CA, Redwood KM, Kerse N. Validation of the nutrition screening tool "Seniors in the Community: Risk Evaluation for Eating and Nutrition, version II" among octogenarians. J Nutr Heal Aging 2014;18:39–43. doi:10.1007/s12603-013-0361-8.
[90] Villareal DT, Apovian CM, Kushner RF, Klein S. Obesity in older adults: Technical review and position statement of the American Society for Nutrition and NAASO, the Obesity Society. Obes Res 2005;13:1849–63. doi:10.1038/oby.2005.228.
[91] Berner LA, Becker G, Wise M, Doi J. Characterization of dietary protein among older adults in the united states: Amount, animal sources, and meal patterns. J Acad Nutr Diet 2013;113:809–15. doi:10.1016/j.jand.2013.01.014.
[92] Tieland M, Borgonjen-Van Den Berg KJ, Van Loon LJC, De Groot LCPGM. Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: Scope for improvement. Eur J Nutr 2012;51:173–9. doi:10.1007/s00394-011-0203-6.
[93] Locher JL, Robinson CO, Roth DL, Ritchie CS, Burgio KL. The effect of the presence of others on caloric intake in homebound older adults. Journals Gerontol - Ser A Biol Sci Med Sci 2005;60:1475–8. doi:10.1093/gerona/60.11.1475.
[94] van der Pols-Vijlbrief R, Wijnhoven HAH, Visser M. Perspectives on the causes of undernutrition of community-dwelling older adults: A qualitative study. J Nutr Heal Aging 2017;21:1200–9. doi:10.1007/s12603-017-0872-9.

[95] Tani Y, Kondo N, Takagi D, Saito M, Hikichi H, Ojima T, et al. Combined effects of eating alone and living alone on unhealthy dietary behaviors, obesity and underweight in older Japanese adults: Results of the JAGES. Appetite 2015;95:1–8. doi:10.1016/j.appet.2015.06.005.

[96] Corish CA, Bardon LA. Malnutrition in older adults: screening and determinants. Proc Nutr Soc 2018:1–8.

[97] Ramage-Morin PL, Garriguet D. Nutritional risk among older Canadians. Heal Reports 2013;24:3–13.

[98] Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of age on validity of self-reported height, weight, and body mass index: Findings from the third National Health and Nutrition Examination Survey, 1988-1994. J Am Diet Assoc 2001;101:28–34. doi:10.1016/S0002-8223(01)00008-6.

[99] Lawlor DA, Bedford C, Taylor M, Ebrahim S. Agreement between measured and self-reported weight in older women. Results from the British women's heart and health study. Age Ageing 2002;31:169–74. doi:10.1093/ageing/31.3.169.

[100] Sahyoun NR, Maynard LM, Zhang XL, Serdula MK. Factors associated with errors in self-reported height and weight in older adults. J Nutr Heal Aging 2008;12:108–15. doi:10.1007/BF02982562.

[101] Niedhammer I, Bugel I, Bonenfant S, Goldberg M, Leclerc A. Validity of self-reported weight and height in the french GAZEL cohort. Int J Obes 2000;24:1111–8. doi:10.1038/sj.ijo.0801375.

[102] Krul AJ, Daanen HAM, Choi H. Self-reported and measured weight, height and body mass index (BMI) in Italy, the Netherlands and North America. Eur J Public Health 2011;21:414–9. doi:10.1093/eurpub/ckp228.

[103] O'Keeffe M, Kelly M, O'Herlihy E, O'Toole PW, Kearney PM, Timmons S, et al. Potentially modifiable determinants of malnutrition in older adults: A systematic review. Clin Nutr 2019. doi:10.1016/j.clnu.2018.12.007.

[104] Brownie S. Why are elderly individuals at risk of nutritional deficiency? Int J Nurs Pract 2006;12:110–8. doi:10.1111/j.1440-172X.2006.00557.x.

[105] van Deursen AJAM, Helsper EJ. A nuanced understanding of Internet use and non-use among the elderly. Eur J Commun 2015;30:171–87. doi:10.1177/0267323115578059.

[106] Hunsaker A, Hargittai E. A review of Internet use among older adults. New Media Soc 2018;20:3937–54. doi:10.1177/1461444818787348.

[107] König R, Seifert A, Doh M. Internet use among older Europeans: an analysis based on SHARE data. Univers Access Inf Soc 2018;17:621–33. doi:10.1007/s10209-018-0609-5.

[108] WHO. Global Health and Aging. 2011. doi:11-7737.

[109] Agarwal E, Miller M, Yaxley A, Isenring E. Malnutrition in the elderly: A narrative review. Maturitas 2013;76:296–302. doi:10.1016/j.maturitas.2013.07.013.

[110] Haakma TA, Wham C. High prevalence of Nutrition risk among community living older people in Woerden, The Netherlands. J Aging Res Clin Pract 2015;4:230–4.

[111] Borkent JW, Beelen J, Linschooten JO, Roodenburg AJC, de van der Schueren MAE. The ConsuMEER study: a randomised trial towards the effectiveness of protein-rich ready- made meals and protein-rich dairy products in increasing protein intake of community-dwelling older adults after switching from self-prepared meals towards ready-made. J Nutr Sci 2019.

[112] Borkent JW, Naumann E, Vasse E, van der Heijden E, de van der Schueren MAE. Prevalence and determinants of undernutrition in a sample of dutch community-dwelling older adults: Results from two online screening tools. Int J Environ Res Public Health 2019;16:1562–73. doi:10.3390/ijerph16091562.

[113] Dulin PL, Stephens C, Alpass F, Hill RD SB. The impact of socio-contextual, physical and lifestyle variables on measures of physical and psychological wellbeing among Māori and non-Māori: the

New Zealand Health, Work and Retirement Study. Ageing Soc 2011;31:1406–24. doi:10.1017/s0144686x10001479.

[114] Rothman KJ, Gallacher JEJ, Hatch EE. Why representativeness should be avoided. Int J Epidemiol 2013;42:1012–4. doi:10.1093/ije/dys223.

[115] Hatch EE, Hahn KA, Wise LA, Mikkelsen EM, Kumar R, Fox MP, et al. Evaluation of Selection Bias in an Internet-based Study of Pregnancy Planners. Epidemiology 2016;27:98. doi:10.1097/EDE.0000000000000400.

[116] Pizzi C, De Stavola B, Merletti F, Bellocco R, Silva I dos S, Pearce N, et al. Sample selection and validity of exposureedisease association estimates in cohort studies. J Epidemiol Community Health 2011;65:407–11. doi:10.1136/jech.2009.107185.

[117] Borkent J, Schuurman L, Beelen J, Linschooten J, Keller H, Roodenburg A, et al. What do screening tools measure? lessons learned from SCREEN II and SNAQ65+. Clin Nutr ESPEN 2020.

[118] Ministry of Health. Eating and Activity Guidelines for New Zealand Adults. 2015.

[119] Department of Health and Human Services. DIETARY GUIDELINES FOR AMERICANS 2015-2020 EIGHTH EDITION. 2015.

[120] RIVM. Dutch National Food Consumption Survey Older Adults 2010-2012. 2013.

[121] Garriguet D. Overview of Canadians' Eating Habits. Stat Canada 2004;2004:82–620. doi:ISSN: 1716-6713.

[122] Ministry of Health. Food and Nutrition Guidelines for Healthy Older People: A background paper. 2013.

[123] Hooper L, Bunn D, Jimoh FO, Fairweather-Tait SJ. Water-loss dehydration and aging. Mech Ageing Dev 2014;136:50–8. doi:10.1016/j.mad.2013.11.009.

[124] Luckey AE, Parsa CJ. Fluid and electrolytes in the aged. Arch Surg 2003;138:1055–60. doi:10.1001/archsurg.138.10.1055.

[125] Hooper L, Bunn DK, Downing A, Jimoh FO, Groves J, Free C, et al. Which Frail Older People Are Dehydrated? the UK DRIE Study. Journals Gerontol - Ser A Biol Sci Med Sci 2016;71:1341=1347. doi:10.1093/gerona/glv205.

[126] Onder G, Liperoti R, Soldato M, Cipriani MC, Bernabei R, Landi F. Chewing problems and mortality in older adults in home care: Results from the aged in home care study. J Am Geriatr Soc 2007;55:1961–6. doi:10.1111/j.1532-5415.2007.01453.x.

[127] Furuta M, Yamashita Y. Oral Health and Swallowing Problems. Curr Phys Med Rehabil Reports 2013;1:216–22. doi:10.1007/s40141-013-0026-x.

[128] Petersen PE, Kandelman D, Arpin S, Ogawa H. Global oral health of older people--call for public health action. Community Dent Health 2010;27:257–67.

[129] Tada A, Miura H. Systematic review of the association of mastication with food and nutrient intake in the independent elderly. Arch Gerontol Geriatr 2014;59:497–505. doi:10.1016/j.archger.2014.08.005.

[130] Quandt SA, Chen H, Bell RA, Savoca MR, Anderson AM, Leng X, et al. Food avoidance and food modification practices of older rural adults: Association with oral health status and implications for service provision. Gerontologist 2010;50:100–11. doi:10.1093/geront/gnp096.

[131] Vandenberghe-Descamps M, Sulmont-Rossé C, Septier C, Follot C, Feron G, Labouré H. Impact of blade tenderization, marinade and cooking temperature on oral comfort when eating meat in an elderly population. Meat Sci 2018;145:86–93. doi:10.1016/j.meatsci.2018.06.004.

[132] Host A, McMahon AT, Walton K, Charlton K. Factors Influencing Food Choice for Independently Living Older People—A Systematic Literature Review. J Nutr Gerontol Geriatr 2016;35:67–94. doi :10.1080/21551197.2016.1168760.

[133] Wylie C, Copeman J, Kirk SFL. Health and social factors affecting the food choice and nutritional intake of elderly people with restricted mobility. J Hum Nutr Diet 1999;12:375–80. doi:10.1046/j.1365-277x.1999.00177.x.

[134] Canada Statistics. Location of Internet access by age group and household income quartile 2020. doi:https://doi.org/10.25318/2210008101-eng.

[135] Ministery of social Development. The Social Report 2016. 2016.

[136] Yoon H, Jang Y, Vaughan PW, Garcia M. Older adults' Internet use for health information: Digital divide by race/ethnicity and socioeconomic status. J Appl Gerontol 2020;39:105-110.

[137] United Nations Department of Economic and Social Affairs. World Population Prospects: The 2017 Revision. 2017. doi:10.1017/CBO9781107415324.004.

[138] Alemayehu B, Warner KE. The lifetime distribution of health care costs. Health Serv Res 2004;39:627–42. doi:10.1111/j.1475-6773.2004.00248.x.

[139] Meerding WJ, Bonneux L, Polder JJ, Koopmanschap MA, van der Maas PJ. Demographic and epidemiological determinants of healthcare costs in Netherlands: cost of illness study. BMJ 1998;371:111–5. doi:10.1136/bmj.317.7151.111.

[140] Sixsmith A, Sixsmith J. Ageing in Place in the United Kingdom. Ageing Int 2008;32:219–35. doi:10.1007/s12126-008-9019-y.

[141] Van Bokhorst-de van der Schueren MAE, Guaitoli PR, Jansma EP, de Vet HCW. Nutrition screening tools: Does one size fit all? A systematic review of screening tools for the hospital setting. Clin Nutr 2014;33:39–58. doi:10.1016/j.clnu.2013.04.008.

[142] MacMahon S, Baigent C, Duffy S, Rodgers A, Tominaga S, Chambless L, et al. Body-mass index and cause-specific mortality in 900 000 adults: Collaborative analyses of 57 prospective studies. Lancet 2009;373:1083–96. doi:10.1016/S0140-6736(09)60318-4.

[143] Langius J, Visser W, Kruizenga H, Reijven N. Meetprotocol handknijpkracht m.b.v. Hand Dynamometer 2017:1–12. https://nutritionalassessment.nl/wp-content/uploads/2017/11/SOP-Handknijpkracht-NAP-1.pdf.

[144] Dodds RM, Syddall HE, Cooper R, Benzeval M, Deary IJ, Dennison EM, et al. Grip strength across the life course: Normative data from twelve British studies. PLoS One 2014;9:e113637. doi:10.1371/journal.pone.0113637.

[145] Bischoff HA, Stähelin HB, Monsch AU, Iversen MD, Weyh A, von Dechend M, et al. Identifying a cut-off point for normal mobility: A comparison of the timed "up and go" test in community-dwelling and institutionalised elderly women. Age Ageing 2003;32:315–20. doi:10.1093/ageing/32.3.315.

[146] Tombaugh TN, McIntyre NJ. The mini-mental state examination: a comprehensive review. J Am Geriatr Soc 1992;40:922–35. doi:10.1111/j.1532-5415.1992.tb01992.x.

[147] Stel VS, Smit JH, Pluijm SMF, Visser M, Deeg DJH, Lips P. Comparison of the LASA Physical Activity Questionnaire with a 7-day diary and pedometer. J Clin Epidemiol 2004;57:252–8. doi:10.1016/j.jclinepi.2003.07.008.

[148] Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39:1423–34. doi:10.1249/mss.0b013e3180616b27.

[149] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–73.

[150] Guigoz Y. The Mini-Nutritional Assessment (MNA): Review of the Literature - What does it tell us? J Nutr Heal Aging 2006;10:466–87. doi:10.1016/S0899-9007(98)00171-3.

[151] Morley JE. Undernutrition in older adults. Fam Pract 2012;29. doi:10.1093/fampra/cmr054.

[152] Wakimoto P, Block G. Dietary intake, dietary patterns, and changes with age: an epidemiological perspective. J Gerontol A Biol Sci Med Sci 2001;56:65–80. doi:10.1093/gerona/56.suppl_2.65.

[153] DiMaria-Ghalili R., Amella E. Nutrition in older adults. Am J Nurs 2005;105:40–51. doi:10.1016/S0749-0690(15)00041-5.

[154] Tieland M, Borgonjen-Van Den Berg KJ, Van Loon LJC, de Groot LCPGM. Dietary protein intake in dutch elderly people: A focus on protein sources. Nutrients 2015;7:9697–706. doi:10.3390/nu7125496.

[155] Volpi E, Campbell WW, Dwyer JT, Johnson MA, Jensen GL, Morley JE, et al. Is the optimal level of protein intake for older adults greater than the recommended dietary allowance? J Gerontol A Biol Sci Med Sci 2013;68:677–81. doi:10.1093/gerona/gls229.

[156] Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia. Curr Opin Clin Nutr Metab Care 2009;12:86–90. doi:10.1097/MCO.0b013e32831cef8b.

[157] Nieuwenhuizen WF, Weenen H, Rigby P, Hetherington MM. Older adults and patients in need of nutritional support: Review of current treatment options and factors influencing nutritional intake. Clin Nutr 2010;29:160–9. doi:10.1016/j.clnu.2009.09.003.

[158] Campbell AD, Godfryd A, Buys DR, Locher JL. Does Participation in Home-Delivered Meals Programs Improve Outcomes for Older Adults? Results of a Systematic Review. J Nutr Gerontol Geriatr 2015;34:124–67. doi:10.1080/21551197.2015.1038463.

[159] Wellman NS, Rosenzweig LY, Lloyd JL. Thirty years of the Older Americans Nutrition Program. J Am Diet Assoc 2002;102:348–50. doi:10.1016/S0002-8223(02)90081-7.

[160] Sharkey J, Haines P. Nutrition risk screening of home-delivered meal participants. J Nutr Elder 2002;22:15–34. doi:10.1300/J052v22n01_02.

[161] Ziylan C, Haveman-Nies A, Kremer S, de Groot LCPGM. Protein-Enriched Bread and Readymade Meals Increase Community-Dwelling Older Adults' Protein Intake in a Double-Blind Randomized Controlled Trial. J Am Med Dir Assoc 2017;18:145–51. doi:10.1016/j.jamda.2016.08.018.

[162] van Til AJJ, Naumann E, Cox-Claessens IJH. JHM, Kremer S, Boelsma E, de van der Schueren MAEE. Effects of the daily consumption of protein enriched bread and protein enriched drinking yoghurt on the total protein intake in older adults in a rehabilitation centre: A single blind randomised controlled tria. J Nutr Heal Aging 2015;19:525–30. doi:10.1007/s12603-015-0471-6.

[163] Folstein MF, Folstein SE, McHugh PR. "Mini-Mental-State", a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–98. doi:10.1016/0022-3956(75)90026-6.

[164] Podsiadlo D, Richardson S. The timed "Up & Go": A test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39:142–8. doi:10.1111/j.1532-5415.1991.tb01616.x.

[165] Innes E. Handgrip strength testing: A review of the literature. Aust Occup Ther J 1999;46:120–40. doi:10.1046/j.1440-1630.1999.00182.x.

[166] Biro G, Hulshof K, Ovesen L, Amorim Cruz JA. Selection of methodology to assess food intake. Eur J Clin Nutr 2002;56:s25. doi:10.1038/sj.ejcn.1601426.

[167] RIVM/Voedingscentrum. Dutch food composition table (NEVO-tabel 2021). 2021.

[168] Gaffney-Stomberg E, Insogna KL, Rodriguez NR, Kerstetter JE. Increasing dietary protein requirements in elderly people for optimal muscle and bone health. J Am Geriatr Soc 2009;57:1073–9. doi:10.1111/j.1532-5415.2009.02285.x.

[169] Denissen KFM, Janssen LMJ, Eussen SJPM, van Dongen MCJM, Wijckmans NEG, van Deurse NDM, et al. Delivery of nutritious meals to elderly receiving home care: Feasibility and effectiveness. J Nutr Heal Aging 2017;21:370–80. doi:10.1007/s12603-016-0790-2.

[170] Zhu H, An R, Number P, Agreement P. Impact of home-delivered meal programs on diet and nutrition among older adults: A review. Nutr Health 2013;22:89–103. doi:10.1177/0260106014537146.

[171] Sidenvall B, Nydahl M, Fjellstrom C. The meal as a gift - The meaning of cooking among retired women. J Appl Gerontol 2000;19:405–23. doi:10.1177/073346480001900403.

[172] Vesnaver E, Keller HH, Payette H, Shatenstein B. Dietary resilience as described by older community-dwelling adults from the NuAge study "If there is a will - there is a way!" Appetite 2012;58:730–8. doi:10.1016/j.appet.2011.12.008.

[173] Hardy SE, Gill TM. Recovery from Disability among Community-Dwelling Older Persons. J Am Med Assoc 2004;291:1596–602. doi:10.1001/jama.291.13.1596.

[174] Gill TM, Robison JT, Tinetti ME. Predictors of recovery in activities of daily living among disabled older persons living in the community. J Gen Intern Med 1997;12:757–62. doi:10.1046/j.1525-1497.1997.07161.x.

[175] Fratiglioni L, Paillard-Borg S, Winblad B. An active and socially integrated lifestyle in late life might protect against dementia. Lancet Neurol 2004;3:343–53. doi:10.1016/S1474-4422(04)00767-7.

[176] Lundkvist P, Fjellström C, Sidenvall B, Lumbers M, Raats M. Management of healthy eating in everyday life among senior Europeans. Appetite 2010;55:616–22. doi:10.1016/j.appet.2010.09.015.

[177] Beelen J, Vasse E, Ziylan C, Janssen N, de Roos N., de Groot L. Undernutrition: who cares? Perspectives of dietitians and older adults on undernutrition. BMC Nutr 2017;3:24–33.

[178] Van der Zanden LDT, van Kleef E, de Wijk RA, van Trijp HCM. Knowledge, perceptions and preferences of elderly regarding protein-enriched functional food. Appetite 2014;80:16–22. doi:10.1016/j.appet.2014.04.025.

[179] Milne C, Potter J, Vivanti A, Avenell A. Protein and energy supplementation in older people at risk from malnutrition (Review). Cochrane Database Syst Rev 2010;29:144. doi:10.1002/14651858.CD003288.pub3.

[180] Beelen J, de Roos N., de groot l. Protein enrichment of familiar foods as an innovative strategy to increase protein intake in institutionalized elderly. J Nutr Health Aging 2017;21:173–9.

[181] Sahyoun NR, Pratt CA, Anderson A. Evaluation of nutrition education interventions for older adults: a proposed framework. J Am Diet Assoc 2004;104:58–69. doi:10.1016/j.jada.2003.10.013.

[182] Rousset S, Droit-Volet S, Boirie Y. Change in protein intake in elderly french people living at home after a nutritional information program targeting protein consumption. J Am Diet Assoc 2006;106:253–61. doi:10.1016/j.jada.2005.10.037.

[183] Eurostat. Ageing Europe. Looking at the lives of older people in the EU. 2019.

[184] WHO. The World report on ageing and health. 2015.

[185] Iecovich E. Aging in place: From theory to practice. Anthropol Notebooks 2014;20:21–33.

[186] Roy N, Dubé R, Després C, Freitas A, Légaré F. Choosing between staying at home or moving: A systematic review of factors influencing housing decisions among frail older adults. PLoS One 2018;13. doi:10.1371/journal.pone.0189266.

[187] Alders P, Schut FT. The 2015 long-term care reform in the Netherlands: Getting the financial incentives right? Health Policy (New York) 2019;123:312–6. doi:10.1016/j.healthpol.2018.10.010.

[188] Njegovan V, Man-Son-Hing M, Mitchell SL, Molnar FJ. The hierarchy of functional loss associated with cognitive decline in older persons. Journals Gerontol - Ser A Biol Sci Med Sci 2001;56:M638-643. doi:10.1093/gerona/56.10.M638.

[189] Johnson S, Bacsu J, Abeykoon H, McIntosh T, Jeffery B, Novik N. No Place Like Home: A Systematic Review of Home Care for Older Adults in Canada. Can J Aging 2018;37:400–19. doi:10.1017/S0714980818000375.

[190] Buhr GT, Kuchibhatla M, Clipp EC. Caregivers' reasons for nursing home placement: Clues for improving discussions with families prior to the transition. Gerontologist 2006;46:52–61. doi:10.1093/geront/46.1.52.

[191] Gaugler J., Duval S, Anderson K., Kane RL. Predicting nursing home admission in the US: a meta-analysis. BMC Geriatr 2007;7:13.

[192] Luppa M, Luck T, Weyerer S, König HH, Brähler E, Riedel-Heller SG. Prediction of institutionalization in the elderly. A systematic review. Age Ageing 2009;39:31–8. doi:10.1093/ageing/afp202.

[193] Fávaro-Moreira NC, Krausch-Hofmann S, Matthys C, Vereecken C, Vanhauwaert E, Declercq A, et al. Risk Factors for Malnutrition in Older Adults: A Systematic Review of the Literature Based on Longitudinal Data. Adv Nutr 2016;7:507–22. doi:10.3945/an.115.011254.

[194] Verbrugghe M, Beeckman D, Van Hecke A, Vanderwee K, Van Herck K, Clays E, et al. Malnutrition and associated factors in nursing home residents: A cross-sectional, multi-centre study. Clin Nutr 2013;32:438–43. doi:10.1016/j.clnu.2012.09.008.

[195] Stange I, Poeschl K, Stehle P, Sieber CC, Volkert D. Screening for malnutrition in nursing home residents: Comparison of different risk markers and their association to functional impairment. J Nutr Heal Aging 2013;17:357–63. doi:10.1007/s12603-013-0021-z.

[196] Tamura K. B, Bell L. C, Masaki H. K, Amella J. E. Factors Associated With Weight Loss, Low BMI, and Malnutrition Among Nursing Home Patients: A Systematic Review of the Literature. J Am Med Dir Assoc 2013;14:649–55.

[197] InterRAI. Organization The interRAI Organization: Who We Are Mission and Vision 2021. https://www.interrai.org/organization/ (accessed May 10, 2021).

[198] Gray LC, Berg K, Fries BE, Henrard JC, Hirdes JP, Steel K, et al. Sharing clinical information across care settings: The birth of an integrated assessment system. BMC Health Serv Res 2009;9:6963–71. doi:10.1186/1472-6963-9-71.

[199] Boorsma M, Frijters DHM, Knol DL, Ribbe ME, Nijpels G, Van Hout HPJ. Effects of multidisciplinary integrated care on quality of care in residential care facilities for elderly people: A cluster randomized trial. CMAJ 2011;183:E724–32. doi:10.1503/cmaj.101498.

[200] Hirdes JP, Ljunggren G, Morris JN, Frijters DH, Finne Soveri H, Gray L, et al. Reliability of the interRAI suite of assessment instruments: A 12-country study of an integrated health information system. BMC Health Serv Res 2008;8:1–11. doi:10.1186/1472-6963-8-277.

[201] Kim H, Jung Y Il, Sung M, Lee JY, Yoon JY, Yoon JL. Reliability of the interRAI Long Term Care Facilities (LTCF) and interRAI Home Care (HC). Geriatr Gerontol Int 2015;15:220–8. doi:10.1111/ggi.12330.

[202] Frederiksen K, Tariot P, De Jonghe E. Minimum Data Set Plus (MDS+) scores compared with scores from five rating scales. J Am Geriatr Soc 1996;44:305–9. doi:10.1111/j.1532-5415.1996.tb00920.x.

[203] Guthrie DM, Davidson JGS, Williams N, Campos J, Hunter K, Mick P, et al. Combined impairments in vision, hearing and cognition are associated with greater levels of functional and communication difficulties than cognitive impairment alone: Analysis of interRAI data for home care and long-term care recipients in Ontario. PLoS One 2018;13. doi:10.1371/journal.pone.0192971.

[204] Hartmaier SL, Sloane PD, Guess HA, Koch GG, Mitchell CM, Phillips CD. Validation of the minimum data set cognitive performance scale: Agreement with the mini-mental state examination. Journals Gerontol - Ser A Biol Sci Med Sci 1995;50:128–33. doi:10.1093/gerona/50A.2.M128.

[205] Morris JN, Fries BE, Mehr DR, Hawes C, Phillips C, Mor V, et al. MDS cognitive performance scale. Journals Gerontol 1994;49:174–82. doi:10.1093/geronj/49.4.M174.

[206] Anderson RL, Buckwalter KC, Buchanan RJ, Maas ML, Imhof SL. Validity and reliability of the Minimun Data Set Depression Rating Scale (MDSDRS) for older adults in nursing homes. Age Ageing 2003;32:435–8. doi:10.1093/ageing/32.4.435.

[207] Burrows AB, Morris JN, Simon SE, Hirdes JP, Phillips C. Development of a Minimum Data Set-based depression rating scale for use in nursing homes. Age Ageing 2000;29:165–72. doi:10.1093/ageing/29.2.165.

[208] Gerritsen DL, Steverink N, Frijters DHM, Hirdes JP, Ooms ME, Ribbe MW. A revised index for social engagement for long-term care. J Gerontol Nurs 2008;34:40–8. doi:10.3928/00989134-20080401-04.

[209] Resnick HE, Fries BE, Verbrugge LM. Windows to their world: The effect of sensory impairments on social engagement and activity time in nursing home residents. Journals Gerontol - Ser B Psychol Sci Soc Sci 1997;52:S135–44. doi:10.1093/geronb/52B.3.S135.

[210] Perlman CM, Hirdes JP. The aggressive behavior scale: A new scale to measure aggression based on the minimum data set. J Am Geriatr Soc 2008;56:2298–303. doi:10.1111/j.1532-5415.2008.02048.x.

[211] Twisk J. Inleiding in De Toegepaste Biostatistiek. Loghum: Bohn Stafleu van Loghum; 2017.

[212] Gaskill D, Black LJ, Isenring EA, Hassall S, Sanders F, Bauer JD. Malnutrition prevalence and nutrition issues in residential aged care facilities. Australas J Ageing 2008;27:189–94. doi:10.1111/j.1741-6612.2008.00324.x.

[213] Vesnaver E, Keller HH. Social influences and eating behavior in later life: A review. J Nutr Gerontol Geriatr 2011;30:2–23. doi:10.1080/01639366.2011.545038.

[214] Clark AB, Reijnierse EM, Lim WK, Maier AB. Prevalence of malnutrition comparing the GLIM criteria, ESPEN definition and MST malnutrition risk in geriatric rehabilitation patients: RESORT. Clin Nutr 2020;39:3504–11. doi:10.1016/j.clnu.2020.03.015.

[215] Shatenstein B, Kergoat MJ, Nadon S. Weight change, nutritional risk and its determinants among cognitively intact and demented elderly Canadians. Can J Public Heal 2001;92:143–9. doi:10.1007/bf03404949.

[216] Mamhidir AG, Ljunggren G, Kihlgren M, Kihlgren A, Wimo A. Underweight, weight loss and related risk factors among older adults in sheltered housing - A Swedish follow-up study. J Nutr Heal Aging 2006;10:255.

[217] Schilp J, Wijnhoven HAH, Deeg DJH, Visser M. Early determinants for the development of undernutrition in an older general population: Longitudinal Aging Study Amsterdam. Br J Nutr 2011;106:708–17. doi:10.1017/S0007114511000717.

[218] Gonzalez-Colaço Harmand M, Meillon C, Rullier L, Avila-Funes JA, Bergua V, Dartigues JF, et al. Cognitive decline after entering a nursing home: A 22-year follow-up study of institutionalized and noninstitutionalized elderly people. J Am Med Dir Assoc 2014;15:504–8. doi:10.1016/j.jamda.2014.02.006.

[219] Zahodne LB, Ornstein K, Cosentino S, Devanand DP, Stern Y. Longitudinal relationships between alzheimer disease progression and psychosis, depressed mood, and agitation/aggression. Am J Geriatr Psychiatry 2015;23:130–40. doi:10.1016/j.jagp.2013.03.014.

[220] Hackett RA, Steptoe A, Cadar D, Fancourt D. Social engagement before and after dementia diagnosis in the English Longitudinal Study of Ageing. PLoS One 2019;14:e220195. doi:10.1371/journal.pone.0220195.

[221] Ulbricht CM, Rothschild AJ, Hunnicutt JN, Lapane KL. Depression and cognitive impairment among newly admitted nursing home residents in the USA. Int J Geriatr Psychiatry 2017;32:1172–81. doi:10.1002/gps.4723.

[222] Volkert D, Chourdakis M, Faxen-Irving G, Frühwald T, Landi F, Suominen MH, et al. ESPEN guidelines on nutrition in dementia. Clin Nutr 2015;34:1052–73. doi:10.1016/j.clnu.2015.09.004.

[223] Helvik AS, Engedal K, Benth JŠ, Selbæk G. A 52 month follow-up of functional decline in nursing home residents - Degree of dementia contributes. BMC Geriatr 2014;14:1–10. doi:10.1186/1471-2318-14-45.

[224] Mitchell SL, Teno JM, Kiely DK, Shaffer ML, Jones RN, Prigerson HG, et al. The Clinical Course of Advanced Dementia. N Engl J Med 2009;361:1529–38. doi:10.1056/nejmoa0902234.

[225] Druml C, Ballmer PE, Druml W, Oehmichen F, Shenkin A, Singer P, et al. ESPEN guideline on ethical aspects of artificial nutrition and hydration. Clin Nutr 2016;35:545–56. doi:10.1016/j.clnu.2016.02.006.

[226] Eurostat. Europop2019. 2020.

[227] Cesari M, Prince M, Thiyagarajan JA, De Carvalho IA, Bernabei R, Chan P, et al. Frailty: An Emerging Public Health Priority. J Am Med Dir Assoc 2016;17:188–92. doi:10.1016/j.jamda.2015.12.016.

[228] Schram MT, Frijters D, van de Lisdonk EH, Ploemacher J, de Craen AJM, de Waal MWM, et al. Setting and registry characteristics affect the prevalence and nature of multimorbidity in the elderly. J Clin Epidemiol 2008;61:1104–12. doi:10.1016/j.jclinepi.2007.11.021.

[229] Evans WJ, Morley JE, Argilés J, Bales C, Baracos V, Guttridge D, et al. Cachexia: A new definition. Clin Nutr 2008;27:793–9. doi:10.1016/j.clnu.2008.06.013.

[230] Pilgrim AL, Robinson SM, Sayer AA, Roberts HC. An overview of appetite decline in older people. Nurs Older People 2015;27:27–33. doi:10.7748/nop.27.5.29.e697.

[231] Schiller LR. Maldigestion Versus Malabsorption in the Elderly. Curr Gastroenterol Rep 2020;22:1–8. doi:10.1007/s11894-020-00771-5.

[232] Cereda E, Pedrolli C, Klersy C, Bonardi C, Quarleri L, Cappello S, et al. Nutritional status in older persons according to healthcare setting: A systematic review and meta-analysis of prevalence data using MNA®. Clin Nutr 2016;35:1282–90. doi:10.1016/j.clnu.2016.03.008.

[233] Crogan NL, Pasvogel A. The influence of protein-calorie malnutrition on quality of life in nursing homes. Journals Gerontol - Ser A Biol Sci Med Sci 2003;58:159–64. doi:10.1093/gerona/58.2.m159.

[234] Landi F, Camprubi-Robles M, Bear DE, Cederholm T, Malafarina V, Welch AA, et al. Muscle loss: The new malnutrition challenge in clinical practice. Clin Nutr 2019;38:2113–20. doi:10.1016/j.clnu.2018.11.021.

[235] Torbahn G, Sulz I, Großhauser F, Hiesmayr MJ, Kiesswetter E, Schindler K, et al. Predictors of incident malnutrition—a nutritionDay analysis in 11,923 nursing home residents. Eur J Clin Nutr 2021:1–7. doi:10.1038/s41430-021-00964-9.

[236] Borkent JW, van Hout H, Feskens EJ., Naumann E, de van der Schueren MA. Behavioral and cognitive problems as determinants of malnutrition in long-term care facilities, a cross-sectional and prospective study. J Nutr Health Aging 2022.

[237] Department of Health and Human Services. minimum Data Set (MDS) 3.0 Resident Assessment Instrument (RAI) Manual. 2012.

[238] Verbeek-Oudijk D, Koper I. Landelijk overzicht van de leefsituatie, ervaren kwaliteit van leven en zorg van oudere verpleeghuisbewoners in 2019. Den Haag: 2021.

[239] Dyck MJ. Nursing staffing and resident outcomes in nursing homes: Weight loss and dehydration. J Nurs Care Qual 2007;22:59–65. doi:10.1097/00001786-200701000-00012.

[240] Simmons SF, Schnelle JF. Feeding assistance needs of long-stay nursing home residents and staff time to provide care. J Am Geriatr Soc 2006;54:919–24. doi:10.1111/j.1532-5415.2006.00812.x.

[241] Reimer HD, Keller HH. Mealtimes in nursing homes: Striving for person-centered care. J Nutr Elder 2009;28:327–47. doi:10.1080/01639360903417066.

[242] Simmons SF, Osterweil D, Schnelle JF. Improving food intake in nursing home residents with feeding assistance: A staffing analysis. Journals Gerontol - Ser A Biol Sci Med Sci 2001;56:790–4. doi:10.1093/gerona/56.12.M790.

[243] Simmons SF, Keeler E, Zhuo X, Hickey KA, Sato HW, Schnelle JF. Prevention of unintentional weight loss in nursing home residents: A controlled trial of feeding assistance. J Am Geriatr Soc 2008;56:1466–73. doi:10.1111/j.1532-5415.2008.01801.x.

[244] Dory M. Enhancing the Dining Experience in Long-Term Care. J Nutr Elder 2004;23:99–109. doi:10.1300/j052v23n03_07.

[245] Sexton CE, Walhovd KB, Storsve AB, Tamnes CK, Westlye LT, Johansen-Berg H, et al. Accelerated changes in white matter microstructure during aging: A longitudinal diffusion tensor imaging study. J Neurosci 2014;34:15425–36. doi:10.1523/JNEUROSCI.0203-14.2014.

[246] Sanchez-Rodriguez D, Locquet M, Reginster JY, Cavalier E, Bruyère O, Beaudart C. Mortality in malnourished older adults diagnosed by ESPEN and GLIM criteria in the SarcoPhAge study. J Cachexia Sarcopenia Muscle 2020;11:1200–11. doi:10.1002/jcsm.12574.

[247] de van der Schueren MA., Borkent J., Spaans G., Nijhof A, Manders M. GLIM in nursing homes; practical implications. Clin Nutr ESPEN 2022.

[248] Eurostat. More than a fifth of the EU population are aged 65 or over 2022. https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210316-1 (accessed June 14, 2022).

[249] Eurostat. Mortality and life expectancy statistics 2022. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Mortality_and_life_expectancy_statistics (accessed June 14, 2022).

[250] Askenäs L, Aidemark J. SUPPORTING ELDERLY LIVING LONGER AT HOME: A FRAMEWORK FOR BUILDING A SUSTAINABLE ECO-SYSTEM, 2020. doi:10.33965/its_ste2020_202001l001.

[251] Borkent JW, Hout HP., Feskens EJ., naumann E, de van der Schueren M. Diseases, health-related problems and the incidence of malnutrition in long-term care facilities. n.d.

[252] Buckinx F, Reginster JY, Morelle A, Paquot N, Labeye N, Locquet M, et al. Influence of environmental factors on food intake among nursing home residents: A survey combined with a video approach. Clin Interv Aging 2017;12. doi:10.2147/CIA.S135937.

[253] Stratton R, Green C, Elia M. Disease-related malnutrition: an evidence-based approach to treatment. Cabi; 2003.

[254] Health counsil of the Netherlands. An evaluation of the EFSA's dietary reference values. Den Haag: 2018.

[255] Scientific Opinion on Dietary Reference Values for protein. EFSA J 2012;10. doi:10.2903/j.efsa.2012.2557.

[256] Kawano R, Takahashi F, Hashimoto Y, Okamura T, Miki A, Kaji A, et al. Short energy intake is associated with muscle mass loss in older patients with type 2 diabetes: A prospective study of the KAMOGAWA-DM cohort. Clin Nutr 2021;40. doi:10.1016/j.clnu.2021.02.049.

[257] Tipton KD, Hamilton DL, Gallagher IJ. Assessing the Role of Muscle Protein Breakdown in Response to Nutrition and Exercise in Humans. Sport Med 2018;48. doi:10.1007/s40279-017-0845-5.

[258] Gaillard C, Alix E, Sallé A, Berrut G, Ritz P. Energy requirements in frail elderly people: A review of the literature. Clin Nutr 2007;26. doi:10.1016/j.clnu.2006.08.003.

[259] Lorenzo-López L, Maseda A, De Labra C, Regueiro-Folgueira L, Rodríguez-Villamil JL, Millán-Calenti JC. Nutritional determinants of frailty in older adults: A systematic review. BMC Geriatr 2017;17. doi:10.1186/s12877-017-0496-2.

[260] Castellanos VH, Andrews YN. Inherent flaws in a method of estimating meal intake commonly used in long-term-care facilities. J Am Diet Assoc 2002;102. doi:10.1016/S0002-8223(02)90184-7.

[261] Plotkin A, Taani MH. Factors associated with food intake, nutritional status, and function among nursing home residents with dementia. Geriatr Nurs (Minneap) 2020;41. doi:10.1016/j.gerinurse.2020.02.004.

[262] Kruizenga HM, De Vet HCW, Van Marissing CME, Stassen EEPM, Strijk JE, Van Bokhorst-De Van Der Schueren MAE, et al. The SNAQRC, an easy traffic light system as a first step in the recognition of undernutrition in residential care. J Nutr Heal Aging 2010;14. doi:10.1007/s12603-009-0147-1.

[263] Lipschitz DA. Screening for nutritional status in the elderly. Prim Care - Clin Off Pract 1994;21. doi:10.1016/s0095-4543(21)00452-8.

[264] Fortin M, Stewart M, Poitras ME, Almirall J, Maddocks H. A systematic review of prevalence studies on multimorbidity: Toward a more uniform methodology. Ann Fam Med 2012;10. doi:10.1370/afm.1337.

[265] Mertz W. Food intake measurements: Is there a "gold standard"? J Am Diet Assoc 1992;92. doi:10.1016/s0002-8223(21)00927-5.

[266] Forbes GB. Some adventures in body composition, with special reference to nutrition. Acta Diabetol., vol. 40, 2003. doi:10.1007/s00592-003-0075-1.

[267] Weijs PJM, Sauerwein HP, Kondrup J. Protein recommendations in the ICU: g protein/kg body weight - which body weight for underweight and obese patients? Clin Nutr 2012;31. doi:10.1016/j.clnu.2012.04.007.

[268] Krok-Schoen JL, Archdeacon Price A, Luo M, Kelly OJ, Taylor CA. Low Dietary Protein Intakes and Associated Dietary Patterns and Functional Limitations in an Aging Population: A NHANES Analysis. J Nutr Heal Aging 2019;23. doi:10.1007/s12603-019-1174-1.

[269] Arganini C, Saba A, Comitato R, Virgili F, Turrini A. Gender Differences in Food Choice and Dietary Intake in Modern Western Societies. Public Heal. - Soc. Behav. Heal., 2012. doi:10.5772/37886.

[270] de Boer A, Ter Horst GJ, Lorist MM. Physiological and psychosocial age-related changes associated with reduced food intake in older persons. Ageing Res Rev 2013;12. doi:10.1016/j.arr.2012.08.002.

[271] Everink IHJ, van Haastregt JCM, Manders M, de van der Schueren MAE, Schols JMGA. Malnutrition Prevalence Rates among Dutch Nursing Home Residents: What Has Changed over One Decade? A Comparison of the Years 2009, 2013 and 2018. J Nutr Heal Aging 2021;25. doi:10.1007/s12603-021-1668-5.

[272] LPZ. Zorgproblemen - Ondervoeding 2022. https://nl.lpz-um.eu/nl/CareIndicators/Malnutrition (accessed June 14, 2022).

[273] Trabal J, Farran-Codina A. Effects of dietary enrichment with conventional foods on energy and protein intake in older adults: a systematic review. [Review]. Nutr Rev 2015;73:624–33. doi:http://dx.doi.org/10.1093/nutrit/nuv023.

[274] Streicher M, Themessl-Huber M, Schindler K, Sieber CC, Hiesmayr M, Volkert D. Who receives oral nutritional supplements in nursing homes? Results from the nutritionDay project. Clin Nutr 2017;36. doi:10.1016/j.clnu.2016.09.005.

[275] Cawood AL, Elia M, Stratton RJ. Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. Ageing Res Rev 2012;11:278–96. doi:10.1016/j.arr.2011.12.008.

[276] Wilson MMG, Thomas DR, Rubenstein LZ, Chibnall JT, Anderson S, Baxi A, et al. Appetite assessment: Simple appetite questionnaire predicts weight loss in community-dwelling adults and nursing home residents. Am J Clin Nutr 2005;82. doi:10.1093/ajcn/82.5.1074.

[277] Lad H, Gott M, Gariballa SE. Elderly patients compliance and elderly patients and health professional's, views, and attitudes towards prescribed sip-feed supplements. J Nutr Heal Aging 2005;9.

[278] Methven L, Rahelu K, Economou N, Kinneavy L, Ladbrooke-Davis L, Kennedy OB, et al. The effect of consumption volume on profile and liking of oral nutritional supplements of varied

sweetness: Sequential profiling and boredom tests. Food Qual Prefer 2010;21. doi:10.1016/j.foodqual.2010.04.009.

[279] van Hamersveld - Kramer M, Perry SIB, Lodewijks E, Vasse E, de van der Schueren MAE. Decision-making regarding oral nutritional supplements for nursing home residents with advanced dementia: A cross-sectional pilot study. J Hum Nutr Diet 2022;35. doi:10.1111/jhn.12955.

[280] Verwijs MH, De Van Der Schueren MAE, Ocké MC, Ditewig J, Linschooten JO, Roodenburg AJC, et al. The protein gap: Increasing protein intake in the diet of community-dwelling older adults - A simulation study. Public Health Nutr 2021. doi:10.1017/S1368980021004134.

[281] Linschooten JO, Verwijs M., Beelen J, de van der Schueren M., Roodenburg A. Low awareness of community-dwelling older adults on the importance of dietary protein: new insights from four qualitative studies. J Nutr Sci 2021;10.

[282] Edfors E, Westergren A. Home-living elderly peoples views on food and meals. J Aging Res 2012;2012. doi:10.1155/2012/761291.

[283] Abbott RA, Whear R, Thompson-Coon J, Ukoumunne OC, Rogers M, Bethel A, et al. Effectiveness of mealtime interventions on nutritional outcomes for the elderly living in residential care: A systematic review and meta-analysis. Ageing Res Rev 2013;12. doi:10.1016/j.arr.2013.06.002.

[284] Hanssen I, Kuven BM. Moments of joy and delight: The meaning of traditional food in dementia care. J Clin Nurs 2016;25. doi:10.1111/jocn.13163.

[285] Keller H, Carrier N, Duizer L, Lengyel C, Slaughter S, Steele C. Making the Most of Mealtimes (M3): Grounding Mealtime Interventions With a Conceptual Model. J Am Med Dir Assoc 2014;15. doi:10.1016/j.jamda.2013.12.001.

[286] Prado CMM, Heymsfield SB. Lean tissue imaging: A new era for nutritional assessment and intervention. J Parenter Enter Nutr 2014;38. doi:10.1177/0148607114550189.

[287] Buckinx F, Paquot N, Fadeur M, Bacus L, Reginster JY, Allepaerts S, et al. Assessment of the energy expenditure of Belgian nursing home residents using indirect calorimetry. Nutrition 2019;57. doi:10.1016/j.nut.2018.05.010.

[288] Dimaria-Ghalili RA. Medical record versus researcher measures of height and weight. Biol Res Nurs 2006;8. doi:10.1177/1099800406288903.

[289] Oddone E, Olsen M, Sandersa L, McCant F, MSSW, Hurley S, et al. How Well Does Patient Self-Reported Weight Agree with Values in the Electronic Medical Record? J Obes Weight Loss Ther 2019;09. doi:10.4172/2165-7904.1000379.

[290] Schoeller DA. Validation of habitual energy intake. Public Health Nutr 2002;5. doi:10.1079/phn2002378.

[291] Kirkpatrick SI, Baranowski T, Subar AF, Tooze JA, Frongillo EA. Best Practices for Conducting and Interpreting Studies to Validate Self-Report Dietary Assessment Methods. J Acad Nutr Diet 2019;119. doi:10.1016/j.jand.2019.06.010.

[292] Epstein J, Santo RM, Guillemin F. A review of guidelines for cross-cultural adaptation of questionnaires could not bring out a consensus. J Clin Epidemiol 2015;68. doi:10.1016/j.jclinepi.2014.11.021.

[293] Pavlović JR, Maksimović MZ, Klopanović O V., Vasilić ZS, Ivković NM, Račić MN. Comparison of Seniors in the Community: Risk Evaluation for Eating and Nutrition, version II and Mini Nutritional Assessment - Short Form in detecting nutritional risk among community-dwelling seniors in Bosnia and Herzegovina. Public Health Nutr 2021;24. doi:10.1017/S1368980020002438.

[294] Wolfe RR, Miller SL, Miller KB. Optimal protein intake in the elderly. Clin Nutr 2008;27:675–84. doi:10.1016/j.clnu.2008.06.008.

[295] Rand WM, Pellett PL, Young VR. Meta-analysis of nitrogen balance studies for estimating protein requirements in healthy adults. Am J Clin Nutr 2003;77. doi:10.1093/ajcn/77.1.109.

[296] Murphy SP, Poos MI. Dietary Reference Intakes: summary of applications in dietary assessment. Public Health Nutr 2002;5. doi:10.1079/phn2002389.

[297] Hultsch DF, Hertzog C, Small BJ, Dixon RA. Use it or lose it: Engaged lifestyle as a buffer of cognitive decline in aging? Psychol Aging 1999;14:245–63. doi:10.1037/0882-7974.14.2.245.

[298] Power JEMH, Lee O, Aspell N, McCormack E, Loftus M, Connolly L, et al. RelAte: Pilot study of the effects of a mealtime intervention on social cognitive factors and energy intake among older adults living alone. Br J Nutr 2016;116:1573–81. doi:10.1017/S000711451600369X.

[299] Kruizinga HM, Beijer S, Huisman-de waal G, Jonkers-Schuitema C, Klos M, Remijnse-Meester W, et al. RICHTLIJN ONDERVOEDING HERKENNING, DIAGNOSESTELLING EN BEHANDELING VAN ONDERVOEDING BIJ VOLWASSENEN. 2019.

[300] de van der Schueren MAE, Wijnhoven HAH, Kruizenga HM, Visser M. A critical appraisal of nutritional intervention studies in malnourished, community dwelling older persons. Clin Nutr 2016;35. doi:10.1016/j.clnu.2015.12.013.

[301] Amella EJ. Feeding and hydration issues for older adults with dementia. Nurs Clin North Am 2004;39. doi:10.1016/j.cnur.2004.02.014.

[302] Keller HH, McKenzie JD, Goy RE. Construct validation and test-retest reliability of the Seniors in the Community: Risk Evaluation for Eating and Nutrition questionnaire. Journals Gerontol - Ser A Biol Sci Med Sci 2001;56. doi:10.1093/gerona/56.9.M552.

[303] Håkonsen SJ, Pedersen PU, Bygholm A, Peters MDJ, Bjerrum M. Speaking the same language: Development of a Nutrition Minimum Data Set for healthcare professionals in primary healthcare. Health Informatics J 2020;26:248–63. doi:10.1177/1460458218824707.

[304] Doraiswamy PM, Leon J, Cummings JL, Marin D, Neumann PJ. Prevalence and impact of medical comorbidity in Alzheimer's disease. Journals Gerontol - Ser A Biol Sci Med Sci 2002;57:173–7. doi:10.1093/gerona/57.3.M173.

[305] Grasso AC, Olthof MR, van Dooren C, Broekema R, Visser M, Brouwer IA. Protein for a healthy future: How to increase protein intake in an environmentally sustainable way in older adults in the Netherlands. J Nutr 2021;151. doi:10.1093/jn/nxaa322.

[306] Domic J, Grootswagers P, van Loon L., de Groot L. Perspective: Vegan Diets for Older Adults? A Perspective On the Potential Impact On Muscle Mass and Strength. Adv Nutr 2002.

[307] Grasso AC, Hung Y, Olthof MR, Brouwer IA, Verbeke W. Understanding meat consumption in later life: A segmentation of older consumers in the EU. Food Qual Prefer 2021;93. doi:10.1016/j.foodqual.2021.104242.

[308] Grasso AC, Hung Y, Olthof MR, Verbeke W, Brouwer IA. Older consumers' readiness to accept alternative, more sustainable protein sources in the European Union. Nutrients 2019;11. doi:10.3390/nu11081904.

[309] Hartmann C, Siegrist M. Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. Trends Food Sci Technol 2017;61. doi:10.1016/j.tifs.2016.12.006.

[310] Silvennoinen K, Heikkilä L, Katajajuuri JM, Reinikainen A. Food waste volume and origin: Case studies in the Finnish food service sector. Waste Manag 2015;46. doi:10.1016/j.wasman.2015.09.010.

[311] Gordon RS. An operational classification of disease prevention. Public Health Rep 1983;98.

[312] Kok L, Scholte R. Ondervoeding onderschat: De kosten van ondervoeding en het rendement van medische voeding. vol. SEO-Rappor. 2014.

[313] Polder J, Hoogenveen R, Luijben M, van den berg H, Slobbe L. Zorgkosten van ongezond gedrag en preventie. 2012.

[314] Ministerie van volksgezondheid welzijn en sport. Nationaal preventieakkoord, naar een gezonder Nederland. Den Haag: 2018.
[315] Ondervoeding K. Partnernetwerk Ondervoeding Ouderen 2022. https://www.kenniscentrumondervoeding.nl/partnernetwerk-ondervoeding-ouderen/ (accessed May 23, 2022).
[316] Visser M, Hung Y, Verbeke W. Protein knowledge of older adults and identification of subgroups with poor knowledge. Nutrients 2021;13:1006–17. doi:10.3390/nu13031006.
[317] Champion V, Skinner C. The health belief model. Health behavior and health education. Theory, Res Pract 2008;4.
[318] Lemmens L, Herber G-C, Spijkerman A, Van Oostrom S. Kansrijke elementen van preventieve activiteiten voor ouderen die onvoldoende bereikt worden. Geron 2018;20:43–7. doi:10.1007/s40718-018-0038-9.
[319] Vlaar P, Kluft M, Liefhebber S. Competenties maatschappelijke ondersteuning. Utrecht: 2012.
[320] BAPEN. Combating Malnutrition: Recommendations For Action. 2009.
[321] Hollaar VR., Naumann E, Haverkort E., Jerkovic-Cosic K, Kok W, de van der Schueren MA. Success factors and barriers in interprofessional collaboration between dental hygienists and dietitians in community-dwelling older people – Focus group interviews. Under Rev 2022.
[322] Verwijs MH, Puijk-Hekman S, van der Heijden E, Vasse E, de Groot LCPGM, de van der Schueren MAE. Interdisciplinary communication and collaboration as key to improved nutritional care of malnourished older adults across health-care settings – A qualitative study. Heal Expect 2020;23:1096-1107. doi:10.1111/hex.13075.
[323] Peeters J, Sleijster S, Laurant M. Een Sterk Wijknetwerk, eindrapportage. Nijmegen: 2020.
[324] Ministerie van volksgezondheid welzijn en sport. Wet maatschappelijke ondersteuning 2015. 2014.
[325] Ministerie van volksgezondheid welzijn en sport. Welke hulp kan ik thuis krijgen van de gemeente vanuit de Wmo? n.d. https://www.rijksoverheid.nl/onderwerpen/zorg-en-ondersteuning-thuis/vraag-en-antwoord/ondersteuning-gemeente-wmo-2015.
[326] Zutphen R van. Borg de zorg. Den Haag: 2018.
[327] Golden J, Conroy RM, Bruce I, Denihan A, Greene E, Kirby M, et al. Loneliness, social support networks, mood and wellbeing in community-dwelling elderly. Int J Geriatr Psychiatry 2009;24. doi:10.1002/gps.2181.
[328] Holup AA, Hyer K, Meng H, Volicer L. Profile of Nursing Home Residents Admitted Directly From Home. J Am Med Dir Assoc 2017;18:131–7. doi:10.1016/j.jamda.2016.08.017.
[329] Ministerie van volksgezondheid welzijn en sport. Wet langdurige zorg. The Netherlands: 2014.
[330] Zichtbare zorg. Handboek Kwaliteitskader Verantwoorde Zorg Verpleging Verzorging & Thuiszorg. 2011.
[331] ActiZ, Verenso, Verpleegkundigen & verzorgenden Nederland Z. Handboekvoorzorgaanbiedersvanverpleeghuiszorg. 2021.
[332] van Nie NC, Meijers JMM, Schols JMGA, Lohrmann C, Spreeuwenberg M, Halfens RJG. Do structural quality indicators of nutritional care influence malnutrition prevalence in Dutch, German, and Austrian nursing homes? Nutrition 2014;30:1384–90. doi:10.1016/j.nut.2014.04.015.
[333] Bauer S, Halfens RJG, Lohrmann C. Knowledge and attitudes of nursing staff towards malnutrition care in nursing homes: A multicentre cross-sectional study. J Nutr Heal Aging 2015;19:734–40. doi:10.1007/s12603-015-0535-7.
[334] Eglseer D, Halfens RJG, Schüssler S, Visser M, Volkert D, Lohrmann C. Is the topic of malnutrition in older adults addressed in the European nursing curricula? A MaNuEL study. Nurse Educ Today 2018;68. doi:10.1016/j.nedt.2018.05.015.

[335] Mawardi F, Lestari AS, Kusnanto H, Sasongko EPS, Hilmanto D. Malnutrition in older adults: How interprofessional teams see it? A systematic review of the qualitative research. Fam Pract 2021;38. doi:10.1093/fampra/cmaa091.

[336] Liljeberg E, Nydahl M, Lövestam E, Andersson A. A qualitative exploration of dietitians' experiences of prescribing oral nutritional supplements to patients with malnutrition: A focus on shared tailoring and behaviour change support. J Hum Nutr Diet 2021;34. doi:10.1111/jhn.12867.

[337] Baldwin C, de van der Schueren MA., Kruizinga HM, Weekes CE. Dietary advice with or without oral nutritional supplements for disease-related malnutrition in adults. Cochrane Database Syst Rev 2021. doi:10.1002/14651858.cd002008.pub4.

[338] Correa-Pérez A, Abraha I, Cherubini A, Collinson A, Dardevet D, de Groot LCPGM, et al. Efficacy of non-pharmacological interventions to treat malnutrition in older persons: A systematic review and meta-analysis. The SENATOR project ONTOP series and MaNuEL knowledge hub project. Ageing Res Rev 2019;49. doi:10.1016/j.arr.2018.10.011.

[339] van Rossum CTM, Buurma-Rethans EJM, Dinnissen CS, Beukers MH, Brants HAM, Dekkers ALM, et al. The diet of the Dutch: Results of the Dutch National Food Consumption Survey 2012-2016. 2020.

[340] Halton TL, Hu FB. The effects of high protein diets on thermogenesis, satiety and weight loss: A critical review. J Am Coll Nutr 2004;23. doi:10.1080/07315724.2004.10719381.

[341] High KP. Nutritional strategies to boost immunity and prevent infection in elderly individuals. Clin Infect Dis 2001;33. doi:10.1086/324509.

[342] Neyens J, Halfens R, Spreeuwenberg M, Meijers J, Luiking Y, Verlaan G, et al. Malnutrition is associated with an increased risk of falls and impaired activity in elderly patients in Dutch residential long-term care (LTC): A cross-sectional study. Arch Gerontol Geriatr 2013;56. doi:10.1016/j.archger.2012.08.005.

[343] Neloska L, Damevska K, Nikolchev A, Pavleska L, Petreska-Zovic B, Kostov M. The association between malnutrition and pressure ulcers in elderly in long-term care facility. Maced J Med Sci 2016;4. doi:10.3889/oamjms.2016.094.

[344] Lee KH, Mo JA. The Factors Influencing Meal Satisfaction in Older Adults: A Systematic Review and Meta-analysis. Asian Nurs Res (Korean Soc Nurs Sci) 2019;13. doi:10.1016/j.anr.2019.06.001.

[345] Philpin S, Merrell J, Warring J, Gregory V, Hobby D. Sociocultural context of nutrition in care homes. Nurs Older People 2011;23. doi:10.7748/nop2011.05.23.4.24.c8480.

[346] Milte R, Shulver W, Killington M, Bradley C, Miller M, Crotty M. Struggling to maintain individuality – Describing the experience of food in nursing homes for people with dementia. Arch Gerontol Geriatr 2017;72. doi:10.1016/j.archger.2017.05.002.

[347] Chou SC, Boldy DP, Lee AH. Measuring resident satisfaction in residential aged care. Gerontologist 2001;41. doi:10.1093/geront/41.5.623.

[348] Wang D, Everett B, Brunero S, Northall T, Villarosa AR, Salamonson Y. Perspectives of residents and staff regarding food choice in residential aged care: A qualitative study. J Clin Nurs 2020;29. doi:10.1111/jocn.15115.

[349] Lowndes R, Armstrong P, Daly T. The Meaning of "Dining": The Social Organization of Food in Long-term Care. Food Stud 2015;4.

[350] Ducak K, Keller HH. Menu planning in long-term care: Toward resident-centred menus. Can J Diet Pract Res 2011;72. doi:10.3148/72.2.2011.83.

[351] Hugo, C Isenring, E Sinclair, D Agarwal E. What does it cost to feed aged care residents in Australia? Nutr Diet 2018;75:6–10.

[352] ActiZ. De cliënt centraal DE MEDEWERKER OP ÉÉN!, CAO Verpleeg-, Verzorgingshuizen, Thuiszorg en Jeugdgezondheidszorg 2022-2023. 2022.

[353] Horeca Nederland. Loontabellen horeca 2022. https://www.khn.nl/tools/loontabellen-per-1-juli-2022 (accessed June 28, 2022).

[354] SCP. Het leven in een verpleeghuis. 2021.

[355] Behrouzi P, Grootswagers P, Keizer PLC, Smeets ETHC, Feskens EJM, De Groot LCPGM, et al. Dietary Intakes of Vegetable Protein, Folate, and Vitamins B-6 and B-12 Are Partially Correlated with Physical Functioning of Dutch Older Adults Using Copula Graphical Models. J Nutr 2020;150. doi:10.1093/jn/nxz269.

[356] Muir SW, Montero-Odasso M. Effect of vitamin D supplementation on muscle strength, gait and balance in older adults: A systematic review and meta-analysis. J Am Geriatr Soc 2011;59. doi:10.1111/j.1532-5415.2011.03733.x.

[357] Berendsen AAM, van Lieshout LELM, van den Heuvel EGHM, Matthys C, Péter S, de Groot LCPGM. Conventional foods, followed by dietary supplements and fortified foods, are the key sources of vitamin D, vitamin B6, and selenium intake in Dutch participants of the NU-AGE study. Nutr Res 2016;36. doi:10.1016/j.nutres.2016.05.007.

[358] Correa-Pérez A, Lozano-Montoya I, Volkert D, Visser M, Cruz-Jentoft AJ. Relevant outcomes for nutrition interventions to treat and prevent malnutrition in older people: a collaborative senator-ontop and manuel delphi study. Eur Geriatr Med 2018;9. doi:10.1007/s41999-018-0024-8.

[359] Visser M, Mendonça N, Avgerinou C, Cederholm T, Cruz-Jentoft AJ, Goisser S, et al. Towards developing a Core Outcome Set for malnutrition intervention studies in older adults: a scoping review to identify frequently used research outcomes. Eur Geriatr Med 2022. doi:10.1007/s41999-022-00617-5.

[360] Teggart K, Ganann R, Sihoto D, Moore C, Keller H, Senson C, et al. Group based nutrition internventions to promote health and mobility in community-dwelling older adults: a systematic review. Res Sq 2021;17.

Summary

Over the last decades, life expectancy has increased rapidly. The process of ageing is often linked to an increase in co-morbidities, malnutrition being one of them. The first expressions of developing (risk of) malnutrition (so-called 'early determinants) may be having problems with grocery shopping or cooking, decreased appetite, swallowing or chewing problems, or an impaired food intake. Eventually, this can result in so-called 'late-phase malnutrition' when malnutrition manifests itself in weight loss, loss of muscle mass and strength and then reduced physical functioning. Thus, malnutrition covers a continuum over time, taking on more serious forms with increasing age.

We studied the continuum of malnutrition during the journey of ageing; from older adults in the community to residents in long-term care facilities. In the community, we assessed prevalence rates and groups at increased risk of malnutrition and tested the effect of ready-made meals on protein intake. In long-term care facilities, we investigated how behavioral-cognitive problems and diseases and health-related problems were related to being malnourished at admission, or becoming malnourished during stay. In addition, we measured the food intake of Dutch residents of long-term care facilities.

In chapter 2, we provided an overview of risk factors for early determinants of malnutrition in Dutch community-dwelling older adults. We used data from www.goedgevoedouderworden.nl, a website that aims to inform older adults about healthy nutrition and malnutrition during the process of ageing. On this website, malnutrition screening tools can be filled in to assess the presence of early determinants of malnutrition (SCREEN II) or symptoms of late-phase malnutrition ($SNAQ^{65+}$). Based on this self-reported data, early determinants of malnutrition (84.1%) and late phase malnutrition (56.8%) were highly present and increased with age. These results underline the importance of such a website to create awareness of malnutrition at an early stage among citizens interested in the topic.

In chapter 3, we compared the data of www.goedgevoedouderworden.nl with the data of www.nutritionscreen.ca. Both websites use SCREEN II as a self-screening tool to identify early determinants of malnutrition. Data from The Netherlands (n=2482), Canada (n=9538), and New Zealand (n=217) were compared. The prevalence of the presence of early determinants of malnutrition differed only slightly between the three countries and ranged from 61.5% (the Netherlands) to 70.1% (Canada). However, individual risk factors differed between countries. These data indicate that early determinants of malnutrition are a common problem in the western societies. As risk factors differed between countries, policy to address these problems should be tailored to national needs.

In chapter 4, we compared two screening tools for malnutrition (SCREEN II and SNAQ^{65+}) within 200 community-dwelling older adults. Prevalence rates of older adults at risk differed widely between both tools: 69.0% were at risk based on SCREEN II, compared to 13.5% based on SNAQ^{65+}.The agreement between the two tools was low (kappa <0.20). Being at risk based on SCREEN II was associated with social factors such as living alone, income and activity level, but also with food intake. These factors belong to the so-called early determinants of malnutrition. In contrast, SNAQ^{65+} was more related to physical function, and presence of diseases and comorbidities and is a better reflection of late-phase malnutrition. While both tools are presented and validated as screening tools for malnutrition, we conclude that they measure very different constructs of malnutrition.

In the ConsuMEER study that was described in chapter 5, we tested the effect of switching from self-prepared meals to ready-made meals in terms of protein intake. In this RCT (n=98), the control group received standard ready-made meals and dairy low in protein, whereas the intervention group received protein-rich ready-made meals and dairy high in protein. During the study, protein intake decreased in the control group (to 0.87 gram/kg bodyweight/day), but remained stable in the intervention group (1.12 gram/kg bodyweight/day). Our data imply that switching towards ready-made meals carries the risk of a decrease in protein intake unless products are chosen that are high in protein content.

In chapter 6, we shifted our focus from the community to long-term care facilities. Based on data obtained from InterRAI (a minimum dataset to record multiple care problems at admission and during stay), we investigated the relation between behavioral-cognitive problems and malnutrition (based on weight loss and/or a low age-specific BMI – the ESPEN 2015 definition), both at admission (n=3722) and during stay (n=4978) in a long-term care facility. We showed that behavioral-cognitive problems and malnutrition were frequently present in newly-admitted residents; nearly 60% suffered from one or more behavioral-cognitive problems and 9.5% were malnourished. Residents with behavioral-cognitive problems were more often malnourished at admission and were more often malnourished during their stay. Especially those with multiple behavioral-cognitive problems were at increased risk.

In chapter 7, we used the same InterRAI dataset to assess the relation between diseases/health-related problems and malnutrition. To assess the role of different criteria for malnutrition, we used three different criteria: weight loss, low age-specific BMI, or the combination of both (i.e. ESPEN 2015 criteria). Prevalence of malnutrition at admission was highly affected by the criteria used and ranged from 8.8% (weight loss) to 27.4% (low age-specific BMI). Incidence rates for malnutrition during stay also differed between the

used definitions, but to a lesser extent (from 8.9% using ESPEN to 13.8% using weight loss). At admission, most diseases (except cardiometabolic diseases) and health-related problems were associated with higher prevalence rates of malnutrition, based on either criterion, but the association was strongest with weight loss. This was also seen in the prospective data but relations were less strong.

Finally, in chapter 8 we measured food intake in residents of long-term care facilities and assessed which groups consumed too little protein and/or energy. We assessed food intake by three-day observations in 189 residents of five different facilities. Food intake was low in most residents and approximately 80% did not reach the recommended intakes for protein and/or energy. Having a protein/energy-enriched diet was associated with a higher intake but also in this group, yet even residents on this enriched diet did not reach the requirements. We therefore advice to change food policy in long-term care facilities towards a protein/energy-enriched diet for all residents, instead of for those individuals with a diagnosed poor intake.

To conclude; malnutrition is a frequently occurring problem in older adults. In the community, the youngest age groups (<75 year) already display early determinants of malnutrition, without a clear expression of late-phase malnutrition. During the journey of ageing, the prevalence of both early determinants of malnutrition as well as late-phase malnutrition increases. Treatment of malnutrition depends on the stage of malnutrition and the underlying problems. Ready-made meals can be used when older adults are not able to prepare their own meals themselves, but meals high in protein should be used in order to prevent a decline in protein intake. In long-term care facilities, malnutrition is even a bigger problem than in the general community. A substantial part of newly admitted residents is already malnourished at admission or will become malnourished during stay. Especially those with multiple behavioral-cognitive problems or diseases are at increased risk. One of the underlying reasons for the high incidence of malnutrition could be the low food intake of residents; nearly all residents consume too few protein and energy. So, during the whole journey of ageing, older adults are at risk of developing malnutrition.

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Explanation of the cover

The cover of this thesis represents the journey of ageing during the period after retirement and is dedicated to the most important persons and pets in my personal life.

Most Dutch residents retire from working around the age of 65. They then face a new period in their life during which they may rest after 40-50 years of working and deserve to spend time on things they really like.

The first picture in the lower left corner is based on a picture of my mum and dad from a holiday in Iceland. During the writing of my thesis, my mum and dad became ~65 and retired. For me, it was a strange idea to realise that they now belong to the age class of my research: they are way too vital! Fortunately, a large group of older adults just after retirement is very vital. The vitality of the 'youngest' older adults is represented by our Dalmatian dog sitting next to them. As most people know, my wife and I have three dogs and Saar, the Dalmatian, is strong and full of energy. She is a true ambassador of healthy ageing and her motto is staying young by acting like being young.

As the years go by, the inevitable process of physical decline starts to take its toll. But with some help, most older adults remain relatively independent. During this period, older adults will probably rely on aid in the form of home care or walking aids, but they still live at home. When I started my master study 'Health Science' at the VU in Amsterdam, my grandparents were in this phase. The second and third couple on the cover is a tribute to them. Our dogs Finn and Linda accompany them as they suit their pace.

In the upper right corner, a couple is sitting before a nursing home, an impression based on the residence 'Libermannhof' where my wife was a manager for seven years and where I am a volunteer. The couple in front of the nursing home are my grandparents. This picture is based on the photo that they made for our wedding in 2020. As their mobility and energy levels were low, they were not able to attend our wedding. We see two people who, at that time, had been married for 67 years and still loved each other very much. Despite low energy levels, they took care of themselves and helped each other when possible. My first dog Emma, who passed away during the first day of my master's program, stands for the oldest aged: loyalty and love.

During the last year of my PhD, my grandmother passed away at the age of 92. This thesis is dedicated to my parents and grandparents whom I love.

The cover of this thesis is designed by Anja Brons. The whole picture is drawn in one line which represents the ongoing line of life.

About the author

Jos Borkent was born on 8 september 1987 in Delft and grew up in Barneveld. In 2005 he finished his VWO at Johannes Fontanus College (Barneveld). Thereafter, he moved to Den Haag to study 'nutrition and dietetics'. After his graduation, he spent his time investing in gold and silver and started his own company (Jos Onderwijs Steunpunt) where he helped students with statistics and their theses.

After the discovery of his love for statistics, he went to the Vrije Universiteit in Amsterdam for his master study 'health science'. He performed his internship/thesis within the department of nutrition, dietetics and lifestyle at the HAN University in Nijmegen under the supervision of Marian de van der Schueren. During this internship/thesis, research was performed on ready-made meals in community-dwelling older adults, resulting in one of the manuscripts in this thesis. After graduation from his MSc, Jos became a teacher of statistics at the InHolland university of applied sciences in Haarlem. However, after 8 months, Jos could not resist the call from Nijmegen to come back. What started as a temporary job, eventually resulted in a PhD project of which the results are described in this thesis.

His job in Nijmegen offered him also something in addition. Just after he started, he met Annita Brons with whom he married in 2020. Together they take care of their own little animal farm consisting of 3 dogs (Linda, Saar & Finn) and 1 cat (Bobby). As Annita is the manager of a long-term care facility (Proteion Libermannhof Gennep), they both have a passion for helping older adults. Jos works as a volunteer at the Libermannhof to keep in touch with his research population.

List of publications

In this thesis

Borkent JW, Naumann E, Vasse E, van der Heijden E, de van der Schueren MA. Prevalence and determinants of undernutrition in a sample of Dutch community-dwelling older adults: Results from two online screening tools. International Journal of Environmental Research and Public Health. 2019 May;16(9):1562-1573.

Borkent JW, Keller H, Wham C, Wijers F, de van der Schueren MA. Cross-country differences and similarities in undernutrition prevalence and risk as measured by SCREEN II in community-dwelling older adults. Healthcare. 2020 Jun; 8(2): 151-165.

Borkent JW, Schuurman LT, Beelen J, Linschooten JO, Keller HH, Roodenburg AJ, De van der Schueren MA. What do screening tools measure? lessons learned from SCREEN II and SNAQ65+. Clinical Nutrition ESPEN. 2020 Aug 1;38:172-177.

Borkent JW, Beelen J, Linschooten JO, Roodenburg AJ, de van der Schueren MA. The ConsuMEER study: a randomised trial towards the effectiveness of protein-rich ready-made meals and protein-rich dairy products in increasing protein intake of community-dwelling older adults after switching from self-prepared meals towards ready-made meals. Journal of Nutritional Science. 2019;8.

Borkent JW, van Hout HP, Feskens EJ, Naumann E, de van der Schueren MA. Behavioral and Cognitive Problems as Determinants of Malnutrition in Long-Term Care Facilities, a Cross-Sectional and Prospective Study. The Journal of Nutrition, Health & Aging. 2022 Jul 26(8): 749-759.

Subitted for publication

Borkent JW, van Hout HP, Feskens EJ, Naumann E, de van der Schueren MA. Diseases, health-related problems and the incidence of malnutrition in long-term care facilities

Hollara V, de van der Schueren M, Haverkort E, Everaars B, Borkent J, Jerković-Ćosić K, van Hout H, Everink I, Naumann E. Associations between problems in oral health, oral function and malnutrition in older people: Results from three databases

Other publications

Verwijs MH, Borkent JW, Schueren MA. Ondervoeding bij ouderen. In Informatorium voor Voeding en Diëtetiek–Supplement 106–december 2020 2021 (pp. 43-66). Bohn Stafleu van Loghum, Houten.

Verwijs MH, Haveman-Nies A, Borkent JW, Linschooten JO, Roodenburg AJ, De Groot LC, de van der Schueren MA. Protein intake among community-dwelling older adults: the influence of (pre-) motivational determinants. Nutrients. 2022 Jan 11;14(2):293-306

Leij-Halfwerk S, Verwijs MH, van Houdt S, Borkent JW, Guaitoli PR, Pelgrim T, Heymans MW, Power L, Visser M, Corish CA, de van der Schueren MA. Prevalence of protein-energy malnutrition risk in European older adults in community, residential and hospital settings, according to 22 malnutrition screening tools validated for use in adults≥ 65 years: a systematic review and meta-analysis. Maturitas. 2019 Aug;126:80-9.

Borkent JW, Naumann E, Vasse E, van der Heijden E, de van der Schueren M, Inventarisatie van risicofactoren voor een verminderde voedingstoestand bij thuiswonende Nederlandse ouderen: uitkomsten van zelfscreening. NTVD. 2020 January 75:1

de van der Schueren, M. A., Borkent, J. W., Spaans, G. W., Nijhof, A., & Manders, M.. GLIM in nursing homes; practical implications. Clinical Nutrition. 2022 Nov; 41(11): 2442:2445 .

Overview of completed training activities

Discipline specific activity	Organising institute	Year
Espen congress - Oral presentation	ESPEN, Madrid	2018
EUgms congress	EUgms, Berlin	2018
Espen congress - Poster presentation	ESPEN, Krakau	2019
Espen congress - Poster presentation	ESPEN, online	2020
EUgms congress	EUgms, online	2020
Espen congress - Poster presentation	ESPEN, online	2021
Nutritional science days	NAV, online	2021
Nutricia online symposium	Nutricia, Online	2021
Modelling of habitual dietary intake	VLAG, Wageningen	2021
LLL courses Nutrition in older adults & Nutritional Assessment and Techniques	ESPEN, Online	2021
Espen congress - Poster presentation	ESPEN, Vienna	2022

Course	Organising institute	Year
General introduction in R	EPIDM, Amsterdam	2019
Clinical prediction models	EPIDM, Amsterdam	2020
Schrijf 2 daagse	HAN, Arnhem	2020
Brain friendly working and writing	VLAG, Online	2021
How to present online	VLAG, Online	2021
Missing data, consequences and solutions	EPIDM, Online	2022
VLAG PhD week	VLAG, Wageningen	2022
Exposure assessment in nutrition research	VLAG, Wageningen	2022
Chemometrics	VLAG, Wageningen	2022

Assisting in teaching and supervision activities	Organising institute	Year
Supervision of MSc students	HAN	2019-2022
Teaching HAN Workshop SPSS	HAN	2019-2022

Other activities	Organising institute	Year
DUSRA meeting	DUSRA, Leiden	2019
Writing research proposal	VLAG, Wageningen	2019
Implementation Integrity codes within AFSG	WUR, Wageningen	2020
ConsuBETER Consortium meeting	HAN	2019/2020
GoedZO Consortium meeting	HAN	2020/2021
Staff MR4 meetings	WUR	2021
PROMISS Webinar	PROMISS	2021
Peer reviewing articles	HAN	2019-2022

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